Design Ideologies of Interactive Space in Digital Culture

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CERTIFICATE OF ORIGINALITY

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Abstract

This research project investigates the current situation in interactive space design, in pursuit of a better understanding of this future-oriented practice of environmental design. Digital culture, in its technological and theoretical influences, has transformed the design of the physical environment in unprecedented ways. Among various explorations of post-digital environments, interactive space design is a discipline that resists simple definition as architecture, computer studies or media design subject, as reflected by its practitioners who adopt diverse approaches in design process and execution. The study aims at achieving tools for description and analysis of the current practice and designers' ideologies in digital culture.

Reflected by selected interactive space projects, which compose a core framework of reference, the research is positioned on the investigation of embodied interaction by accommodating digital interactivity in physical environment design. With a human-centred research approach, analysis of descriptions of ideologies in interactive space design necessitates two distinct sets of languages and focuses: from users' and designers' points of view, respectively.

In the probe of descriptions of interactive space design from the user's point of view, themes around interaction interface, user participation and their experience were examined through observation and case studies, supported by theories on environmental psychology and human-computer interface design. Alternatively, the description of the same subject by designers of the spaces showed another focus that explains the themes of interests and ideologies behind the production of interactive spaces,

with data gathered from writings and designer interviews. These descriptions are juxtaposed and reveal a misalignment of perspectives and expectations between designers and users of interactive spaces.

This dual description of interactive space design is an analogy to distinctions made in the study of human-computer interfaces between technology-centred and user experience-centred understandings of interaction. A discussion provides an overview of theories on application and theory-oriented ideology, user involvement, and evaluation and development cycles of design products. Research findings are analyzed with the aid of these theories to articulate the current ideologies of environmental design within digital culture, and propose a number of meaningful methods of conceptualization and visualization to describe, analyze and evaluate the practice of the interactive space design.

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Chapter 1
Introduction

This research is an investigation of the influences of digital culture on design ideologies in environmental design of interactive spaces. Digital culture, generally speaking, affects the context of design through the transformation of technological and social aspects, so that designers have adapted, exploited, or appropriated new circumstances of technology development and society, then consequently changed the milieu of various design disciplines. Computers, communication networks and digital media have not merely provided new tools for design production, but inspired creativity in design processes and theories with the implications and employment of such technologies.

"Interactivity" between humans and machines is one of the most significant parameters of the machine and electronic ages, and by the reinforcement of digital technologies, media and computer networks, interactivity takes on added dimensions in capabilities that people may be able to interact and communicate with the computer, with intelligent systems embedded in the environment, and with one another through digital mediation.

In the post-digital age, characterized by a more humanist and less technocentric approach to technologies, discussion of "interactivity" has also changed. Interactive spaces, in which the built environment is central to the interactions initiated by the people inhabiting them, have obtained considerable attention from designers and technologists. In their envisaged future of human environments, interactive spaces accentuate interactivity between people and the built environment; for instance, architecture becomes responsive to human actions, and experience of everyday tasks is

enhanced by virtual mediation. These explorations seek for more integrated bonding between humans, the built environment, and digital media.

In light of the observation of the current situation of interactive space design and digital culture, one big question of this research is: what are the topics of interest in interactive environment design, and the ideologies of interactive space designers in digital culture, which influence the thought process of both the design and experience of physical environments combined with digital media and technologies?

1.1 Digital culture and design of spatial interactivity

This research is motivated by the observation that interactive space designers look at digital media and technologies and their significances differently from post-digital perspectives. Attention has shifted from the mere increase in quantity of technology types and media content to the development of strategies to get the most out of the omnipresent digital influences in more creative ways. In digital culture, technological advances have definitely pushed forward new applications of digital media and technologies, but it should not be overlooked that the general prevalence of utilizing these technologies also produced a driving force, and more importantly a testing ground for designers to bring creativity into reality.

Influences of digital culture on environmental design ideologies can be noticed from recent considerations in the design of the city, architecture and space usage being transformed by information technologies, communications networks and digital media convergence. For users of such spaces, the strategies of using or interacting with city facilities, buildings, and other designed spaces have changed their ways of spatial perception of architecture and environments.

Within digital culture, and focusing on spatial interactivity, research and development have already achieved some results for real life application, the most apparent ones being “smart homes” and “smart offices”; they are good examples of how users may benefit from mediated spaces for customizing, controlling and commanding the environment with digital technologies, and the environment can be designed to better understand and serve the needs of users in digital culture. However, these are not the primary topic of this research. It can also be observed that some experiments are carried out to

demonstrate new experiences for users through spatial interactivity, outside of established typologies such as home, office, etc. At this stage, the design of experiential interactive space is still an emerging discipline that requires more knowledge for better understanding.

The situation mentioned above seems to be a natural evolution of design, as technology development and its culture are gradually "absorbed" into the design of the environment and users of society. Under the constant transformation of our culture and environment by digital media, a thorough understanding of the current effects of digital culture is crucial for investigation of interactive space design.

Looking back to the machine age, Walter Gropius's "the New Architecture and the Bauhaus" (1965) explained his vision of new architecture with the application of "new technologies" at that time such as new building materials and mass-production manufacturing processes. His vision remained influential on modernist architecture, since his insights of design theories, disciplines, building techniques and strategies, and even architectural aesthetics that were suited for the absorption of new technologies in buildings reflected the essence of the "new technological culture" of the machine age. Moreover, Gropius's architecture empirically demonstrated the application values and feasibility of his machine age design ideologies. As digital technologies and media can be considered the new building materials of the post-digital age, designers are in search of methods to apply new ideologies and achieve new disciplines and theories for designing built environments that reflect the digital culture of our times.

1.2 Definition of subject

The research will look into environment design in digital culture, and among various approaches in virtual-meets-physical space design, it focuses on the design of interactive spaces and the design ideologies conceived by the designers or practitioners in this area. Here is a general definition of important termed used and ideas around the topic of discussion:

- **digital culture**: the new technological and social context for various design disciplines under the influences of digital technologies, media and theories;

- **interactive space**: a discipline of environment design coupling with digital media that results in interactive and responsive properties to the users of the immediate space;

- **design ideologies** of interactive spaces: the designers' inspiration and conceptual approach to exploring possibilities in integration of digital technologies in physical space design, and the actual practice of accommodating digital media in the built environment (as opposed to using digital technologies only as the tool of design or production);

- **user experiences** of interactive spaces: the users' perception of their use and interaction with designed spatial interactivity, with its accompanied psychological effects;

- **experiential interactive interface**: human-computer communication interface, in which the purpose of interaction emphasizes user experience, not functional task fulfilment.

The research has a human-oriented approach – it is about "interactivity engaging people in the process of interaction". This is intended to suggest that the subject is not merely about the users "interacting" with the interactive spaces, but also about the involvement of the designer "interacting" with the users. In the design of built environment, designers acknowledged that digital media offered them new inspirations and challenges. This is a back-and-forth process: from designers' point of view, digital design methods give them new tools, new possibilities in experimentation and new notions to break conventions; from users' perspective, usage and perception of spaces have changed by accessibility of virtuality and therefore developed new requirements and paradigms for designers. The concurrent discourse of exploration and expectations in design poses more questions to the complicating relationships between people and interactive spaces.

1.3 Research questions and objectives

The research is aimed at finding out and understanding topics vital to the discussion of the current design discipline of interactive spaces and the ideologies involved, by the assessment of the interactive space design situation in general, then more specifically looking into design practice and acquiring descriptions of the subject from the users and designers of interactive space projects. Also reflecting the big question of research, the topics of interest for designers and the influence of digital culture on their thought process will help compose an integrative discussion of design ideologies. At this point, a

few research questions identify the key areas of interest:

1. What is the current situation of interactive environment design under digital culture? What types of interactive spaces are observed? What are their characteristics, design strategies and values?

2. In what ways are users involved in interactive spaces? What are the modes of involvement and the respective experience of users? What are the significant areas to consider when designing interactive interfaces of such spaces for user interaction?

3. What are the post-digital inspirations and approaches towards environment design in research and practice? How do designers "look at" design now as reflected by their ideologies and explorations in interactive environment design practice? What are the roles of "designers" now?

The questions act as the guidelines for data collection and indicate the areas of knowledge to be identified from this research. Based on the research questions, the main objectives of this research project can be introduced as follows:

- to identify and understand the current topics of interest of interactive space design;

- to study the involvement and experience of users in interactive space design;

- to investigate design ideologies of designers in the design practice and design process;

- to examine how designers look at environment design now from post-digital perspectives; and

- to discuss the current environment design practice as observed from interactive space projects.

The objectives will inform the scope of research, theoretical framework and methodology to be employed in the phases of the research process.

1.4 Proposition

Considering interactive space design as an emerging practice, it is not surprising to see that both technologists and artists are actively participating in research, development and artistic exploration of interactive space design, and producing a number of realized projects for demonstrating ideas and potentials. There are also critics who analyze this area of practice, gathering data and collecting empirical evidences in the hope to grasp more thoroughly this discipline of work.

In observation, realized projects include, but are not limited to, works from architects, interactive designers, computer engineers and media artists; this implies greatly a multidisciplinary approach in the ideologies behind design and execution of completed projects. Although the current situation is that many projects are realized within technology research or art contexts, these works tend to transcend laboratory or gallery contexts, and are released as applied experiments or public art to be encountered in everyday situations. Besides, commonplace spaces are becoming increasingly interactive that human actions are more prevalently mediated with embedded digital technologies. With their relevance in day-to-day experiences, such projects are valuable interactive space designs for investigation.

Despite similarity in practice, different types of practitioners and critics show very different points of departure in describing their own and others' works, and the design thinking behind them. In general, though highly diverse focus of attention was found in their descriptions and writings about interactive space design, two perspectives are most commonly expressed: the first is mainly about "new experiences of users", and the second one is about "new possibilities explored by designers" enabled by interactive media and technologies in environmental design.

Such descriptions motivate an investigation of the relationship between environment design, digital media and people, while "people" means the users and the designers of interactive space design. Design ideologies can be examined by investigation of:

- **interactive space and designers** – designers' response to interactive space opportunities;

- **interactive space and users** – users' expectation of interactive environment design now.

From a design researcher's point of view, this two-sided enquiry into the topic is intended to address the subject in a bi-dimensional manner and consider digital culture as influential to the designers' dominant role of decision making, and also as influential to the users' changing needs that may compose a part of designers' considerations.

1.5 Need for research

Although extensively explored in practice, interactive space is a design discipline with limited published scholarly references. Writings on the subject are generally found on the Internet rather than in library collections – it is still an emerging niche of cross-disciplinary environmental design. More specific and academic discussion of its design ideologies and user experiences is needed for scientific descriptions and analysis of this practice.

The need for scientific analysis is driven by a few reasons. The first one is that interactive space as an area of design research is loosely defined. Many perspectives of descriptions co-exist, but there seems to be a lack of a common framework for mutual appreciation between research groups having different dispositions. The second reason is based on the observation that writings of interactive space design, including those written by design critics, show ambiguity in descriptions, and designers are inarticulate in conveying ideas and intentions behind their designs. Without a well-defined set of languages within the design community, it would be even more difficult for other people to comprehend this design discipline. Thirdly, discussions are now mainly from the creator's perspective on technical-based grounds. Human-oriented factors or user comments are seldom included, or juxtaposed with designer comments to evaluate goals and intentions of designs.

As primary sources of information, descriptions of the design discipline by the people involved would be valuable for a critical review of the subject on the ideologies of design, which is not readily accessible from existing literature. By the end of this research, it is hoped that the subject can be conceptualized, achieving methods for describing, analyzing and evaluating interactive space design as a field of practice. For instance, through the use of structured terminology or taxonomy, researchers,

designers, users and writers alike will be able to communicate ideas around this discipline more effectively and accurately, in order to recognize more thoroughly the relevant issues and ideologies influencing the development of interactive space design and research.

1.6 Outline of the thesis

The thesis is structured in eight chapters and an appendix. The main body of research starts from Chapter 2, a literature review chapter, in which literature and writers on digital culture, environment design and human-oriented design are reviewed and summarized by topic. The literature review leads to a theoretical framework of this research in Chapter 3, that establishes the scope of research, a detailed definition of the subject and selection criteria for data collection. Chapter 4 explains the methodology employed and the procedures carried out in data collection stages.

The two following chapters contain the details of findings of research on descriptions of interactive space design from the user's and the designer's perspectives. Chapter 5 investigates user experience in interaction space projects by observation studies, and explains user involvement, types of interactive spaces, and evaluation criteria of projects. Chapter 6 looks into the descriptions by designers by conducting designer interviews and analysis of design contexts, theories and practice of practitioners in interactive space design.

The research findings are analyzed in Chapter 7. It discusses the findings of descriptions and ideologies involved in interactive space design, supported by theories of psychology and interface design. The research is concluded in Chapter 8, followed by appendices where extra project information, transcripts of designer interviews and references can be found.

Chapter 2
Literature Review

To start looking at the subject in detail, a literature review related to digital culture and design was conducted, which was generally fundamental and text-based material. They helped to identify relevant areas of knowledge and theories to explain general thinking, concepts and keywords of environment design influenced by digital media and technologies. The investigation into the topic is supported by books, articles and websites, which built up the core references to inform the theoretical basis of this research, and consequently support the formulation of a framework of study to direct the data collection and analysis processes. Examples of realized digital environment designs are also valuable project references illustrating the multiplicity of design ideas in digital culture.

The literature review covers a broad range of knowledge related to the digital design of the environment. The first part is background knowledge including the general influences of digital culture on the city, society and environment design, for example the dematerialization and communications networks on the design of the city and the built environment, and the changing perspectives towards the design of architecture in the post digital age. Themes of digital design theories, digital technologies and media in environment design were also reviewed in order to examine the influences of digital tools and media on the design process and production stages of architectural design.

The second part reviews the ways digital media contribute to the ideas of environmental interactivity, which is experience-based and linked to human interactions. The discussion segregates different points of view on spatial interactivity enabled by digital media, including artistic exploration

of interactive art combined with digital or electronic media, technological development and integration of ubiquitous computing and embedded systems in architecture, and the study of embodied human actions in interactions through communication interfaces. References will relate to the fact that such environments require an orientation towards the human mind and body through the study of haptic interfaces, situated actions, social meanings, human scale, and mental models. The design of space contributes to the shaping of human actions and experience by context and affordance, and by careful planning of human computer interface design.

The third part talks about human involvement in interactive spaces. Environmental psychology, human-machine communication and user experience are major topics researched to understand user-centred design practices. Writings on these topics inform the implications and significance of designing for the users in the construction of physical, virtual and social contexts of environmental interactive interfaces, and how users actually perceive and react to designed systems, and how they respond to stimulations through their behaviours and emotions.

2.1 Digital culture and environment design

Digital culture has exerted broad effects on many aspects of design consideration. Digital lifestyle, influenced by pervasive social phenomena, has introduced a shift in paradigm and underpinned new grounds for design explorations. New requirements, new tools and new opportunities directly or indirectly influence the workflow of designers and architects through their integration of digital technologies and media. In addition, experimental design influenced by digital theories, methods and inspirations has overturned some of the preconceptions in environment design and led to the discovery of different concepts to recognize the relationship between people, artificial (virtual or physical) constructions and the natural environment – some built design projects would have been inconceivable or impossible to realize without utilizing the computer and related digital media. This section introduces topics on the digital city and society, and on digital culture, technologies and design of the built environment.

2.1.1 The digital city and society

Digital technologies and media have changed society in terms of the ways people access and use

places. Similarly, the development and design of the city and its facilities have reflected the impact of virtual spaces, computer networks and wireless communications in the physical urban environments. Many writers have noticed and studied the effects on design of public spaces, lifestyles of users of digital technologies in the recent digital culture. Mirrored versions of physical reality and information augmentation, for example, enable new means of manipulation of objects and interaction with places. Overlapping of virtual experience on the existing physical environment, on the other hand, may result in interesting ways people use, perceive and interact with the environment. The attributes of both domains are thus reflective and additive, resulting in "hybrid environments" with combined characteristics. Environment design is also being re-informed by the digital culture of society. Notions of spatial experience, perception and production have changed due to our closer interaction with virtual spaces. Guidelines and suggestions of designing and using hybrid spaces compose a major research area for the evaluation of the advantages and drawbacks in such designs.

- Nicholas Negroponte's "Being Digital" (1995) describes situations and visions of digital technologies and design culture in the post digital age. Dematerialization of matters is catalyzed by the development of computer network and easy data transfer. Described by Negroponte, the post digital world is composed of "atom and bits" – physical and virtual building blocks – where virtual information and digital media give rise to new ways of experiencing daily life and new requirements for design of the future digital society. He also mentioned that the augmentation of information on physical objects, linked and shared intelligence, and convergence of media have changed entertainment, communications, manipulation of space and objects, education, and even business models. Some suggestions were made on how people can benefit from the digital world through interface design, where he explained some standards required for designing digital systems in the connected world of digital technologies.

- William Mitchell has written a series of books, "City of Bits: Space, Place, and the Infobahn" (1995), "E-topia: 'Urban life, Jim--but not as we know it'" (1999), "Me++: the Cyborg Self and the Networked City" (2003), and "Placing Words: Symbols, Space, and the City" (2005) discussing the influence of digital technologies on lifestyle, space usage, architecture, and urban spaces, examining the subject with varied scopes and focuses. "City of Bits" discusses the virtual counterparts of places and hybrid places, and how people access such places in the digital society. "E-topia" is positioned on the urban scale,

explaining how the development of cities and usage of urban spaces are being affected by communications networks, telematics, software and locative technologies. "Me++" concerns new relationships between the body and the city in digital culture denoted by Mitchell as "the cyborg self" and "the networked city". It is a comprehensive study of how digitally augmented human bodies have become more integrated into networked built environments, and how people interact with places and with each other in the digital culture with wireless networks and location-specific information. It suggests that digital culture impacts the city most profoundly when digital content and its accessibility gains direct connections with the physical environment.

- In the information era, digital technologies have reshaped the multi-faceted environment design discipline by intensive digitization. Stephen Graham and Simon Marvin, in "Telecommunications and the City: Electronic Spaces, Urban Places" (1996), explained that telecommunications networks have been a strong rendering agent of the development of the city as explained by how the low costs yet high speeds of information networks extend the effects to a city's every inhabitant. They also noticed that as virtual places become more prevalent, the similarities and differences between virtual places and their material counterparts are proven to have their respective pros and cons. They believe that the virtual environment is going to enhance but not replace the physical environment. Attentions thus shift to the strategies in interconnectivity and interactivity between digital and physical systems. Graham also edited a book collecting articles on mobility, information networks in the city and communications in urban spaces, called "the Cybercities Reader" (2004).

- Anthony Townsend carried out a number of studies on wireless networking and the city. In his paper "Mobile Communications in the 21st Century City" (2000), Townsend researched the use of mobile devices and mobile communications services in the urban environment, and considered mobile phones as "a spatial technology", since mobile phones reorganize space usage, enhance navigation in the built environment, and aid exploration of places as mobile phone users are less bounded by specific locations for connectivity and communication. The decentralizing effects of mobile communications also facilitated changes in city planning and traffic control, that configurations of space and time have been increasingly challenged by mobile access of networks. His view

on mobile devices as "personal objects", which are extensions of the body, explained some recent phenomena of interpersonal communication with the influence of time management, costs of communication, textual communications and personal identity.

- Timo Kopomaa specifically discussed mobile phone usage and users in the city in the book "the City in Your Pocket: Birth of the Mobile Information Society" (2000). Taking a social perspective, he observed that mobility rehabilitates the function of the city as an arena for sharing information and maintaining social contacts. The mobile phone has also become more personal and the use of mobile phones alters the way people gather, communicate and behave in public places and communities. Behaviours of social interactions, public etiquette, means of communication and associated psychology remained important issues in his study. He observed that connectivity and communication are no longer based on physical proximity thanks to the ubiquitous information infrastructure.

2.1.2 Digital culture, technologies and design of the built environment

In the post digital design culture of architecture and design, digital design theories have emerged and designers have challenged the inert and inanimate characteristics of material architecture. With computer-aided design, rapid prototyping and advanced manufacturing tools, designers can experiment with representations of the invisible data space in physical manifestation. These technologies not only help designers come up with design solutions with optimum efficiency and performances but also facilitates the "form finding" design approach in architecture by the use of computer algorithms to explore new forms in 3D computer models. This has also inspired many designers to experiment with the power of digital data and digital processes to generate exciting architectural forms.

- On digital culture and architecture, the books "Designing for a Digital World" (2002) and "Digital Tectonics" (2004) edited by Neil Leach included articles by writers and designers explaining their philosophies and design thinking on digital architecture design. In "Designing for a Digital World", writers explained how design disciplines have been influenced by post digital thinking categorized as "digital culture", "digital cities", "digital tectonics" and "digital realities", where people, designers, communities, design processes and design methods have all undergone transformations, requiring

appropriate change in design strategies, and also opening new areas for exploration. "Digital Tectonics" is focused on physical constructions, which substantially featured designers who employ digital tools for design to facilitate production, or manifest digital philosophies in designing complicated buildings and structures conceived by designers in the post-digital milieu of influences on architecture design. Digital techniques for new forms using ruled surfaces, structural topology, parametric rules, and for production such as computer-aided manufacturing and rapid prototyping were exemplified in the designers' realized projects.

- Peter Anders's article "Cybrid Principles: Guidelines for Merging Physical and Cyber Spaces" (2005) discussed the design principles of physical environment augmented with virtual space, that he called the "cybrid" space. He suggested that materiality and permanence in architecture is constantly being challenged by the accelerated, asynchronous and distributed culture. In such cybrid environments, spatial design should provide meaningful settings within which digital information may be turned into useful knowledge. Relationships, configurations and experiences of hybrid spaces thus present a whole new design discipline addressed by artists, researchers and designers. He proposed the needs for context, coherence and corroboration in a cybrid space design where material and simulated environments are integrated, static and time sensitive behaviours are exhibited and experiences are both direct and through the extensions of media.

- "AD: Architecture and Science" (2001) edited by Giuseppa Di Cristinaby contains essays written by architecture theorists, who explain how traditional architecture is challenged by new developments in technology and science in recent years and the emerging theories of architecture design. Modern philosophies have informed designers on application and explorations of virtuality, deformation, non-linear mathematics, non-Euclidean forms, dynamics, folding, and genetics in the inspirations of architectural design. The ideas did not originate from the development of digital technologies, yet computational science is an important driving force that facilitates such explorations, as they often require complex calculations to achieve results.

- "Architecture in the Digital Age: Design and Manufacturing" (2003) edited by Branko

Kolarevic collected essays about old and new design processes, philosophies and theories in digital design. Also a book featuring writers' and designers' articles, this book is introduced by Kolarevic's essays on digital tectonic theories coupled with computational techniques currently employed and explored by architects, and manufacturing technologies used in digital production, but many essays are more concerned with how designers in actual practice adopted digital design theories into the design and production processes, illustrated by a number of realized projects as examples. The examples demonstrate a wide range of design thinking in design projects putting digital tools in practice, which were utilized in the stages of data collection, design development, decision making, evaluation, structural engineering and production.

- "Folds, Bodies & Blobs: Collected Essays" (1998) edited by Greg Lynn is composed of essays by theorists and himself who share similar thinking regarding the organic design of architecture, in the belief that buildings are organisms that respond, adapt and transform according to natural environments. His design philosophy is influenced by digital technologies in design for their power of animation and simulation of natural forces that are consequently applied in the form and structure of buildings. Analogies to genetics, skin and skeleton of organisms, even evolution and mutation to architecture have been influential to his work, and he has applied these to his design thinking using morphing and calculation techniques in his projects which are presented in his monograph "Animate Form" (1999).

- Lars Spuybroek from NOX Architects published "NOX: Machining Architecture" (2004) which features selected projects from his office. His experimental designs are greatly inspired by the dynamics of body movement, the elements and invisible forces that are later manifested on the computer for design development, experimentation of forms, digital modelling, and finally computer aided manufacturing. Digital inspirations and techniques are documented and explained in the book, revealing the studio's areas of exploration and strategies in designing dynamic forms and interactive spaces only enabled by extensive application of digital technologies.

- The Architectural Design (AD) journal has been publishing issues on digital design and technologies. "Contemporary Processes in Architecture" (2000), "Contemporary

Techniques in Architecture" (2002), and "Emergence: Morphogenetic Design Strategies" (2004) include a wide range of essays on digital design processes, techniques and strategies employed in the digital architectural design community.

2.1.3 Summary

The literature review of influences of digital culture on the design of the city, architecture and hybrid spaces has introduced fundamental knowledge of recent situations for further research. Many writers, designers and researchers, who address different scopes of research and discussion, have examined themes in digital design of the built environment.

Generally in digital culture in the city, the human body is getting more direct connections with architecture, and in turn with the city through massive coverage of computer networks, connected information nodes, convergence of media and wireless means of communications. In "Me++" (2003), Mitchell explained that body extensions work in a way from which we benefit from the digital characteristics of synchronous and asynchronous interaction. Environmental interaction is therefore not necessarily only a real time process. "Real space and real time" is being challenged by recording, random access and on-demand capabilities of the digital realm. He also defined spatial and temporal specificity of messages that are of great importance in designing experience in physical space with an additional, parallel layer of virtual information; discontinuity, fragmentation and dispersion are common concepts transforming how we perceive the built environment. This is catalyzed by the use of wireless technologies which contributes to the accelerated changes of spatial perception and interaction.

In the design of the built environment, materiality and permanence in architecture, on the other hand, integrate with our extended nervous systems and immaterial information to call for more dynamic, fluid and time-based architecture in spatial design (Mitchell, 1999; Leach, 2002). How designers are inspired by digital culture and how they should react to the latest conditions still need to be defined and studied; scholars are still in search of the "rules" for designing hybrid spaces, and a comprehensive theoretical background has yet to be identified. Anders's (2005) paper is an example that tries to propose a guideline for designing satisfactory hybrid environments blending virtual influences in the physical constructions. Other designers look at new relationships between environment design and digital media from different perspectives. Some only consider digital technologies as tools for design

like the use of computer aided manufacturing in design workflow. For some, like Lynn and Spuybroek, digital technologies are more than tools. They are media for design development, exploration of ideologies and demonstration of theories through the design of digital architecture. Therefore design products and process seem to be influenced by digital culture in different ways, requiring more specific identification.

For the influences of digital tools and theories on architectural design, invisible forces and animated sequences are observed to be strong design inspirations, which induce practical solutions in many different forms of the built environment. Now the built environment is not perceived as static and permanent as before; it acts as a background and interface for interaction with virtual activities, so adaptation and fluidity of the environment will fulfil an experience-based design that responds to the unstable fluctuation of human actions, time and information flow. Designers are not only using very different approaches to understand and represent dynamic behaviour in designing spaces but they also definitely benefit from enabling digital information exchange in physical spaces. "People" are considered to be more directly involved in the post digital environments, but the ways in which they contribute to design is an open question for examination.

2.2 Explorations on spatial interactivity: design, art and digital media

People gain more interactivity with the environment through the mediation of digital media. Not merely an effect of technologies, the convergence of media results in easy and remote information exchange, a diversity of media formats that provokes multiple senses, and an enhanced interconnectivity and interactivity between human and environment systems. In the development of interactive technologies and their potentials for application, different points of view are observed within the different focuses of description and execution to integrate physical environments and interactive media.

Some consider the development of architectural embedded technologies to be linked to the design of an ubiquitous computing environment from an application standpoint, which looks at how people can benefit from environmental intelligence delivered through communication channels provided by digital media. Others may investigate the design of human actions and environmental knowledge involved in mediated environments where users are simultaneously interacting within physical and

virtual systems in context. Finally the reference to digital art's exploration of spatial interactivity reveals that the encouragement of involvement of people in the creative process has long existed, made possible by employing digital media as a design medium.

2.2.1 Interactive technologies, ubiquitous computing and haptic computing

From a technological perspective, ubiquitous computing is the most talked about area of knowledge related to environmental interactivity. The term "ubiquitous computing" was first articulated by Mark Weiser of Xerox Palo Alto Research Center in 1988. It is an idea about "computing that does not live on a personal device of any sort, but is in the woodwork everywhere" (Greenfield, 2006, p.11). It is said to be roughly the opposite of virtual reality in that the computer is embedded pervasively in the environment with the people within in. A few key environmentally embedded interface elements considered to be influential to the design of more tangible ubiquitous computing environments, include sensor technologies like accelerometers and pressure sensitive surfaces; tags to identify users or objects like radiofrequency identification tags; actuators such as servomotors for kinetic systems for flexible structures; participatory controls like motion and position tracking; gesture and voice recognition systems; and displays of different sizes to be applied on various surfaces. These technologies enable people to achieve higher levels of natural interaction with the body, and higher complexity of feedback from the environmental system. Now with more advanced technologies, haptic interfaces enable even more means for interacting with the environment.

- On human-machine and human-computer interaction mechanisms, Norbert Wiener introduced the ideas of cybernetics, and the analogy of machine agents to human beings in his book "The Human Use of Human Beings: Cybernetics and Society" (1954). Wiener discussed examples of designing self-regulating machines and strategies of putting "intelligence" in machines that resembles nervous systems and behaviours in living organisms, and their effects on society. His theories on cybernetic mechanisms and feedback loops have been seminal for theorists, technologists and scientists in designing human-machine and human-computer interactivity and their interfaces in machines, computer and environmental systems.

- Adam Greenfield's "Everyware: the Dawning Age of Ubiquitous Computing" (2006) gives an overview of topics on ubiquitous computing and design thinking in the world

of digital technology-mediated environments. What he means by "everyware" is the embedded and transparent digital technologies, processing power and intelligence being increasingly pervasive in our everyday environments. The book is composed of 81 short theses, starting with a general introduction to ubiquitous computing, to its characteristics and technologies, the driving force for its development, issues in designing with ubiquitous technologies and its effects on society. "Everyware" is considered to become more influential to the users, acting on the scale of the body and bringing new relationships between people, buildings and places. He considers development in ubiquitous computing to be still underway and proposed some principles and precautions to notice when applying ubiquitous technologies in the everyday world.

- The article "Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms" (1997) illustrated Hiroshi Ishii's research on tangible interfaces from the MIT Media Lab in 1995. It testified to a few possibilities of tangible user interfaces for human-computer communication using physical and graspable objects. It has already described the use of ambient media including sound, light, airflow, and water movement for background interfaces, allowing peripheral human perception. At that stage, environmental input and output systems were not highly developed, but pioneered the prototype for an integrated environment for haptic interface design. Ishii's experiments were achieved by a distribution of processing power in the built environment, such as walls, doors and other surface, that is currently becoming more feasible as microprocessors get cheaper and smaller with better miniaturization technologies. It is a discipline that highly involves science of both computer engineering and social areas.

2.2.2 Embodied interaction in mediated environments

Interactive space design is a human-oriented practice and requires the design of communication interfaces for human-environment and human-computer interactions. On the basic level, interactive space is very much about the engagement of and the exchange between the human mind and body and the immediate environment. Embodied interaction concerns the environmental cognitive background, haptic orientation and experiences of manipulating virtual objects with reference to physical space (McCullough, 2004). Understanding the embodied predisposition, spatial perception and cognitive background gives environmental interaction more meaningful definitions, and the relationships

between “stage, actors and props” may describe how actions can be facilitated with information.

- Malcolm McCullough writes about situated interactions and embodiment in the design of architecture integrated with digital systems in his book “Digital Ground: Architecture, Pervasive Computing, and Environmental Knowing” (2004). He explained that, though universal mobility is enabled by pervasive networks and distributed computing, human actions are still situated and connected to the immediate context and settings of the physical environment. In disembodied interaction, by manipulating the dataspace with any option of the converged digital media, an interface is not bound to any meanings of the user’s spatial perception; but embodied interactions directly position the user in the context of resources of physical settings and embedded technologies. He uses a perspective of understanding the relationships between the body, the mind and the physical environment – the body contributes to the engaged activities of interaction, the mind constructs a cognitive background, and the environment provides habitual contexts. He proposed that situated interaction occurs from the “intentionality in contexts”. Intent concerns one’s attitudinal or perceptive states, whereas context helps shaping perceptual selectivity from background knowledge. This means actions result from the correlation between intent and context around a common cognitive background.

- “Where the Action Is: the Foundations of Embodied Interaction” (2001) by Paul Dourish is a book about embodied interaction, the design of a model of human computer interaction. Also a piece of work on human actions and environmentally embedded intelligence, it explained that embodied interaction is grounded on foundations of “tangible computing” and “social computing”. Tangible computing represents the embodiment of human actions while recognizing the physical situations, realized through technologies such as ubiquitous computing, augmented reality and tangible interfaces; and social computing attends to the meanings of embodied actions in the social context, which include interpersonal communications and changes of social conduct in communication through mediation of interfaces. Therefore the “site” itself provides meanings both physically and socially. Dourish emphasized that embodiment of human actions should be manifested physically in the world, executed real time in the real space.

2.2.3 Interactive media and art

There are numerous artworks that can be categorized under "digital art". Since the introduction of early forms of computational technologies, artists have been the first to experiment with this new medium in art and raise questions about the influence of incorporating computers into everyday life, in both technological and social areas. Conversely, these art forms are considered innovative in that they inform the development of computation technologies with latent possibilities and future design directions. Many artworks come in the form of interactive installations and designed environments, resulting in new experiences of interaction between users and space in experimental projects using digital technologies and media as the medium of artistic exploration. One significant step towards art with digital technologies as the medium is that it shifts the production of artworks from an object-based to a process-based perspective, and often changes the position of the audience from a passive viewer to that of an active participant. Research resources consist mainly of online material for a broader range of up-to-date reference projects.

- On digital technologies and art, Christiane Paul's "Digital Art" (2003) describes how the development of digital technologies has influenced ideologies of artists and designers to engage the audience in the creative process and areas of exploration through art and experimental projects. Her study reveals a long history of artistic exploration of communications technologies from the age of telephone, satellite, storage media, computers, the Internet to mobile networks, and artists' employment of digital media as tools and medium for artistic expressions in the post-digital culture. She identified a number of important artists and artworks which exploited the potentials of digital technologies, discovered new design theories, raised questions about the digital society and even showed insights on possibilities in technological application and development.

- In Lucy Bullivant's edition of Architectural Design journal, "4d Space: Interactive Architecture" (2005), she reviewed environmental design projects, many of which are art-based projects, and compiled articles by the designers of these projects in a comprehensive issue. Designers explained their design intentions and strategies behind the production of projects, and writers expressed their views on integration of interactive media in the built environment, architecture, and public spaces. In Bullivant's

book “Responsive Environments: Architecture, Art and Design” (2006), which is more focused on realized architecture, installation and art projects, she approached designers and artists to talk about ideas behind their interactive space designs. She classified some common formats of “responsive environments” as, among others, interactive building skins, responsive artworks, intelligent walls and floors, exhibition spaces, embodied interfaces for dance and smart domestic spaces.

- The website of Ars Electronica, www.aec.at, contains news on the digital art scene and an archive of information about media art and interactive installations that have been showcased in the festivals or exhibitions. Projects and artworks featured in the previous years of festivals and competitions can be found.

- www.medienkunstnetz.de is an online database of media art and design projects, with a number of research articles on interactive art and design.

- www.we-make-money-not-art.com is a blog with updated news on art and design projects tagged under different categories, including many interactive space projects, and interviews with designers and creators.

- www.interactivearchitecture.org is a blog run by Ruairi Glynn from the Bartlett School of Architecture. He collects news specifically on technologies and projects related to interactive architectural design and installation artworks.

2.2.4 Summary

A growing number of human activities now have higher dependence on digital devices, which are designed to deliver even more software functions through convergence of digital media. In daily experience of space, in contrast, spatial perception is shaped by software functions, as people are no longer restricted by designed architectural rules. Also with the aid of digital information, heterogeneous activities are possible in the same place used by many people. Many research projects are being conducted to evaluate a number of scenarios, and to explore how these functions should be designed to mediate with the physical backdrop, such as ubiquitous computing and situated interaction. Both disciplines require the use of architectural input and output interfaces which are often referred as “smart

environments". The design of spaces which support different programs or activities according to user needs through embedded systems in architecture will enhance the ability to perform certain functions in appropriate backgrounds.

The development of environmental digital technologies is thus becoming more important in the research of ubiquitous computing. This also implies the need to attend to the ability for people to communicate with the embedded processing systems in the built environment. One aspect in which designers are trying to develop a better computing interface is in the design of tangible interfaces, which means that humans can communicate with computers by manipulation of physical objects situated within a physical context with environmental knowledge. Other than "tangible interface", similar terms like "things that think" used by the MIT Media Lab, or "the disappearing computer" used by a joint EU initiative extend the idea of integrating intelligence into everyday objects and even clothing within smart environments, and thus to investigate new properties, experiences and functionality.

Ideas of human or body-centred design of embodied interactions are observed when referring to the literature of ubiquitous computing. Paul Dourish (2001) believes that interactions count on the relationship between the activities and the space in which they are carried out – the configuration of space, the relationship of body to task and physical constraints. According to Hiroshi Ishii (1997), an environment should be able to identify where you are, who you are with, and what is around you. And finally the value of design will "fall from objects to experience, from performance to appropriateness, from procedures to situation, and from behaviour to intent" (McCullough, 2004, p.50). McCullough explained further that in the discussion of human actions and perception of interactive or intelligent environments, embodied actions are limited firstly by the physicality of the body. In the design of space, body-centred design has to consider body orientation, range and scale. These factors have been employed in design in order to build a haptic orientation with its concern for "sensation, motion, posture and expression". This idea has long been absorbed into architectural design, and in the design of spatial interactivity, contexts shape actions in the way that they frame intentions by suggesting improvisatory, constraints, cues and possibilities, and may induce interactivity by the consideration of social distance and spatial literacy.

Artistic explorations of architectural spaces also contributed considerably to the scene of research and practice of engaging human actions in mediated spaces. The exploration of interactivity in digital art, especially in the form of physical installations or immersive environments, has greatly informed

the design industry which tries to apply digital technologies into the built environment. As a matter of fact, despite the close relationship between art and digital technology, "interactive art" long existed without direct linkage to the digital media. The word "interactivity" has been given different meanings throughout the period, but since interactivity met digital media, a large amount of effort has been put on the human-computer interaction interface, which is still the focus now, though the interface itself is getting more transparent than before. Another interaction is the interpersonal interaction involved, which emphasizes different aspects of communication such as the process, the content or the behaviour of the participants. The results of experimental art forms have influenced the design of spatial interactivity towards a more human-centred approach including customization, personalization, open participation and communication.

No matter whether looking from technological, communication interface design or artistic points of view, human involvement remained the central attention in the design of interactivity. Design of environmental interactive systems with the aid of digital media and technologies always requires the consideration of human factors. Though principles of design have been proposed and experiments have been conducted to investigate human participation and behaviour in environmental spaces, little has been achieved by directly approaching the people who use and actually take part in the embodied interactions with designed systems, to understand how people get engaged in and experience interaction and what behaviours would be observed in interactive environments mediated by digital media. The investigation of people in interaction may justify some of the different views on the subject and compose a comprehensive description of design thinking and theories of human-centred interactivity.

2.3 Human-oriented design: communication interfaces and user experiences

As designing spatial interactivity between humans, environments and computer systems involves a great deal of embodied human action in the environment, the design discipline has become highly human-oriented, putting the users in the central role of consideration. Many writers are aware of the human-centredness in the design of communication interfaces. Related fields of knowledge such as psychology, behaviour, emotions, environmental cognition and perception, actions and feedback and user experiences have become more crucial factors in the design of interactivity. Interactive interfaces, human psychology and user experiences are closely connected to each other, and particularly in embodied interaction, these human oriented subjects imply needs for more extensive study on the

users communication with the physical environment through communication interfaces.

2.3.1 Environmental psychology in human perceptions

Environmental psychology is influential in various design disciplines including environment design, architecture and urban planning. When computer interfaces are integrated into the physical environment, for example through embedded systems and tangible computing, cognition and perception of the environment become inseparable parts of the user experience in human-computer interactions. Environmental psychology itself is a collection of theories and studies of human perception of not only the physical settings of environments, but also social, natural, and cultural aspects that affect the mental and behavioural responses of human beings. Literature is selected to inform the psychological effects of architectural or other physical settings in interaction interfaces.

- "Environmental Psychology" (1978) by Bell, Fisher and Loomis introduces a comprehensive knowledge in environmental psychology. Common areas of study include perception of the environment in physical, social and cultural contexts, behavioural effects of noise, temperature, air pollution and wind, personal space and territoriality, crowding and familiarity of environments. They discussed a number of ways in which people perceive the environment, through sensation of stimuli, and the processing of sensory information by perception. Spatial perception involves factors of distance, size, location, movement, habituation and change, which also change human attitudes to the environment. The book mentioned a few theories for approaching environment-behaviour relationships, namely environmental stress approach, arousal approach, environmental load approach and understimulation approach. The different approaches relate human psychology to the environment by different types of stimulus-response relationships, social and affective or emotional consequences in the process of perception.

- Steen Eiler Rasmussen's "Experiencing Architecture" (1962) discussed the relationships between elements of architectural design and human experience of physical structures, illustrated by various important projects of architecture and urban planning. In spatial experiences, design thinking and theories have been applied in the design and planning of buildings in pursuit of communicating psychological effects to people. Psychological

effects of solids and cavities, colours, scale and proportion, rhythm and texture, light and sounds are all influential on human experience in designed spaces. Rasmussen linked such mental effects on humans to design theories in architecture applied in existing buildings, structures and environments, to explain the underlying design of psychological effects and experiences intended by architects and urban planners who successfully manipulate design elements for human perception.

- "The Image of the City" (1960) by Kevin Lynch is a book on urban theories based on a research on how people perceive urban environments, and process environmental information while navigating in the city. One of the most significant findings is the mental maps of people and "imageability" of the city for understanding the urban environments. Using several cities as examples, and conducting environmental studies and interviews with the inhabitants, the results included explanations of how design elements affect human perception in establishing mental maps, and suggested design disciplines for planning of cities that are easier to navigate and more perceivable by the city dwellers, where he proposed paths, edges, districts, nodes, and landmarks as prominent supporting factors for mental imagery.

- "Architecture and You" (1981) by William Wayne Caudill writes about how people perceive, experience and appreciate environment design and architecture, as well as what kinds of influence environments can supply to our psychology, behaviour and spatial experience. He mentioned that people experience architecture in intellectual, physical and emotional ways, and conversely "good" architecture should be able to convey meanings to fulfil human experiences in these aspects. He also mentioned some other environmental psychology related issues such as social and cultural effects in the design of architecture, which can be appreciated by people from different places and different times.

2.3.2 Human actions, human computer interaction and interfaces

Interactivity between human and environmental systems requires communication interfaces supported by digital technologies and media. The required knowledge resembles that involved in the design of interfaces. Firstly, in human-computer interaction, the design of representations in computer

systems takes into account human factors of psychology, usability, and user actions and feedback in the process of interaction. Another resemblance lies in physical interfaces commonly found in product designs, where designers need to consider how products and information can be perceived, and successfully used to provide positive user experiences. Writers and scholars in engineering, computer science, as well as interface designers, are increasingly looking at human factors in the design of such systems, and the practices become more user-centred, in order to design easy-to-use, understandable, useful and usable products for productive and experiential purposes.

- On human computer interfaces, Brenda Laurel, in her book "Computers as Theatre" (1991), draws connections between human-computer interaction and theatre, where human-computer interface design resembles a stage where users become actors to engage in interaction. Human agents in interactions are less observers but more like actors engaged in the virtual environment composed of representational objects, supportive props and cues and computer agents, through which human interactions are grounded in context. She also wrote about mental models in interactivity, and proposed a few design principles for human-computer interactions. Interface design approaches the design of user actions, paying attention to the context, incidents in interactions, and agencies; in addition, in human computer interactivity, frequency, range, significance and immersiveness are critical considerations.

- About user-centred design, Donald Norman's "the Design of Everyday Things" (1990) provides another approach to assess human-product interface design and suggests tactics to design user-centred interfaces, including the ideas of psychology of actions and cognitive knowledge. On physical interfaces, he started with the discussion of affordances of objects in manipulation; but his views on interface design not only apply to product design but also to information design and the design of computer interfaces. He regarded interfaces as the communication of conceptual models between the user and the designer through the system image of the design product. In order to support human actions, the interface should present a good conceptual model for user perception, have good mappings for determining relationships between actions and results, and give continuous feedback upon user actions. The book concluded with a set of principles that suggest the need of taking into account human factors in designing products, informative systems and control interfaces for more user-friendly experiences.

- "Designing Interaction: Psychology at the Human-Computer Interface" (1991) edited by John Carroll is a collection of essays by designers and developers of human-computer interfaces, who have taken the approach of the involvement of human psychology in interactions. Essays are centred around the design of computer artifacts and tasks with the focus on user psychology and cognition, users' points of view, user actions in interactions, empirical study of use, and communications between users and designers in the design of computer interfaces.

- Essays and resources on user-centred design can be found on Donald Norman's website www.jnd.org.

- www.interaction-design.org is a website containing an encyclopedia, references and resources on interactive design, human centred design, human computer interface design and related fields of knowledge.

2.3.3 User experience and emotion

In user-centred design disciplines, the studies of "user experience" or "human emotions" induced by design products have surfaced to be essential elements in good designs. In practice, "user experience" is a broadly defined field of knowledge. In interactive environments, however, its major concerns are the experiential values of users' interaction within human-computer and human-environment interfaces. Not much has been established specifically for experiences in interactive space design, but general knowledge can be borrowed from industrial design disciplines, in which various types of positive psychological and emotional effects are considered favourable in design products.

- "Emotional Design: why we love (or hate) everyday things" (2004) by Donald Norman extended his theories on user-centred design to the emotional aspects of design products, noticing their influences on human psychology, attitudes and actions, and the complementary roles of affect and cognition for making judgement and interpreting the world respectively. He proposed that the affective and evaluative functions of emotions act on three levels of processing – visceral, behavioural and reflective, that mediate between sensory perceptions and motor reactions of human beings. Designing with

these levels at work is connected with the emotional effects conveyed by a number of factors of the design, for example, appearance, touch and feel; function, performance, usability and pleasure; and interpretation, understanding, reasoning, self-image and memories.

- McCarthy and Wright's "Technology as Experience" (2004) is based on the design of human-computer interaction. The book is focused on "the experience of living with technology", drawing references from human-computer interactions and related user experience. They regard that the influence of technology on daily life interprets "the relationship between people and technology in terms of the felt life and the felt or emotional quality of action and interaction". They further suggest that the study of users' interactive experience needs to consider sensual, emotional, compositional and spatio-temporal aspects.

- Mehrabian and Russell's "an Approach to Environmental Psychology" (1974) is a discussion of environmental psychology and human behavioural responses termed as approach-avoidance behaviour. They considered behavioural responses as driven by emotional responses, which result from the stimulus components of the environment combined with a person's personality. The emotion-behaviour relationship was framed in three emotional responses of pleasure, arousal and dominance. The book showed some research methods to justify the framework by empirical evidence of evaluating user emotions based on physiological responses and verbal descriptions, and revealed that positive reinforcing stimuli of the three emotional responses are directly connected to more favourable environments.

- "Affective Computing" (1997) written by Rosalind Picard is a book about intelligence in computing, and explores ideas on how computers can generate, express, communicate, recognize and understand emotions in human computer interactions. She believes that emotions are both physical and cognitive, while bodily and mental components are interconnected in the formation and effects of people's emotions. Understanding signals for reading human emotions is the starting point of her study, when she indicates that facial expression, vocal intonation and motor responses are some common and apparent forms of expression of human emotions, which will help in the design and construction

of affective machines.

- A website by Nathan Shedroff – www.nathan.com, along with his book "Experience design 1" (2001), collected his essays and presentations on user experience design, and links to other resources on research and projects related to experience design in information design, web design, interactive interface, and business strategies.

2.3.4 Summary

The creation of experience in both architecture and consumer products has as one of its goals the communication of designers' thinking and intentions to the end users. In this sense, the design of human-environment interface in interactive space communicates its experience to the users, which shows similarities to the practice of human-computer interfaces. Designing computer interfaces, or "artifacts" interface scientists call them, is greatly concerned with the "virtual representation" of reality, much proven by the design of the graphical user interface on computers. This discipline has been compared with the physical environment, such as when considering Laurel's (1991) view of looking at the computer interface as a stage containing props and cues and of course, the actors. Looking back to the situated interaction now, Lucy Suchman (1987) mentioned that "the organization of the situated action is an emergent property of moment by moment interactions between actors, and between actors and the environments of their actions" (McCullough, 2004, p.52). The analogy of computer interface design to the physicality of the environment system may suggest that the design of spatial interactivity counts on the organization and manipulation of physical space design as an interface.

Related to this combined virtual with physical interface, the knowledge of human-computer interaction interfaces and physical interfaces in product design lead to the idea of studying "user-centred design" as a criterion of better design. Though they may put emphasis on different aspects, the introduction of ideas of "affordance" and "mental models" laid a foundation for understanding human predispositions on the interaction and usage of design, no matter as software, everyday objects or environments, with their concern for bridging knowledge between psychological and physical groundings. For instance, the idea of affordance refers to the "perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (Norman, 1990, p.9). Affordances give clues on how things may operate and therefore, what underlying actions users can enact upon them. In the built environment, affordance lies in the context,

the inherent properties of the environment. People associate contexts with particular states of intent, for example from past experiences, so that it eventually shapes user actions. Design of physical space aspects, like scale, relationships or type, are believed to be part of the environmental affordances that provide intrinsic knowledge for possible interactions.

Because environmental cognition and action are so closely related, the design of interaction may even start with mechanisms of perception, namely mental models. They consist of the direct engagement and peripheral awareness of mentally constructed representations of spatial relationships. This mapping of information with the learned experience will directly challenge the design of environment in terms of users' spatial literacy and expectations. To understand possible actions we need to acknowledge that they are grasped through engagement, latent predispositions, and inherent properties of the environment (McCullough, 2004). One question remains in the effective communication of "conceptual models" between users and designers in the planning and design of representations, both physical and virtual. As the interface is the only common channel for the exchange of information, a clear and appropriate presentation of the designer's conceptual model on the interface can provide for the affordance and a better reference of mental models for cognition and hence user actions and experience. Since the virtual representational space now overlaps much with the physical environment, it appears that environmental psychology and spatial planning knowledge from the architecture discipline can revive in the design of embodied interaction.

Apart from cognitive processes, human psychology is not disconnected from the emotional aspects being emphasized in the design of "user experience" in the recent years. Both experience design and human emotions in design are comparatively young fields of study, as seen in the diverse descriptions and approaches of evaluation of the topics by designers and theorists. Common descriptions of user emotions are the positive functionality, pleasure, social and personal identity in the use of products. More specifically in stimulus-response effects, emotions are directly evoked by the environmental stimulation of the human senses in the process of interaction. User-centred design now addresses experiential values in design; as for interactive space design, environmental interfaces take a more critical role in providing positive emotions for the users through well-planned physical and cognitive frameworks and contexts by the designers.

2.4 Project review

Several projects of digitally mediated environment design were reviewed in the research study in order to define a theoretical background for demonstration of design execution. Some of them do not fit into the scope of this research project, or were not selected as key references in the theoretical framework. Nevertheless, a few projects are listed below as significant or relevant examples which informed the extensive practice and experiments of designers in the design of interactive or digital culture-inspired environments. Several of them will be referred to for discussion in more detail later.

- Can You See Me Now, Blast Theory, Dublin, 2002. www.blasttheory.co.uk

- Blinkenlights, Chaos Computer Club, Berlin, 2001. www.blinkenlights.de

- Yellow Arrow, Counts Media, New York, 2004. yellowarrow.net

- Aegis Hyposurface, dECOi, CeBIT, Hanover, 2001.

- Telegarden, Ken Goldberg and Joseph Santarromana, Linz, 1996. goldberg.berkeley.edu/garden/Ars

- Trace, Greyworld, Hampton Court, 2004

- Standards and Double Standards, Rafael Lozano-Hemmer, Basel, 2004.

- Vectorial Elevation, Rafael Lozano-Hemmer, Mexico City, 1999.

- CICCIO, Interaction Ivrea, Europan 7, 2003. projects.interaction-ivrea.it/ciccio

- Kinetic Light Sculpture, Christian Moeller, Frankfurt, 1992.

- d-tower, NOX Architects, Doetinchem, 2003. www.d-toren.nl

- Son-O-House, NOX Architects, Son en Breugel, 2004.

- Liquid 2.0, Daan Roosegaarde, Rotterdam, 2006.

- Urban Diary, rude_architecture, Berlin, 2001.

- ACCESS, Marie Sester, SIGGRAPH 2003. www.accessproject.net

- The Legible City, Jeffery Shaw, Antwerp, 1988.

- RemoteHome, Tobi Schneidler, London/Berlin, 2003. www.remotehome.org

2.5 Conclusion

The literature review has informed the research topic of discussions by scholars, researchers and designers on current technological and social situations of digital culture, and various influences and digital theories of environment design in the post digital age. Review of the diversity of points of view of descriptions and assessment of the topic suggests that a focused and precise scope of research is crucial to position the research study in the loosely defined but broadly inclusive discipline of digital environment and interactive space design.

There are several findings from the literature review that need to be addressed in the research of digital culture in design. For instance:

- digital culture gives rise to new relationships between space, people and digital media and technologies as conceived and envisioned by designers;

- as reflected by the approaches and practices of architects, the use of technology and application of media can be influential in the design process and design products;

- the physical environment is becoming more integrated in communication interfaces as computing becomes increasingly haptic and ubiquitous;

- designing is an activity that communicates concepts, and through design products, designers are able to communicate with the users;

- different points of view on spatial interactivity affect the description of the same subject with different focuses and assessment criteria;

- interaction interface design is a human-oriented discipline, yet little has resulted from the discussion from the user's point of view;

- human needs and mediated activities are designed based on the actions and behaviours in the relation between the body and the environment;

- human experience involves effects of behaviours and emotions, connected to the psychology and physicality of interactions, and they can be evaluated by different approaches.

These findings represent a background for formulating the criteria for choosing data concerned with the scope of research, and areas of assessment of the topic, which will be introduced in detail in the next chapter on the theoretical framework. They also present some potential gaps in which this research can be positioned to justify the need for research of this topic, that is a combination of technological and anthropological, user and designer, experiment and application descriptions of environmental interactivity.

Chapter 3
Theoretical Framework

Owing to the ambiguity in the genre and mixed definitions on the term "interactivity", "interactive spaces" is a broad domain of design studied by researchers and critics with varied viewpoints, with their own methods of definition, assessment of the subject, and criteria for selection of reference material. The theoretical framework chapter aims at defining the scope of research of this paper to clarify the perspective of research employed and related issues to include, for the sake of a concise positioning of the study in the wider field of knowledge.

3.1 Scope of research

As reference for this research study, a matrix of interactive space projects compose the core of investigation, forming an empirical base of orientation, and around this matrix data was collected and knowledge acquired. Among the large collection of interactive space projects, those selected for review and observed as evidence, support the discussion of the practice, ideologies and strategies of the design of interactive spaces. "Interactive space" design projects in this paper were selected by the following key criteria:

1. the project regards digital culture and technologies as the design ideology;

2. the project is experience-centred, regarding digitally supported spatial experiences,

rather than a system-centred environmental computer interface;

3. the project involves human participation through an interface with which users interact. As a result, user actions comprise inseparable initiation of interactive activities or contribution to the content of the interaction;

4. the project has a direct relationship to spatial issues and a strong attachment to the built environment, especially those with major concern with physical space design;

5. the project incorporates certain concepts of interaction strategies with awareness of recent application of digital technologies in environmental design.

Definition of the criteria will be elaborated in the following sections, and the matrix of projects introduced and explained in Chapter 5, findings from user descriptions of interactive space projects. Since the research is derived from found projects as evidence, references from the literature review are brought into discussion for definition of design ideologies, interactivity, modes of user involvement and technologies employed in environment design inspired by the overall digital culture. For that reason, the theoretical framework is also a summary of preliminary findings to guide the later phases of the research study.

3.2 Current practice of environment design inspired by digital culture and its associated technologies

The investigation of the topic has revealed a great diversity of approaches employed by researchers, developers and designers in response to current circumstances and future development of the built environment made possible by digital technologies. Most designs tend to have a strong focus on user-oriented, technology-driven, or theory-based approaches, while some demonstrate a combination of those design considerations. But here common concepts of digital culture-inspired environment design are presented according to their orientation towards the design product or design process, their integration of digital culture and technologies as design ideologies or as design components, and different visions of bringing together virtual and physical spaces with digital technologies.

3.2.1 The linkage of environmental design and digital culture

Bouman (Bullivant et al., 2005, p.16) observed two aspects in which digital technologies had implications for architecture design. One aspect he mentioned is a "strong divergence between designers who predominantly merely adopt new technologies to facilitate the old design process(…) and the very few who have applied these new design instruments to the task of renewing and innovating through design, trying to find new forms, new strategies, new processes and new techniques". This statement articulates two streams of design approaches, to be inspired by the digital culture in design, or to apply digital tools to traditional design processes. This research aims at the investigation of influences of digital culture on design ideologies, that correspond to "the task of renewing and innovating through design".

In practice, digital culture can be influential in the design product or the design process, and may be considered valuable as design ideology or as design component. Judging from recent design concepts, practices and strategies, integration of digital culture and technologies in design can be achieved in a vast number of ways. The scope of this research emphasizes the design of interactive environments as design products. In order to understand the linkage between the existing design products and their related ideologies, areas or stages of design that designers consider appropriate to integrate digital technologies can be analyzed by the categorization of common concepts of environment design inspired by digital culture. The following figure (fig. 3.1) describes the linkage between environment design and digital culture and a few examples in environment design.

		Digital Culture and Technologies	
		As Design Ideology	As Design Component
Environment Design	Product Oriented	Design products that provide framework for exchange and communication - dynamic tectonics (b) - mediated spaces (c) - interactive environments (c)	Design products that feature virtual data as design content - indexed environments (a) - augmented environments (a) - virtual places (d) - representational infoarchitecture (d)
	Process Oriented	Design processes that concern achieving design with digital thinking - digital tectonic theories (b) - algorithmic design methods (b)	Design processes that utilize digital technologies as tools for design - digital construction and production technologies (e) - building information modelling (e)

fig. 3.1 Environment design and digital culture and technologies

3.2.2 Common concepts in digital environment design practice

The examples of design concepts in the above figure can be grouped into five common themes or visions that designers are exploring to bring virtual influences into physical space design. The identification of these concepts indicates that among the field of influence of digital culture, "interactive environments" is only one of the many possibilities in designers' exploration, but does not isolate itself from other types of thinking and technologies of digital design. The concepts are organized as follows.

(a) Augmentation of physical experience by virtual data

The superimposition of virtual data has proven itself to be useful for providing extra information about the physical world delivered through digital media. Databases keep records of "bit versions" of our environments, describing the "atom version" counterpart; they intermingle to enhance our daily experience and offer us interesting ways to interact with the physical space (Negroponte, 1995). The layer of representations is directly overlapped on the physical environment. In indexed environments, the common technologies engaged are global positioning systems, geocode databases and mobile gadgets which use extensively wireless networks. Augmented environments require movement or motion tracking technologies and display technologies, like projections or head mounted displays.

Examples:

- indexed environments: GIS & GPS city, location based services, environment tagging and annotations
- augmented environments: mixed and augmented reality

(b) Embodiment of virtuality

It is becoming more common in the design community to "expose" virtuality in the built environment for practical or artistic purposes. Text, images, sounds, and motions and their means of dynamic representation are found in informational building designs, and networked information further expands their capabilities. Under new tectonic theories, physical spaces are designed out of information ideology, and architecture is deformed by the effects of invisible forces to develop a unique digital aesthetic of fluidity. Algorithmic design allows designers to achieve complex forms originated by simple sets of algorithmic rules. In dynamic tectonics, display screens and architectural "pixels" are widely used for visual effects, and embedded actuators in architecture can produce effects ranging from

sounds and/or visuals to kinetic structures.

Examples:

- dynamic tectonics: information visualization systems, actuator structures
- algorithmic design: parametric design generation, growth simulation
- digital tectonic theories: architectural surfaces, genetic analogies

(c) Facilitation of information exchange in physical environment

When communications technologies blend into physical constructions, human interaction is supported by the environment, and human interaction with the environment is mediated by virtual functions. The relationship between body actions and places complicates information exchange in various resulting contexts, but physical communication interfaces emerge under appropriate spatial configurations. As well, human communication now benefits from the digital combined with physical interface found in mediated spaces. The employment of sensors and recognition technologies to detect human input enables users to communicate with the built environment, while display technologies and embedded systems produce feedback to close the communication loop.

Examples:

- interactive environments: interactive systems, environmental feedback, haptic interfaces
- mediated spaces: embedded systems, software programs, networked spaces

(d) Virtual spaces

Online places, virtual architecture and digitized city representations are the products of overlapping information and physical spaces, they address the issue of dematerializing the environment as a virtual representation with consideration of physical interaction and material design totally abandoned.

Examples:

- representational infoarchitecture: virtual reality, data spaces
- virtual places: online "places", virtual architecture

(e) Computational tools for building production and management

Computational design and production tools help realize complex calculation and form production from digital files to building materials, while smart spaces can regulate their own performance and understand user expectation.

Examples:

- building information modelling: performance and energy conservation systems
- digital construction and production technologies: CAD and CAM, rapid prototyping, customized components production

Since (d) is only concerned with virtual environments, and (e) is not related to experiential spaces, they are not used as references for studying interactive space design.

3.2.3 A research on products of environmental design with digital culture and technologies as ideology

The orientation of design product or process can be figured out by looking at what stages of design have been influenced by digital culture, but it needs some explanation on whether the designer has brought in digital media as influential in design thinking to innovate design, or for the application of technologies to facilitate old processes. Contrasting digital design ideologies and components of these design concepts could differentiate the design practices and approaches of designers with the inspiration or application of digital culture and technologies in the built environment.

- **Digital culture and technologies as design ideology**

When digital culture and technologies are taken as an ideology of design, the main idea observed is to offer a backdrop for virtuality or for the interconnection of various influences, rather than using virtual representations directly as design components.

In environment design products, methods to realize connectivity and communications, interactivity or dynamic responses have been explored. The interest is in the organization of digital technologies in a confined space, where a structure is established and people, objects and environments are connected by digital media. Communications between

the elements present in the space are possible, but the design is focused on how dynamic communication or interactivity is achieved, not by specifying the actual content of communication, as in projects of pervasive networking. Similarly, an environment design process inspired by digital culture provides the opportunity to use digital methods or theories in accordance with a variety of ideas, such as algorithmic design or digital design theories. Generative and parametric design are basically the design of computational rules, in which different combinations of data are experimented with to explore possibilities of design solution, essentially the influence of computational processes in data randomization and generation in digital culture.

The common characteristic of taking digital culture as ideology is that designers take responsibility for design of the virtual "container" or "rules" – HOW virtuality as a dynamic influence, contributed by designers or other parties, can be processed to generate design or to achieve the desired effects in the final outcome.

- **Digital culture and technologies as design component**

Digital culture and technologies as design component, on the other hand, puts emphasis on the "content" or "variables" of virtuality. In many cases, it is applied directly ("as-is") or predefined by certain authorities, and designers approach the design of WHAT variables are fed into or allowed in a system.

Environment design products with applied components usually have a high dependence on the content of virtual data to supplement the experience of the built environment, whether it is the bit version reflection of the physical place or a superimposed and augmented virtual space. The values of indexed or augmented environments are based on the content of database like textual and visual data, or the design of virtual representations revealed to the users of space, as in location based services. They still require the design of the communication structure, yet the systems live within the constructive archive of data content. If applied in the design process, virtual data is prone to be applied as variables being fed into a system; or it is already designed to be put directly in a tool merely for digital workflow, such as using calculations to meet a certain designated structural or formal outcome, or the use of CAM and rapid prototyping to "translate"

modelled building forms into data version for ease of transfer and production.

The "how" and "what" elements, without a doubt, are closely interrelated just as the "rules" control the accommodation of "variables", while the "content" informs the choice of the "container." In this research, having said that, digital culture and technologies as ideology in environment design will remain the focal point of investigation. The reason for choosing this perspective is that, as mentioned by Bouman, only a limited number of designers is actually involved in innovative strategies for designing digitally inspired environments; and by observing and analyzing projects and concepts inspired by digital culture, the ideologies of these designers play more dominant and proactive roles in determining the design of space over the pragmatic nature of application of data and technologies as components of design. Consequently, the scope of research in interactive spaces will be about environmental design products with digital design ideologies – designing products that provide a framework for exchange and communication – as the main definition of scope and the parameter for selection of interactive space design projects, centred around issues of dynamic tectonics, mediated spaces, and interactive environments in the broad sense of interactive spaces.

3.3 Experience-centred interactive space design

Another observation made by Bouman (Bullivant et al., 2005, p.16) in digital technologies on architecture design is "an incredible number of people (designers) trying to adopt these technologies to make environments smarter, smoother, more neutral and capable of being monitored(…) in contrast, there are relatively few trying to use technologies facilitating smart environments to enhance people's experience, to make it more complicated but also more challenging". In the domain of human computer interface design, Laurel (1991, p.22) stated that human-computer activity may be divided into two broad categories of productive and experiential, and "experiential activities, such as computer games, are undertaken purely for the experience afforded by the activity as you engage in it, while productive activities such as word processing have outcomes in the real world that are somehow beyond the experience of the activity itself". McCarthy and Wright (2004) also noticed the recent "shift in nomenclature toward Interaction Design or User Experience Design when referring to relationship between people and interactive technologies" and "a broadening focus from computers to a wide range of interactive technologies and from work-related tasks to lived experience". It seems "experiential values" and "user experience" in design have been major fields of interest in the post digital era of

interface design but the practice itself in interactive spaces is still under development.

Specific descriptions about experiential values in interactive spaces have rarely been defined, but some writers have studied experience and emotions in the psychology and usage of design products and interfaces, resulting in different perspectives on user experience as a discipline in design. Jordan (2000) has an industrial design oriented approach, looking at four types of pleasures in the experience of use of products – physio-pleasure, socio-pleasure, psycho-pleasure and ideo-pleasure. Norman (2003) suggested three levels of processing experience in the brain: visceral level, behavioural level, and reflective level that link the sensory input and motor output of the human action cycle, as well as pleasure, social and cultural values in emotional design. McCarthy and Wright (2004) proposed "four threads of experience" to describe ways of enriching experience of people in activities mediated by technologies. It consists of sensual, emotional, compositional and spatio-temporal aspects.

As revealed from various writers' standpoints of looking at human experiences in the use of design, designers have applied psychological, physical, sensory, aesthetical, and emotional factors to enrich user experience of design products. Not to mention that environmental psychology has long contributed knowledge of psychological and emotional effects on human beings of space planning and architecture design.

The details of the above aspects would not be necessary at this stage, since it appears that "user experience" or "experience design" can be complicated and alternately specialized for description of different approaches. However, experience-centred interactive spaces, borrowing descriptions of human-computer activities, can be referred to as environmental interactive systems that are built for purely experiential activities and do not require the accomplishment of "tasks" traditionally found in computer systems for an "outcome of work". Projects centred on the exploration of new or enhanced experiences of space by digital technologies will remain the focus of this research.

3.4 Definition of interactive spaces

As we can see from the section on environmental design concepts, interactive space design is a product-oriented discipline with ideology from digital culture that facilitates the flow of information by providing a framework for exchange of communication. The study of interactive space projects will

look at how user actions become an inseparable initiation of activities or contribution to the content of the interaction exchange in information structure.

To define interactive space in one sense, user participation is necessary – despite extensive debates on "interactivity" and "interactive environments", the word "interactivity" in this research project means, in particular, interaction involved with humans above all. Bullivant (2006, p.7) instead used the term "responsive environments" to mean "spaces that interact with the people who use them, pass through them or by them". The preliminary observation study conducted for this research also concluded that in interactive spaces, people interact with the environment, with the digital system, with other users, where navigation, control and contribution are the major modes of participation involved in interactions through environmental interfaces. To see this relationship, the idea of communication interfaces takes an important position, as it would define the exchange channel and mediation "protocol" between systems. Users as a result experience "interactivity" in a combination of environmental, computer and social communications.

Also noted is the study of "embodied interaction" by Dourish (2001) who has observed that the human-computer interface has moved from tangible and social computing to embodied interaction, characterized by its "creation, manipulation, and sharing of meaning through engaged interaction with artifacts" (p.126). He believes that both tangible and social computing share common principles for us to experience the world "through directly interacting with it, and that we act in the world by exploring opportunities for actions that provides to us – whether through its physical configuration, or through socially constructed meanings" (p.15-16). It implies that interactive spaces, like embodied interaction, are considerably based on "the world" or the context of the environment, which shapes and guides human actions. How people behave and interact in interactive spaces would partly rely upon the designer's planning of environmental and social contexts in the design.

3.4.1 General structure of interactive interface

With reference to simple cybernetics concepts first developed by Wiener (1954), interactive spaces can be regarded as the communication between two different systems completed through a feedback loop. Its high resemblance to a human-computer Interaction system draws a simplified interpretation of the feedback loop, with the user and the computer linked by an interface (fig. 3.2). Five major components are identified. According to Paul (2003) in her study of feedback mechanisms in digital

art, the user, the input interface, the output interface, the back end, and the front end denote the main nodes for the flow of information, here put into a feedback loop for a visualization of an information structure.

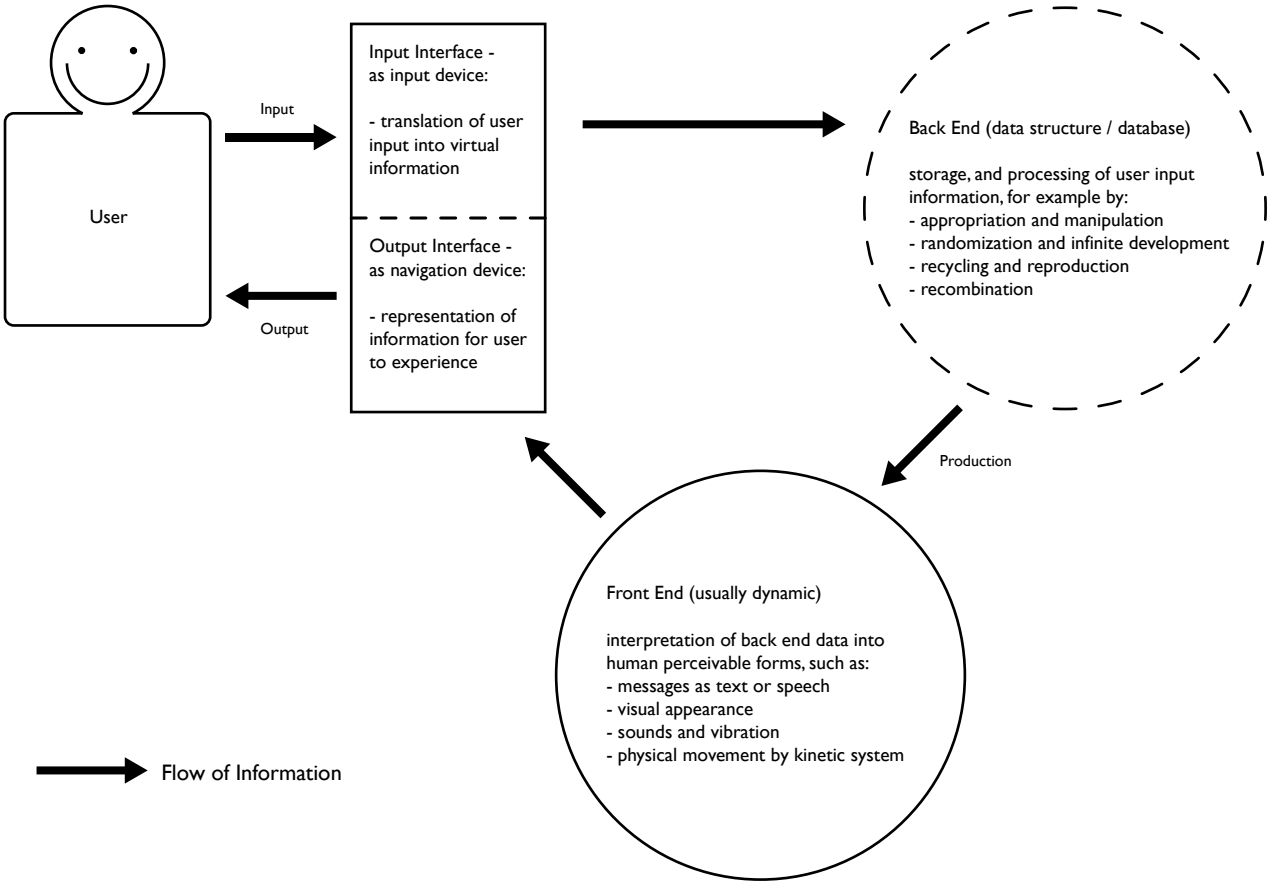


fig 3.2 Feedback mechanism in interactive spaces (visualized from Wiener (1954) and Paul (2003))

1. **User**

It refers to the inhabitant of the environment, especially a participant in interactive spaces. In human-centred and experiential environment design, the user is essentially the initiator of interaction.

2. **Input interface**

It is the input device for the users to directly input information, or one that captures user action as information, which will be translated into computer understandable format.

3. **Back end**

Data processing and storage is operated by the hidden information structure known as the back end, the core of an interactive space, in which user input information can be processed in several ways depending on the designed algorithm or instruction; common methods include appropriation and manipulation of existing data, randomization and infinite development, recycling and reproduction, and recombination.

4. **Front end**

The result of processed data in the back end is used to produce the front end where information is interpreted into different formats for the user to experience. Usual forms are messages as text or speech, visual appearance, sounds, and physical movement by kinetic systems.

5. **Output interface**

Another interface, the output interface, is essential for users to navigate the front end information, giving its fundamental purpose as an output device.

The layers of interfaces are especially remarkable as "a digital object can be described as one or more interfaces to a database of multimedia material", considered by media theorist Lev Manovich (Paul, 2003, p.70). In order for the user to experience and interact with the invisible data structure, the interfaces primarily allow input and output of information, and the configuration of the interfaces designates as well the type of information being communicated between systems, including how the information is translated, what actions a participant should take, and how a user may navigate the information, just as McLuhan (1964) referred to as "the medium is the message", that also reflects the "container" and "content" relationship of information structure.

The constant information flow as the "message" passes through the whole feedback loop in real time, which gives rise to the time-based quality of interactivity. The response of the data structure usually produces an immediate feedback, but does not necessarily accompany instant "visualization" in the front end. Many interactive projects exercise the manipulation of time using database, and only unveil the feedback at scheduled periods of time, or even at the request of the user. It is practical to take advantage of the "archiving" of user information, under controlled randomization or multi user input,

upon the yield of "never-repeating" outcomes or accumulative effects; in these circumstances it would be beneficial to assign "time lags" between a considerable amount of output over an instant feedback.

3.5 Attachment of interactive spaces to built environment and embodied interaction

The attachment of the nodes in the feedback loop to the environment is closely connected with the types of information or modes of interaction of the interactive space. In the study of interactive space, the output interface, for instance, is usually attached to the front end for direct "visualization" of the process output. In fact the design of environmental systems is considerably based on the integration of input and output interfaces into physical settings such as the design of ubiquitous computing environments. In interactive spaces, the interfaces, a vital part of the feedback loop of communication, have to exhibit a close connection with the built environment and the user. Usually the environmental interfaces for embodied interaction are body oriented, and share close proximity to user actions.

The configuration of information nodes in the feedback mechanism corresponds with the scale of the interactive structure (fig. 3.3), though there is no direct relationship between the scale and the format taken in environment as discussed in Chapter 5. Under usual circumstances, the front end and the output interface stick together to produce direct feedback for users' interaction, and because the back end is hidden, from a user's point of view, the location of the back end is of marginal importance. Besides, attention should be paid to the fact that many interactive spaces can also be accessed through communications networks, for example through webcam broadcasting, that would break the normal feedback loop relation to the environment; hence in the diagram below the remote output interface is excluded.

The scale of interactive spaces in relation to the human body confines the embodiment of user interaction differently by the arrangement of interface technologies. Projects of installation scale are usually directed at embodied actions within a comparatively defined space, and the level of interaction between the user and the built environment is the highest among the three different scales, namely installation scale, architecture scale and urban scale.

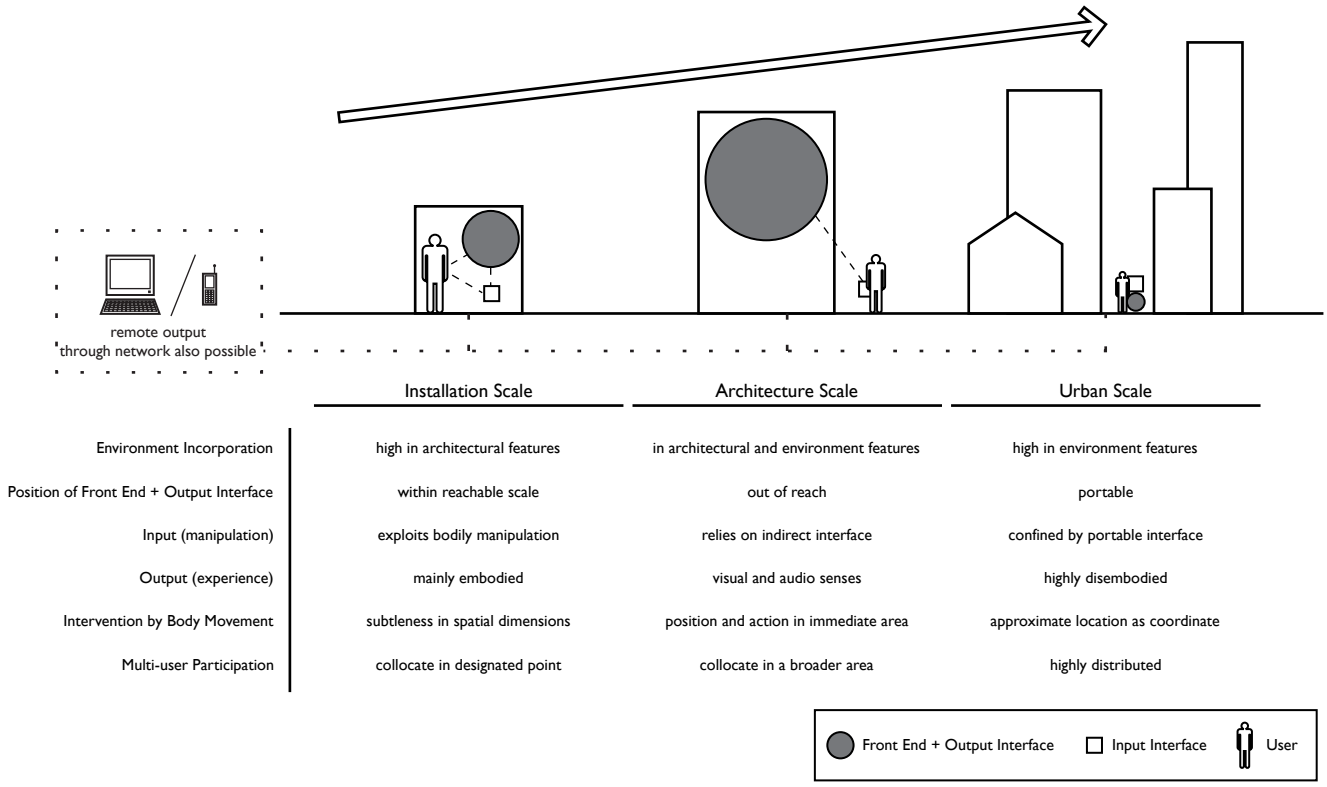


fig. 3.3 Interactive space scale and feedback loop (excluding remote interface)

1. **Installation scale**

In this scale most interaction loops can be completed on site with the advantage of applying embodied interaction like body movement, posture, manipulation of objects, and even facial expressions. Projects belonging to this category usually incorporate architectural features, though they may not be a part of the designers' original consideration. In multi-user participation, users who collocate in the installation are free to communicate spontaneously.

2. **Architecture scale**

When the project is at an architecture scale, it is "on display", inviting or imposing both active participants and passive viewers in the public area to pay attention to the work. Since the front end and output is usually out of reach, the input interface should be detached from the main output domain for user input, but still retain to some extent the bodily involvement in the surrounding area.

3. **Urban scale**

Projects on the urban scale require the feedback loop to be completed at the point of the users, whose location is dynamic due to constant movement. The front end and interfaces have to be very portable, attached to the body, and due to the limitation of portable interfaces, user experience may be confined to disembodied interaction. In fact, unstable context, user mobility and distributed user participation have always been of greatest interest for designers. Environment features and the urban conditions also play important roles in the interaction process.

The projects selected as references in this study, therefore, only range from installation to architecture scales, and in general they show features that enable mostly direct, embodied interaction and real time communication. These projects also demonstrate greater incorporation of environmental strategies in the design of interactive frameworks as they explore bringing digital technologies and virtual environments into the physical space and context.

3.6 Human-oriented interactivity and participation in space

Designers have noticed the inherent power of appropriating digital media in space. In spite of variations in formal aspects, there are a few common components to be addressed. As described by Paul (2003), digital systems are usually interactive, participatory, dynamic and customizable. An interactive interface may show only one or a combination of these components, for instance most narration-based systems invite viewers to customize the navigation without the need for participation in the process.

In this report on interactive spaces, more emphasis is put on "interactive" and "participatory" components, as users can engage in an environment by their own actions rather than through mere mental and sensory reception. The interaction started by the intervention of the users directs the environment to respond according to the design of the usually open-ended information structure. The information structure defines the parameters set by the designers (pre-defined framework) for users to modify, or in some cases, the users define the parameters (open framework). The dependence on user input to the structure makes the space participatory, suggesting multi-user information input, although it may not necessarily be collaborative.

Interactive space requires a constant flux of information to run; occasionally, the designers only provide the information structure but the content is left open to the "database" composed by user participation. Intervention in interactive spaces lets users "customize" the content in a number of ways: from simple navigation of the content, assembly or reorganization of existing structure, to the contribution of information. Since the "information" that users submit is highly subject to individual actions and preferences, interactive spaces are highly "dynamic" to respond to the greatly changing flow of data and to generate an infinite number of "results" for a tailor-made user experience.

Interaction now can be direct or indirect; remote or on-site; synchronous or asynchronous; which means interaction does not simply modify the content, but implicates varying degrees of control over space, context and time. Moreover, the investigation of mediation or facilitation of audience interaction and contribution has become more prevalent in design practice, combining digital communications technologies and social networks and eventually leading to an extreme complication between the designer, the user and the environment yet to be examined.

3.6.1 Means of engagement and participation of users

Users can be engaged in environmental interaction in a few combinations of situations – either actively or passively, and either on-site or remotely. To better define the subject, only active engagement of users and on-site participation are investigated for their design considerations in mediating physical environment and human actions, therefore projects of passive or remote participation are excluded from the study as they give different characteristics on the feedback mechanism.

- **Active engagement and on-site participation**

  Through direct interaction & performance, individual or multiple collocated users interact with the feedback system directly, usually in real time and site specific, and connected to the design of the physical backdrop. To design spaces for active and on-site participation, attention should be paid to how the physical environment design may influence human actions and the ability of users to successfully communicate with the feedback system. Projects used as core references in this research all allow active and on-site participation, for example "Deep Walls" by Scott Snibbe (2003), and "Bubbles" by Michael Fox (2006).

- **Active engagement and remote participation**

By remote control & telepresence, users participate remotely, though actively, through communications networks, like the Internet and mobile networks. Users of this type of interaction are isolated from the environment backdrop of the actual site. Input and output will depend on the disembodied media on remote terminals like mobile gadgets, computers, keyboards and screens. Examples include "Telegarden" by Ken Goldberg (1995), "Vectorial Elevation (Relational Architecture #4)" by Rafael Lozano-Hemmer (1999), "Blinkenlights" by Chaos Computer Club (2001), and "ACCESS" by Marie Sester (2003).

- **Passive engagement and on-site or remote participation**

Usually found in the passive engagement categories are projects about environmental mapping in the interactive systems that only detect the changes in the environment as input. Passive participation does not encourage or have direct means for users to react in response to the feedback system, and the design does not concern effective communication between users and the environment, or the needs and diversity of human input. On-site examples include "Kinetic Light Sculpture" by Christian Moeller (1992) and "Son-O-House" by NOX Architects (2004); remote examples are usually connected spaces as seen in "RemoteHome" by Tobi Schneidler (2003).

3.7 Formulation of matrix of core projects

From the preliminary study and refined scope of research, a matrix of 18 selected interactive space projects categorized by their formats of environmental interface and modes of user involvement in interaction resulted. This is a way of describing projects in empirical studies based on the projects' connections and concerns to the built environment and experiences in human interactions, fulfilling the five criteria of "interactive space" established at the beginning of this chapter – meaning that the projects demonstrate digital design ideologies, are experience-centred, engage user participation through an interface, have strong relationship with physical spaces and deal with digital interaction strategies.

The matrix is also a proposed type of taxonomy for common formats found in interactive spaces

with respective number of participants involved in interaction with the system, which will aid further discussion of findings in later chapters. Details about the matrix will be discussed in chapter 5. The selected projects are:

- URBANforest, Markus Appelbäck, Staffan Björk, Håkan Carlsson, Linus Lundahl and Eddy Svensson, Ars Electronica Festival, 2006.

- Bubbles, Michael Fox, Los Angeles, 2006.

- Reciprocal Space, Ruairi Glynn, Plymouth, 2005.

- Memento, Ulrike Gollner and Jeldrik Schmuch, Ars Electronica Festival, 2006.

- MOVE, Andrew Hieronymi, Ars Electronica Center, 2006.

- Thermoesthesia, Kumiko Kushiyama, Ars Electronica Center, 2006.

- Messa di Voce, Golan Levin, Ars Electronica Center, 2006.

- Body Movies, Rafael Lozano-Hemmer, Rotterdam, 2001.

- Homographies, Rafael Lozano-Hemmer, Sydney Biennale, 2006.

- Subtitled Public, Rafael Lozano-Hemmer, Madrid, 2005.

- Tune Me, Stefano Mirti, Line Christiansen and Stefano Testa, London, 2005.

- Audio Grove, Christian Moeller, Tokyo. 1997.

- Insound Out, Christian Moeller, London, 2001.

- Dune 4.0, Daan Roosegaarde, Rotterdam, 2006.

- Wind 3.0, Daan Roosegaarde, Rotterdam, 2006.

- Deep Space, Yasuhiro Santo, Hong Kong, 2006.

- The Layer, Andrew Shoben, Dublin, 2000.

- Deep Wall, Scott Snibbe, 2003.

3.8 Conclusion

The theoretical framework has established the main scope of research and defined a list of criteria of data collection so that methodology can be formulated strategically and accordingly to address the objectives of the research study. But more importantly, it explained the definition of the key topics, such as "interactivity", "interactive spaces", "experiential interfaces" denoted in this research, as they are vaguely defined subjects such that different researchers may investigate similar topics with totally different scopes and definitions.

A careful definition of the scope can avoid misunderstanding and ambiguity of the subject, it can also inform the topic of research of potential areas to notice, the positioning of this study in the larger context of similar researches. The explanation of design products and processes, and the use of digital culture as a design component or design ideology indicates the need for investigation into innovative development of mediated experiences in the design of physical spaces using digital technologies and media. The focus on human initiated interactivity also justified the reference of cybernetic mechanisms and feedback loops for the discussion of interactive experience in interactive spaces.

The scope set for this research is human-oriented, and it aims at investigating the relationships between people, physical spaces and digital media and technologies. The methodology in the next chapter will reflect this human-oriented disposition in the selection of reference material and the studies conducted in various stages of research.

Chapter 4
Methodology

This chapter explains the research procedure and the methodology applied in various stages. The research subject has been revised and re-focused throughout the early stages, when the background studies were carried out which consisted of environment scanning, book research and pilot study. The preliminary findings showed weaknesses in the original topic of research and necessitated a repositioning towards the study of design of interactive spaces. Yet the work done in the background studies was valuable groundwork and context for later stages of research.

Interactive space design appears to be a practice and a base of knowledge bonding environments, digital technologies and people. Besides, the people involved have become more directly and extensively engaged in the "interactivity" feature with omnipresent digital tools and digital media convergence. Most significant connections between people and interactive environments are contained in the perceptions and ideas of the people who use them, and the people who design them. To investigate the practice (the design products) and knowledge base (the design ideologies) in interactive space design, accessing information from users and designers would inform the current situation and relationship among digital culture, space and people in the description of the discipline from the user's and the designer's own perspectives.

The similarities and differences of the description of interactive spaces from both perspectives were analyzed comparatively, and discussion of findings achieved by linking to theories in human-computer interface design and cognitive psychology support the empirical data of user experience

behaviour and designer comments on design of interactive environments.

Application of grounded theory methodology is appropriate in this research, as it provides a qualitative basis with an empirical, observation-oriented approach, necessary in environment, user and designer studies. Corbin and Strauss (1990) introduced procedures for data collection and analysis of grounded theory that inform the research process of investigating interactive spaces, and constitute a few key stages in the research process. For example, the sources of data include observations, interviews, books and websites, and data collection processes have been interrelated to data analysis to direct further steps of work, including conceptualization of data, categorization, making comparisons and verifying empirical data with theories. While no theory is generated from this research, several methods of categorization and description of interactive spaces are proposed in the findings. These features, characteristics of the most dominant features developed through grounded theory methodology, can be found throughout the stages of this research project.

4.1 Background studies

Starting with the city and communication networks, background studies were conducted in the first few months to acquire fundamental knowledge to help set the scope and define more specifically the research topic. Information from a broad range was collected during the initial stage of study to familiarize myself with current issues and to learn the basics of fundamental theories and terminology. As a result, other than book research, a major part of study was in the form of observation and environment scanning, with analysis and organization of findings to compose meaningful knowledge. The wide coverage of preliminary studies employed some different types of data collection methods in the pilot studies, and consequently resulted in preliminary findings.

4.1.1 Book research and environmental scanning

The book research aimed at identifying areas of knowledge relevant to environment design in digital culture. A thorough understanding of the related topics and framing of the scope of research are especially important since environment design is a multi-faceted discipline. Writers, researchers and designers take up different points of departure and approaches for assessment of this subject, as indicated by book and Internet articles, and a survey of projects and their reviews by art and design

critics conducted in the early phase of the project. In the background study, research material was collected by centring on the design of physical spaces as influenced by digital media and technologies. Some of the issues that may aid discussion of the subject were selected:

- Digital technologies and their influence on society

- Communications networks and the city

- Digital architecture design

- Hybrid environments and interactive environments

- Digital art and experimental design projects

- Research and development projects for future application of digital technologies in environment design

However, it is impossible to describe the current scene of interactive space design only by information gathered from book article research. Journal articles and Internet resources, additionally, build up a supplementary but highly relevant pool of information on new theories of media art, architectural design, interactive environments, and the latest development in digital cultures in design, which are not yet a mainstream topic in library collections. This article research stage provided a collection of different ideas about mediated environment designs, especially interactive spaces with the study of designing human interaction with spaces and architectural digital systems, which are later grouped under several main topics of design concepts and ideologies.

To see what practice is out there in the real world and the people working in interactive space projects, an environmental scanning on interactive space practice was also conducted. The environmental scanning partly aims at achieving a general description and categorization of the current practice in interactive space design through investigation of mediated environment projects. Unlike the literature review, the environmental scanning relied heavily on online material, composing a survey of recent art, research, commercial and experimental projects.

An initial analysis of the above topics has shown that people are increasingly involved in the communication with the environment enabled by digital technologies and media. Examples include phenomena in society and city, studied by writers such as William Mitchell (1995, 1999, 2003), Timo Koopomaa (2000), and the manifestation of ideas explored through art projects like "Can You See Me Now" by Blast Theory (2002) or art/commercial projects like "Yellow Arrow" by Counts Media (2004). They investigated the influence of digital culture on the everyday use of environment and explored new ways of communication and contribution to the environment with digital technologies and media. Users from these new possibilities and the design thinking of post digital design environments.

From this point of view, it seemed that users of space and architecture are inseparable from the agenda of designers in the creative process when digital technologies exert their effects on daily lifestyle and everyday environments. Matters around people and environment design, especially those mediated by digital technologies, were considered appropriate for investigation. Hybrid, mediated or interactive environments have been the focus of, interestingly, both scientists and artists in the development of spaces that react, respond, adapt or evolve according to user actions and needs. Tangible computing, for instance, was an early research of the "Tangible Media Group" at the MIT Media Lab founded by Hiroshi Ishii in 1995. Ubiquitous computing, on the other hand, has been an important topic in the scientific research community, reflected by a consortium "Things That Think" again at MIT in 1995 and the EU initiative "the Disappearing Computer" to develop embedded computing systems in daily environments since 2001.

Artists in the computer age have long investigated the powers and implications of digital technologies in the environment through interactive installations, from as early as 1988, in the work "the Legible City" by Jeffrey Shaw to design a new narration of the city in relation to human actions, to the continuous development of artwork series by Rafael Lozano-Hemmer to question human interaction with environments, and mediated interpersonal communications through new technologies in recent years.

The comparison of different ways of thinking about the design of environments in digital culture and the closer involvement of end users of space led to diverse comments and approaches on this design discipline. The background studies therefore resulted in the decision to study interactive space users and designers, which was expected to show interesting results on descriptions of experience and ideologies.

4.2 Preliminary findings in pilot studies

At this point, the research topic shifted from communications in the city to interactive space design ideologies. However, alongside library research and environmental scanning, some pilot studies were conducted. The preliminary findings no longer resulted in straightforward information for the discussion of the revised research topic; but the background studies can been regarded as preparation work for the research, which helped me understand the language, terminology and issues related to the field, and where data collection and analysis methods were learnt. Below is a brief overview of pilot studies carried out and the preliminary findings achieved from the background studies.

(a) Observation on connectivity in the city and mobile phone usage

The research started from observation of connectivity in the city, through the study of local facts in city images, usage of information networks, and general lifestyle of mobility in the urban environment. Findings assured that the connectivity to information and the establishment of communications networks in Hong Kong are transforming our daily life and the usage of space and public places to a great extent, and interconnectivity between digital media and the built environment reconstructs spatial practice and program as well as environment settings and interaction.

This exercise employed a few data collection methods: collection of mobile phone usage and service data on the Internet and from service providers, observation of city environments and behaviour of users of mobile gadgets and related technologies. Tools for observation were formulated by the exercise performed in Hong Kong, in the application of a structured checklist on observation of the city and the users of mobile gadgets, using photo research, and short interview questions about the use of mobile communication networks. This set of tools allowed the reproduction of the research exercise in Berlin on a short study trip, after which the results obtained from both cities were compared and contrasted. They were subsequently analyzed to reinforce the discussion of influence of networking in the city and its citizens, in particular their uniqueness in highly populated city like Hong Kong (fig. 4.1).

Observation techniques practiced in this study were employed again in the research of

user behaviour and environment observation of interactive spaces, as well as interviews with designers.

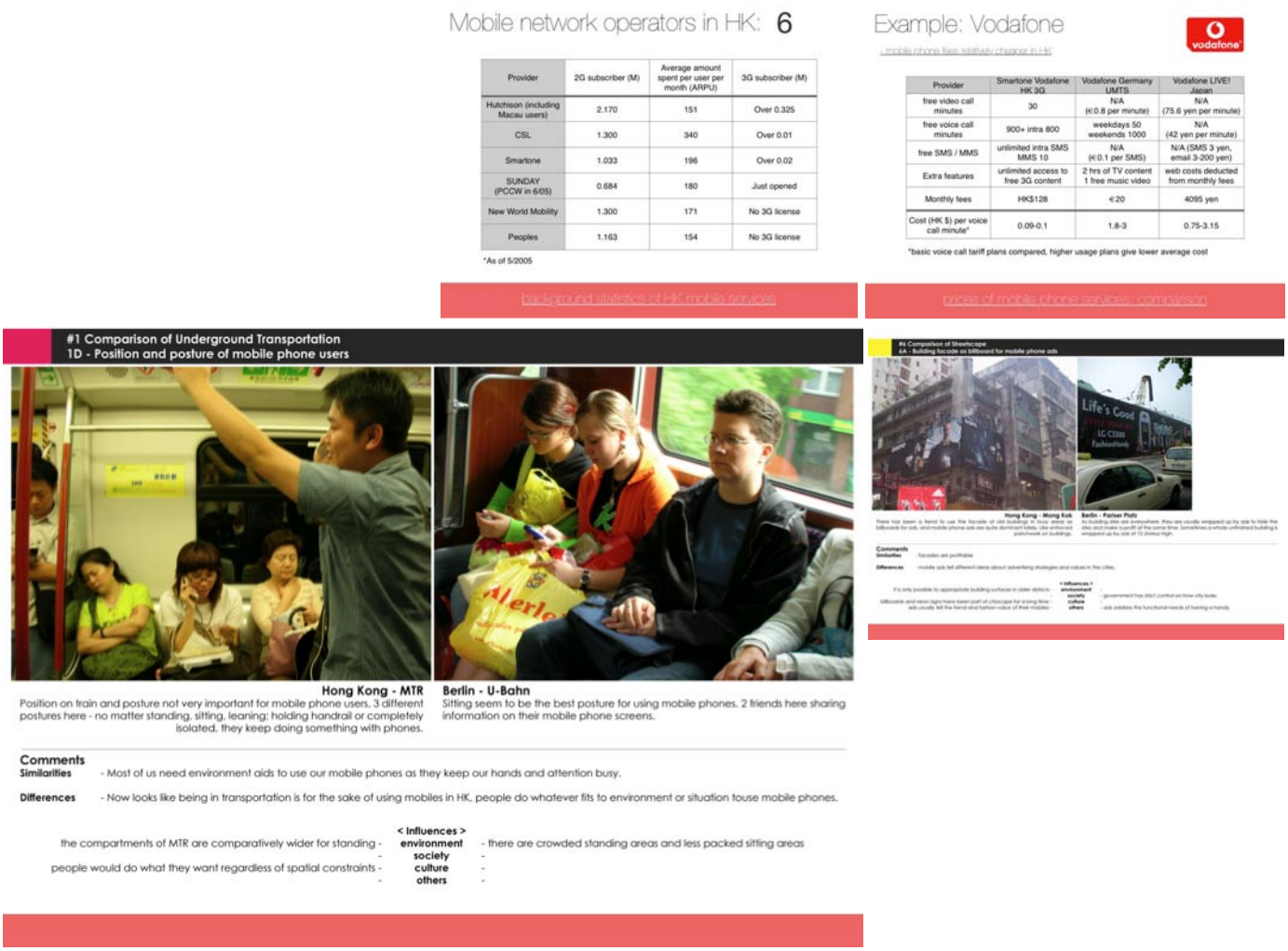


fig. 4.1 Observation studies on connectivity in the city and mobile phone usage

(b) Convergence of digital media and locative technologies

Another study tried to find out how media convergence, locative technologies and ad hoc networks can yield new ways of interaction and communication, for innovative usage to enhance urban experiences and improve communication. For mobile phones, higher processing power, wider bandwidth for Internet connection, mega-pixel cameras, local networking capabilities and locative technologies all change how people interact with each other and with physical spaces. It also showed its capability of being a digital input and output device, which expands user experience from simple voice communication to modern architectural concerns of electronic observation, command and control,

broadcast and feedback mechanisms (fig. 4.2).

Environment scanning has been done to gather existing information on actual usage of these technologies of other cities, since the technological situation in Hong Kong was too immature to inform the original topic – posing potential weaknesses of the research. But from this study, it was also observed that more innovative ideas were developed by users and researchers than the service providers. Analysis of interaction models started to surface and it was observed that digital media and technologies have opened up more channels for user interaction with the environment, challenging fixity of spatiality and temporality in human interactions, turning to the interest in looking at future visions in environment design in digital culture.

User experience in different communication modes

		from service provider communication			entertainment			information					service	
		Video call	Webcam connection	Video msg	music video download	online game	live broadcast	news / traffic / sport	infotainment	locate people	city navigation / location ads	best route	gamble / bank	shopping
temporal involvement	synchronous	X	X		X	X	X			X	X	X	X	
	asynchronous			X				X	X					X
communication mode	1 to 1	X	X	X										
	1 to group			X		X				X				
	1 to public													
people in communication	direct user connection	X	X	X						X				
	anonymous parties					X								
	nobody		X		X		X	X	X		X	X	X	X
location information	be located										X			
	locate other places									X	X	X		
disembodied info	data				X	X	X	X	X					
	services												X	X
embodied info		X	X	X										
purpose of usage	observation		X				X	X	X	X				
	command / control			X	X						X	X	X	X
	broadcast													
	feedback interaction	X				X								

		from users entertainment				information		from projects					Others	
		playing chicken / happy slapping	bluetooth chat with video	file exchange (pictures, MP3…)	digital shoplifting	mobile journalism	mblog	Headmap	Monopoly Live	Uncle Roy	City guide	Smart home	Barcode / OCR reader	digital wallet
temporal involvement	synchronous		X					X		X	X	X	X	X
	asynchronous	X			X	X	X		X					
communication mode	1 to 1			X										
	1 to group	X	X	(X)	X			X		X				
	1 to public	(X)				X	X	X	(X)					
people in communication	direct user connection	X	X	X	X			X						
	anonymous parties	X	X	(X)	(X)	X	X	X	X	X				
	nobody										X	X	X	X
location information	be located							X		X	X			
	locate other places								X					
disembodied info	data		X	X	X			X	X	X	X		X	
	services										X	X		X
embodied info		X	X					X		X	X	X		
purpose of usage	observation				X			X	X		X			
	command / control							X				X	X	X
	broadcast	X		X	X	X	X							
	feedback interaction		X				X			X				

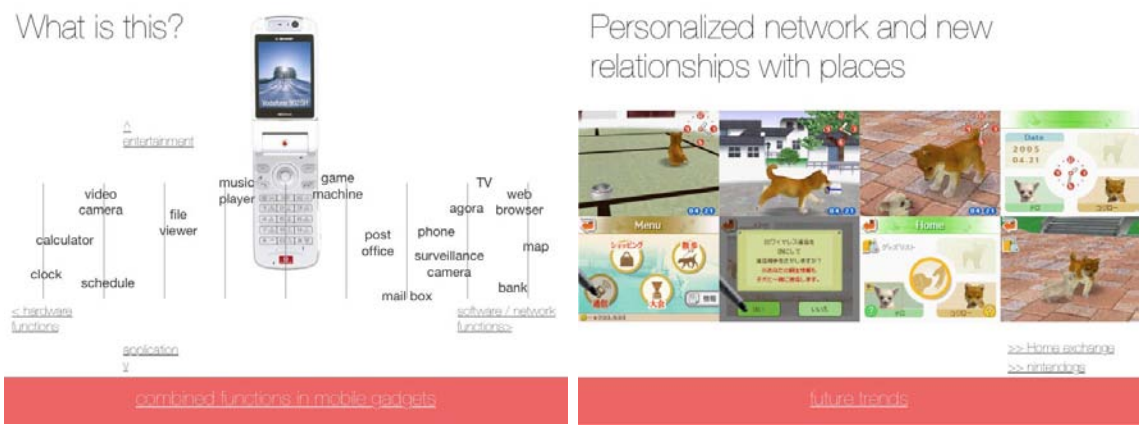


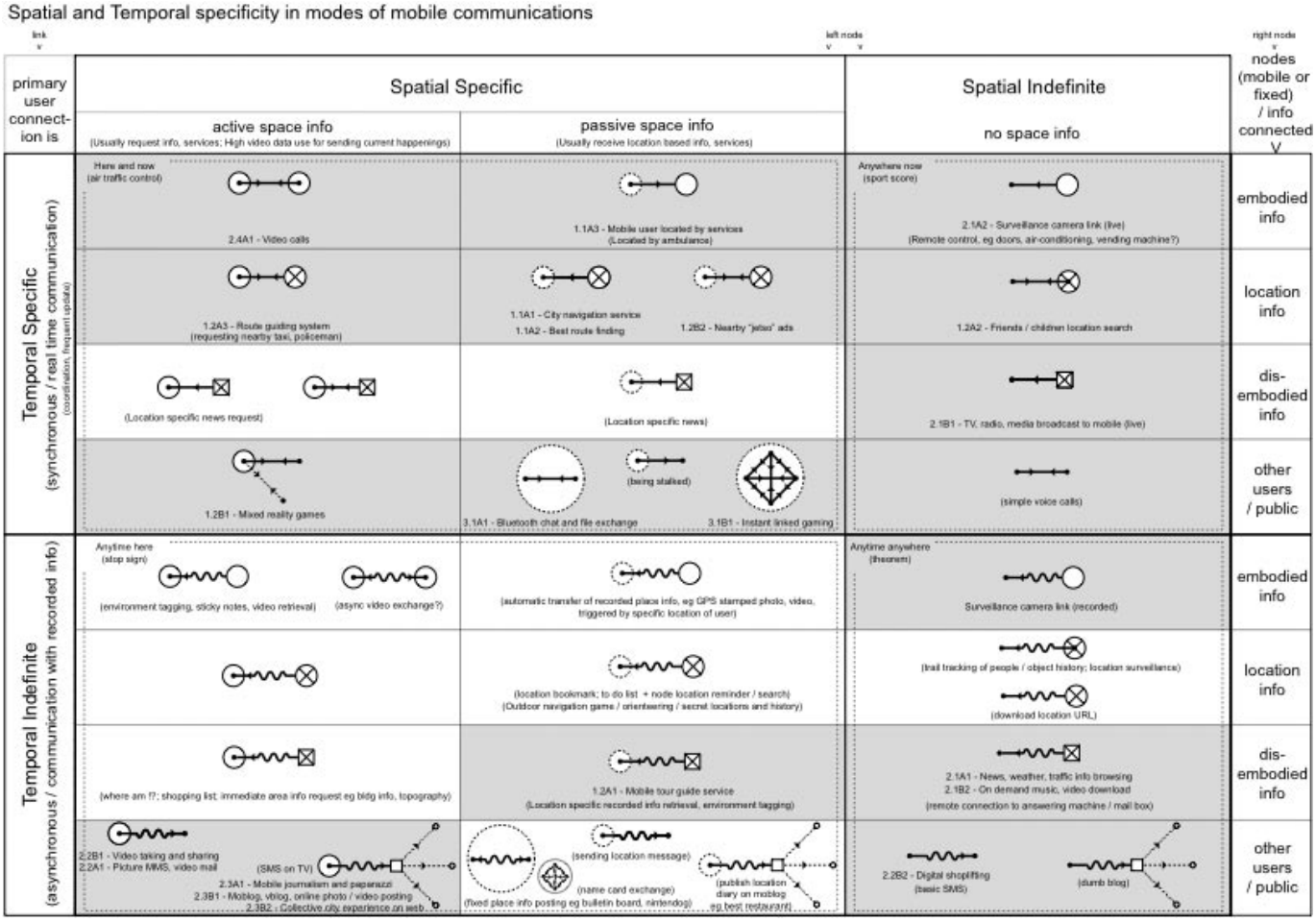
fig. 4.2 Studies on media convergence, locative media and experience of users

(c) Communication modes, spatial and temporal configurations and user participation

Further study of communication methods and locative technologies revealed the interaction involving embodied information of physical spaces is usually in close contact with temporal aspects. Temporal and spatial relationships therefore contribute a key understanding of interactive spaces in daily life. From an alteration of Mitchell's (2004) figure of temporal and spatial specificity, a number of existing modes of communication are organized into a taxonomy chart and some new modes of organization can be deduced from figure 4.3 (top). The chart can help explain how we actually use bodily information nodes to interact with the environment.

In another exercise on the research of interactive art projects, the focus is on the physicality of the environment and the digital means to interact with it. The research finds that mobile devices are undoubtedly effective tools for interaction as many projects now take mobile phones as a universal, bring-your-own component, By using architectural sensors and haptic interfaces, space itself can also become a transparent interface for responsive or learning environments. Another issue in interactive art is the participation value engaged. It is also crucial to notice how people, on their own, in a group, or in a community, can contribute to environmental interactive art. Various modes of participation inform the public interest in collaborative interaction in the built environment, by using their contribution of information, people gain more freedom to broadcast and access information (fig. 4.3, bottom).

Nodal connections in this study already gave some clues to communications models related to cybernetic mechanisms in the built environment, digital database and other combinations found in the feedback loop of interactive spaces. Embodied and disembodied interaction, synchronous and asynchronous communication models are also important factors for describing user participation in interactive environment systems. Analysis visualization and taxonomy of interaction types were learnt in the process of analyzing observation results with basic theories.



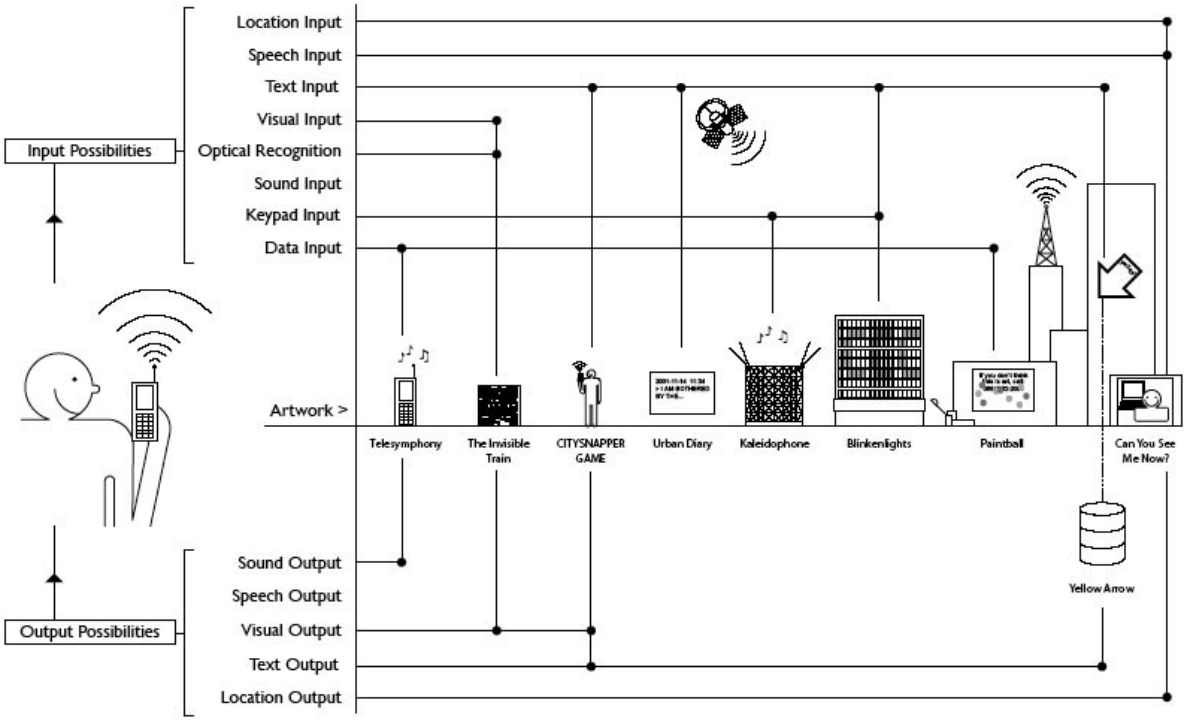


fig. 4.3 Studies on spatial and temporal configurations and modes of communication

4.2.1 Summary of background studies and preliminary findings

The background studies contributed to major findings regarding terminology and concepts employed in interactive space critique and practice, which became the introductory datum upon which later research was built. They also informed how the research topic should be approached, examined and discussed. The preliminary findings concluded with an overview of current design exploration & strategies, related technologies, and common design concepts found in digital culture-inspired space designs, found in the theoretical framework chapter.

The range of reference projects was further narrowed down to define a focused scope of projects about human interactivity and participation. The broad range of research material and the variety of perspectives, nonetheless, helped in composing comprehensive background knowledge on the subject and recognizing various approaches to designing and investigating interactive spaces. This led to a more accurate positioning of the research within the complicated domain of interactive environment design practice.

Many mediated environment and interactive space projects, as well as their creators, were also identified from environmental scanning. These projects showed the extensive investigation of the subject through current practice by different parties and individuals, demonstrated the execution of visionary ideas in environment design in digital culture, and provided ground and evidence for studying actual formats, application and usage of such spaces. Accompanied reviews of the projects by art and design critics, if available, were also valuable resources as they acted as models for project assessment and evaluation methods.

4.2.2 Refocused research topic on design products and their design ideologies of interactive spaces

The preliminary findings revealed that experiences and perceptions of space are now designed with the understanding and integration of existing digital media and tools, and the creative restructuring of these media and tools to provide meaningful results. This new typology of new user experience is still in its early phase, while explorations have been made by designers to investigate how digital technologies and media can be utilized to obtain new design theories for physical space designs. The original proposal led to a study concerning design as products, but overlooked that the creative process is mainly determined by designers' ideologies, now influenced by digital culture, where new solutions

are driven by their visions of the future design of digital environments.

After repositioning the research project, I continued to look at, more specifically, the "interactivity" between users and environments demonstrated by interactive space projects. However, further research would be focused on the investigation of ideologies behind designers, trying to find out the issues of interest, inspiration, vision, design thinking, strategies, and approaches behind the design of interactive space projects. In other words, interactive space projects were to be assessed by both the "design products" view from the users in embodied interactions, and the "design ideologies" view from designers working to inform what is happening in the scene of environment design in digital culture.

Before further action, a theoretical framework was defined in order to position investigation of interactive space design, specify research approaches and establish a benchmark for evaluating relevance of research material. From the pilot research, common formats and modes of involving users were observed, resulting in a simple and straightforward tool to categorize the interactive space projects found in the background studies. These two elements bridge design descriptions from both the views of design products and design ideologies, since the spatial format is the strategy of design to integrate physical environments, perceived directly by the users; and interactivity in space needs design planning of experience, in which users are the main "actors" in the interactive process. This categorization not only explained some taxonomies of empirical evidence of interactive spaces and allowed for an easy categorization, but also limited the scope of research by only allowing relevant projects of physical environment oriented projects for this research.

This was finally accomplished by the analysis of typologies of interactive spaces and a matrix of projects categorized by their common format and modes of user involvement, resulting in a taxonomy for interactive space projects. The matrix started small but was later filled up with 18 core projects for reference by 14 designers and artists. Further research was based on the taxonomy and core of project references leading to the investigation of two major groups of people concerned with interactive space designs, namely the users (or participants) and the designers.

4.3 Study of user experience

The first aspect of interest from the project reviews of the background study is the user experience

of interactive spaces, an area that remains a central focus of designing and developing environmental interactivity. Project descriptions of interactive space projects frequently claimed to provide "new experiences" for users or participants, yet designers resist making explicit explanations of what it really means to user interaction with regard to the planning of experiential space design. Experiences of environments, on the other hand, seemed to be different from what is usually called "experience design" used in the disciplines of industrial products, customer services, or computer interfaces, since traditionally architectural experiences have been tied to the psychological effects on people through spatial planning. "Experience" in interactive spaces represents an interesting but ambiguously developed area of knowledge despite its extensive experimentation by practitioners.

The meaning of "experience design" in interactive spaces thus is deduced from a reverse perspective – the empirical demonstration of experience of use by the study of its users. Users' perspective of describing interactive spaces provides hints to the language, scope and focus of discussing experience matters in environment design. User observation, experiencing interactive spaces in person, and case studies of projects were conducted as the major part of investigation to gain an understanding of the experience of interactive spaces from a user's perspective in relation to the physical design of the built environment. Theories about interactivity, including human-computer interface design, environmental psychology and user participation were references to explain these practices.

It is believed that how users perceive and describe interactive environments is mainly based on the personal and actual experience of communication with the environment as an interface, in contrast to the intentions of the projects and their designers who aim to explore new experiences but leave an open situation yielding unexpected results. In light of this, it would be useful to develop a set of criteria for assessing interactive environments from the users' perspective.

4.3.1 On-site observation of interactive space usage

The first part of collecting data on user experience was a study of interactive environments, including analysis of the projects, user observation and my own experience of interacting with them. The purpose of the observation is to investigate patterns of usage and user behaviour in interactive spaces, connected with their relationship with design elements in interactive environments. Some websites provided descriptions and video recordings of usage of interactive space projects, but to see long duration interaction and usage patterns of a larger sample of users in real life, some projects were

observed during a visit to exhibitions at the Ars Electronica Festival 2006, an annual festival about art and digital culture in Linz, Austria, in which digital art and installation projects were presented and available for study.

According to the taxonomy of interactive spaces resulting from the theoretical framework, art projects and installations concerned with interactive spaces and user participation were selected for reference. This observation not only provided information on usage patterns, but from my personal observations, it also helped assess the projects' execution of the design of space. The observation of projects was expected to provide information on user behaviour as shaped by designers' strategies of integrating physical and digital technologies in the environment. The projects were observed in a number of aspects as follows:

- spatial attributes: how users perceive and experience the space (physical and representational) designated by the project, and the way spatial elements were brought into integration;

- user participation attributes: how users participate in the interactive experience, and the actions and decisions made possible through the planning of interaction strategies in the project;

- interactive system and digital technologies: how the project was executed by the application of digital technologies for embedded spatial interactive systems, such as input and output interfaces, to achieve embodied interaction of the users in the design product.

Angrosino (Denzin and Lincoln et al., 2005) mentioned in his essay on observation study that "social scientists are observers both of human activities and of the physical settings in which such activities take place". The statement corresponds with the observation of users of interactive spaces where the physical (and even hybrid) settings are equally significant data to notice. Usually called "participant observation" in social science, the observation of users includes recording the activities and reading the body language and gestures of the participants. For the observation study of user behaviour of interactive spaces, these factors become critical in collecting data about user experience, but may not yield insightful results by merely neutral observation without situating oneself in the

interactive experience. Researchers in this case take up the role of a participant-observer to develop the perspective of a participant of the activity. This type of observation has been practiced from the pilot study, and a "focused observation" was conducted in the user study to "concentrate on well defined categories" based on the preliminary findings of research. The observation results were supplemented by other sources of data to verify the validity of findings and explanations.

The user behaviour and personal experience of the projects were recorded as pictures and observation notes, containing keywords to describe empirical patterns of interaction behaviour with such spaces. They are both open-ended surveys of projects but the observation also contained a semi-open checklist of items to be noted, which was defined by the knowledge developed in the background studies and the theoretical framework. This aided the discovery of specific information suited for the analysis of user experience with environmental effects. The keywords were later organized, conceptualized, and categorized into major themes, and based on that, interactive experiences were analyzed and used as the means to build up the set of criteria for project evaluation of user experiences, referring to theories in cognitive science and interactive interface design.

4.3.2 Building up a tool for user experience evaluation

Theories related to user interactivity were identified to supplement the observation material, reinforcing definition of possible explanations for evaluating interactive space and human experience. The most relevant areas included environmental psychology and human computer interface design, selected for their common emphases on environmental perception and study of human factors in design, and for the relative strength in underpinning the discussion since academic reference of these areas can be readily obtained.

A review of theories, plus the analysis of the results of observations, resulted in ten criteria for evaluation of interactive space experience, grouped under three categories, namely cognitive process, sensory perception and emotional effects. They assisted the explanation that interactive space design involves a combination of experience in the built environment through a communication interface, by different degrees of engagement of users' participation and consideration of their interests. The criteria will be used as a tool to indicate the emphasis of designers' intention of design, and the ability of the environmental system to communicate the design intentions with its users' mental models.

The findings to discuss interactive space projects from the user's perspective, language, themes of interest and finally the criteria for evaluating interactive experience were brought into application by taking five projects from the Ars Electronica Festival as case studies. In the case studies, the ten evaluation criteria were applied to discuss the levels of cognitive, sensory and emotional values in the interactive space projects, ranging from low to high. The levels revealed different focus of planning interactive experiences and their relative strengths and weaknesses in designing user-centred interfaces. These results can be compared side by side by organizing the information into figures showing the possibilities to enrich understandability, interactivity and appeal of designs.

To conclude the findings, this study of user description of interactive experience was summarized, reflected by the case studies, in ten factors for consideration in the design of spatial and virtual interaction interfaces to enhance interactive experiences and facilitate user participation. Details will be discussed in Chapter 5 on user study.

4.4 Study of designer ideologies

Another perspective for assessing the design of interactive spaces is through the probe of designers' inspirations and ideologies. To find out how designers describe their own projects, it is necessary to get primary information from designers themselves, for their ability to provide insiders' views of conceptual data on decision-making and processes in design, which cannot be obtained by observation. Designer descriptions also tend to be more specific in ideas, and directed to the use of language, terminology and themes in the designer community. But this kind of information is not readily available exclusively in publications; to understand how designers describe their projects, therefore, it was approached in several ways:

- a survey of research topics has been conducted by looking at conference papers in computer-aided architecture design to find out what areas of knowledge or influences are considered important by researchers in designing interactive spaces;

- profiles of interactive space designers and artists were identified from their websites, and their areas of activities in design such as projects and publications were analyzed and organized;

- interviews with the designers were arranged to enquire about their inspirations and ideologies in producing interactive spaces, in their own words.

Achieving an understanding of descriptions of interactive spaces from the designer's perspective, as opposed to the user's, could show the inspirations, intentions, values and even thought processes of designers behind the design of mediated environments, the issues they wanted to address, or answers they wanted to find out in the digital culture through design production and research. The study of designers would also explain the complicated situation of interactive environment design combined through an assortment of knowledge, philosophy, and practice from different disciplines. It was expected to reveal very different results from the investigation of both perspectives, and therefore, to generate interesting results by comparing and contrasting the user-centred design approach and the designer-oriented approach for a comprehensive study of the subject.

4.4.1 Survey of research topics

Research on digital architectural design is carried out by institutes around the world, and many are associated with interactive environments, ubiquitous computing or connected spaces. As digital culture in design has an extensive influence on the design community, getting to know the current topics being researched by researchers in schools of architecture and design could inform the study of the latest issues of concern and future visions of the practitioners. Researchers' presentations and articles were significant sources of primary information about design ideologies and intentions, since they have to explain their projects to convince the audience about their topics of research. This work therefore tells a lot about designers' focus and language of description from the creators' point of view, so that commonly held topics of design ideologies and explorations could be identified, leading to further discussion on interactive space design in digital culture.

The visit to the eCAADe Conference 2006 was a good opportunity to listen to researchers' presentations of their research projects on digital architecture and related disciplines. The title of the conference that year was "communicating spaces", which included more projects concerning interrelationships between design and digital media compared to topics of past conferences. Papers submitted had a high proportion of topics around hybrid environments, ubiquitous computing, digital design education and application of digital media, which are more or less relevant to the study of

interactive environments. Nevertheless, only research projects around user participatory space design will be included for reference here.

From the presentations and the research articles, keywords and general design concepts as described by researchers and designers were easily obtained to summarize the nature of each project. This is compared to the common concepts of environment design in digital culture recognized from the background study. The topics, keywords and concepts were thus analyzed and organized in categories based on their design context, design theory and design practice. The resulting grid of categories presents common topics of interest to designers, later employed as a tool to compare the design approaches of digital environments, and to show the tendencies of connections of ideologies in the emerging interactive spatial practice and explorations seen from designers' perspectives in the research and design community.

4.4.2 Designer profiles and fields of activities

Designers of interactive spaces now come from diverse backgrounds and take very different routes in their practice. Since setting up the matrix of projects as the taxonomy for interactive space projects, new members are filling the core project references. As a result, more practitioners and their work done throughout their practice were discovered. However it only informed the subject matter by the design products but did not contribute to the study of designers' ideologies. To find out the active areas in which interactive space designers, artists, architects operate, and to understand their origins, shifts and focus of practice, designer profiles that include work and field of activities would aid the explanation of the multi-disciplinary knowledge of interactive spaces.

Designers from very different backgrounds, and with different design approaches, were selected from the taxonomy to take a closer look at their fields and timeframe of activities in interactive space design, teaching, art and architecture disciplines. Seven people were chosen, and data was collected based on their history of work, profiles, CV, publications and practice on interactive space design for analysis. The seven chosen designers are:

- Michael Fox (architect, architecture teacher)

- Ruairi Glynn (architecture and media arts student)

- Stefano Mirti (architect, interaction designer, interaction design teacher)

- Christian Moeller (architect, artist, media art teacher)

- Daan Roosegaarde (artist)

- Yasuhiro Santo (architect, interaction design teacher)

- Andrew Shoben (artist)

Putting the data into a timeline showed their comparative active areas and orientation of practice in academic, interaction design, architecture and art disciplines. This organization of their fields of training, activities, projects, and publications shows the trends and shifts of practice of the designers in digital culture.

4.4.3 Designer interviews

Designers of several selected interactive space projects in the matrix of core references were interviewed to obtain information on their description and explanation of their projects. The interviews acted as follow-up studies of the designers and their projects. Five out of the seven chosen designers answered a set of interview questions via either email or telephone. The interviews were valuable sources providing primary information suited to the theoretical framework of the research to support discussion of the subject of design ideologies.

As Fontana and Frey (Denzin and Lincoln et al., 1998) mentioned, there is a need to access the setting and understand the language and culture of respondents in interviews, the survey of research topics in the eCAADe Conference functioned as the preparatory work on the language and themes of interest to designers in digital design practice, and to gain insightful ideas from the designers. The merit of applying a semi-structured interview directed the interviewees in a focused scope of enquiry, yet remained open-ended to allow breadth of data from the designers with their own language and dominance of ideologies in explanation, to remedy potential biases of information collected from the background studies of digital design concepts.

In the semi-structured interviews the designers were asked five questions about design approaches, inspirations and intentions, strategies, implications and visions of their projects in the interactive space design discipline. This set of questions came from the objective to understand the thought process and issues affecting design consideration and decision-making in digital culture. In the interviews, the designers were requested to answer the questions relating to their selected projects, therefore explaining their projects from the creators' standpoint. Later analysis made a comparison by looking at the same projects from both designers' and audience's perspectives.

The interviews were analyzed by comparing the answers of different designers to each question, to find out similarities and differences among their ideas on interactive space design. Keywords were compared and grouped into categories of design concepts. The interview resulted in the four types of designers according to their design approaches and their design intentions, finally supported by putting their projects back into the grid of concept categories to discuss their design ideologies, which will be explained in Chapter 6 on designer study.

4.5 Bridging between the designer's and the user's descriptions of interactive spaces

Analysis of the two part findings of user and designer descriptions is aided by verification of theories of related disciplines. The results of user experience and design ideologies are connected in common design approaches including user-centred design, interface design, and cognitive psychology.

The research has resulted in a few categories of design ideologies in interactive spaces, findings of two-sided description of environmental interactivity, and the influence of digital culture on the creative process, forming the major areas of analysis. Since the results are made by observation and interviews, comparison of the two major findings on user behaviour and designer ideologies required significant knowledge to underpin an analysis of empirical data. Based on further literature review, the following fields of knowledge were identified and investigated for discussion:

- user-centred design on usefulness, usability, and experience planning;

- interface design on communication models between systems, such as human-computer

interface and physical interface;

- cognitive psychology, relating to environmental psychology, mental models, understanding and cognition, and user behaviour;

- creativity process such as decision-making, collaborative design, design and development approaches, design evaluation and revision process.

These areas were expected to shed light on the discussion of the current situation of interactive space design, its design strategies and ideologies, and its complicated linkage with users and many disciplines of knowledge useful to the design community. The findings and analysis are expected to lead to a conclusion in the final chapter of the thesis, in quest of answers for the main questions of the research study.

Chapter 5
Findings I: Design Descriptions from the User's Experience

Details on environmental interface format and user experience in interactive spaces

Descriptions of design can differ greatly in terms of the point of view, access to information and language. To recognize how people view the interactive space design discipline, the descriptions from both designers' and users' perspectives reflect their attitudes and focus of interests. The first part of the investigation will look into the areas of concern to users of interactive spaces by conducting an observation study on user behaviour in the process of interaction in interactive spaces. Experiential spaces are selected for examination, and the observation study is directed at the interactive experience of such projects. In the interactive process, users signal their feelings toward the design of space through their behaviour patterns; the observation study aims to find language for description of user experience in the course of interactivity within a defined environmental system.

The study does not involve direct discussion of the design with users, but approaches with the intention of finding out what areas of consideration would be useful to evaluate interaction space design in a user-centred context, judging by the behavioural patterns observed, and analyzing the implications later interpreted as cognitive, sensory and emotional aspects. Data collection would be more valuable and effective through structured observation, with a goal-driven data collection strategy to find out descriptions closely connected to the framework of study.

5.1 Formats of environmental interface and modes of user involvement

Before the start of user observation, background knowledge of interactive space projects was vital to identify a core for further research. Preliminary research stages reviewed some projects of digital culture-inspired environment design. Since the research topic was refocused to interactive spaces, the most relevant projects were selected and categorized in a matrix of projects used as the core reference for the research project (fig. 5.1).

The matrix presents the taxonomy of interactive spaces based on the format of environmental interface and the mode of user involvement in each project. Initially the matrix was simply a benchmark for including or excluding project references for use in the background study, but further observation and experience in interactive spaces led to the insight that the environmental formats and user involvement modes are commonly found in interactive space designs. Consequently, the taxonomy was applied as a selection criterion for most relevant projects for the detailed observation and case studies discussed in the next sections, further adding new projects to the matrix which contains 18 projects. Project information, descriptions and general analysis of environmental interface and interaction of these core projects can be found in Appendix A.

5.1.1 Common architectural interface formats: tectonics, ambience, projection

To enhance people's experience of physical space and merge different dimensions of experience using digital technology, designers try to make spaces more fluid, flexible and communicative. In the design of interactive spaces, effort is put on the design of the environmental interface, which in turn accounts for the design of the physical context. According to Bouman (Bullivant et al., 2005), there are four ways of achieving this: by animating space such as using projection technology; by making spaces interactive with sensor technology; by merging remote environments with a common interface; and by connecting to remote places through communications networks. Taking a perspective in physical interactions, Ishii (1997) has been researching tangible computing, where he looked into three categories of architectural interactive elements: surfaces, such as desks, doors and walls; ambients, including peripheral channels like light, sound and air currents; and tangibles, meaning graspable and manipulable physical objects.

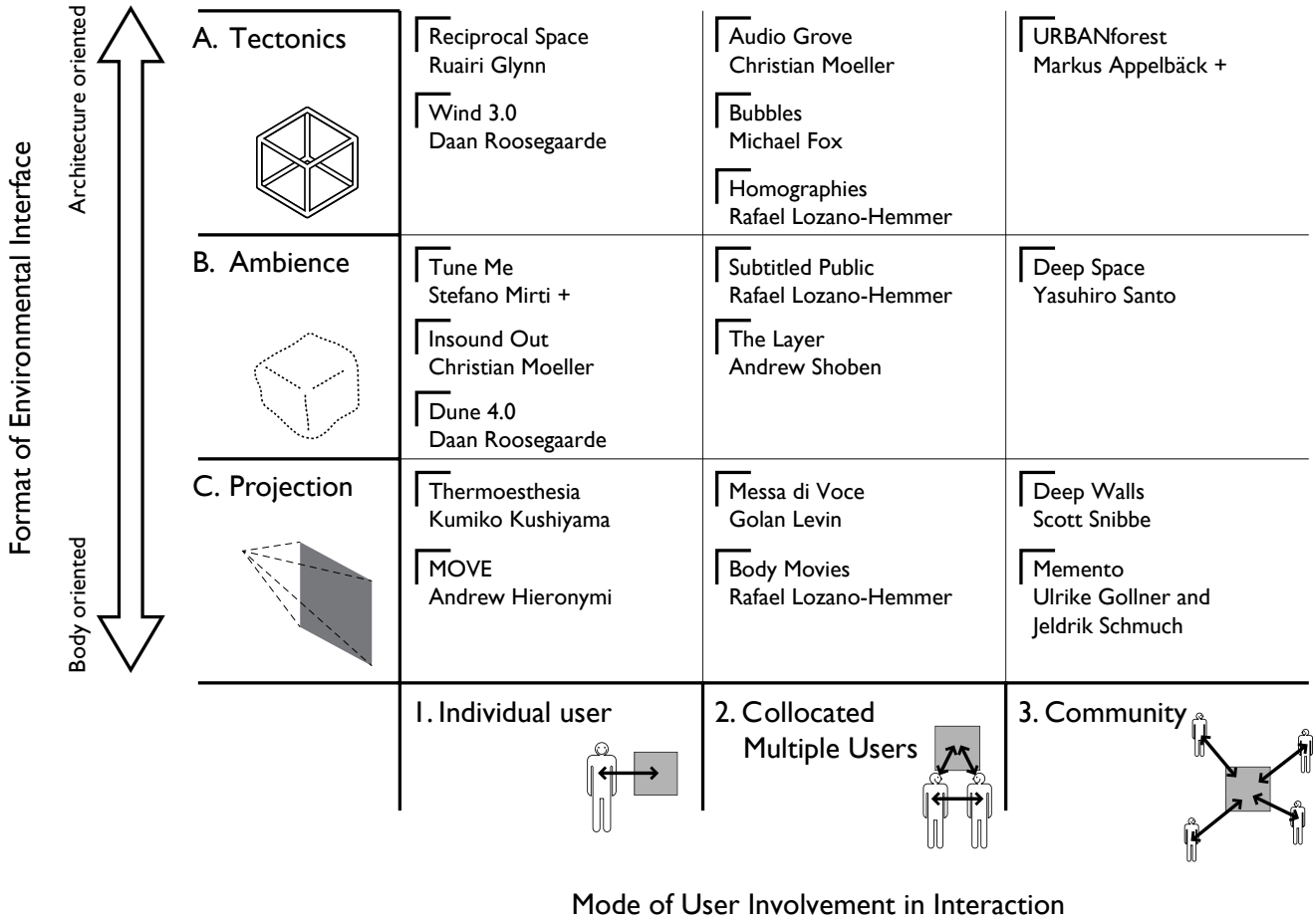


fig. 5.1 Matrix of interactive space projects by format of environmental interface vs. mode of user involvement in interaction

From the common formats of interactive spaces observed, the environment they relate to or create can be categorized, although not exactly as Bouman or Ishii suggested, into the following categories. (Virtual environments in which physical space is completely dissolved, or remote access where environmental context is ignored are not included). In these forms the interaction interface ranges from architecture-oriented to body-oriented (fig. 5.2). The portability of the project (the possibility to transport the system to other places and reconstruct it with the same effects) and specificity to site and context are revealed by this taxonomy.

A. **Tectonics**

The interface utilizes architectural elements as an integrated means for interaction. To be an interface that users can interact with, tectonic features are usually tangible, custom-made, and built into existing environments with the application of embedded sensors

and actuators. This requires the architectural element or structure to possess dynamic versatility to "respond" to the change of information. Touch sensitive types and robotics that produce physical feedback usually fall into this category. The high attachment level makes the interface greatly site and context specific and not readily portable. "Audio Grove" (A-2) by Christian Moeller is an installation in which users can control lighting and sound system in the gallery context by touching touch sensitive posts. "Wind 3.0" (A-1) by Daan Roosegaarde is a sound sensitive "wall" that responds to the users' positions and sound level, creating changing air currents by the embedded ventilators, which will transform the properties of the physical surface made from innumerable strands of fibres.

B. **Ambience**

Unlike tectonics that emphasize the "built-in" features, ambience means the generation of peripheral atmosphere or the "plugging in" of physical components onto existing structures for creation of intangible but dynamic spaces. Common forms are light & sound environments to generate "space" perceived by non-tactile human senses. These projects usually depend on the composition between the immediate physical environment and the body, thus they are site and context specific and but portable. Andrew Shoben, in his project "the Layer" (B-2), appropriated a footbridge by mounting a carpet embedded with sensors, so that people walking on the bridge could make sounds and compose melodies with their footsteps. "Tune Me" (B-1) by Stefano Mirti is an immersive environment installation concerning the interrelations of touch, sound and light. The outcome is a demonstration of a new experience of listening to the radio, augmented by visual light atmosphere, tactile vibration and pulses.

C. **Projection**

Using projectors and projection surfaces or backdrops as the method of environment creation, this type of interface is projected onto surfaces, and users basically interact with the virtual representation "on-screen" – which is the overlapping projection of visual elements of an ordinary computer screen on architectural backdrops. Tracking and sensing technologies are usually needed to supplement the projection. Taking the flexibility and scalability of projections, projected environments are highly portable. How they relate to the physical environment is determined by where the projection space

is and on what background the visual information is projected; for example, buildings can be augmented by large scale projection, contributing to the projection's low site specificity. "Body Movies" (C-2) by Rafael Lozano-Hemmer employs building scale projection to encourage public users to interact by "projection" of their own shadows on building facades and to reveal underlying images.

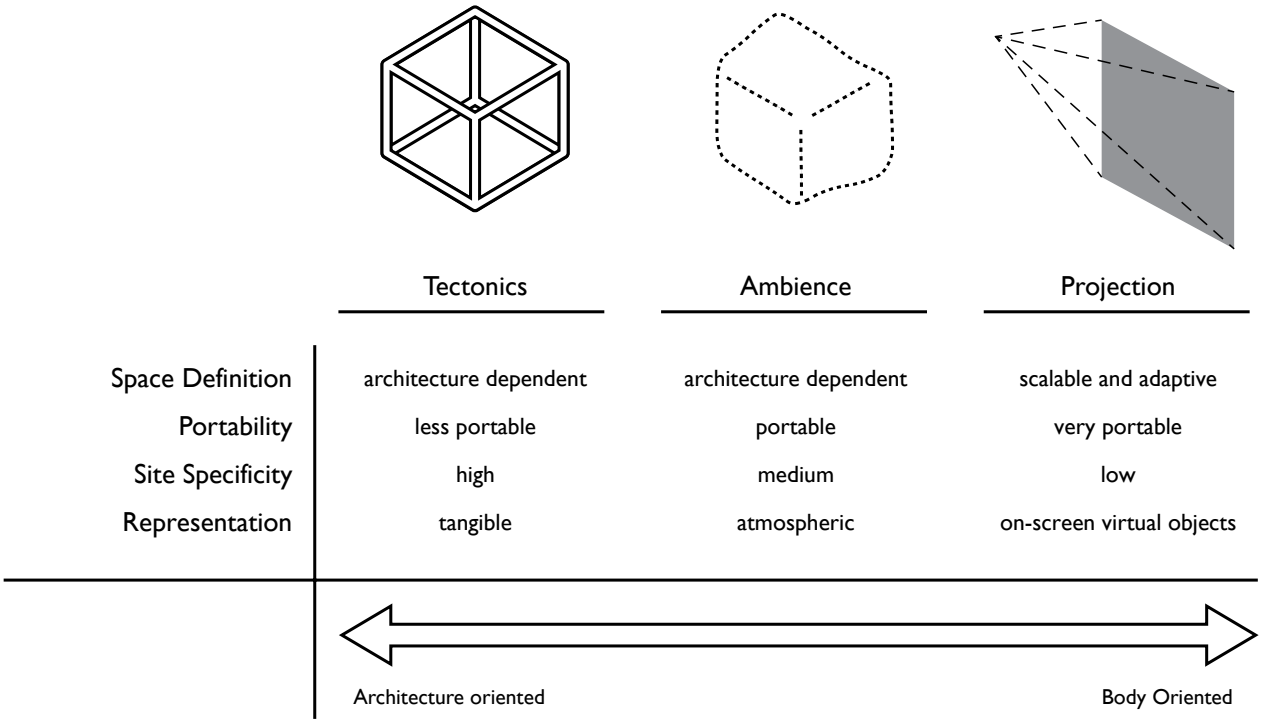


fig. 5.2 Common environmental interface formats in interactive spaces

5.1.2 Modes of user involvement: individual, collocated multiple users, community and experience

User involvement in an interactive space may involve a few different kinds of interaction or communication. The two major interaction types are human-computer interaction and computer mediated human-human interaction. In interactive spaces, the environmental system communicates with the users, and also facilitates the interpersonal communication between collocated people, or members in a community (fig. 5.3). Under these modes of user involvement, feedback time, communication distance and user experience differ for they involve diverse interaction strategies. Here the number of users defines the mode of involvement in embodied interaction.

1. **Individual user**

Many designs only allow a single person to participate for a highly personal experience. In the exploration of the interactive space, most participatory actions are executed to carry out communication between the user and the computer. This type of interaction most resembled traditional human-computer only communication interface, therefore, with its longer history, it is the most easily found among all types. Interaction is usually direct and straightforward – observation and navigation types of interaction often exist with "single user at a time" participation, which is sometimes constrained by spatial or technological limitations. In "MOVE" (C-1) by Andrew Hieronymi for example, the idea of interaction is the embodied version of a simple single user video game, in which the user, tracked by a motion sensing and positioning camera, avoids the "attacks" of the computer component as a projection on the floor.

2. **Collocated multiple users**

If more users are present in the same physical environment, the collocated users may communicate directly under the mediation of the interface. The result is that a user can interact with the computer system and with other users at the same time. In fact this strategy contributes to a cooperative style of interaction. Cooperative participation of users facilitated by interactive system has played a great part in taking advantage of on-site and real time input and output factors. "Messa di Voce" (C-2) by Golan Levin is a good example, by using voice input and projection, multiple users can create and manipulate objects on screen with the feedbacks additive by recognition of the input of multiple users. In this case, collocated users are encouraged to interact with one another to enhance the interactive spatial experience.

3. **Community**

If an interactive space enables or requires the participation of a large group of users, participants naturally form a community linked by the system, and users are free to interact and communicate based on others' contribution of information. The central prominence of community interaction relies on the users' collaborative exchange and active broadcasting of information. Though on site interaction is always considered to be real time, community communication usually takes advantage of the temporal

properties of digital media and allows asynchronous interaction, especially from other contributors to the system. Databases play an important role here: the ability to store interaction data enables users to receive feedback that is collective, accumulated from past users. This means the system runs continuously and evolves over time. Users of "Deep Walls" (C-3) by Scott Snibbe interacts with the collage of "drawers" of the shadows submitted by past participants, at the same time they leave their own for the next users, composing a collective feedback.

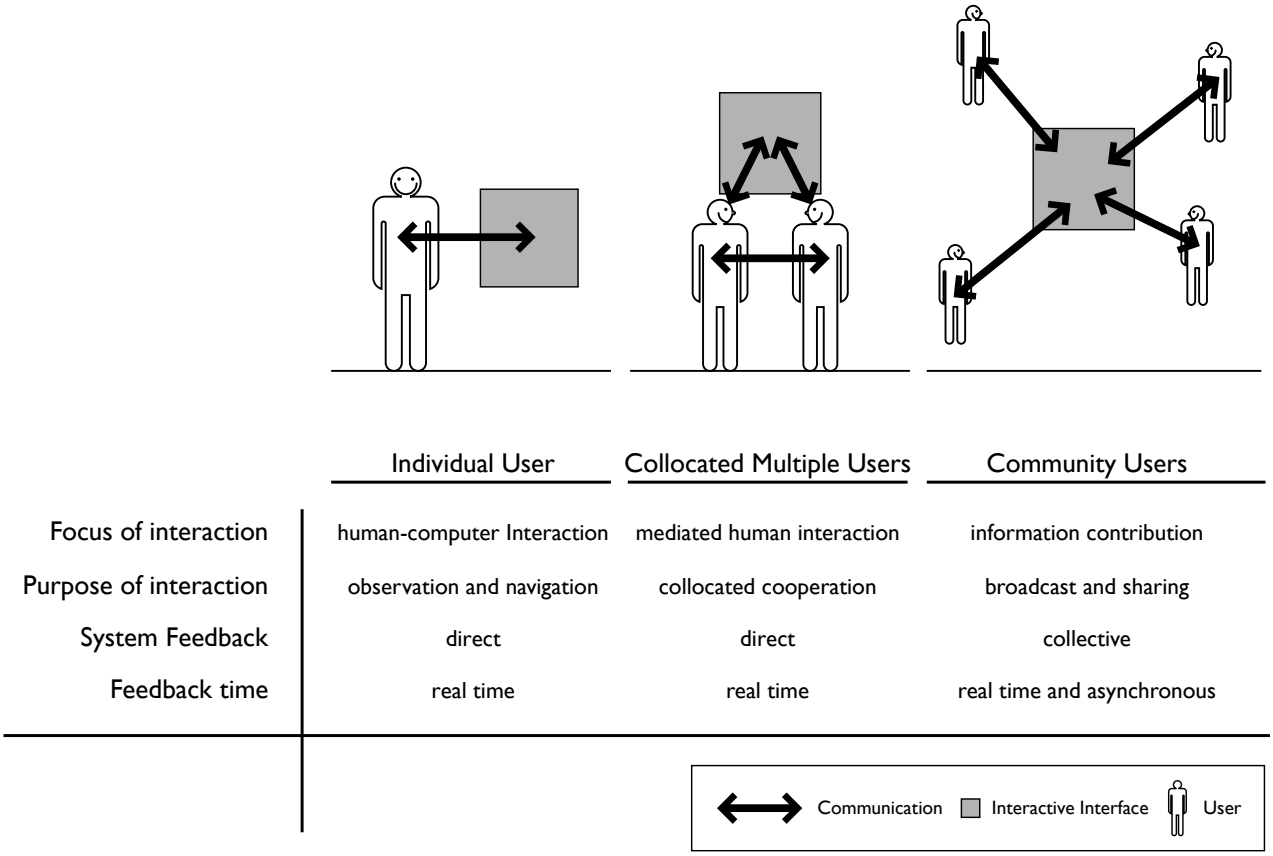


fig. 5.3 Common modes of user involvement in interactive spaces

5.2 Observation of user behaviour of interactive spaces

To obtain information on user behaviour, observations were made by visiting and studying interactive installations and exhibitions at the Ars Electronica Festival 2006. The study consists of observations of the behaviour of users or participants in interactive space projects from a third person's

perspective, as well as my personal participation in the interactive spaces. The study aims at finding out how the interaction experience is conceived without prior understanding of the ideas behind the design of the interactive space projects. A set of observation criteria was set to focus areas of descriptions for analysis. The criteria were derived from the theoretical framework, in order to emphasize the interaction experience regarding human participation, the feedback mechanism of the interfaces and the relationship with the built environment. The early categorization of projects in spatial interface formats with user involvement modes also helped the selection of relevant projects. Projects were observed in terms of:

1. Basic information
    - description of key experience of spatial interaction
    - input interface
    - output interface

2. Spatial interface
    - space definition (How to define the boundary of the interaction area? When does the user "step into" the space of interaction?)
    - fixity to the site (How is the interface connected to the existing environment?)
    - site specificity (What is the linkage to the original characteristics of the site, including physical context and participant involvement strategies?)
    - physical representations (Are physical props or objects used in the interface?)

3. Participation
    - actions involved (What actions are suggested, allowed or accepted in interaction?)
    - interaction opportunities (What strategies of interaction are involved? Can they contribute to the system and interact with other users?)
    - types of feedback received (What types of feedback are generated by the system?)
    - social interaction (Is there social interaction between users?)

4. Detailed description notes from the 3rd person perspective and personal experience
    - behaviour patterns of users in interaction
    - adequacy, effectiveness and satisfaction of interaction of both spatial and interactive systems

Written texts and pictures were recorded from about ten relevant projects in the exhibition. The raw data recorded from observation were analyzed by first looking for keywords and putting them into categories based on common conceptual themes. The keywords mainly came from the description notes but the general description of participation means and spatial interface techniques are supplementary to the discussion. The categories were later refined with the help of knowledge about the design of human computer interfaces and environmental psychology into elements of description of interactive space experience from users' perspectives. The results show that description from a user's point of view is inclined to the physical and mental experiences, "usability" and communication of "conceptual models" through the combination of physical and computer interfaces, in other words, user-centred design issues.

5.2.1 Approaching descriptions of interaction experience

For the reference of data analysis, a few approaches to discussing experience in environment and design have been identified, drawn from psychology and interface design knowledge as mentioned earlier. Starting from how to perceive, experience and appreciate architecture and built environments, it is first believed that human experience in space is a combination of three dimensions, namely intellectual, physical and emotional (Caudill, 1978). These basic dimensions draw to considerate three types of design thinking in the studies of both design of space and interactive system: intellectual aspects in human experience relates to the cognitive process of understanding, like composition and functions; physical factors relate to the sensory perception and bodily stimulation and its physical reactions; emotional needs are the internal feelings towards cultural and social values common among human beings, reflected in design considerations. In the study of designing user experience, therefore, existing knowledge was put into cognitive, sensory and emotional aspects to better describe the subject.

In order to understand descriptions of the experience of interactive spaces, keywords picked out from the observation study of users of interactive space projects are grouped as follows (fig. 5.4):

a/ **Cognitive process**

- keywords about cognitive process, perception, orientation and mental references are considered to be psychological issues related to cognitive science.

b/ **Sensory perception**

- keywords for actions, senses, behaviour and temporality are linked to the stimulus-reaction cycle of human behavioural and sensory systems in the process of interaction.

c/ **Emotional effects**

- keywords about feelings, preference and active engagement represent the emotional aspects directed at the "attractiveness" of the designed space and its ability to prolong interaction.

a/ Cognitive process	b/ Sensory perception	c/ Emotional effects
Keywords about perception	Keywords about actions	Keywords about feelings
- clear / simple / difficult	- make / do	- interesting / meaningful
- intuitive / natural	- manipulate / input / create	- fun / playful
- consistent / coherent	- move	- freedom
- appropriate	- observe	- enjoy
- confusion	- contribute	- curious / frustrated
Keywords about mental activities	Keywords about senses	Keywords about preference
- understand	- hear / see / touch	- willingness
- expect	- sounds / visuals / voice	- preference
- interpret	- gesture / posture	- selection
- predict	- stimuli	- customize
- associate		- favourable
	Keywords about behaviour	
Keywords about mental references	- response / feedback	Keywords about active engagement
- suggestion / reflection	- difference / variety / range	- body movement / actions
- language / symbol / hints		- think / decide
- goal / purpose	Keywords about time	- opponent
- past experience / representation	- immediate / instant	- social communication
- props / objects	- simultaneous	- encourage / invite
- resemblance	- continuous / ongoing	
	- past	
	- frequent	

fig. 5.4 Categories of keywords from user behaviour observation

Firstly, cognitive process is an area that involves the study of human cognition and understanding of the environment, a basic study in environmental psychology. The design of the built environment with regard to geometry, scale, and rhythm are some methods to facilitate human perception of space (Rasmussen, 1964). Design with the knowledge of mental maps of orientation enhances spatial readability (Lynch, 1960). In the design of human-computer interfaces, cognitive science on mental

models and designing "representations" aid understanding and controlling computer systems, and have strong linkage with our experience of the physical space (Laurel, 1991). Hence the study of context, representations, affordance, mapping and mental models are useful for understanding both built and virtual environments.

Secondly, in architectural design, sensory perception is concerned with the stimulation of human senses in experience. Lighting, sound, smell, touch, even temperature and ventilation are traditionally important factors for designing pleasant inhabited environments (Bell, Fisher and Ross, 1978). Designers also plan ahead for possible bodily actions preformed on the materiality of architecture elements and their different feedback to various senses (Rasmussen, 1964). It is also suggested that new digital and building technologies provide more opportunities for complex visual and kinetic features in the design of interactive systems and their interfaces (Bullivant, 2006). Technologies for sensory stimulation have been for a long time at designers' disposal but designing meaningful interaction poses a bigger challenge for preferred sensory experiences by incorporating appropriate senses, intents, actions and feedback in interaction planning and strategies.

Last but not least, emotional values are becoming more important in the planning of design products. Positive emotional effects are closely related in the "usability" of design products, so in architectural design, promoting positive attitudes for users, for example in work space or school to enhance efficiency of production and learning by design, has been another important area of environmental psychology (Bell, Fisher and Ross, 1978). In general, people are usually attracted by designs that are pleasurable to use or comfortable to inhabit, meaning better "user experiences" over other designs (Jordan, 2000; Norman, 2004). Now taking into account the social needs of human beings, the design of physical spaces and interactive systems try to facilitate interpersonal communication by spatial arrangement or putting in social behaviours in designing computer agents.

5.3 Development of an evaluation tool for user experience in interactive spaces

After identifying the major themes in the description of interactive experiences, it is necessary to define more specific criteria for analyzing interactive space projects to understand how users perceive, interpret, experience and participate in design. To further summarize the main themes of cognitive, sensory and emotional factors in a design decision making process, the following considerations are

proposed for planning interaction experience in interactive space design, with reference to theories of environmental psychology and human computer interface design:

a/ Cognitive process

- the encouragement of environmental interaction by guiding users through understanding and gaining knowledge of the environment through mental processes (information processing such as past experience association, mental mapping, logical thinking and reasoning).

> In Laurel's (1991) suggestions for "design principles for human-computer activities", she mentioned that representations would be made more accessible and people would naturally know what to do with them by representing real world objects and real world phenomena, known as metaphors or similes, in the design of human computer interfaces. The idea of association to past experiences enhances the familiarity of contexts and representational objects, which sometimes act as the props and cues to aid understanding of the representational world. In fact, she mentioned the consistency of context for interaction should be reflected by the "objects, actions and tools of the representational world" to enable people to successfully and directly interact with the representation. This is also supported by Norman's (1990) "principles of design for understandability and usability", when he explained that knowledge should exist in the environment by providing a clear conceptual model, and the consideration of affordance, constraints and mapping can make interactions more natural and intuitive, and help people learn how to interact with novel environments.

b/ Sensory perception

- the involvement of a variety of sensory stimuli (usually visual, auditory and tactile) that assists user communication with space through user actions, and especially added sensory experiences that are impossible in conventional environmental situations.

> In interactive spaces, users' experience of participation can be greatly altered by sensory stimuli, since most actions are linked to the control of and feedback from the environment made possible by digital technologies. Actions, control and feedback of the interactive system are directly dependent on sensory stimulation, as the level of "interactivity" is partly characterized by three variables, namely frequency, range and

significance (Laurel, 1991, p.20). These variables are concerned with human computer interactions in which they determine "how often people could engage in interaction", "how many choices were available" and "how much the choices really affected matters". She also added that "participating in the actions of the ongoing representation also arise from sensory immersion and the tight coupling of kinaesthetic input and visual response" (p.21). Feedback is also considered to help cognition by "sending back to the user information about what action has actually been done and what result has been accomplished" (Norman, 1990, p.27). The responsiveness of the system thus contributes to the satisfaction of usage by generating appropriate feedback experienced by different human senses. Interactive spaces are also inclined to experiment with "new experiences" augmented with digital technologies, so interesting sensory experiences normally not possible may add dimensions to human sensory perception.

c/ Emotional effects

- the appealing, positively reinforcing emotional effects (such as happiness, curiosity, anticipation, and sociability) evoked or induced by the environment interaction that result in preference of participation through further user responses and exploration.

In the study of interactive space design, human emotions are concerned with the interaction experience and people's willingness to engage in active participation. Mehrabian and Russell (1974, p.8) suggested that human behaviour responses are affected by primary emotional responses shaped by the environment and personality. In their theory of emotional responses of the study of environmental psychology, three variables of pleasure, arousal and dominance "summarize emotion-eliciting qualities of environments" and are determinant factors for "approach-avoidance behaviours such as physical approach, work performance, exploration and social interaction". These three variables are measurements of environmental effects on linear dimensions – from pleasure to displeasure, the feelings reflected through facial expressions; from sleep to frantic excitement, where arousal level can be identified by physiological and social measures; and from dominance to submissiveness, in which users feel either restricted or unrestricted and free to act. These scales combine to determine the behaviour of physical approach, exploration, performance and communications of preference, all are important in the process of experiencing interactive spaces.

5.3.1 Ten criteria for evaluating interactive space interfaces for user experience

Appropriated from the above theories, and adjusted by considering the data collected from the observation studies, a set of ten criteria is defined to better support the discussion and description of interactive space design from users' experiences and perspectives (fig. 5.5).

a/ Cognitive process	1. **Familiarity** – does the interface design (e.g. space, representation, visual language) associate with the users' *real life experience*? Is the interaction means *intuitive and user-oriented*?
	2. **Accessibility** – is the interface accessible by providing *clear purposes or goals, hints and cues* for users so that they can *easily understand* how the interaction works?
	3. **Coherence** – do *representation elements* of the interface and *planning of interaction strategies* compose a coherent user interaction experience?
	4. **Predictability** – are the behaviours of the interface *"predictable"* by the users; does it respond in accordance to the *users' expectations*?
b/ Sensory perception	5. **Responsiveness** – do users receive *timely* and *significant or meaningful response* from the system upon user input actions?
	6. **Diversity** – is a *wide range of user input* suggested, allowed and understood by the system? Can the system generate a *variety of feedback* respectively?
	7. **Continuity** – can users *frequently interact* through a *continuous exchange* between user and system, with plenty of system initiation and response?
c/ Emotional effects	8. **Appeal** – can the interface provide an *appealing interaction experience* to users, for example with pleasure, sociability or novelty?
	9. **Arousal** – is the interface providing an *appropriate level of arousal* (through involvement of physical and social user activity) and *encouragement in interaction*?
	10. **Freedom** – Do users have the freedom to *select from options* or *change the "parameters"* of the system (e.g. content, duration…) to adapt their preference or needs?

fig. 5.5 Ten criteria for evaluating interactive space interface for user experience

5.4 Application of the ten criteria for evaluation: case studies of five interactive space projects

To show how the set of criteria can be applied in the evaluation of experience of interactive space projects, here five case studies of projects at the Ars Electronica 2006 are selected, their observation results are presented and explained by putting comments under the ten criteria of cognitive, sensory and emotional experiences. Keywords related to the main categories are highlighted in colour.

1. Memento	Ulrike Gollner and Jeldrik Schmuch, Ars Electronica Festival, 2006

The installation enables users to leave their trace of existence in the defined area by a projection of their shadows onto the wall. Body movements of the users are captured by a video camera, and replayed in different timeframes symbolized by faded intensity of the image over time. Users therefore can observe the existence and behaviours of past participants, or interact with the older shadows by producing their own projections on the wall.

Interface technologies

- input:	Infrared sensing camera for silhouette capturing
- output:	Visual projection

Spatial interface

- space definition	Marked area on floor
- physical fixture	Fixture of projector and infrared lights
- site specificity	Circulation area for involvement of passers-by
- phy representations	None, virtual only

Participation

- actions involved	Body movement and posture
- interact opportunities	Interaction with previous user inputs as screen images
- feedback types	Visual feedback on screen
- social interaction	Collocated users and previous users as community

Experience

1. Familiarity	It is easily understandable by the visual language and the interaction means is clear by instant projection of past and current users' shadows on screen. The interface becomes a kind of mirror that tells the use of space in different times of the day.
2. Accessibility	There are no clear goals or purposes, interaction is up to the users' interpretation.
3. Coherence	The interaction strategy of body movement and silhouette making is simple and visual language is consistent.
4. Predictability	As the screen is like a mirror of user movement and gesture, it is very predictable. Though sound is supposed to be a part of interaction, no sound is heard at the time of observation.
5. Responsiveness	Users can see feedback immediately and interact with shadows of past users. The idea of storing a user's own movement in the system for future users to see, and observing past users in different timeframes is interesting as the time factor can be explored in space.
6. Diversity	Users can only see their own shadows and gestures as feedback. The interaction is highly dependent on the participation of past users.
7. Continuity	Users can interact as frequently as desired as the system is continuously running, but encouragement of interaction is not strong.
8. Appeal	It is fun for groups of people who make shadows and interact with the shadows of past participants; but some people may find it is not so meaningful to actively participate with the system.
9. Arousal	Though interesting to look at, the shadows of past users of the space are in fact not a strong element to provide an initiation ground for interaction of future users.
10. Freedom	It is a simple and direct installation that shows one interactive strategy, but no imposed rules of interaction. Users are free to participate.

Cognitive process Sensory perception Emotional effects

2. Messa di Voce

Golan Levin, Ars Electronica Center, 2006

Up to two users can speak or sing into the microphones provided by the installation to create virtual objects and effects on the screen. The objects and effects interact with the shadows projected on the screen by participants and other observers. It resulted in simultaneous manipulation of virtual space by the volume and pitch of voice and body movements in a social environment.

Interface technologies

- input:	Motion sensing camera, microphones
- output:	Visual projection

Spatial interface

- space definition	Area in front of the projection surface
- physical fixture	Fixture of projector, lightings, selection knob and microphones
- site specificity	As stand-alone installation
- phy representations	Microphones and a knob for stage selection

Participation

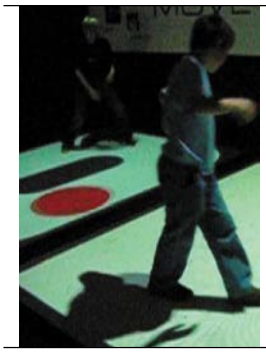
- actions involved	Body movement and speech or voice input
- interact opportunities	Voice produces virtual objects on screen, which in turn respond to body movements
- feedback types	Visual feedback on screen
- social interaction	Collocated multiple users

Experience

1. Familiarity	The props (microphone) intuitively suggest the use of voice input and associates with singing or speaking experience.
2. Accessibility	The purpose is easily understood in interaction: the users' shadows interact with the virtual objects made on screen as a result of voice input.
3. Coherence	The interaction strategy of voice and shadow is carried out throughout different stages. Though the interaction is primarily about producing a variety of virtual visual objects on screen through voice input, it is coupled with further interaction of these objects with users' own shadow.
4. Predictability	Volume and pitch of voice input are clearly reflected from the virtual objects produced and therefore predictable in interaction.
5. Responsiveness	Users can see feedbacks immediately and changes made in interaction are reflected directly in understandable ways. The media translation of visuals and voice encourages users to act bodily and make sounds and visuals simultaneously resulting an integrated interaction experience.
6. Diversity	Though input is limited to body movement and voice input, they create a diversity of feedback effects inviting users to change their behaviour in every stage.
7. Continuity	Users can interact as frequently as desired as system is continuously running, and the visual feedbacks encourage further interaction.
8. Appeal	It is fun to use and look at, and it induces social interactions between users, and invites involvement of other passive participants when their shadows "accidentally" interact with the objects on screen.
9. Arousal	An exploration effect is achieved by triggering the curiosity of interacting with the user's voice in many different combinations of means.
10. Freedom	5 stages are selectable anytime by user preference.

Cognitive process Sensory perception Emotional effects

3. MOVE	Andrew Hieronymi, Ars Electronica Center, 2006



An area for interaction is defined by the projection of a screen image onto the floor. Users engage in the interaction with selection of "stage" by stepping into the area, where the user's position is tracked by a camera. Six different stages allow users to interact with the computer agent by moving around the space with different strategies, for example to avoid the attack of a computer opponent.

Interface technologies

- input:	Motion sensing camera
- output:	Visual projection

Spatial interface

- space definition	Projection area on floor
- physical fixture	Fixture of projector and infrared lights
- site specificity	As stand-alone installation requiring active participation
- phy representations	None, virtual only

Participation

- actions involved	Body movement
- interact opportunities	6 different types of interaction with screen images
- feedback types	Visual feedback and sounds
- social interaction	Computer as opponent

Experience

1. Familiarity	The interface is a virtual version of chasing games, and the visual language and symbols in representation link to common human experience. It is interesting to have a fluid marking of game area on the ground through projection to chase with the virtual transparent existence of the opponent as a "shadow".
2. Accessibility	Due to "over-simplification" of language users may find difficulty in understanding the goals of the different stages without proper cues. Sounds are rarely heard or inappropriate in the interaction (only appropriate is the "you died" sound"), users do not have an idea whether the input is valid and favourable.
3. Coherence	Generally coherent use of visual language and interaction strategy but in some stages they are broken, which causes confusion.
4. Predictability	Interface feedback is predictable with regard to body movement, that is to avoid "death" caused by touching the "ghost".
5. Responsiveness	Probably due to improper calibration of system, user input is not responsive, and users do not receive understandable response to suggest game start.
6. Diversity	User input is limited to preset stages and body movement as location on stage.
7. Continuity	Users interact continuously. The system initiates interaction by offering stage selection.
8. Appeal	The behaviour of the computer opponent benefits from the virtuality (it can grow in size or multiply in number…) so users will find it fun to experience chasing games in a new way.
9. Arousal	An appropriate level of interaction is maintained throughout the experience involving both bodily and mental participation so that users are willing to interact.
10. Freedom	6 stages are available for selection on user preference. But the lack of supporting sensory stimuli hinders the user interaction with the interface.

Cognitive process Sensory perception Emotional effects

4.Thermoesthesia

Kumiko Kushiyama, Ars Electronica Center, 2006

Images of fire, snow and ice are projected on a surface embedded with sensors. Users can touch the surface to manipulate the projected objects, and meanwhile feel the changes in temperature of the surface produced by a cooling system. Hand movement and touch of the surface generate sounds and visual changes according to different ways of touching.

Interface technologies

- input:	Light sensitive projection surface
- output:	Visual projection and temperature changing tabletop

Spatial interface

- space definition	Space around tabletop as interaction area
- physical fixture	Fixture of projector and table with embedded sensors and temperature control
- site specificity	As stand-alone installation requiring active participation
- phy representations	Table like fixture

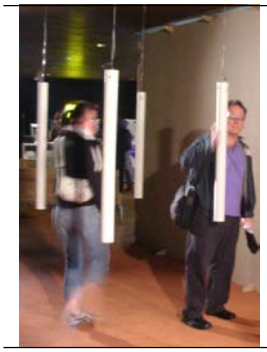
Participation

- actions involved	Hand movement and touch
- interact opportunities	3 types of interaction for “touching” virtual objects
- feedback types	Visual feedback on screen, temperature and sound
- social interaction	No, single user only

Experience

1. Familiarity	One interesting factor is to manipulate virtual objects with hands using different interaction means with touch on a table top setting, but association with a tabletop environment contradicts the interaction means of hand touch by a single user; predefined orientation resembles a computer “desktop” interface.
2. Accessibility	Ongoing projections give clues to the purpose of manipulating visual effects with hand movement. Interaction is straightforward and understandable.
3. Coherence	Coherent use of interaction strategy throughout the program. The integration of temperature change in the tactile interface added to the dimension of visual and audio representation of natural elements of snow, ice and fire.
4. Predictability	Users expect the use of both hands in interaction, and tabletop setting suggests multiple users; but in fact the interface only allows single hand interaction
5. Responsiveness	Real time sound, visual, and not so real time temperature response upon touch and hand movement.
6. Diversity	3 different stages focus on different input methods of “duration of click”, “drag” and “velocity of move” using hand movement, with different feedback respectively
7. Continuity	The system is open for continuous interaction but interruptions are enforced by defined stage time.
8. Appeal	Despite limitations, users are in general curious about how virtual system behaviour can be altered by embodied hand movement, with tactile temperature feedback.
9. Arousal	The interactive experience is an alternative opportunity for users to manipulate these elements that is impossible in real life. Constant feedbacks encourage further interaction.
10. Freedom	Duration and program of interaction are predefined by the system.

Cognitive process Sensory perception Emotional effects

5. URBANForest	Markus Appelbäck, Staffan Björk, Håkan Carlsson, Linus Lundahl, Eddy Svensson Ars Electronica Festival, 2006
	The installation is composed of five plastic tubes suspended from the ceiling and a microphone on a stand. Each tube is embedded with a speaker and touch and tilt sensors. Users can record sounds with the microphone and assign them to the tube of choice. Upon touching, the tubes will play the recorded sounds and tilting changes the pitch of the sounds. The system is customized by past and current users, for composition of a mix of sounds by different interactive strategies with the fixtures.

Interface technologies

- input:	Touch and tilt sensitive tubes and microphone
- output:	Speakers

Spatial interface

- space definition	Arrangement of plastic tubes
- physical fixture	Tubes embedded with speakers suspended on ceiling and microphone on stand
- site specificity	Size and spatial arrangement inflexible but draws attention to installation
- phy representations	Tubes as “trees” activated by touch / tilt

Participation

- actions involved	Touching and moving objects
- interact opportunities	Recording own voice and interacting with previous user inputs as sound collage
- feedback types	Audio feedback
- social interaction	Collocated users and previous users

Experience

1. Familiarity	Intuitive by suggestion of simple touching and tilting of hanging cylinders, with association of playing musical instruments in natural environment.
2. Accessibility	Instant sound feedback through tactile interface defines the purpose by interaction.
3. Coherence	Coherent use of installation element. Exploration of sound effects drives curiosity of space usage.
4. Predictability	Focuses on unpredictable but understandable output, also leads to limited expectation from users, but use of haptic interface and embodied actions to control sound mixing and interesting distortion of effects, which are normally accomplished in computer systems only, can be achieved.
5. Responsiveness	Receive real time and understandable sound response upon touch and tilt actions: touch makes a sound and tilting changes the pitch.
6. Diversity	Wide range of user input allowed by customization, output limited to sound but with variation. Both input and output do not present predefined selections but rather an “analog” range.
7. Continuity	Users can interact as frequently as desired as system is continuously running, and voice input is stored for later participants. Continuous flow of voice and audio senses with the analog feedback of analog body input suggests the physical manipulation of virtuality.
8. Appeal	Manipulation of sounds and composing original mixes of other users’ voices seem to be creative, fun and playful. Collaborative contribution of voice recording and touching induces social communication between collocated and past users (like the use of voice messages).
9. Arousal	The interaction welcomes the active participation and contribution to the system and users are willing to try finding out the results of interaction.
10. Freedom	Users can customize any selection of tree sounds by voice recording, in a number of ways of preference.

Cognitive process Sensory perception Emotional effects

The idea to employ a tool for evaluation by categories is so that we can look at how interactive projects would actually be perceived by experiencing a design product of interactive space. Since this evaluation is supporting evidence for user-centred design, analyzing the level of cognitive, sensory and emotional factors in the design of interactive environment may reveal levels of understandability, interactivity and preference of interactive space projects (fig. 5.6). Projects with higher level factors in the cognitive process in interface design are better understood by their users; higher level sensory involvement yield more interactive experiences; and designs with more positive emotional effects are usually more preferable. Yet higher levels in these categories only indicate an emphasis on "user-centredness" in design strategy, therefore the tool of evaluation should not be considered the only measuring factor to judge whether a project is well designed or successful.

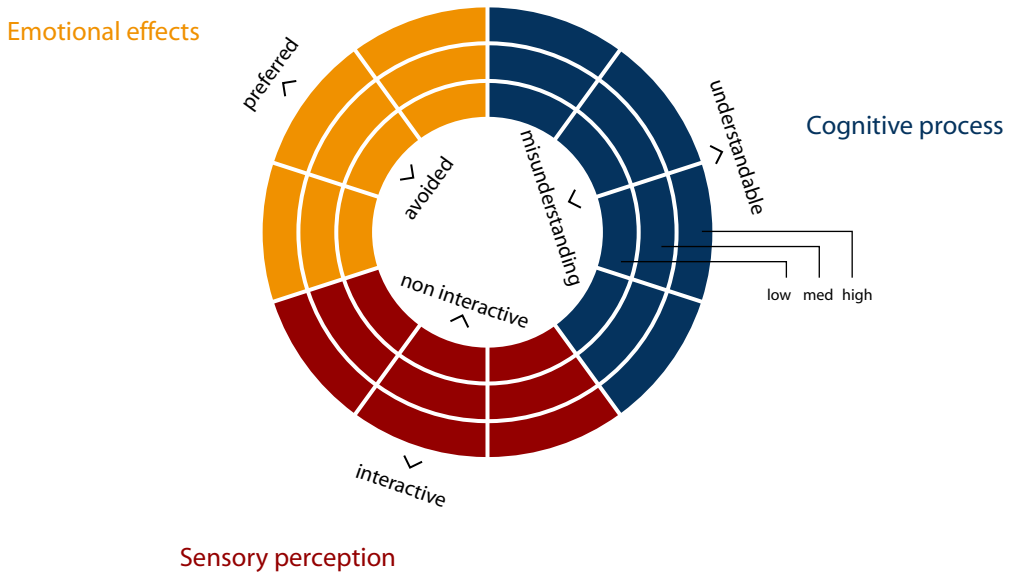
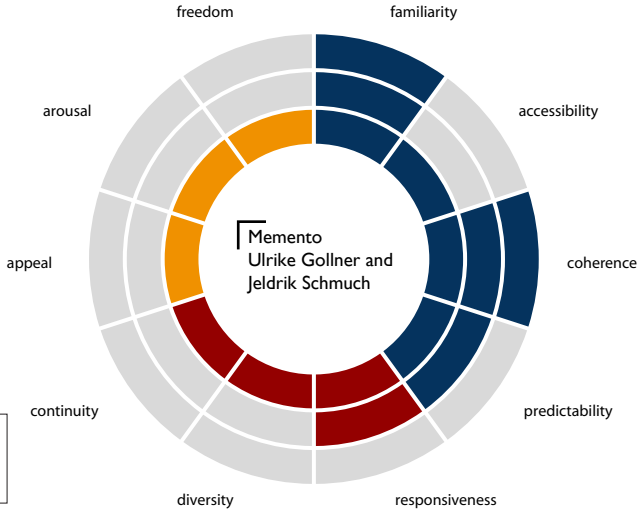


fig.5.6 Chart of levels of three categories of user experience in interactive interface design

On the following pages, the analysis of five case studies of projects in terms of their interactive experience has been graphed according to their levels of user orientation factors, supplemented by a short comment on the strengths and weaknesses of the projects in each of the evaluation categories (fig. 5.7).

Emotional effects

Weakness:
lack of initiation



Cognitive process

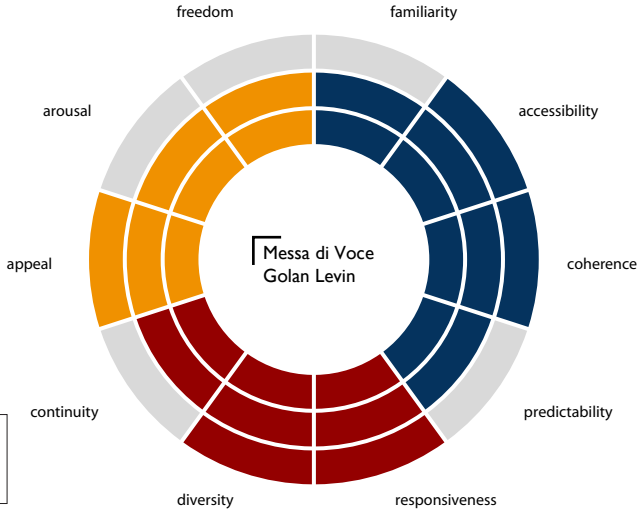
Strength:
simple but effective visual language

Sensory perception

Weakness:
non encouraging and monotonous interaction

Emotional effects

Strength:
induce passive participants and social actions



Cognitive process

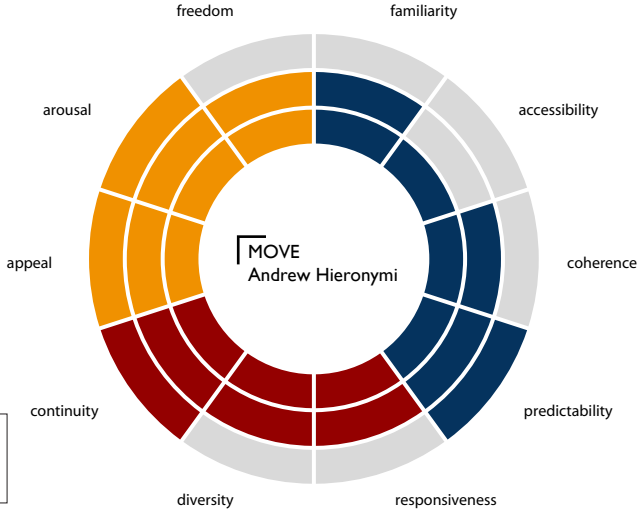
Strength:
intuitive interface and simple goal

Sensory perception

Strength:
involvement of multiple senses in interaction

Emotional effects

Strength:
new experience in traditional chase game



Cognitive process

Weakness:
goals unclear and interface difficult to learn

Sensory perception

Strength:
system invites interaction

fig. 5.7 Analysis charts of five case studies of interactive space projects at Ars Electronica Festival 2006

5.5 Understanding user-centred design description: designing physical and virtual interface for user experience and participation

If the discipline of interactive space design is seen as an applied science, "usefulness" and "usability" are seemingly vital elements in the decision making process for better solutions. Though the discipline is still immature and under development, knowledge regarding architectural design and interface design has long existed, and building up knowledge from user descriptions is a valid method

in research and development.

In experiential interactive systems, such as the interactive space projects studied in this research, "usability" dominates over "usefulness" as a criterion, in order to ensure that users can easily and successfully interact in the designed environments – providing better "user experiences" in the process of interaction. Thus we can look at interactive space design as a combination of human-environment interface and human-computer interface design matters, since both are concerned with cognitive science, sensory qualities and emotional values. The understanding and application of such overlapping knowledge of human computer interface design and environmental psychology in design could make interactive spaces more enjoyable to use. To conclude the findings of the observation study and evaluation results, we can take a look at how user description can inform design strategies for interactive spaces.

a/ Cognitive process: grounding intent by providing knowledge in hybrid context

- **Drawing reference to familiar situations from past experience**

In design of context composed of both material and virtual elements, users can better understand a context with reference to familiar situations rather than a completely novel context in which users have no past experience for orientation. Difficulty in orientation within space hinders spatial perception and grounding intent for actions. Memento (C-3) is a simple interface where participants can see reflections of their body movement on screen just like the everyday experience of looking at oneself in the mirror. To help understand the representation space, the use of different colour tones with a label of time suggests that the screen image is also composed of reflections of users from different past timeframes, implying that the reflections of the current users will also be recorded and open to user interaction in the future.

- **Suggesting purposes and providing cues and props for better understanding**

Designing mixed environment systems considering the "embedded" knowledge of objects and providing extra cues for understanding can help users figure out what to do, especially in designs with somewhat novel interaction experiences. Thermoesthesia (C-1) requires users to touch a table-like prop with a temperature-changing surface. As it requires the intent to touch with the hands, the projection of natural elements

on the tabletop surface, which is designed at an appropriate height, provides hints for participants about key interactive strategies. Visual feedback and sounds generated by hand movement are extra cues to suggest different touching strategies in different stages.

- **Producing coherent behaviour in physical and virtual representations to interaction patterns**

When designing representations of the interface, the behaviour of representations might follow coherent feedback upon interaction. Moreover the interface would be easier to "learn" if similar results are produced by the same user interaction pattern. In Messa di Voce (C-2) users pick up the microphone and expect their voices are the initial means of interaction. The screen therefore visualizes their voices as if their shadows are singing "materialized" songs as virtual objects. Throughout different stages, participants use the same set of interaction models to produce visual effects on the screen and further interact with body movement, and this is reflected in the coherent behaviour of virtual objects, though enabling different interaction strategies, like balls bouncing in response to "touching" in one stage and creating spikes around a user's own shadow by voice input in another stage.

- **Conveying the designer's mental model and thinking about the user's mental model**

The design of the interaction interface is the only channel for designers to project their mental models. This includes how this would provide the users with information for perceiving the interactive environment and considering what mental models would result in users' minds. MOVE (C-1) is a project transforming the movements of computer games into reality and suggests users jump and chase to avoid getting hit by the computer opponent. Using visual language of representing the stage as a white background, the user as a grey object and the "bad guy" as a red object, users can easily understand that the goal of interaction is avoiding attacks from the opponent, and the user's mental model is reinforced in various stages by different stage constraints, so the users can predict the behaviour of the interface and interact accordingly.

b/ Sensory perception: support and facilitation of direct and extended actions

- **Giving timely and meaningful feedbacks**

Feedbacks from the interaction interface can signal that user action is being accepted and results generated, which may suggest follow up interactions. Timeliness and meaningfulness of feedback are therefore facilitation factors for an enjoyable interaction experience. Real time feedback is usually employed for continuous interaction, as demonstrated by URBANforest (A-3) in which user actions are directly responded to by playing sounds recorded in a suspended "tree" in response to touch, while tilting them to different degrees can further make the pitch higher and users can hear the results in real time. This feedback mechanism is intuitive and gives users a clear mapping of actions to results.

- **Accepting multiple interaction and feedback possibilities**

Interactive interfaces accepting multiple interaction possibilities are more intuitive and the interaction would not be constrained to limited means of action. The combination of a wide range of sensory responses also contributes to more integrated immersive effects in experience. As Messa di Voce (C-2) accepts user input with voice and body movement, participants can extend their actions by manipulating virtual objects with combined strategies resulting in a subtle interaction experience. Thermoesthesia (C-1) on the other hand achieves good immersion effects by the integrated visual and sound effects combined with touch augmented with temperature changes.

- **Initiating and continuing interaction**

Interactive interfaces can support user actions by taking the leading role to initiate interaction, and to maintain interaction by giving continuous feedback for users for subsequent reaction. Messa di Voce (C-2) invites interaction by requiring users to step into the area of interaction when picking up microphones in front of the screen. It also gives continuous feedback upon voice input and gives hints on next steps in the interaction by reaction of on-screen elements by user-projected shadows. Interaction is continuous and there is no official ending to interaction; the selection of stages also enhances continuous participation with the interface.

c/ Emotional effects: encourage exploration of mediated experience

- **Designing interesting interactions and facilitating interpersonal communication**

Interesting interactions can enhance the interaction with positive emotions for the participants, and in turn increase the willingness and duration of interaction in the designed space. Good-looking or playful designs are usually preferred by users. Though "interesting interactions" may mean very different concepts according to different designs, raising curiosity, creating new types of interactions and facilitating social interactions have been observed to attract user participation. URBANforest (A-3) and Messa di Voce (C-2) are two interactive projects that are fun to participate in as they generate interesting results – transforming body movement to changing sounds and turning voices into various types of objects. They are also group-friendly activities, requiring collaboration in interaction to facilitate interpersonal communication.

- **Encouraging active participation in the interactive process**

The ability to "encourage" active participation in the design of interactive spaces centres on the planning of interaction experience and scenarios of actual use of the interface. This may need the strategic planning of both the physical configurations and program sequence in the interaction process. The combination would result in a more satisfactory interactive experience, since the design considers methods of engagement of mental and body activities. MOVE (C-1) invites participation with its changing projections and awaits users to trigger interaction by physically engaging in the projected environment. Continuous visual and sound feedback encourages continuous input actions by the users. At the end of each round, the interface offers selections again, encouraging further exploration of other stages.

- **Offering freedom of choice and customization in interaction**

Unconstrained interaction could produce more positive emotional effects for participants, hence better experience. The options for users to decide the duration of interaction, choosing different ways of interaction and even contributing to or customizing the system will give more dominance for users and ensure that the interaction experience is suited to their preferences. URBANforest (A-3) is a community contribution project

that allows interaction between people at different times of access to record their own voices and messages. This to some extent invites participants to customize the resulting sound mix output by their own sound clips. Messa di Voce (C-2), on the other hand, offers users the possibility to choose from different stages by putting in a stage selection knob.

5.6 Conclusion

The study of user behaviour in interactive spaces has resulted in the description of interactive experience with cognitive process, sensory perception, and emotional effects in interaction. These factors are commonly investigated by disciplines concerned with the importance of user-centred approaches in design, such as psychology, and communication interface and experience design.

Focus of interest of the user centres on their personal feelings towards design. This often leads to "evaluating" design from the role of an end user; normally user descriptions include how a design looks, how something works and if a certain product is comfortable to use. These aspects of description are also valid departures of judgment in environment and architecture design, but as the current study is on the interactive experience of environmental interfaces, the success of communication in human computer interface also comes into question. Users' points of view are inclined to personal views, which are not as descriptive as that of critics or designers themselves on the "design", but represent the description of their experiential and emotional aspects towards a design product, with the fact that users do not necessarily know or care about how design decisions were made and how designers were inspired; there is no way for a typical user to access the "insider" information from the design industry. Their language use is more general as opposed to scientific, analytic, and in-depth contemplation using jargon and concepts employed by designers or design critics. People can only read design from all that exists in the product itself, and based on this information, judge and describe what they like or do not prefer about it in their own language.

Composing the description of design products from the user's point of view by studying the behaviour of users in interactive spaces reflects that the "usability" of design is directly and primarily linked to their experience. "Usability" of experiential interactive spaces imposes central criteria on the understandability, interactivity, and preference factors of the design of environmental interactive

interfaces. These descriptions are not new kinds of effects that only appeared under the influence of digital culture, as references can already be borrowed from the knowledge of user interface design and environmental psychology; yet interactivity in environment design has brought in new types of user involvement and communication between systems. Consequently, spaces seem to be evolving into communication interfaces increasingly requiring user engagement, involvement, participation and contribution. Mediated social interactions are also becoming more common in experiential spaces. The design of interactive spaces now finds "usability" vital, but it is not the only factor to contribute to preferred interactive experience.

Descriptions from general use of design products are valuable for evaluation and further revising design, a process that is common in computer interface design workflow (Carroll et al., 1991) In the discipline of designing interactive spaces, with its core substance of human interaction and designing fluidity in space, the idea of looking at design from a user's perspective and concurrently revising design of space seems to be natural and inevitable. The ten criteria for evaluating user experience of interactive spaces, namely familiarity, accessibility, coherence, predictability, responsiveness, diversity, continuity, appeal, arousal and freedom, become a way to inform consideration of the shaping of user's mental model through interface interaction.

From this observation, digital culture has a more direct influence on the creativity of space design – users are passive in seeing the results of the applied ideas of inspiration in digital culture, when designers are leading the development with visions of designing spaces with interactivity. It is impossible, however, to access the designers' intentions and inspirations behind the design of interactive spaces from the observation of behaviours of users in interaction. The next chapter will look at the ideas behind design of interactive environments and find out how designers account for user involvement and interactivity in the thought process of design.

Chapter 6
Findings II: Design Descriptions from the Designer's Perspective

Themes of ideologies, perspectives about interactive environment design

The other side of this research into design of digital culture is the probe of descriptions of interactive space design from the designer's perspective. Designers' descriptions on this topic inform discussion of design thinking, interests, and explorations influenced by digital culture in the design of built environments. The significance of assessing interactive spaces by approaching the designers, in contrast to users, is that one can discover the ideologies and inspirations in the design process from a first person perspective, which would not be possible by only assessing the design product from the users' perspective. The study of designers' ideologies of interactive space can be expected to result in very different areas of interest and topics of description than that of users, with different points of view, access to information and language of description in the design community,

To acquire primary information on design ideologies, research conferences and interviews with designers are both effective channels through which designers can directly explain their ideas and objectives, and convince others by description of their work with their original ideas regarding thought and production processes. This study tries to find the issues and ideologies that designers believe have influenced their creative processes towards interactive space practice, and the perspectives and roles of designers in digital culture.

The study was conducted in three parts. Referring back to the section about "current practice of environment design inspired by digital culture and its associated technologies" in the theoretical framework, there are five common design concepts of environment design being employed by designers. By comparing with these design concepts, an investigation of research projects presented by designers and researchers at a digital architecture conference constituted the primary source of data in design ideologies and processes, and helped to find how designers describe their work in their own language. The topics of ideologies of designers and researchers tell us the most influential fields of design or design related thinking in the current practice in interactive space design. The second and third parts of the research are studies of the designers in the practice of interactive space design. Profiles of selected designers with a timeline of their activities in disciplines related to interactive environment design are covered, including interviews about design ideologies behind their interactive space projects.

6.1 Analysis of topics in digital design from research projects

Research conferences and the accompanying research papers are well-structured sources for getting information on designers' presentations of their design projects along with their ideologies and approaches. By attending a conference in computer-aided architectural design in Europe (eCAADe) in September 2006, presentations and articles prepared by researchers offered valuable data for investigation of the designer's descriptions of digital environment design. From the conference presentations, some common topics of research were recognized from projects with diverse points of departure, not limited to projects of interactive space design. It is, however, necessary to understand the related fields of knowledge, for the research projects were often observed to possess combined design theories and ideologies.

In this report, an observation and analysis of selected eCAADe 2006 papers will be used to identify common topics of ideologies of concern to designers. Before going into detail, the common concepts of environment design in digital culture in the theoretical framework is reviewed for a basic reference to narrow down the selection of papers (fig. 6.1), since the research projects in eCAADe consisted of a wide range of materials, from computer programs, shape grammars to education in design, thought to be of minor relevance to the study of interactive spaces.

The five common concepts were:

- (a) augmentation of physical experience by virtual data, (b) embodiment of virtuality, (c) facilitation of information exchange in physical environment, (d) virtual representation of physical spaces, and (e) computational tools for building production and management. As mentioned before (d) and (e) are omitted from the study of interactive spaces, and out of the five, only (b) embodiment of virtuality and (c) facilitation of information exchange in the physical environment are concerned with taking digital culture as part of design ideologies, and (a) augmentation of physical experience by virtual data is related to the design of augmented experiences. The related subcategories are shown again in the following table:

		Digital culture and technologies	
		As design ideology	As design component
Environment design	Product oriented	- dynamic tectonics (b) - mediated spaces (c) - interactive environments (c)	- indexed environments (a) - augmented environments (a) - virtual places (d) - representational infoarchitecture (d)
	Process oriented	- digital tectonic theories (b) - algorithmic design methods (b)	- digital construction and production technologies (e) - building information modelling (e)

fig. 6.1 Concepts related to research projects of interactive environment design

The product-oriented concepts of environment design combined with digital culture as ideologies are the major parts of research for the study of users' descriptions. Though interactive spaces remain the main focus of the research, the other concepts are commonly-found relevant topics of description to aid discussion, supported by the observation that many projects and designers of interactive spaces overlap two or more of these concepts. "Interactive environments" here means the involvement of human in spatial interaction and the possession of responsive properties upon human actions in the digitally mediated environmental design product, so actually it is not uncommon for designers to combine ideas in design process and practice to generate interactive spaces in the design execution.

The definition of major categories of designer descriptions was achieved by selecting relevant research projects concerned with mainly interactive environments, but not excluding others of the above subcategories of ideologies, with the help of previous observation and literature studies, 16

research projects relevant to the above design ideologies were chosen as examples. A study of these research papers, and an analysis of their keywords, will be used to categorize the issues addressed in the design and research community.

6.1.1 Themes of design context, design theory and design practice in interactive environment design

A list of the titles of the 16 selected research projects of the eCAADe 2006 conference is shown below (fig. 6.2). For every one of them, the keywords of the abstract found in the research papers are included. A general description of the design context, design theory and design practice was noted after the analysis of the main ideas of the abstract and content of the research article. Each project may contain mixed design context, theory or practice, but for this discussion, only the prominent one was picked for analysis. Keywords are categorized by analysis of:

- **design context**: the major background interest of investigation for the research project;

- **design theory**: the theory or approach of digital design or exploration of spaces;

- **design practice**: the execution of ideas as design products, or the method taken to achieve the goal of research.

Sometimes the keywords used by the researchers and designers may not truly reflect the ideas explained in their research papers. This is usually found in the use of general, broadly defined terms or jargon such as "interactive", "mediated space" or "interface". The differentiation of design context, theory and practice nevertheless helped explain the actual meaning of the keyword used by the researchers in their projects. For example, the term "interactive architecture" in this research means the practice of digitally mediated space design that allows user communication via an architectural interaction interface; referring to the eCAADe 2006 conference papers (Bourdakis and Charitos et al., 2006), similar definition of "interactive space" is used in the project "Deep Space" (p.428); the term may actually mean "responsive embedded system" in design context (p.176), "architectural visual displays" in design practice (p.610), or "real time evolution design process" in design theory (p.560). This reveals that it is not the best way to assess a research project by simply looking at the keywords

Page no.	Project title	Keywords as in abstract	Description of context / theory / practice of project
32	Ethics of virtuality… virtuality of ethics	Virtual environments, ethics, place, trust	Psychology in virtual representation of physical space in scenario design (2-2-2)
114	3D motion tracking in architecture, turning movement into form – emerging uses of a new technology	Motion tracking, animation, design process, augmented reality, digital fabrication	Exploration of design using motion in space for achieving dynamic forms (1-1-1)
122	Abstractions as a means of interacting with the environment	Abstractions, diagrams, design processes, interaction	Selection of dynamic information as material of design using generative parameters (3-1-1)
176	Teaching pervasive computing for architects, a simple but powerful building simulator explaining the potential and power of pervasive computing through hands-on exercises	Pervasive computing, ubicomp, interactive architecture, education	Embedded computing in responsive environment for new experiences (3-3-2)
298	Form follows function: activities defined function, gesticulates space	Emergence, self organizing maps, activities, space	Automation of adaptive spatial form responding to user activities using generative parameters (1-3-1)
392	Screen space: navigation and interactivity	Multimedia, interface design, interactivity, navigation	Spatial cognition and interaction influenced by media in architecture by interface design (2-2-3)
420	Spatial diagnosis as a means to design mediated spaces	Spatial diagnosis, mental imagery, digital media, mediated spaces, user-space communication	Cognition and psychology in mediated spaces relating to human computer interface design (2-3-3)
428	Deep Space	Interactive spaces, collaborative virtual environments, twinned spaces, mixed realities, mediated social interaction	Spatial social interactions in mediated spaces by communication interface design (2-3-3)
454	Space time pixels	Awareness, ambient media, body interfaces, social interaction	Social interaction in connected spaces by communication interface design (2-3-3)
552	"High code" architecture, a diagram of de-materialization and reinstallation of architecture	Architecture, representation, image, iconic	Design process through virtual representation of space by data manipulation (1-2-3)
560	3D real-time design environments for interactive morphogenesis of architectural space	Interactive architecture, 3D real-time design environments, space folding, user driven spaces, virtual collaborative design	Psychology and cognition of real time design process by user interaction through behaviour rules (2-1-1)
610	My building is my display, omnipresent graphical output as hybrid communications	Pervasive computing, immersive video, interactive architecture, human computer interface	Technologies used for fluid information design applied in architectural display (1-1-1)
626	Intelligence technologies as a means of enhancing spatial experience	Ambient intelligence, environmental design, activity theory, adaptation	Embedded intelligence and pervasive technologies in space emergence for enhanced spatial experience (3-1-2)
636	Mediated space and kinetic architecture, the synergy of co-development	Mediated space, synergy, kinetic structures, controlling, algorithms	Automation of fluid architecture as mediated and kinetic spaces using algorithm design (1-1-1)
640	(Inter)facing the wall – integration of digital and building technology	"smart" wall, real-time, interaction, information visualization	Social interactions in responsive system by communication interface design (2-3-3)
724	Perception and cognition in real and virtual computer generated architectural space, an experimental approach	Perception, cognition, virtual architectural space, real-time navigation	Cognition of representation space in planned scenarios (2-2-2)

Design context Design theory Design practice

fig. 6.2 Sixteen projects from eCAADe conference 2006 observed about design in digital culture – analysis of combination of design context, theory and practice

used by the researchers; but if a keyword is comprehended with its meaning in design context, theory or practice, ambiguity can be minimized. This phenomenon, nonetheless, revealed the trend in the use of language and vocabulary by practitioners in describing environmental design projects with post-digital influences.

Despite the multiple meanings of terms used by designers, similar keywords, or their underlying concepts, were organized into the same categories of design contexts. Starting from the three design contexts, related design theories and practices were derived, and keyword adjustments were made when necessary to represent more precise meanings (fig. 6.3). The major design contexts are:

1. Digital architecture design and technology

This area relates to the design of architecture with the help of computation tools, digital theories of fluidity and dynamic elements in architecture and using the computer to develop building forms with digital tools or by emergence and algorithms. The main goal of exploration in this area has a strong tendency to the design of tangible physical structures. It can be easily observed that this area of context has a higher orientation to the design process.

2. Environmental psychology and human behaviour

The human-centred context of psychology and behaviour usually investigates perception, cognition and usage of mediated, hybrid or augmented environments. They concern the new experiences and behaviours of users in such spaces influenced by environmental and psychological effects. Designs within this area of ideologies are often product-oriented, that practice includes scenario planning and experience design.

3. Computer and informatics

This category is about the organization and manipulation of information structures and embedded technologies in architecture. Highly related to engineering disciplines, the focus is on designing spaces that are adaptive and connected by ubiquitous computing technologies, including communication networks and interface design for interaction between systems.

By understanding the keywords with their positions in design context, theory and practice, ideas

				Design Theory	Design Practice
Design Context	1. Digital architecture design and technology	- design process - digital technologies - automated design - motion, animation - digital fabrication	>	- fluid architecture - emergence of space - real time process	- information embodiments - behaviour rules, algorithms - dynamic forms - generative parameters - kinetic structures
	2. Environmental psychology and human behaviour	- psychology - perception - cognition - mental imagery - social interaction	>	- augmented reality - virtual representation - mediated spaces - adaptive spaces	- spatial experiences - scenarios
	3. Computer and informatics	- pervasive technologies - embedded intelligence - information selection	>	- ubiquitous computing - responsive systems - connected spaces - user driven spaces	- data manipulation - communication interface design - interactive environment - navigation

fig. 6.3 Keywords organized in categories

explained by designers are categorized under major topics of ideologies in designer description. The further categorization of topics under theory and practice are supported by findings in the theoretical framework. For example, the design practices reflect the three types of environment design products having digital culture as ideologies, namely dynamic tectonics, mediated spaces and interactive environments. Digital architecture, hybrid environments and ubiquitous computing were adapted from the other concepts in digital environment design. The categories now compose a grid of ideologies starting from the three major contexts, then their closely related design theories and practices. The grid will be used as a tool to analyze design and research projects, to see their connections between design context, theory and practice. It also narrows down the scope of designer's discussion topics, which will aid in the analysis of designer interviews in a later section.

The final grid of ideologies of environment design in digital culture contains the major themes as follows (fig. 6.4):

Design Context		Design Theory		Design Practice
1. Design and technology	>	1. Digital architecture	>	1. Dynamic tectonics
2. Psychology and behaviour	>	2. Hybrid spaces	>	2. Mediated experiences
3. Computer and informatics	>	3. Ubiquitous computing	>	3. Interaction information structure

fig. 6.4 Major themes of ideologies of environment design in digital culture

The numbers shown after the description of design context, theory and practice of each of the selected research papers refer to these themes respectively. The numbers also illustrate the overall design approach, starting from the context, to the application of theory and actual execution of design practice. More subtopics under each theme were defined based on an analysis of the preliminary research, theoretical framework and the study of research papers in the digital architecture conference. They show the common ideologies, issues of interest and design thinking of designers in the design and exploration processes.

Design Context		Design Theory		Design Practice
Design and technology - design research and technological development - digital design: automation, optimization, randomness - computer aided design process and decision making	>	Digital architecture - motion, movement, fluidity and forces in architecture - digital information as design material - temporality and emergence of space	>	Dynamic tectonics - form finding: auto-tectonics, dynamic forms - evolution rules: generative, parametric, and behaviour design - kinetic elements and embodiment of virtual spaces
Psychology and behaviour - spatial psychology: perception, cognition, memory, meanings - social interactions and communication - user behaviour and behavioural patterns	>	Hybrid environments - virtual representation of physical space - information supported environment: characteristics and potentials - user defined spatial program and function	>	Mediated experiences - adaptive spaces and systems - scenario planning and events in design - user experience design
Computer and informatics - communications: ICT, computer interaction - information: analysis, selection, interpretation - simulation: artificial intelligence and performance - pervasive technologies	>	Ubiquitous computing - responsive architectural systems - environmental nervous system - connected physical spaces	>	Interactive information structure - communication interface design - information mapping and interpretation - information organization design: narration, navigation and relationship

fig. 6.4 Subtopics of ideologies around environment design in digital culture

6.1.2 Application of the grid of design ideologies

The research papers from the eCAADe 2006 conference are mapped onto the grid of ideologies, which shows the tendencies of environment design in digital culture with their design approach or employment of design context, theory and practice (fig. 6.5).

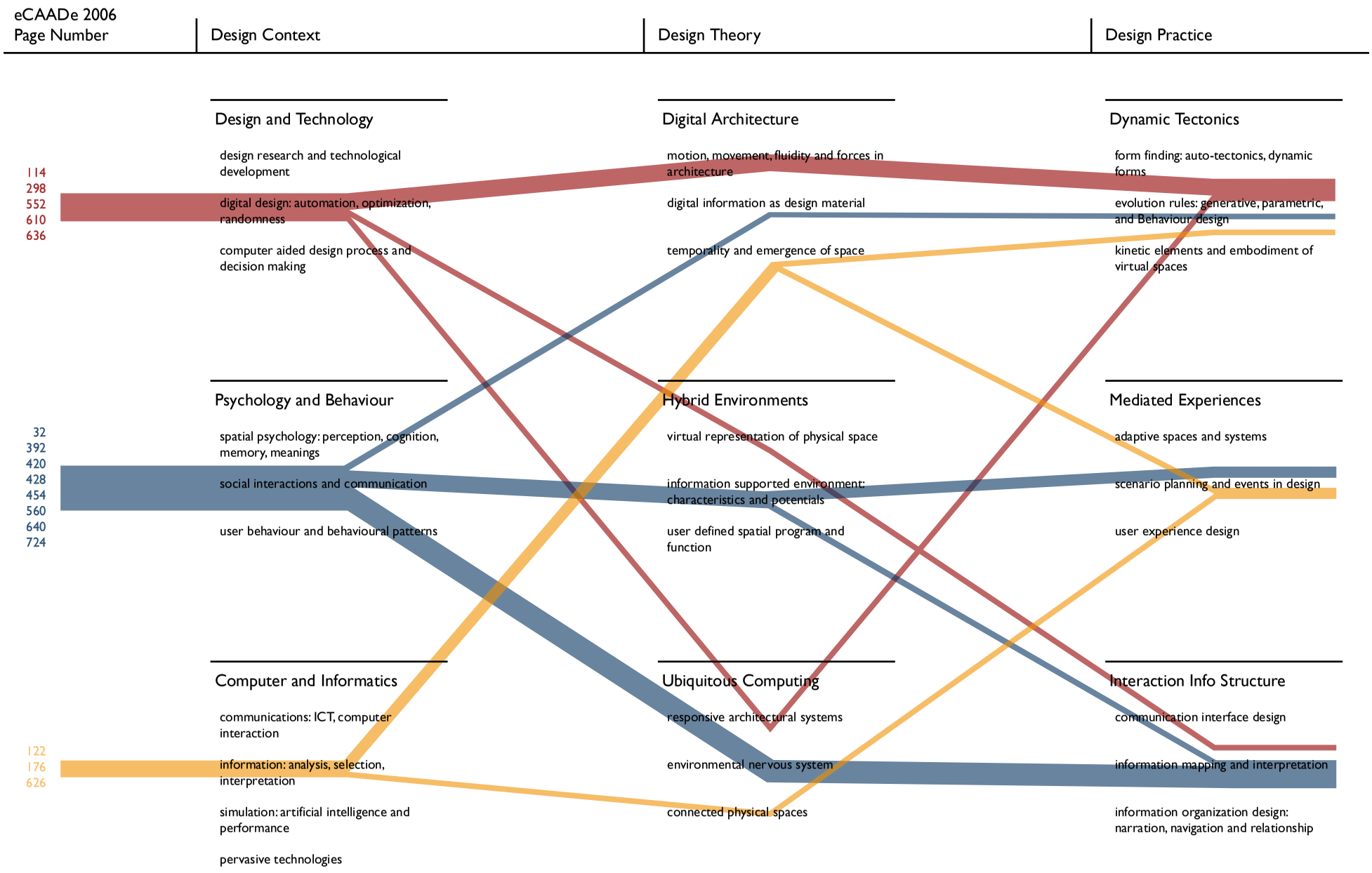


fig. 6.5 Categories of design ideologies and tendency map of research projects in eCAADe conference 2006

The tendency map shows that in the selected research projects, many of them do not follow a straight line of design approach that sticks to the same set of ideologies throughout the design context, theory and practice. It is, in contrast, common to see that designers tend to explore different areas of ideologies in a project, which is not readily legible by only evaluating the design product. As a result, this map is a simple representation for describing relevant issues, inspirations and approaches of digital environment designers, which is closer to the designer's point of view and use of language.

Noticed are also main trends of approach in projects with design context in psychology and behaviour. The projects are concerned with human psychology, interactive experience and interface design, which have much resemblance to the interactive space projects in previous observation studies. Further details will be discussed at the end of this chapter.

6.2 Designer profiles and timeline of fields of activities

From the project matrix in the theoretical framework, some designers have been identified along with their interactive space projects. The investigation of the profiles of designers or practitioners in interactive space design aims at finding out the background information, inspirations and design thinking of their works to complement the study of the projects themselves. By first understanding the background of the designers, the possible influential themes of ideologies or the predispositions of mind sets allow analysis of their creative process. The study of designer backgrounds, and fields of activities further informed the designer interviews carried out at a later time.

The profiles of the seven selected interactive space designers (or architects, or artists) were found on their websites or homepages. Below are descriptions quoted from the original sources, such as their own biographies or CV's, with minor editing for consistency, along with short descriptions of their projects which represent one of their contributory works to the matrix of interactive space projects. Alongside the profiles and short descriptions, their other works related to interactive environment design were also taken as reference in addition to their activities in academic, artistic and design domains; a timeline of activities resulted, showing the orientation of projects, writings, conferences and fields of practice of their activities.

The selected designers have good publicity in the community of interactive space design. Selection was based on their diversity to take up different design ideologies suggested by their interactive space projects for a comprehensive view on the topic, and the possibility to carry out further interviews. The designers also compose a range of periods in interactive space design, possibly with different influences based on time of technological and cultural context; this is to avoid a biased description of design ideologies from designers of similar backgrounds. The diversity was later confirmed in the timeline analysis.

6.2.1 Designer profiles

(As of March 2007)

Michael Fox	Architect, architecture teacher www.foxlin.com
	Michael Fox is a founder and principal of Fox Lin Inc. In 1998, Fox founded the Kinetic Design Group at MIT as a sponsored research group to investigate interactive architecture. Fox directed the group for three years. In 2001, Fox founded Odesco (Ocean Design Collaborative) in Venice California from which the office of Fox Lin has evolved. Prior to founding Odesco, he served as an assistant to engineer and inventor Chuck Hoberman in New York, and as a design team leader for Kitamura Associates in Tokyo, Japan. His practice, teaching and research are centered on interactive architecture. Michael has lectured internationally on the subject matter of interactive, behavioral and kinetic architecture. He has won numerous awards in architectural ideas competitions and his masters' thesis at MIT received the outstanding thesis award for his work on computation and design processes. Fox's work has been featured in numerous international periodicals and books, and has been exhibited worldwide. He has taught on the subject matter of interactive, behavioral and kinetic architecture at MIT, The Hong Polytechnic University, the Art Center College of Design in Pasadena and Southern California Institute of Architecture (SCI_ARC) in Los Angeles. He is currently assistant Professor of Architecture at Cal Poly Pomona. **A-2 The Bubbles** – an adaptive space installation with bubble like volumes that inflate and deflate by detection of user motions and activities.

Ruairi Glynn	Architecture and media arts student www.interactivearchitecture.org
	Ruairi Glynn graduated from MediaLab Arts, University of Plymouth in 2005, and from St Martins College of Art in 2001. He is now a student of Diploma in Architecture, Bartlett School of Architecture, University College London. He currently works part time for dRMM Architects and freelancing as an Interactive Media Designer as well as exhibiting his own projects in Bristol and London. He also runs www.interactivearchitecture.org, which is an online regularly updated resource on interactive art, architecture, interaction design tutorials, interesting new materials and technologies. His interests in multimedia design and interactive architecture have led to several awards. His recent work has included the role of Project Manager of 'RIP MIX BURN', a two day conference exploring digital technology's redefinition of the culture industry. He also acts as a visiting tutor on Interactive Architecture to the University of Plymouth. **A-1 Reciprocal Space** – responsive surfaces that reconfigure themselves in response to the presence and motion of the people.

Stefano Mirti

Architect, interaction designer, interaction design teacher
www.interactiondesign-lab.com

Stefano Mirti is an architect who has worked in Italy, Tokyo, Seoul, Bangkok and the Mekong Delta. From 1998 to 2001, he worked as a Post-Doctorate Researcher at Tokyo University and lectured at Tama Art University (Tokyo). He there designed such unique projects as the polycarbonate house and the neon gardens, and initiated Now the Future, a project for a digital image atlas of the world. While in Italy, he was one of the founders of Cliostraat, a design group of architects, artists, and photographers, that designed houses, parks, public facilities (including the library and the "Owl" building in Quarrata, Italy), sports facilities (San Giovanni, Italy), and temporary exhibition pavilions. He was three times awarded the prestigious Europan architectural prize (1995, 1997 and 2001). He studied architecture at Torino Polytechnic (Italy) and obtained his Doctoral Degree with a PhD thesis ("Kiss The Future") on the architects Charles Eames and Franco Albini. Stefano Mirti also taught at his former Department of Architecture in Turin.

From 2001 to 2005 he is an associate professor at Interaction Design Institute Ivrea, where he is also in charge of e1 (exhibition unit). From January 2006 he is in charge of the design school at NABA. Stefano Mirti is now a partner of Id-lab (Interaction Design Lab) where he carries out numerous activities.

B-1 Tune Me – an installation for new experiences of radio listening by creating an immersive environment with coloured lighting and vibration, changing according to different moods and touch interfaces.

Christian Moeller

Architect, artist, media art teacher
www.christian-moeller.com

Christian Moeller is a pioneer in the design of interactive architectural installations. He studied architecture at the College of Applied Sciences in Frankfurt and was a Scholarship holder under Gustav Peichel at the Academy of Fine Arts in Vienna. In 1990 he founded his own studio and media laboratory in Frankfurt. He headed the ARCHIMEDIA research institute at the College of Design in Linz, Austria and was Professor at the College of Design in Karlsruhe, Germany before he moved to Los Angeles in 2001. He is now a Professor in the Department of Design and Media Arts at UCLA.

He is an artist working with contemporary media technologies to produce innovative and intense physical events, realized from handheld object to architectural scale installations. Over the past two decades, his body of work represents one of the original and most complex investigations of what is possible to be revealed by the intersections of cinema, computation, music and physical space. Bridging art and architecture, his work is informed by emergent digital media and how these media have transformed the landscapes of experience across multiple scales. By harnessing sound, light, weather conditions, motions, and human emotions, Moeller creates spaces that are responsive and manipulable.

A-2 Audio Grove – a sound and light installation in which touch sensitive posts create lighting and shadow patterns and sounds in accordance to different ways of touching by visitors.

Daan Roosegaarde

Artist
www.studioroosegaarde.net

Daan Roosegaarde is a young sculptor/architect working in Rotterdam, the Netherlands. He studied at the Academy of Fine Arts AKI in Enschede and the Berlage Institute, a Postgraduate Laboratory of Architecture in Rotterdam. His work explores the dynamic relation between architecture, people and new media. His sculptures are a collision of technology and the human body. In this interaction the sculptures create a situation where visitor and (public) space become one.

Roosegaarde's projects have been shown at international exhibitions at V2, Netherlands Media Art Institute & 5th Triennale in Slovenia and published in Items, NRC Handelsblad and IdN. In 2006 he launched Studio Roosegaarde in which series of interactive artworks are created. He also lectured about art and architecture in the Netherlands.

A-1 Wind 3.0 – a structure built out of a number of ventilators and fibres in the result of an interactive surface which reacts to sounds user motions.

Yasuhiro Santo	Architect, interaction design teacher yasu.santo.com
	Yasuhiro Santo graduated from the Architectural Association School of Architecture in 1995 and re-joined the school as a full-time electronic media tutor and the Electronic Media Lab supervisor in the same year until he moved to Hong Kong in 2000. He was an academic staff at School of Design, HK polytechnic University where he taught and researched in the area of interactive systems, environmental and interactive media design. His interest is in looking at combinations of digital, kinetic and networked systems in relation to architectural spaces. He had exhibited a range of installations based on networked HCI interfaces in the past. He is currently investigating methods and strategies for tangible and network enhanced collaborative environment and particularly interested in utilizing ambient information. **B-3 Deep Space** – the installation of custom made display and motion detection units augments user contributed visual elements reacting to the activities in the physical environment.

Andrew Shoben	Artist www.greyworld.org
	Andrew Shoben is a former lecturer at the royal college of art, and is a visiting professor to several universities in the UK and the USA, and is a research fellow at Goldsmiths University. He founded Greyworld in Paris in 1993 with the goal to create works that articulate public spaces, allowing some form of self-expression in areas of the city that people see every day but normally exclude and ignore. Its aim is to establish special intimacies through the unexpected articulation of objects installed in these spaces – to 'short circuit' both the environmental and social expectations supplied by the surrounding urban environment. Spaces are created that offer the passer by an opportunity to join an unexpected 'community of presence', initiating an intimate communication which often leads to a personalization of the environment. Greyworld have exhibited their work internationally, with permanent installations in twelve countries. Their latest installation, 'the source', opens the London stock exchange every morning. **B-2 The Layer** – an installation in which passers-by of a carpeted footbridge generate sounds and melodies by walking on the sensor-embedded carpet.

6.2.2 Activities of practitioners in interactive space design

The above profiles explain that practitioners of interactive space design often come with training in architecture, environment design, art, media art, computing or engineering studies. In the early stage of research it was observed that interactive space design is a discipline having a combination of architecture, art, design and interactivity descriptions. The backgrounds of designer training imply to some extent the themes of ideologies influential to their works; and their reference to themselves as artist, architect, or interaction designer gives a hint on their preferred position and approach to work in interactive space design. Their work paths are presented in the following timeline (fig. 6.6), to further confirm their preference for domains of activities, and reveals how they present ideas and projects in three major contexts – art, architecture and environment design, and interactive and digital design.

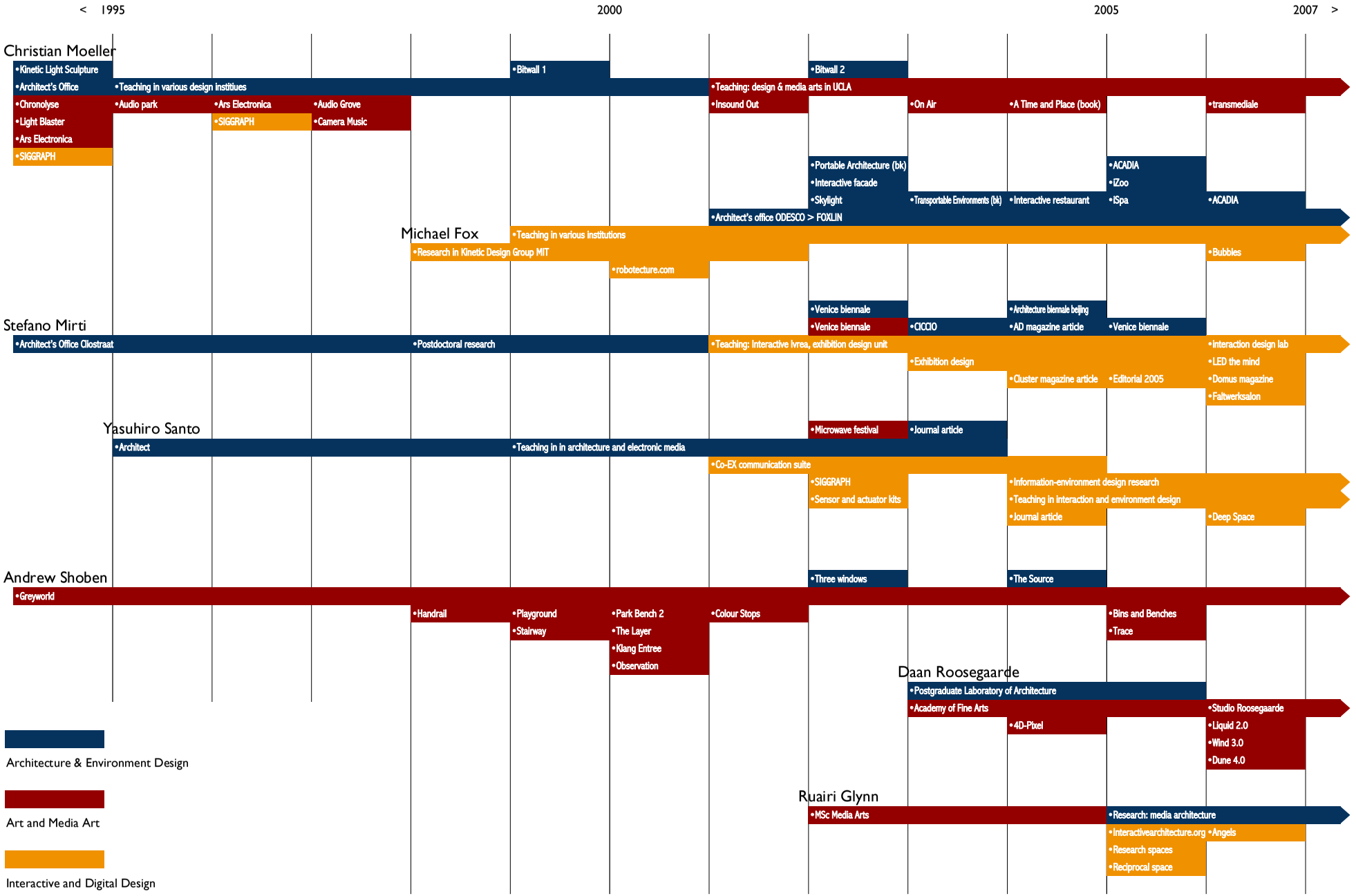


fig. 6.6 Timeline of designers' fields of activities related to digital environment design

Activities of designers were labelled with their appearance in these different fields. The timeline reveals that their self reference is in close connection with their major fields of activities, represented by dominant colours, long spanning and continual lines. For example, Mirti and Santo both started in architectural practice but are now teaching in interactive design disciplines, where Shoben and Roosegaarde have always been publishing their work in art-oriented contexts. Fox and Glynn are more interested in the architectural qualities of interactive spaces. Moeller has shifted from his interest in architectural spaces to art-based projects in his career.

The complication of the interactive space discipline could be accounted for by the widespread influence of digital culture on ideologies of architecture, art, design and interactive media. In this mixed creative environment, practitioners are naturally free to choose from a pool of ideas to experiment and produce works in mixed media, ideas and approaches. Style of work is another factor determining their roles and positions in the discipline: artists can generally be said to be more experimental in nature, where architects and designers may look at the application possibility in practice, or interaction designers might put emphasis on human interactivity through design. In general, the positioning and orientation of a designer could be affected by:

- background training
- personal interests, preferences and values
- influential ideologies and approaches
- style of work
- field of publication
- institutional context for the designer's activities

Therefore the roles of practitioners may be more diverse than designers, media artists, interaction designers, or interface engineers, depending on the positions they would like to take in this discipline, despite the relevance of work to interactive space projects. Practitioners from different positions may prefer different styles and themes of descriptions for interactive spaces. On the other hand, this mixed discipline implies the requirement of a wide range of knowledge that challenges traditional design thinking and practice in the design community.

6.3 Designer interviews

The objective of the designer interviews was to find out the designers' descriptions of ideologies underlying the production of interactive spaces, and their attitudes towards the discipline of interactive space design. The interviews were conducted in a semi-structured format, with interview questions set out in advance to direct data collection by phone or email, while allowing designers to talk about their own ideas without predefined concepts. Interviews were granted by the seven designers in the design profile study, and five of them have responded to the interview questions. The designers interviewed are:

Yasuhiro Santo – has interest in developing systems for co-existent environments;

Stefano Mirti – works under constraints and goals defined by client and project briefs;

Ruairi Glynn – looks at ways to bring new media into architecture to see interesting results;

Andrew Shoben – thinks art should incorporate public participation and creative experience in the city;

Daan Roosegaarde – produces dynamic sculptures which are finished by visitor interactions.

To approach designers' ideologies, the areas of enquiry were condensed into five major questions for the selected interactive space designers. They were asked about their core values and approaches in interactive space design practice. With the help of the description of one of their realized design projects, the questions are aimed at finding out the following factors in design thinking:

1. **Approach** – the reason behind the work, their core values or main interests, and the driving force to design interactive spaces;

2. **Inspirations and intentions** –what they want to achieve or demonstrate through the projects;

3. **Strategies** – their concept of important topics and attitudes towards interactive space design;

4. **Role within greater cultural context** – implications of the projects on environment design, its influence on creativity, and challenges or opportunities in digital culture;

5. **Ideals and visions** – ideals and visions on future interactive space design.

The answers were the results of designers' personal descriptions of their ideologies in producing interactive environments, and were analyzed by comparison to sort out similarities or differences in their descriptions. The five questions are shown below (fig. 6.7).

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1. Why have you chosen to work in the field of interactive spaces? How would you describe your approach to the design of interactive environments?

2. Please comment on the inspirations and intentions of this project (specified in each interview). What did you want to achieve or demonstrate with this project?

3. How did you achieve these intentions in the project? What are the strategies of choosing specific types of interaction?

4. What do you see as the implications of this project within the greater design field? What can be learned from it by designers or architects? How can these ideas be taken further?

5. If there is no limitation on budgets and workforce, what would be your ideal project to work on? Can you describe it and explain why?

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fig. 6.7 Five questions for designer interview

6.3.1 Analysis of the interview answers

The answers from the interviews were arranged in tables for comparison. The transcripts of the interviews can be found in Appendix B, but for now the analysis will compare the answers by the key ideas for each question. Analysis will be made for each question, to look at the keywords, agreements or contrasts of description. In cases where ideas were not expressed after the immediate question, the answers may be rearranged to fit in the analytical topics. Also, some of the answers shown here may

not be exact quotations made from the original transcript but organized and interpreted from a general understanding of designers' statements.

1. Approach

- Why have you chosen to work in the field of interactive spaces? How would you describe your approach to the design of interactive environments?

	Yasuhiro Santo	Stefano Mirti	Ruairi Glynn	Andrew Shoben	Daan Roosegaarde
Reason of work	Education background > architecture and computer analysis, use of computer and internet in architecture	By chance > architecture education and practice, teaching experience in information design	Education background > architecture and media art, explore different creative media	Composer of music for contemporary dance > artistic exploration of creating art that encourages people to play with their environment	Trained as a sculptor, also studied architecture> wants to produce dynamic, unfinished sculptures to reflect production process
Core values / main interests	- connected physical spaces by network - change the perception of connected spaces as one entity	- to cross traditional architecture with digital tools and media - interaction design and (though not necessary) new technology	- use materials that reflect the world around us - application of digital interfaces to physical space	- to transform viewers into catalysts for unique creative experience - challenge public's spatial perception	- the fluidity of work comes from the new user input
Driving force	- development of a series of linked open interfaces to connect spaces	- a good client	- prototype possible interactions of built installation - achieve a compromise between ideas and realities of material and technology available	- articulate the expectation of social and environment of transit spaces through interaction	- explore the dynamic relation between architecture, people and new media

When talking about design approaches, all designers seemed to be influenced by digital technologies and were interested in exploration of new relationship of space (or architecture), people, and new media (or technologies as new material) for design. Computers, the Internet, information, multimedia and dynamic media are examples of technological influences on design ideologies and processes of designing architecture or space.

The statements regarding application of materials and media of our times, the changes and challenges of perception and experience, and engagement of people in the designed environment may indicate some major ideologies of digital culture in interactive spaces.

"Exploration" appears to be a common approach to design, revealing the common approach in interactive space design that designers generally do not refer to the design process as a closed production stage. But from the core values, interests and driving forces of the designers, it seems Santo, Shoben and Roosegaarde have defined approaches to continue achieving their main interests through a series of projects; in contrast, Glynn and Mirti are more adaptive in design, and are open to different possibilities in design. The difference is also noticed in the profile of projects on their websites.

2. Inspirations and intentions

- Please comment on the inspirations and intentions of this project. What did you want to achieve or demonstrate with this project?

	Yasuhiro Santo (refer to "Deep space")	Stefano Mirti (refer to "Tune me")	Ruairi Glynn (refer to "Reciprocal space")	Andrew Shoben (refer to "The layers")	Daan Roosegaarde (refer to "Wind 3.0")
Inspirations	Coexistence and communication of users in different spaces and the perception of sense of coexistence	Varied inspiration, also respond to the requirements from the client > test own ability, limits and possibilities	Inspired by something (reading, other designers) and develop own work, user communication with environment (history of gestures) to generate new possibilities, goals and shared outcomes	Inspired by the city and public art > challenge the static imposition of public art into people's environment	The work becomes an extension of our skin by reacting to human behaviour (relate human activities to the changing appearance of sculpture)
Intentions	To explore and experiment ways of connecting spaces and find out possibilities of communication of users	To respond to the task and do the best within ability > the project brief of the client	To examine how we see architecture as servant to our needs and become a mutual player to us in built environment by creating dance like performance	To encourage people to navigate through the city by sound > creating sensory environment using sound as an evocative medium	To produce a human-machine interface which reacts to the sounds and motion of the visitors
What to achieve / demonstrate	A natural experience of shared / public spaces	Nothing specific, but to experiment and push forward to extreme possibilities	An understanding of the principles of physical computing and practicalities	Create art that responds to and reflects diversity of life of users living in or passing through a particular space	Define an architecture which is not a sum of doors, walls and windows but exists out of hundreds of fibres which move along with you

The inspirations of designing the specific projects inform the descriptions of the projects from the creators' points of view. Santo, Shoben and Roosegaarde were inspired by people and environment: the psychological aspects, behaviour, activities and human space relationships. They appear to consider interactive space as a human-centred design practice. Mirti and Glynn on the other hand do not have specific sets of inspirations to guide design directions, and are willing to test out possibilities.

The design intentions of Santo and Mirti are more solid and goal driven. Santo's intention to find out ways to connect spaces, and Mirti's intention to respond to the project requirements suggest the need to work with a clearly defined goal or a defined scope. Glynn, Shoben and Roosegaarde believe in the exploration of conceptual themes by project production: "to examine architecture as servant to our needs", "to encourage people to navigate the city", and "to define an architecture which is not a sum of doors, walls and windows" are comparatively vague concepts in design, implying a great range of possible goals and solutions.

Roosegaarde, Shoben and Santo aim at the demonstration of concepts by creation of design products as pieces of evidence; Mirti and Glynn emphasize the testing and learning process through hands-on exercises of design production. This may be related to the nature of the "jobs" of the designers: Shoben and Roosegaarde consider the projects as art pieces; Santo takes his work as a part of the development of co-existence systems; Mirti believes projects are solutions to problems given by clients; and Glynn sees his works as research projects for his exploration to employ new media in architecture design.

3. Strategies

- How did you achieve these intentions in the project? What are the strategies of choosing specific types of interaction?

	Yasuhiro Santo	Stefano Mirti	Ruairi Glynn	Andrew Shoben	Daan Roosegaarde
Important areas of interactive design	- architectural tangible interface - user defined program, temporality in architecture	- interactions are effects under a set of given constraints to define design strategy	- architecture becomes more fluid and responsive	- legibility of the public - translation of movement into sound, among other environmental input and output, e.g., colour and shape / light and generative display	- the user builds up a story, like the idea of a conversation, by interacting with the work
Attitude towards interactive space design	- non-intrusive, passive interaction - transparent "virtual space" - test, observe results and try out next - new ways of utilizing existing technology to achieve interesting results - new scenarios and unexpected results by combination of interactive means	- understand the need of new media and interactive tools, and their appropriateness of application of technology - new and traditional media not clearly split, interactivity is implied in design in this era	- mutually develop final behaviours with the environment system - have preconceived ideas of how interactions play out, but most interesting ideas result from interaction exchange with the installation	- experimentation through different ways of input / output - ideas come first, find technology to realize it	- always tries to work with different types of interaction since human behaviour is highly varied

Varied description focus and language are observed in the answers about important areas of interactive design. This appears to be due to the diversity of perspective or belief that designers hold when designing products of different nature and format.

One common attitude towards interactive space design is that, from the answers of Santo, Glynn and Roosegaarde, they like to see interesting or even unexpected results from "mutual development" of people and interactive spaces. It means that by combining of different interactive strategies, new scenarios or unforeseen results and behaviours of systems are often explored by interactive space designers, or they look for unplanned and adaptive qualities in space that usually require human interaction to complete the design. Glynn, Shoben and Roosegaarde's strategies are also idea-driven and more experimental in choosing technologies and types of interaction; Santo and Mirti look for understanding of and ways to apply new media and technologies.

Santo talked about the test, observe and revise cycle of design.

4. Role within greater cultural context

- What do you see as the implications of this project within the greater design field? What can be learned from it by designers or architects? How can these ideas be taken further?

	Yasuhiro Santo	Stefano Mirti	Ruairi Glynn	Andrew Shoben	Daan Roosegaarde
Influence on creativity	- suggest possibilities that others can take up and apply to functionality - sharing with open source: building systems so that environments get hooked up by other designers using same protocol	- design thinking in the long term - work to be bridged further by others when found appropriate - to work in horizontal system, great deal of communication needed to come to shared goals	- the use of bottom up design - collaborative design	- democratize creative experience	- design is not based on a single idea of an designer but generated via input from its visitors - the hierarchical model of work is dissolved by communication with software engineers, material producers, and inhabitants

continued on next page >

Implications on environment design	- experiment of new possibilities of application of interaction systems in different contexts and scales - adaptive space by spatial evolution according to user behaviour	- (user experience becoming more important though not the case of his work) - interactive design not different from traditional design > strong knowledge of traditional architecture design still needed before adding new things to it	- architecture could reconstruct itself to infinite differing conditions with flexible construct such as transformable surfaces - environment is becoming more aware of our physical and emotional needs	- art can be embedded into fabric of buildings rather than sitting alongside as an static object - (interactive) art now is not allocated a specific location within a building nor limited to visual experience only - art as integral part of how people understand and experience their surroundings	- The more intelligent the system is behind the more the work will be capable of handling several inputs at the same time and therefore become more sensual, more adaptive and more dangerous.
Challenges / opportunities	- adaptive interactive systems that can be put on any site - communication through interface between machine and human - real time generative / evolutionary reconfiguration of space	- design with technological changes nowadays - try to bring experiments to work in everyday world	- environment could spatially transform, optimize efficiency in response to human needs	- alternative understanding of role of art – to roam free environmental art, art without altering the look of environment	- keep exploring the wide world of technologies

About the influence on creativity and implications on environment design, there seems to be an agreement of breaking down the hierarchical structure of architectural or design workflow by sharing, open source, collaborative or a cross-disciplinary work process. Santo, Glynn and Roosegaarde believe environments will become more adaptive; also of concern to the designers are the sensual, emotional and experiential factors in environment design with the integration of digital media and technologies.

The opportunities viewed by the designers confirmed the themes of ideologies found in the research study, like adaptive systems, communication interfaces, generative design, responsiveness and transformation according to user needs. Mirti and Roosegaarde expect an ongoing exploration of new technologies in design in the hope of bringing experiments to everyday application.

5. Ideals and visions

- If there is no limitation on budgets and workforce, what would be your ideal project to work on? Can you describe it and explain why?

	Yasuhiro Santo	Stefano Mirti	Ruairi Glynn	Andrew Shoben	Daan Roosegaarde
Ideals	"I would like to build a building, right in the middle of a public space where a lot of people pass by and use it, it can be like a public park where people lay around and sit down, in different parts of the world, to try my ideas out in an architecture space. It's like an art project."	"I don't know... it would be lovely to have a commission from some kind of religious entity. To design a temple or a church or a cemetery using new technology, modifying the actual interaction. This would be nice."			"It would be great to do something with a music/ cinema center somewhere in L.A. or Mumbai where people are accustomed to dynamics."
Visions			"I have no idea, but I'd like to work with more engineers and dancers. I enjoy their fascination with precision and creativity. I think they are both important contributors to the future of interactive architecture."		"I have stopped believing in making objects and started to believe in landscapes. Creating landscapes is something amazing since you can really surrender to it since it is so much larger than yourself."

When asked about ideals of interactive space in their own opinion, two designers mentioned that they have no ideas. Shoben did not answer this question. This is probably due to the speculative nature of the question and they find the question not appropriately set. Nevertheless, Santo and Roosegaarde mentioned they would continue what they are doing now, but probably in an upgraded version that extends them to their full potential.

6.3.2 Summary of interviews

As a general summary, some agreements or contrasts from the answers of the designers have provided supportive statements on themes of ideologies, approaches, inspirations and strategies of work which could not be collected by other means of investigation. The interviews also provided some

insights of the design process and changes in creativity in digital culture from designer's own experience and description of their practice of interactive space design.

6.4 Types of designers: designers' attitudes, reactions towards interactive space design

From the interview analysis, the designers can be organized into four types by their design approach and design nature (fig. 6.8):

- **Design approach**: adaptive or defined approaches and inspirations

Designers with adaptive approaches and inspirations usually do not have rigid ideologies about producing design of interactive projects – they are rather open to different influences and methods employed for execution of design. Designers with a defined approach have defined scope, and comparatively specific philosophies or areas of inspiration that guide them through the thought process for project production.

- **Design nature**: application or experiment in intentions and strategies

Designers of application nature tend to have goal driven intentions and strategies, and design products usually are aimed at recognizing and consolidating design concepts. Designers with experimental nature emphasize the exploration of possibilities, in many cases do not have preconceived ideas about the actual results of the design product, and they have idea driven strategies seeing projects as testing grounds for design.

		Design Nature	
		Application	Experiment
Design Approach	Adaptive	Designer type - Stefano Mirti	Researcher type - Ruairi Glynn
	Defined	Developer type - Yasuhiro Santo	Artist type - Andrew Shoben - Daan Roosegaarde

fig. 6.8 Four types of interactive space designers

The four types of designers are not unique to interactive space design and are also found in other design disciplines; they only illustrate some common attitudes and positions of designers taken up

by the practitioners in the interactive space discipline. The effects of digital culture, ideologies and technologies on designers, nonetheless, have differently shaped the design approaches and the nature of design products, informed the creative process, and characterized their intentions through interactive space production.

- **Designer type**

From this organization of designer types, it appears that "designer type" practitioners with adaptive approach and application nature consider the core substance the problem solving ability of "designers" – the ability to work on varied situations and come up with solutions for design problems. Though with varied inspirations, only appropriate digital culture and technologies were considered and chosen for the application in the design products, which suggests different but clear goals of achievement requiring the aid of digital mediation in the environment. For Mirti, he believes architecture supported by "new technologies" is a natural step in the current scene of design, and "interactivity" is an assured effect resulting from designing with digital technologies as the building materials of today.

- **Developer type**

"Developer type" designers with application nature and defined approach also concentrate on problem solving, but with a specified area of work through design practice, and aim at developing defined knowledge for application. Seeing possibilities of future design in digital culture and technologies, they examine and develop unexplored ideas, in pursuit of applicable interactive space systems in the built environment. Santo envisages the "co-existence" experience of users in spaces connected with computer networks. He developed a series of applied systems as design products, testing and evaluating possible means to connect people in physically remote places in a non-intrusive manner.

- **Artist type**

In contrast, defined approach and experiment nature fit the general image of the "artist type" whose works are means of expression and artistic exploration, with their consistency of style through defined ideologies of influence and practice of execution of ideas. Digital culture and technologies constitute the inspirations themselves for experimental projects, and their design ideologies and products are connected by the exploratory

values of digital characteristics such as "dynamic" and "participatory" factors in the built environment, for achievement of interesting or unexpected results generated from environmental interactivity. Shoben is inclined to the interest in unplanned behaviours of people as the outcomes enabled by the design of interactive spaces. Roosegaarde has a comparatively architectural approach, and his sculptures are manifestations of his statement of unfinished structures dynamically completed by interactivity with people.

- **Researcher type**

"Research type" designers with adaptive approach and experimental nature draw influence from various sources and are prone to explore different areas and test different methods of design. They do not limit themselves to a specific scope of exploration but tend to question the possibilities of digital culture and technologies, trying to acquire broad domains of knowledge through hands-on experimentation as design products. Ruairi hopes to understand the ways digital technologies may allow built environments to understand human needs, and his work tries to explore this knowledge with diversity, reflecting varied inspiration from digital culture.

Lastly, Mirti and Santo are both from architecture backgrounds and seem to combine traditional architecture practice and interactive design practice – to master the essentials and acquire new knowledge for interactive space design. Their early practice and training are believed to contribute to the application nature in interactive space design. Glynn, Shoben and Roosegaarde have art backgrounds and interactive spaces are tools for learning or media of expression. It is not uncommon now to see designers referring to experimental projects as "art projects" due to the experimental nature of design.

The different types of designers also have connections to the designers' answers about collaborative design thinking – architects and designers now have more opportunities, or are practically required, to work with programmers, engineers, media artists and even general users in interactive space design to manifest design products. This means that in a group of practitioners of different orientation, "interactive space designer" is a broad term to include all these "practitioners" in interactive space design. The result is that the description of design ideologies has to be a mixture of these practices for communication of ideas, while new combinations of ideologies seem to be a strong reason to keep practitioners working in the interactive space discipline.

6.5 Understanding designers' descriptions in interactive space design

Designers describe their projects in terms of a set of themes and languages of design ideologies, and from the research paper review and designer interviews, they tend to focus on the description of the design process and production stages. The designers interviewed talked about many areas of ideology that influenced their works, yet in this research study, the scope still centres on the selected interactive space projects as a benchmark for analysis.

6.5.1 Main categories of ideology in descriptions by interactive space designers

Bringing back the grid of design context, theory and practice into discussion, the selected research topics for eCAADe 2006 are further narrowed down to the ones with a general user-oriented context on the subject of "psychology and behaviour" for comparison, and the reference projects by the five interviewed designers are superimposed on the grid, analyzing their design ideologies based on the information gathered from the interviews (fig. 6.9). The composition illustrates the most dominant themes of ideologies in digital culture influential to interactive space design.

According to the diagram, the majority of projects started similarly in human psychology and behavioural aspects, and applied the theories of hybrid environments and ubiquitous computing. The node of ubiquitous computing is obviously the most visited area of design theory by the designers. Ending in all of the three design practices, the projects take up dynamic tectonics, mediated experience or interaction information structure in the execution of design as analyzed in the formats of environmental interfaces of design products.

The main categories of design ideology in interactive spaces are:

- Design context: psychology and behaviour

- Design theory: hybrid environments, ubiquitous computing

- Design practice: dynamic tectonics, mediated experiences, interaction information structure

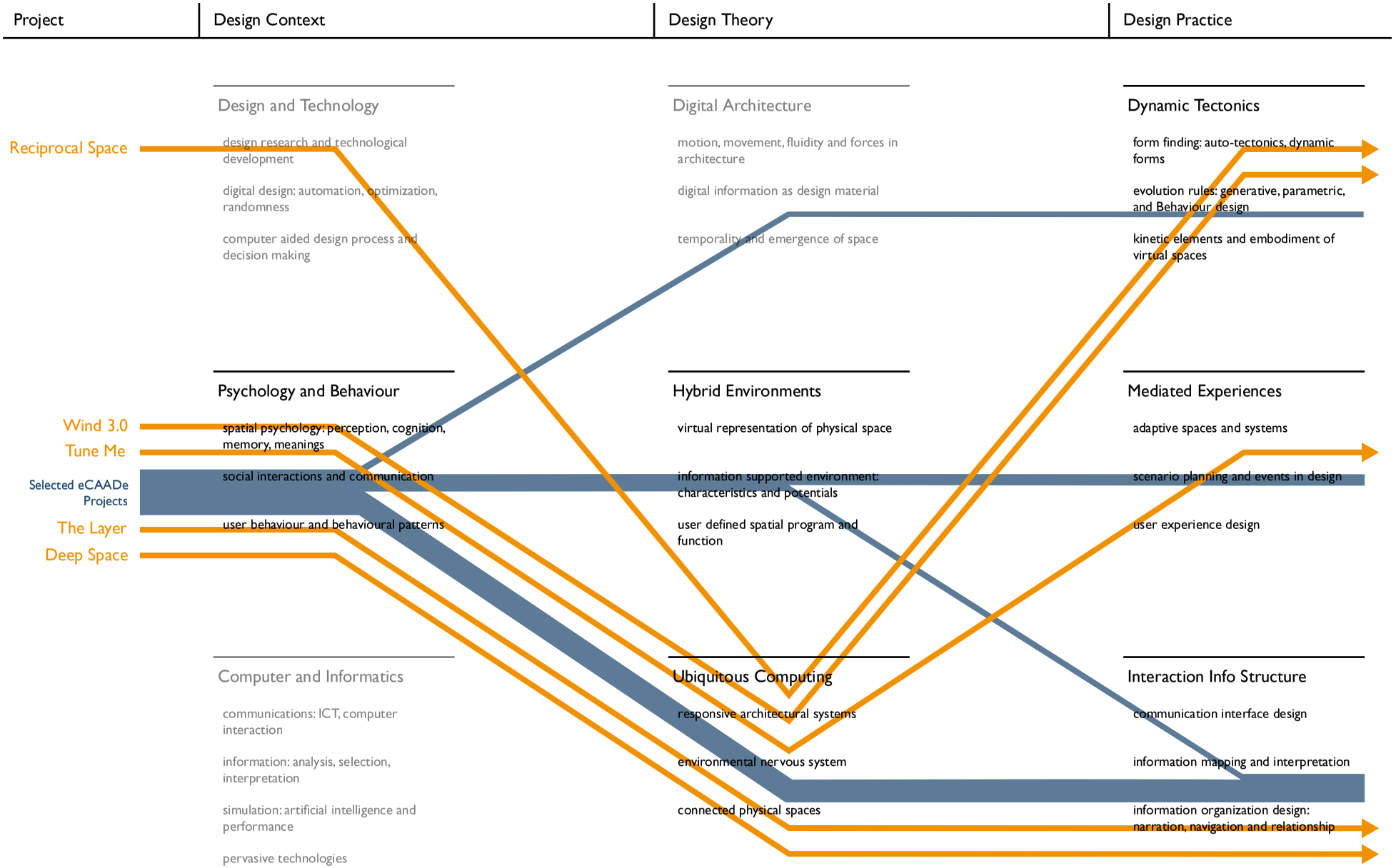


fig. 6.9 Major areas of ideologies of interactive space designers

Obvious trends in the combination of ideologies in the projects are observed. One of them shows bonding between hybrid environments and mediated experiences, and another is a stronger one between ubiquitous computing and interaction information structure design. It reveals that, though many projects consider user psychology and behaviour as an important component in interactive space design, only a few have actually worked on the planning of scenarios, events or adaptability of space to user needs. In addition, more designers put effort on the design of technical systems as interactive interfaces in ubiquitous computing environments and regard user experience as a goal to be explored.

The context of human psychology and behaviour is relevant to the general nature of interactive space design as a user-oriented discipline, in the sense that "users" make up an integrated part of the design system in the environment. From the interviews with designers, they are interested in "new relations between space, people and digital media". Human perception, cognition, social interactions and behaviour are common topic references made by the designers as core inspirations of design, demonstrated by the projects "Deep Space", "Tune Me", "the Layer" and "Wind 3.0" and claimed by other research projects in the conference papers.

Design theories in hybrid environments are most relevant in projects to combine physical and virtual representations into an integrated space; though not shown in the diagram, some projects observed in the user study employ this theory, like "Messa di Voce" and "Memento" which have projections as the spatial interface. Designers also explore the fluidity of digital media for the design of more adaptive spaces. Ubiquitous computing is another major theory in product-oriented design for its concern with pervasive technologies and networks embedded in the environment. Architecture-oriented projects experiment with digital technologies used in ubiquitous computing systems, like motion tracking cameras, sensors and feedback systems of displays, lighting and sounds (information on environmental interfaces of projects can be found in the appendix).

At last, other than the few who are interested especially in tectonic structures, the preferred design practices are the design of mediated experiences and interaction information structures. They are not directly linked to the environmental formats of tectonics, ambience and projections. Mediated experience in interactive spaces is the design of space that may facilitate interaction by adaptive systems or the planning of possible events and scenarios that are allowed, suggested or prohibited by designers. It is similar to the design of "program" in architecture or "user experience" in industrial design, and

is greatly influenced by the user-centred consideration of design. But most projects deal with the interactive structure in which designers plan the interface, the input and output of the system, and how information is organized and interpreted in possible combinations of structures to get interesting outcomes or effects.

One detail to notice is that the most prevalent design path starting from "psychology and behaviour" design context, to "ubiquitous computing" theory and ending with the practice of "interaction interface structure" is often observed in design projects of interactive spaces. Both ubiquitous computing theory and practice of interaction interface structure are built on an engineering basis, requiring knowledge of computer engineering and design of information structures such as the use of technology and the logic of the translation of information in the system. This path is a comparatively technology-oriented approach to the design of interactivity in environments. Without careful planning, it could become technology-dominated and overlook the ability to effectively involve users in the interaction. This approach contributes as well to the "collaborative" design process involving engineers in the production of interactive spaces commonly mentioned in interviews.

6.6 Conclusion

Investigating interactive space design from the designer's perspective leads to finding the ideologies behind projects, perspectives of different types of designers in the discipline, and other topics of interest in digital culture. By participating in a conference about digital architecture design, analyzing its research papers, conducting a study of designer profiles and consequently interviewing them, the results are substantially informative for discussion of influences of digital culture on design thinking and creativity processes in environmental design.

Not much could be achieved by using or studying a design product in the hope to find out the designers' ideologies, or considerations made in the design process, since there are different degrees of ability of designers to convey ideas through design execution. In many cases, the descriptions from a user's perspective of the product may be imprecise and limited in insights with regard to the designers' intentions, strategies and approaches in designing such spaces. The point of view in designers' descriptions is predisposed to the designer's ideologies, creative processes and design thinking regarding interactive space projects. The use of language is descriptive; terms and jargon, though at times imprecise, are

directed at the concepts and ideas commonly used in the design community.

Design ideologies related to interactive spaces were analyzed and categorized into a grid composing themes based on design context, design theory and design practice. For the description of interactive space projects, design context of psychology and behaviour, design theories of hybrid environments, ubiquitous computing, and design practices of dynamic tectonics, mediated experiences, interaction information structure are the dominant areas of ideology behind designers' exploration of not only new relations between space, people and digital media, but also new experiences. User involvement is believed to be crucial in interactive spaces; although user perception, cognition, behaviour, participation and experience are common inspiration for designers, and they believe the built environment is getting more adaptive to human needs, including social, experiential, sensual and emotional aspects. Interactive space projects are currently observed to have a technology-oriented design approach over a user-oriented approach in their projects.

The perspectives and attitudes of designers may contribute to their own intentions and achievements by designing interactive space projects, as explained by four types of designers identified, but a rather common reason for work was the "exploration" of ideas through the execution of design projects, considering design products as testing grounds, looking for possible unexpected results from practicing design. Due to difficulties in definition, many experimental projects are published as "art projects" for the sake of demonstrating designers' concepts and visions through the design products to make statements and provide evidence. Some designers consider them tools for expression, some look for the application value of experiments, and some would like to acquire knowledge out of the experiments.

It appears that digital culture at this stage provides new inspirations for designers, opens opportunities for them to explore unknowns and experiment with undiscovered areas of possibilities to bring influences of fluid, adaptive and dynamic digital media as the building material for today in the design of physical environments in the hope of engaging people directly with immediate spaces and enriching human experience.

Users' and designers' descriptions of interactive space design will be brought together in the next chapter for an analysis, in order to find out a comprehensive description of the discipline and the theories that support findings of the two parts of investigation.

Chapter 7
Analysis: Design of Environmental Interaction Interfaces and Relevant Theories

From the observations, background studies, and the data collected and analysis resulting from the two parts of findings, a reasonable amount of information has been achieved for discussion of the current scene of the interactive space design discipline, based on the investigation of the users' and designers' descriptions on the subject by use of language, focus of interest and points of view. In this analysis chapter, relevant knowledge and theories will be employed to support discussion of some views on the subject achieved from the research.

Interactive space design is observed to have strong linkage between psychology and the design of the "communication interface", and a phenomenon composing the two-sided descriptions from the users and the designers. A discipline involved extensively with users, it is similar to the studies of psychology in human-computer interface design. It seems that the study and design of environmental interaction interfaces can benefit from the science and psychology of designing communication interfaces.

Since the scope of research emphasizes experiential values of environmental interfaces, selection of references for analysis will aid explanation of human cognition, experience and action in interactions. In addition, the studies gathered information about current practice, research and design process of interactive space in digital culture; writings on design processes and practices will also be employed for explanation of work and thought in the current interactive space design community.

The analysis will present the comparison of descriptions of design by users and designers, general

thoughts on interactive spaces, the role of "the user" in ideologies, and the current scene in the creative process of the interactive space design discipline. Statements inserted throughout this chapter will highlight the key insights gained through the analysis of findings.

7.1 Comparison of user and designer descriptions

The previous chapters have examined the perspectives of users and designers in their descriptions of interactive space design and design projects. For a quick reference for comparison, the points of view, focus of interest and use of language of their descriptions are summarized in the following table (fig. 7.1):

	User descriptions	Designer descriptions
Point of view	Description of design as executed	Description of intentions through design
Focus of interest	Experience of use, evaluation	Experimentation, demonstration of ideas
Use of language	Emotional, general	Conceptual, use of jargon

fig. 7.1 Comparison of user and designer descriptions of interactive space design

The table shows very different views in all three aspects of description from the two parties having direct engagement with interactive spaces. The user's perspective tends to describe what is encountered in the course of interaction – the "usability", "understandability", "user-centredness" and "user experience" of the interactive system. First, this tendency is unquestionable for the fact that interactive space explicitly involves human interaction with the environment system, at least as defined in the theoretical framework of this research study; and second, the projects studied are experience-based rather than designed to support achievement of tasks. User descriptions are emotional, evaluative, and focused on the design as executed. Designers, in contrast, tend to describe the design intentions and creative process, and value the demonstration of ideas through design through conceptual language used in the design community.

Working on interactive spaces and producing projects gives rise to very different expectations of users and designers on the design products. On the user side, the projects are expected to be the

execution of design ready for application in real life for "use" and "experience". The implementation of ideas in realized projects induces usage and inevitably evaluation: organized from research findings, the evaluation of interactive experience by cognitive process, sensory perception and emotional effects. Designers' expectation in designing products is found to be inclined to the demonstration of ideas and experimentation. Ideologies of designing interactive spaces by designers, including digital design, human psychology and behaviours, and computer and informatics, suggest very diverse intentions and approaches in realizing design projects, where the intrinsic concepts of the design products are believed to outweigh their applicability. Concerns with actual interaction in application, and what happens after the project is produced, do not seem to interest designers as much as the exploration of ideas by designing.

To see an overview of ideologies of design projects again, the interactive spaces observed and evaluated from the user's perspective, no matter whether high or low in consideration of "user-centredness" of interaction experience, are brought back into the grid of ideologies analyzed with the project descriptions by their designers from source material, which can be found in Appendix A. The charts of levels of "user-centredness" of experience of the projects are shown again for comparison. In the figures below (fig. 7.2, 7.3), ten projects, including five from the observation study in findings part one and five designed by the designers interviewed in findings part two, will be put into the themes of ideologies for a juxtaposition of dominant areas of thinking applied in interactive space design.

By comparing the diagrams, there do not seem to be very strong linkages between the levels of "user-centredness" from the experience of design evaluated from the user's perspective and the design ideologies of the projects conceived by the designers. Only three out of ten projects are about the design of mediated experience in design practice, namely "Messa di Voce", "MOVE", and "Tune Me". Comparatively, only few designers are actually planning and designing interactive spaces to enhance experiential aspects in spatial interactions. The design of information structure is more prevalent in designers' practice.

Also noticed is that the design context of human psychology and behaviour is an area being revisited by most of the projects, from the view that "interactive spaces may challenge traditional perception of space and its design". In designing interactive spaces, it goes beyond the environmental aspects to perception of the interactive system or interface; and even further to social interactions and communication, user behaviour and behavioural patterns. Yet, unlike in traditional architectural

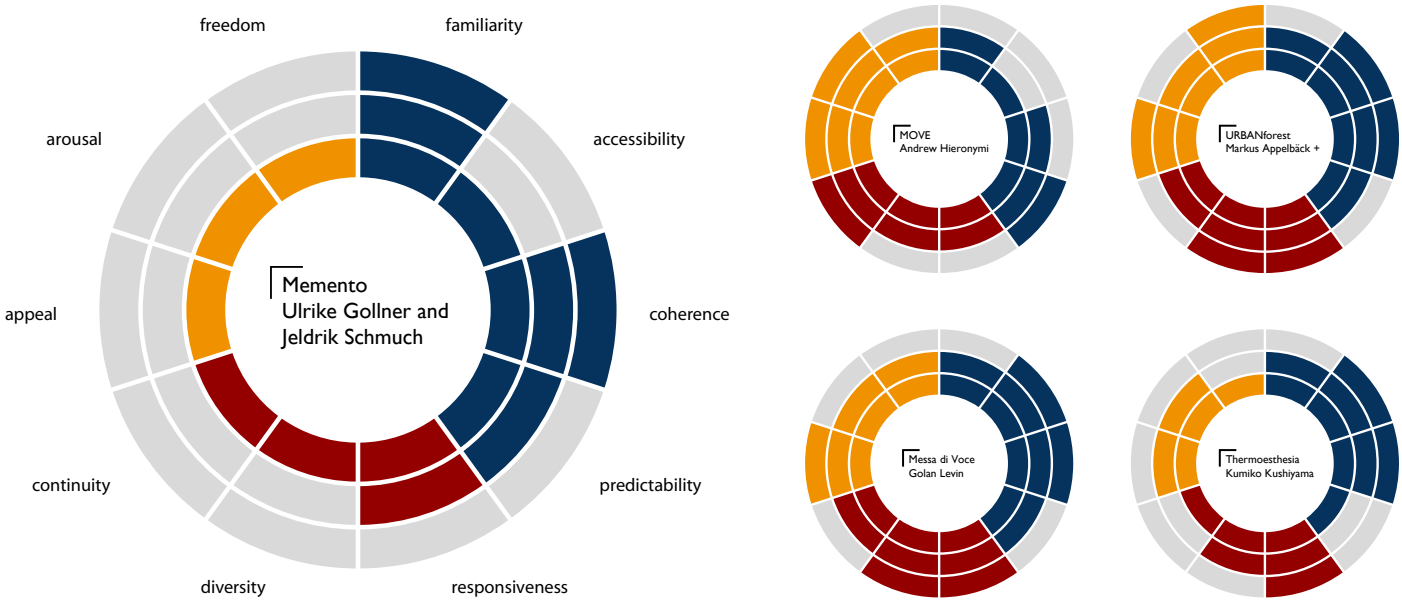


fig. 7.2 Five interactive space projects evaluated by the "user-centredness" in user experience

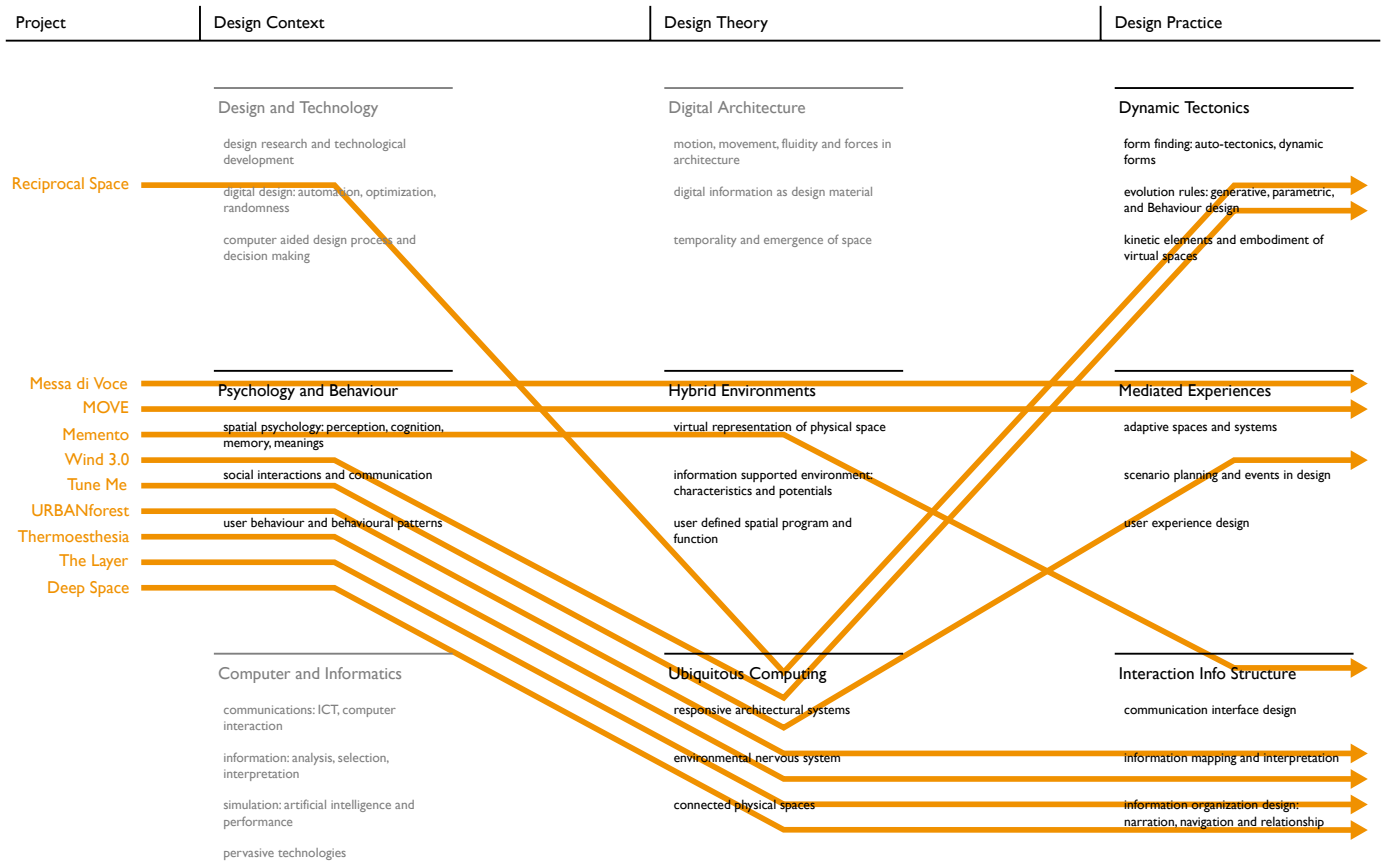


fig. 7.3 Ten interactive space projects and their design ideologies

design, these issues about environmental psychology are usually considered as unexpected outcomes or effects of interactions, rather than the driving force or goal to achieve by the interactive space design. From some of the descriptions of design intentions, designers tend to "explore", "challenge" and "observe" users' perception of space through the projects.

In the design theories, designers explore possibilities of overlapping virtuality into physical spaces or embedding intelligence into physical environments. Design strategies are generally connected to the theories of design in designer descriptions. For instance, hybrid environment and ubiquitous computing are two major categories that strategies are based on. These strategies describe the possibilities of environment design in digital culture with responsiveness, connectedness, adaptability, interactivity, flexibility and fluidity of the built environment enabled by digital technologies and networks. However, when comparing these two areas of theories, user-defined, customized or personalized spaces were in fact not often explored in the projects studied; only "Messa di Voce" allowed for user selection of screen effects for preferred spatial experience. Most of the other projects are connected to ubiquitous computing, a theory in which designers are solely responsible for the configuration of environmental interface systems which determines how communications take place. Though there is much for designers to explore, the user is omitted from the focus of design considerations, but later imposed into the environmental result.

7.1.1 The design of communication interfaces

Statement 1: Interactive space design is the design of a communication interface composed of environmental and computer interfaces.

To start the analysis, interactive space design can be analyzed as the design practice of environmental interface combined with computer interface. Previous study of design ideologies indicated that interactive spaces are highly related to human psychology and behaviour in design context, and to ubiquitous computing and hybrid environments in design theory. The knowledge of human psychology and behaviour was well reflected in the study of user evaluation of interactive space projects in the cognitive, sensory and emotional aspects in psychology, and ubiquitous computing and hybrid environments can be seen as a combination of environmental and computer interfaces (McCullough, 2004; Anders, 2005).

The design of the "communication interface" of interactive environments allows users to interact with environmental and computer systems with the "flow of information" as in cybernetic feedback. Designers take responsibility in the design for both virtual and physical "containers" to accommodate the "content" of interaction filled in by the users, defining what kinds of interactions are allowed and accepted, and present this knowledge to users by providing clues and constraints through the information in the design only. The interface design is not only for the users to communicate with the environment, the computer and the collocated users. It also involves the communication of conceptual models transferred between the designer and the user. As noted by Dourish (2001, p.56), "human-computer interaction can be thought of as a form of mediated communication between the end user and the designer, who must structure the system so that it can be understood by the user, and so that the user can be led through a sequence of actions to achieve some end result". It is related to the conceptual models of designers and users in the design of the interactive system.

7.1.2 Conceptual models and the system image

Statement 2: Interactive space design is "user-oriented", but not necessarily "user-centred".

The different focus of descriptions of users and designers are first of all connected to conceptual models in design. Norman (1990, p.16) suggests in the design of user interface, that a design model is the designer's conceptual model; the user's model is "the mental model developed through interaction with the system"; and "the system image results from the physical structure that has been built" (fig. 7.4).

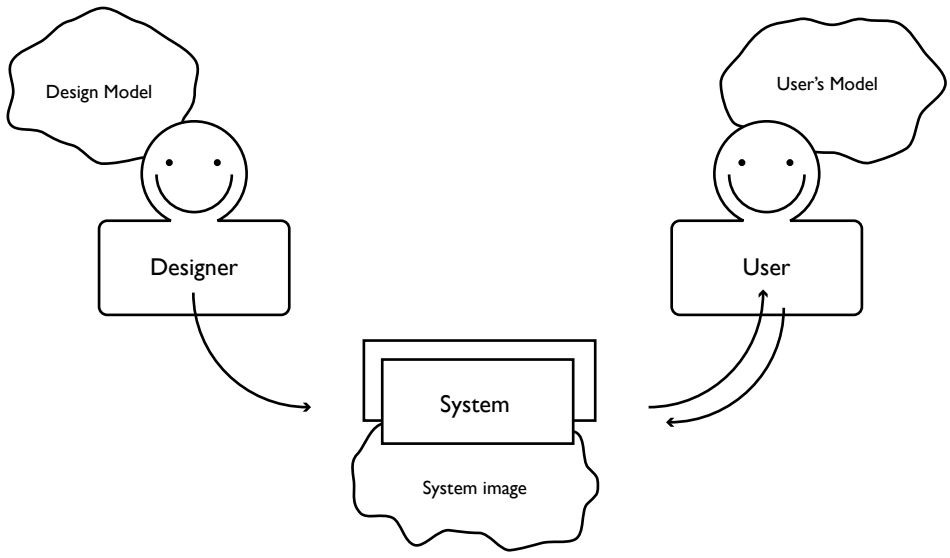


fig.7.4 Conceptual models (redrawn from Norman, 1990)

In general, he explained (p.16), "the designer expects the user's model to be identical to the design model. But the designer does not talk directly with the user – all communication takes place through the system image." Designers are normally detached from the users. In interactive space design, the interaction interface is the only communication tool between designers and users. However, the projection of a conceptual model onto the system image is a one-way process; whether the user can understand the design of physical (environmental) and virtual (computer) representations or not is usually not the central focus of designers. The conceptual models are here concerned with the access of information – if the design model is mainly about design intentions, there seems to be no clue from the system image through which users can understand the intentions of a design.

Norman added that (p.16), "if the system image does not make the design model clear and consistent, then the user will end up with the wrong mental model." The evaluation criteria of the user description study summarized some of the concerns of the users in interactive space design; they are actually the comments made about the users' communication with the system image, including the physical environment, objects, context, virtual representations, and computer agents. The success in the two-way communication between the user's model and the system image counts on a well-planned system image on the above factors to reflect the design model.

In the projects studied in this research project, designers do not aim at planning and projecting a system image for the designers through the design of the physical structures. Especially in art-based projects, like "Memento" and "Thermoesthesia", designers intended to produce fabricated, fictional interfaces with digital technologies in controlled environments. These environments are comparatively inefficient in generating apparent system images, and in turn forming a clear user's model in conception. Users are required for interaction but are not a major consideration of designers; interactive space design seems to be more "user-oriented" than "user-centred" in the design practice.

7.1.3 Summary

Concluding the comparison, the descriptions of interactive space design from the user's perspective are about psychology on cognitive process, sensory perception and emotional effects, and lead to the evaluation of different levels of "user-centredness" in design. Besides, though themes of description on interactive spaces relate to psychology and behaviours in ubiquitous computing environments, the

actual practice of designers does not necessarily lead to the consideration of experience of users, but to the development of interface structure in architectural spaces to explore new possibilities for exchange between users and the environment. Interactive spaces are communication interfaces possessing physical and virtual representations at the same time.

To sum up the analysis of descriptions of design, interactive spaces are applied science involved in the design of environmental and computer interfaces, including architecture, human psychology, and computer engineering. In the eyes of the interactive space designers, user involvement may be important or even essential; but this does not make interactive space design a user-centred design practice without taking into account the system images and users' conceptual models. Designers are driven by their own goals or ideas, and this may diminish the consideration of "usability" in exploration of interactive space projects, giving the impression of it being "user-oriented" but not necessarily "user-centred" design.

7.2 Differences in perspectives of descriptions from users and designers

Discrepancies between the user's and the designer's descriptions of interactive space design reveal the mismatch among their points of view and expectations from the design projects.

7.2.1 Different points of view of design description

Statement 3: Design of experiential interactive spaces tends to create "new experiences" in environments, but users' cognition of space is based on "learnt experiences".

The two-sided phenomenon of perspectives of descriptions in design is also observed in human-computer interface design, which is also concerned with psychology but differs in scope of investigation. A few essential terms are introduced here. Norman (Carroll et al., 1991, p.17) in his paper on human-computer interaction, defined the relationship between human, artifact and task. A "cognitive artifact" is "an artificial device designed to maintain, display, or operate upon information in order to serve a representational function," that usually means on the computer. The "representational device" in turn includes "the representing world" of "a set of symbols." Through the "artifact", users accomplish the

"task" which is the goal of the resulting interaction.

He proposed two views of artifacts, the system view and the personal view (fig. 7.5). The system view sees the user, the artifact and the task as one system; whereas in the personal view, the user of the artifact sees the task is actually changed by using the artifact. The similarity of this to interactive space design is that, the designer taking up the system view, considers the user as part of the interactive system, while through the design of the "artifact" as physical and virtual representations, users can better interact with the environment. But the users consider the goal of interaction to be confined by engagement with the use of the "artifact" as an imposed medium. Taking up the personal view, they consider how the interface design, including representations, affects channels of interaction. This results in the different points of view of descriptions from designers and users: designers think the interface design enhances users' interactive experience, but users think the interface means something extra to learn and interpret.

Regarding the term "experience" and experience-based descriptions, designers and users have very different interpretations and understandings. From the user's perspective in the use of an artifact, their perceptions and actions are based on past experiences, in order to "accomplish the task" with the designed interface. The evaluation criteria describe ease of getting to their goals and the sensory and emotional experiences in the process of interaction through the use of the "artifact", that is something extra and foreign to the learnt experiences. Designers' definition of "new experiences" are the descriptions of their intentions for the achievement of unknown possibilities, and their experimental projects unavoidably put users in the designed system as experimental subjects, who may be later studied through observation of their behaviours and emotions regarding novel interfaces – the areas that interviewed designers are interested in.

In the designer interviews, Santo, Glynn, Shoben and Roosegaarde mentioned their interest or intention to explore new experiences or new ways of interaction and communication in interactive spaces. The explorations are in fact the outcomes of the interaction between designed spaces and users, but in many cases, since designers take up the system view, the whole environmental system is regarded as the key factor to make new experiences happen. Yet there are some projects that pay attention to "ease of learning" and "learnt experiences" of users in novel interfaces, like "URBANforest" and "Messa di Voce" in which interactions are made familiar, by constructing new experiences on the basis of past spatial experiences.

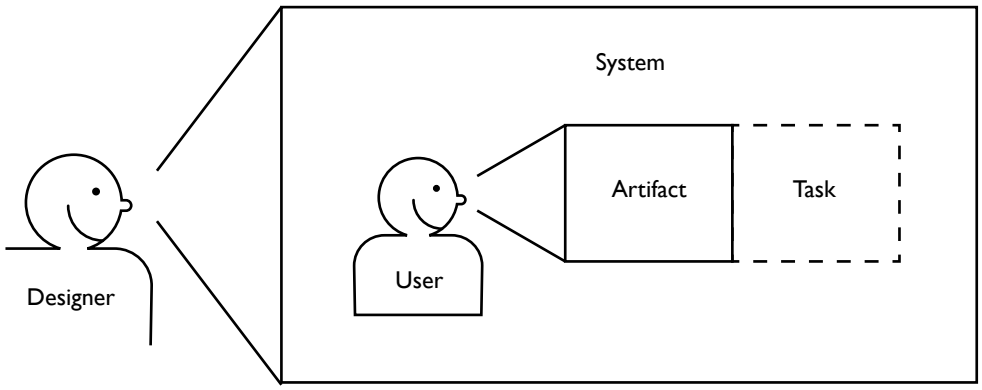


fig. 7.5 System view and personal view (adapted from Norman, 1991)

As a result, though both parties take into account human psychology in the description, users would be more concerned with design execution in terms of its understandability, usefulness and positive experience in interactive spaces, perceived and learnt based on their past experiences of spatial interactions. In designers' descriptions, designers are more inclined to describe the design intentions, visions and demonstration of ideas to engage users in possible new spatial experiences through the interface design. Mediation of applicability and vision in interactive space design, from different perspectives, appears to be a complicated task for designers to accomplish.

7.2.2 Different expectations from design products

Statement 4: Interactive space projects are applied experimental apparatus for designer's exploration and demonstration of ideas and visions.

Some designers are more concerned with applicability of designs while others are driven by their vision of interactive spaces. Descriptions are varied and discrepancies in conceptual models occur if designers do not aim for the "usability" expected by users. The ideologies of design contexts, theories and practices have varied levels of user-orientation and technology-orientation. As in other fields of design, research and development especially on the use of new technologies or media, tend to employ technical-based design ideologies. Interactive space design projects in this study have shown a strong tendency towards technology-oriented ideologies in ubiquitous computing and interactive information structure.

The expectations put on interactive spaces by users and designers contribute to the fundamental differences in design descriptions. First of all, users in particular expect and favour high applicability of design products even if the interface design is purely experiential. For designers, although projects with an application nature are more related to usability or applicability of design, many have been observed to focus primarily on the establishment of architectural features of technological systems or interactive interfaces as mentioned by the designers in the interview. On the other hand, experimental projects usually intend to become research studies, define theories of design, and in extreme cases only to express the designer's ideas in art-oriented projects. Designers' expect design products to demonstrate ideas and vision of interactive spaces through production. Such design obviously reveals common designer ideologies, but are not aimed at the design of actual interactions between users and environmental interfaces, hence the discrepancy in descriptions.

Despite similarities in explorations, the only differences between the designers are those that seek application nature and look to the practical execution values in computer interface design; whereas experimental designers aim at theoretical development, or to solidify their own exploration and vision. It appears that experiential interactive spaces are still immature, requiring more studies and experiments before application for general usage.

Human-computer interface designers also see the gap between application and theory in design objectives. Pylyshyn (Carroll et al., 1991) has noticed that, despite the importance and necessity of long term theoretical development in research, practical progress in design is seldom related to scientific theories, but is related to the invention of new products, methods or techniques, due to the difficulty of coming up with theories to describe how things are in real world practice. Landauer (Carroll et al., 1991) has a more specific view that in human-computer interface design, the use of theory is constrained and modest, and broad, detailed, and accurate theories that will replace empirical cut-and-try as the foundation of design cannot be expected. Yet, Landauer also mentioned that to develop usefulness and usability of design, prototyping could provide an empirical basis on which observations of task performance and evaluation with reliable feedback could measure the success of design and guide evolution.

Theory development may not be essential in designer's agendas, but most interactive space projects rely on prototyping and, probably in some cases, empirical studies for exploration of possibilities in

future application. The "design and development" ideology here does not seem to mean "design and application". It explains the "researching by doing interactive space design" intentions of designers and projects in observation. The difference in objectives of the design experiments is whether observations and evaluation of design products are made, like the observation conducted in this research to study user behaviour and the evaluation criteria subsequently developed, to complete the whole process of development, which can serve as a way to bring users' and designers' description of interactive space design closer.

7.2.3 Summary

Discrepancies in users' and designers' descriptions are due to the different points of view that in turn reflect the different expectations towards the general environment interface design, its design products, and the interaction process within.

Different interpretations of "experience" are caused by designers taking users and their psychology and behaviours as "models" fitted into fictional contexts for exploration of "new experience", but users rely on "learnt experience" for actual interaction with environmental interfaces. The differences in expectations can be explained by the system image of design, which usually acts as the mediator between the user and the designer. But in the design of environmental interfaces, the system image serves neither the user's perception of the system, nor correctly projects the designer's design intentions. The mediator role of the system image in applied design products can only be facilitated if both designers and users share similar expectations, but designers' view of projects as "applied experimental apparatus" jeopardizes the system image for designers' and users' communication of conceptual images.

7.3 "The user" in design ideologies

As earlier mentioned regarding the "user-centred" or "user-oriented" aspects of interactive space design, it seems that in traditional architectural design, the concern of users is usually related to space usage, accessibility and ergonomics in the design process. Consideration of the user in the design process does not really relate to how people may experience the space. Digital culture in design of environments has broken some of these preconceptions in architectural design, as found in the designer's ideologies, that architecture becomes more adaptive to human needs, programs become more flexible and users

can communicate in more ways with the built environment. Under these new paradigms, traditional space usage and program are being challenged. The design of interactive spaces may become more user-oriented than ever, since the design of "user experience" has surfaced in the design community.

7.3.1 Human psychology and actions in interaction experience

Statement 5: Environmental interactive experience is physical, cognitive and emotional.

Interactive space design involves "the user" in a number of ways. Since it is mainly about interface design, from a psychological and behavioural standpoint, interactive environments are judged by their experiential values in user interaction. "Experience design" is a broadly defined term even in the design discipline, where Shedroff (1999) proposed that "Experience Design is not merely the design of Web pages or other interactive media or on-screen digital content. Designed experiences can be in any medium, including spatial/environmental installations, print products, hard products, services, broadcast images and sounds, live performances and events, digital and online media, etc." Seeing this omnidirectional application of the knowledge, the definition in this research is limited to the experience of human interaction with physical and computer interfaces. In interactive and spatial experiences of humans, though, "emotion" is the area of knowledge greatly linked to the "experience" of users, and pursued by a number of scholars or writers who believe human emotions are central to user experiences in using design products, such as Jordan (2000), Vogel and Cagan (2002), and Norman (2004), who developed their own theories to evaluate emotional values in design.

In Picard's (1997) study of emotions in computing, she suggested that emotions are physical and cognitive, and they are all correlated but not distinctly separated – she said, "one could argue that cognitive responses include all responses of the brain, which includes neurophysiological controls and subconscious appraisal mechanisms, and therefore all emotions are cognitive. On the other hand, one could argue that all cognitive events reduce to physiological events, and therefore all thoughts and emotions are purely physiological. (…)emotions can be caused by thoughts and they can be caused by physical mechanisms of which we are not conscious" (p.24). From the observation studies, the ten criteria of evaluation based on cognitive process, sensory perception and emotional effects are a similar definition of "experience" with interrelated effects between the mind, body and emotions.

Originally the three aspects used in this research were derived from environmental psychology, the intellectual, physical and emotional aspects (Caudill, 1978). Combined with the design of interactivity, cognitive aspects consider environmental psychology, cognitive science, psychology in human-computer interaction, and affordances in the interface design; physical aspects on human actions and reactions, feedback received by various senses are common in interactive interfaces; and generally speaking, emotional aspects deal with pleasures, social activities, and arousal and freedom. The ability of designers to apply knowledge of the three aspects in the design of representations, the context and interaction programs of an interactive system could enhance the experience of interacting with such spaces, and make sure users can easily understand how the systems work, including physical interfaces and computer interfaces.

User actions are integrated by a combination of body and mind processes. The study of user actions using an interface was conducted by Norman (1990); he called this the action cycle. It shows that human action has two aspects: execution, which means "doing something", and evaluation, which means "the comparison of what happened in the world with what we want to happen" (p.47), meaning comparing the result with the goal. Applied in the design of interactive interface, the design should ideally, through representations in "the world", enable users to understand what actions are

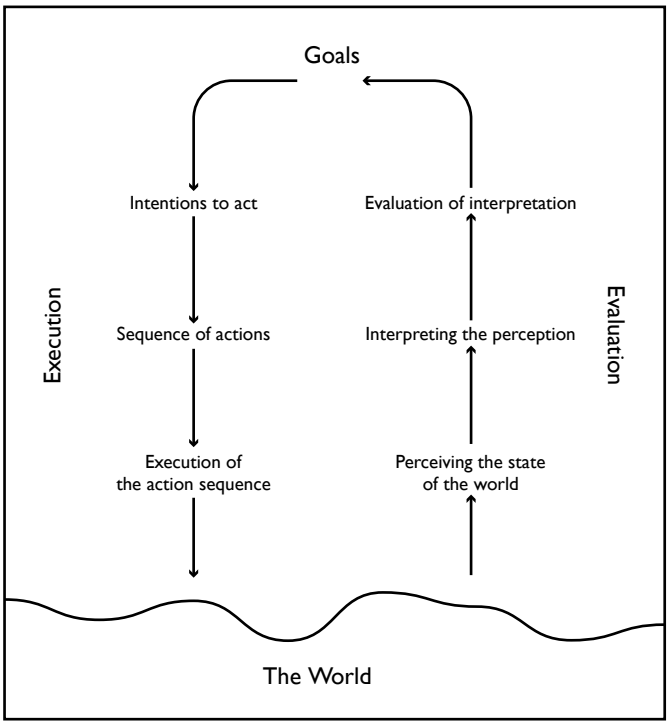


fig. 7.6 Seven stages of actions (adapted and redrawn from Norman, 1990)

possible and show the state of the system for the user to compare the result with the expectation. This was further defined in "seven stages of actions" (fig. 7.6). In the seven stages, psychology takes place especially in "the intention to act", "perceiving the state of the world" and "the interpretation of the perception". "Usability" of interfaces then links to the evaluation of interactive space projects, described in the study of user description, that relates to the success of psychological effects in the interface design.

According to cognitive and sensory factors of the ten evaluation criteria, these three of the seven stages of actions are explained. Firstly, familiarity and accessibility relate to the definition of a consistent context for grounding intent of action as mentioned by McCullough (2006), that corresponds with the "intention to act" in the seven stages of actions; for users to "perceive the state of the world," the responsiveness, diversity and continuity criteria allow the interface to facilitate the perception process through sensory stimuli; the design of context and representations are judged by the coherence and predictability for correct "interpretation of the perception." These criteria do not cover all seven stages of actions, but in action psychology, user descriptions concerning these three stages of execution and evaluation support interaction with the interface.

Defining "emotional effects" in a narrower sense, different types of "pleasures" are usually focuses for designing user experiences in using design products, that may include appearance, pleasure and effectiveness of use, self images as suggested by Norman (2003) or the four pleasures of physical, social, psychological and ideological pleasure by Jordan (2000). Again "emotions" in user experience are a complicated factor. Yet holistically, Desmet (2002) defined eight categories of emotion in his research of emotions in design products (fig. 7.7). His definition is based on two axes of pleasantness and arousal. Similar to the definition of evaluation criteria of appeal and arousal in this research, interactive experiences are more preferable with higher "pleasantness", and higher "arousal" supports more "interactive experiences". By using the word "appeal" as opposed to "pleasure", it becomes an inclusive and more generic criterion for different types of "pleasures", not confined specifically to appearance, tactile or social pleasures. The third dimension of freedom is unique in interactive systems. Experiential interfaces are preferred if the users are not restricted or confined in the interaction as mentioned by Laurel (1991). Emotions can direct psychology and actions in interactions, and preferred interfaces suggest active and prolonged interaction with the environmental system.

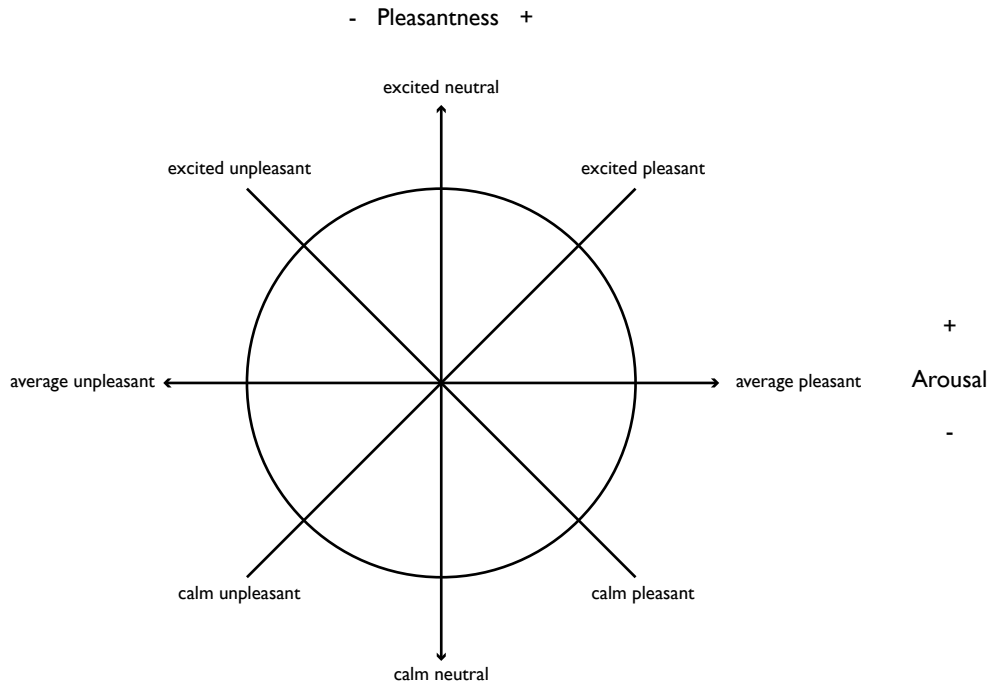


fig. 7.7 Eight categories of emotion (adapted and redrawn from Desmet, 2002)

7.3.2 User communication and behaviour in interfaces

Statement 6: Interactive spaces are apparatus for various communication activities.

The design of interfaces is not the only concern for users in interactive space design. The ideologies of human psychology and behaviour also include social interaction, communication and behavioural patterns. This is where designers have been exploring interactive spaces. Since interactive space design is mainly about interface design, it implies a large number of communication aspects involving the user for meaningful interactions. How people behave or communicate in space are taken up by some designers as design intentions, but some ignore this. As mentioned before, some designers see the interaction as outcomes and effects resulting from the design product, and some research interactions and behaviour patterns as empirical observation studies. Either way, however, the meaning of interactive spaces comes from the involvement and accommodation of human communication in the designed environment and its enclosed representations.

In digital culture, environments, objects, people and computers are connected to each other via information networks and pervasive technologies. Through embedded systems, designers of interactive

spaces are observed to experiment and develop interfaces for a number of possibilities engaging people as key motivator (or human input) of interactions. Different types of human-computer interactions and human-human interactions are possible through integration of embedded digital technologies in the built environment. There are three types of behaviours concerned in interactive interfaces, and their communication strategies with participating users have the following characteristics (fig. 7.8):

Behaviour in participation strategies	Agent in communication via interface
Observe, command and control	- virtual representations - environment and objects
Social interaction and pseudo-social interaction	- computer agents - collocated human users
Observe, broadcast and social interaction	- community of human users

fig. 7.8 Characteristics of common user behaviours via environmental interactive interface communication

Environment interfaces, when completed with computer interfaces, transform into a communication apparatus, including input and output devices for users to carry out cybernetic communication.

1. **Observe, command and control**

Environments become input and navigation devices for communication with embedded computer systems.

- User communication with virtual representations

the design of interfaces that mostly rely on human input to navigate or directly command and control a computer, like the manipulation of virtual objects in "Thermoesthesia" or the observation and navigation of past user movements in "Memento".

- User communication with environment or objects

the interface allows the user to control the environment or the environment adapts to human commands. "Reciprocal space" is a kinetic structure that transforms according to the user's body movements as input.

2. **Social interaction and pseudo-social interaction**

Mediated human-human or human-agent interactions are allowed, and environments define backdrops and necessary supporting factors for interaction.

- User communication with computer agent

the interface includes computer agents, so that though they are not human agents, the system simulates social interaction and human behaviour and responses. “MOVE” is an example of users interacting with a computer agent opponent.

- User communication with collocated users

multiple users in interactive space design can experience mediated social interaction as an enhanced social experience supported by digital technologies. Interface design can allow collected user input like “Messa di Voce”.

3. **Observe, broadcast and social interaction**

The role of environment incorporates navigation and input devices and a mediator between users. This type of environment has a strong tendency towards the use of space as a communication medium.

- User communication with community users

the interface not only allows observation but also enables users to broadcast their own contribution in the system. Input of other users can be observed and acted on, hence there is also social interaction. This type of interface including social computing features is observed in “URBANforest” in which user contribution is an inseparable part of interaction.

Designers work with different combinations of the above possible behaviour and communication means in the design of interactive interfaces. Different levels of navigation, engagement, participation, contribution, or space configuration by users of the interface define a variety of interactive experiences for the users. These behaviours can be planned ahead or kept open for random results, as preferred by designers; but in user-centred design, consideration of possible communication and participation behaviour is a major part of design ideology, where users are considered in advance to predict results for better usability or user experience in interaction.

7.3.3 User participation and scenario planning of user interactions

Statement 7: "Scenarios" and "user experiences" in interactive spaces may be considered outcomes of design, not prerequisites.

It seems that the close and direct involvement of users in interactive spaces makes the discipline more "user-centred". However, the emphasis on "user-centredness" in psychology, actions, behaviour and communication is often considered by designers as "experience design" or "scenario design" in the design ideologies of interactive spaces. By definition, scenario-based design in human-computer interface design is, as suggested by Carroll, Kellogg and Rosson (1991, p.81), a "task-oriented technique for envisioning an artifact in use before it is built" and design "begins with a list of user questions" that can be "analytically generated, gathered empirically, for example by interviewing prospective users, or gleaned from direct observation of use". In their article they proposed that, with a comprehensive set of "user interaction scenarios", functions and representations in an interactive system are put into contexts of use, enumerated and defined, and "articulate exactly how particular tasks will be accomplished". This definition opens an important question in user-centred design methods – does interactive space design really mean applying either participatory design or scenario design in the design process?

In experiential interactive spaces, the goal of interaction for its own sake replaces the goal of task-completion. It is observed that some designers take "user interaction scenarios" as a series of questions such as how the users can "participate", what user actions are allowed, what types of feedback are generated, how the other human or computer agents communicate and how context and representations support user actions, without including clear goals. As they take care of the "experience" of the user, some designers claim the projects are about "experience design". In fact, designers only non-scientifically created "fictional scenarios" and "conditional events". "Experience design" is the term used by many to simply justify their intention to explore "new experiences" of users with digital technologies and media. This kind of "scenario" or "experience" is a container for varies kinds of communication, but leaves much to unknown outcomes as it lacks the vital part of analytically generated and empirically gathered information about the users before and during the design process.

The distinction is that, normally in user participatory design, end users are considered collaborators,

who are invited to contribute and co-develop in the early stages of the design process, and designers are supposed to learn from the input of users, such as suggestions and comments, to achieve more user-centred "products". As for scenario design, it tries to foresee what can be done before a product is designed, with preliminary studies of users' actions, needs and expectations. Carroll, Kellogg and Rosson (1991) explained some roles of scenarios in design. Firstly, in the design process, scenarios clearly illustrate the specifications and functions of the design product; secondly, they can be used as guidance or instruction of use for users; thirdly, the original set of scenarios can be applied for evaluation of usability of the design product; finally, design-by-emulation is possible as scenarios lay a context of technology evolution and facilitate design revisions. The difference of use of some common terminology in interactive space design of designing "user participation", "scenarios" and "experiences" clash with expectations of "user-centred" methods of design.

Experience design and scenario planning are valuable in designing interactivity, but study of users in the design process, evaluation of usability and design-by-emulation are usually absent from interactive space design now. Nonetheless, "experience" and "scenario design" claimed in the design ideologies are relatively user-centred in interactive space design practice by paying attention to human actions and perceptions in the interactive process. Some projects contain ideologies of scenario planning or experience design started by putting the user situation in the central position and supporting the design of interfaces that understand users' needs, and therefore are more usable and enjoyable. The creation of "MOVE" is inspired by the designer's observation of user behaviours in virtual game environments, producing an embodied counterpart. "Messa di Voce" planned several fictional but experiential scenarios of the system for interaction of different number of users. These projects have also probably taken up the evaluation and redesign process by observing use and interviewing users, fulfilling higher levels of user-centredness in the ten criteria set out for evaluation carried out in this research.

7.3.4 Summary

The fascination of user psychology and behaviour in interactive space design is somewhat like the study of human-centred computing but not user-centred design. Though some designers focus on understanding human psychology, behaviour and social interactions in interactive spaces, and how they react and adapt in such spaces, more projects have been observed to deal with the development of new strategies in design of communication interfaces but not truly concerned with user-centred ideologies, such as usability, understandability, human experience and interaction scenarios. Designers seldom

mention clear goals for exploration of human factors, nor theories to find out specific areas of human psychology and behaviours. From this observation, interactive designers and projects are technology-centred, concerning the practical use of technologies under different controlled circumstances.

Viewing user experiences and scenarios as outcomes of interactive spaces, designers possess the mind set of a user-oriented but not user-centred design approach or intention, especially when work has been fictionally and non-scientifically created to testify for user psychology and behaviours, rather than designed by learning from the actual behaviours and needs of users. However, in the digital culture, environment designers may be able to learn from the "user-centred" design process of participatory methods, found in more social and empirical disciplines like human-computer interface or consumer product design.

7.4 Influences on thought process in interactive space design

The influence of digital culture on design practice, creativity, thought processes and decision-making in interactive space design is illustrated by the study of designers and the accompanied interviews. The most distinct observation is recognition of the different standpoints of interactive space designers that reflect the diversity of ideologies continuously borrowed from other disciplines in this multidisciplinary subject. The integration of a broad range of knowledge, in addition to the complication in design discipline definition and position of the projects and designers, such as architecture, art, multimedia, or applied computer science and engineering, presume that interdisciplinary communication and collaborative work are becoming more intense in the design process.

7.4.1 Collaborative and shared creativity

Statement 8: Interactive environment design tends towards an open, horizontal design process with knowledge shared across disciplines.

All the interviewed designers have mentioned that the design process and workflow have become more open compared to traditional architecture, becoming "non-hierarchical", "bottom-up", or "horizontal". Collaborative design processes were observed in the interactive projects. Designers are

most often required to possess computer and engineering knowledge, or work with people with such knowledge, for both practical reasons and because a main objective of design intention is to develop technologically new environmental interfaces. Also mentioned is user input in the design process, concerned with the experience or scenario-based designs, as many see the creativity of interactive design found in the channels generated for user input and communication.

To explore the potentials of digital culture and technologies in design, designers keep expanding the network of knowledge to include more disciplines to push forward extremes. Most obvious ones are the involvement of dynamic information such as dance, music, and, though not yet employed in interactive space design, more kinds of dynamic information employed in other environments such as genetics, Internet traffic and locative media. These areas of knowledge may be currently under development by designers who seek application values and feasibility in situated, embodied interactive environments. Designers with adaptive approaches are generally more open to integrating different disciplines as inspirations, and for application in the design process.

The sharing or bridging of knowledge or results in design and research are more important in digital culture-inspired ideologies. The interactive designers interviewed or studied in this research, regardless of application or experimental nature, are only exploring, testing or examining possibilities of interactive spaces by doing projects and do not consider the work as a "closed" design product. Actually many interactive works come in series or the designers take the learnt knowledge, design strategies or the product further in their later works. Not only to demonstrate the ideas and goals of the design, these projects are often good sources of references for other designers to employ or develop in their own work, partly due to the situation that the interactive space discipline is somewhat young and in its exploration stage, and also partly due to the ease of technically recomposing the project specifications and transferring digital data employed in the interface design by nearly everyone, as proposed by Santo and Mirti. They would like to see the experiments and ideas being taken up by different parties, applied in different contexts and situations to see their potentials and interesting or unexpected results.

7.4.2 Integrating research and practice in interactive spaces

Statement 9: Producing interactive space projects is a method of research and prototyping.

From the results of the interviews, interactive space designers are inclined to use design projects as testing grounds for their ideas, especially for designers of experimental nature. When asked about their design intentions and achievement or demonstration of their projects, their answers are abstract ideas, like "to create art that responds to and reflects the diversity of users' lives", or "to explore and experiment ways of connecting spaces". These do not give clear definitions of the goals they expect to achieve through the interface design, but look for random outcomes that are unknown until the completion of design. This supports the claims of "exploration" intentions through experimental projects, art projects and "examination" projects for designers to observe "randomness", "interesting results", "unexpected results", and "new experiences" in the environment.

Many designers are actually doing research projects instead through creating and executing design products. Pylyshyn (Carroll et al., 1991, p.42-43) made a few points about the relevance of scientific research to practice in human-computer interface design. The article stated that scientific research is concerned with "collecting objective observations and establishing taxonomies", "collecting small scale generalizations, mini models, and sets of related principles of limited scope", "collecting paradigm cases to go with generalizations… (including) paradigm empirical demonstrations, paradigm experimental methods, even paradigm apparatus for doing the experiments", "developing tools and methodologies for empirically exploring some natural domain of events and properties", and finally "developing a sensitivity to what matters in a certain field".

Compared to these definitions of scientific research related to design, designers are contributing their works to compose a bigger picture in the design research community. By doing design of interactive spaces, the exploration of methods, tools, apparatus, methodologies in the projects may end up with empirical demonstrations and small scale generalizations which turn into knowledge for understanding the situations in the field of interactive space design. Though this is not yet commonly found in the practice of experiential interactive space design, Santo and Mirti both revised design of interactive space in their serial projects "Co-Ex" and "CICCIO" respectively, as seen in their timeline of activities. They may have approached revision through the observation and analysis of users that later turned into knowledge for further prototyping, bringing research and exploration closer to practice.

The "research by design" methodology is in fact a valid option in the research of human interface design, as Carroll (1991, p.12) said, "one of the best ways to demonstrate the value to design of a psychological concept or method is to use it in design and demonstrate the advantage." Inventions

embed in the perspective of design as a process of learning or as research method for development. Building interactive spaces as experiments in design help in exploring possibilities and constraints, prototyping possible scenarios and new possibilities, so that design is not thought of as "application" but as a proactive practice in developing and testing of principles. It is even considered an alternative methodology when theories cannot achieve good applicability in real life situations called "evaluation-oriented design" or "empirically controlled application" by Greif (Carroll et al.,1991). In this future oriented design discipline, research, development, testing and inventing are justified design intentions, achievement and demonstrations, which explain the "research by design" method employed by designers over the "applicability" method in experiential interfaces.

7.4.3 Users and designers co-development

Statement 10: Iterative design drives evolution in design of interactive spaces with the help of user evaluation.

Reviewing the evaluative descriptions of users and developmental descriptions of designers, a combined ideology of co-development would benefit both groups of people engaged in interactive space design. Carroll's (1991) view on mutual opportunity explained that, by mutual understanding, users can impact designs usefully, and designers are forced to work more seriously with and within the design process, to support and participate through design work to identify useful designs. Exploration and invention of interactive spaces especially seek opportunities for application and the need for user feedback is critical in making designs more useful or applicable.

Carroll, Kellogg and Rosson (1991, p.79) further pointed out, in the study of human-computer interfaces, that the task "implicitly sets requirements for the development of artifacts to support it", and the artifact "suggests possibilities and introduces constraints that often radically redefine the task for which the artifact was originally developed". It is known as task-artifact cycle to drive evolution for both tasks and artefacts (fig. 7.9). In this view, technologies, methods and strategies used in the design of interactive spaces are supported by requirements of users, and the user's "paradigms", purposes and goals of space usage can be further extended; they are both important driving forces in designing interactive spaces from the designer's point of view.

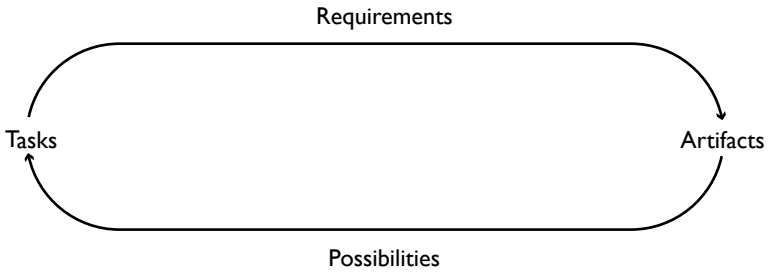


fig. 7.9 The task-artifact cycle (redrawn from Carroll, Kellogg and Rosson, 1991)

Here a lot relates to the assessment of the outcomes or effects of the design as a form of user study. Test and evaluation of design is a key factor driving usability as mentioned in previous paragraphs, but user feedback as a means to drive design evolution is also noticed by researchers in interface design. Henderson (Carroll et al., 1991) believed development processes are inseparable from interface design in his model of the development process, in which five activities of use, observation, analysis, design and implementation form a cycle of design development process (fig. 7.10). The figure shows that iterative workflow is suggested by observation and evaluation of use of the interface, and the design is concurrently revised or redesigned for the evolution of design products. It concerns the understanding of user experience as a starting point of development, and through a series of "research" procedures resulting in records, patterns and specification, the revised design is implemented for users at the end of the cycle.

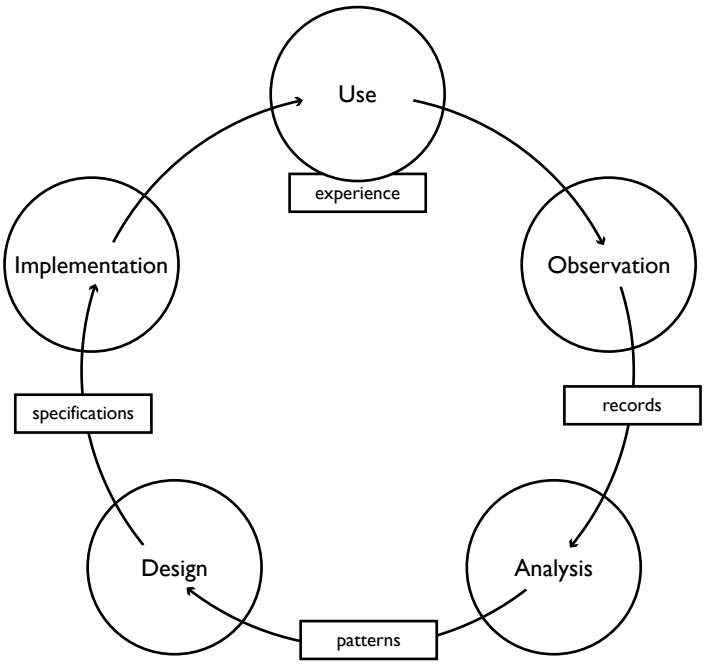


fig. 7.10 Activities and products of the development process (redrawn from Henderson, 1991)

The ten criteria of experience evaluation from users' perspective may be a good starting point for designers to think about the applicability of experimental design projects in future application. Particularly for designers with application natures, explorations can come to feasible solutions with the help of user evaluation as a further step beyond implementation of ideas in design projects. In fact even designers with an experimental nature can also shift their work from experiment to application through the anticipation of possible user evaluations. Shoben has demonstrated the possibility of applied art in his work "Trace" (2004), which combined his ideas of interactive public art that also functioned as hints for users to navigate through a maze. User experiences thus become valuable information for evaluating functionality in designs.

In light of the development process model, it is believed that if usage observation and evaluation is taken into consideration by the designer, interactive space design can be more user-centred, and people in the designed environment can better benefit from the possibilities brought about by digital culture and technologies, and help the user and the environment, the user and the computer, and the user and the designer to understand each other better. Designers, on the other hand, receive reciprocity in the way that environment interface designs are improved by user feedback and more can be learnt from the empirical evidence of use to understand the relationship between the environment and user needs and behaviours.

7.5 Conclusion

The statements made in the previous sections summarize the views on interactive space design, made by the analysis of research data and findings supported with related theories. They comment on the design of interactive spaces generally as a discipline, and some relations between the environmental interfaces and the people involved in the design and the interaction of such systems.

- Statement 1: Interactive space design is the design of a communication interface composed of environmental and computer interfaces.

- Statement 2: Interactive space design is "user-oriented", but not necessarily "user-centred".

- Statement 3: Design of experiential interactive spaces tends to create "new experiences" in environments, but users' cognition of space is based on "learnt experiences".

- Statement 4: Interactive space projects are applied experimental apparatus for designer's exploration and demonstration of ideas and visions.

- Statement 5: Environmental interactive experience is physical, cognitive and emotional.

- Statement 6: Interactive spaces are apparatus for various communication activities.

- Statement 7: "Scenarios" and "user experiences" in interactive spaces may be considered outcomes of design, not prerequisites.

- Statement 8: Interactive environment design tends towards an open, horizontal design process with knowledge shared across disciplines.

- Statement 9: Producing interactive space projects is a method of research and prototyping.

- Statement 10: Iterative design drives evolution in design of interactive spaces with the help of user evaluation.

Interactive space design is the design of interfaces that combine environmental interfaces with computer interfaces, through which users are engaged in interactions as various communication activities, including human and computer agents, and physical and virtual representations. In experiential interfaces, design ideologies are oriented to human psychology and behaviour in the design context, but tend to focus on technology-based design in practice. Despite the essential participation of users in interactions, interactive space design is user-oriented but may not be user-centred as observed by discrepancies in points of views of descriptions of, and expectations from, design projects by users and designers.

Design ideologies and inspirations compose a patchwork of ideas from a broad range of cross-disciplinary knowledge, giving interactive space design its characteristic of multidisciplinary influences in design processes. Designers explore and testify to new ways to combine this knowledge and these influences to define new relationships between space, people and digital technologies and media, revealed in a high proportion of experimental or developmental projects for "new experiences". The final outcomes of projects are viewed by designers as applied experimental apparatus to demonstrate ideas and visions, and even for testing its users in controlled environments. Because interactive spaces are a developing design discipline, research and prototyping are common intentions of design.

Opposite to the designer's descriptions, users experience spatial interactions from cognitive, physical and emotional aspects. Their high levels of involvement in interaction directs expectation of application values putting emphasis on usability, and that new experiences are built on learnt experience. Comparatively, users are in the passive positions in the development of interactive space design, and now even the more user-oriented design processes would only use fictional scenario design and do not incorporate participatory design methods or scientific study and analysis of user behaviours and use patterns. But it is believed that design processes are becoming more open and horizontal. User involvement in the design process as a co-development design strategy can benefit both users and designers in the evolution of design as an iterative process of evaluation and revision.

Chapter 8
Conclusions

The thesis has investigated the ideologies of design involved in interactive spaces in digital culture. Taking the opportunity to access active contribution from designers and practitioners in the practice of interactive space design, in particular the ones who aspire to explore the experiential qualities in interactive spaces, this research topic accessed valuable resources for data collection from realized projects as empirical evidence, as well as the people engaged in the design practice.

The proposition of this research is that the influences of digital culture on design do not just come from the direct application of digital technologies in the design process of architecture and environment design, but also from the ways in which post digital society's conception and usage of space, the capability of digital media in the environment, and the people who inhabit hybrid spaces with physical and virtual structures are presenting new requirements for environment design and new expectations for the designers.

A two-part investigation of ideologies of interactive space design from the users' and designers' perspectives was therefore conducted to probe into the current situation. This research document illustrated a method of comparing and contrasting designer-user descriptions on designs, meanwhile resulted in a number of ways of conceptualizing the field of interactive space design practice, which hopefully could aid better description, understanding and analysis of interactive space designs by different parties participating and contributing to this emerging design discipline.

The conclusion summarizes the research study, addresses its key findings and aligns them to the research objectives and questions outlined in the initial phases of the research.

8.1 Summary of the thesis

Design ideologies in digital culture are influenced by the effects of technical and social transformation, on the design community, and on the end users of design products. In practice, the design of environmental computer "interfaces", and the emphasis on experiential values in such interactive spaces as opposed to functional task fulfilment, have brought the discipline into a close relation with the people and users in interaction instead of a focus on the more common "task" in human-computer interface design.

By accessing data from interactive space projects, the research study examined the two sides of descriptions of design to find out the ideas that designers want to realize, and the expectations reflected by the experience of users in the actual process of interaction. Approaching the research from users' and designers' perspectives has revealed that interactive space design is a user-oriented discipline, though at this particular point not user-centred; human psychology and behaviour, spatial perception and cognitive science, embodied actions, user experience, social meanings and communication interfaces are commonly involved in the user-oriented ideologies of designers.

In particular, this investigation reveals that interactive space design involves both technology- and user-oriented ideologies, but designers and users have very different expectations from the practice. User-oriented ideologies are often explored as outcomes of design experiments by designers, to explore and demonstrate their ideas; while only few designers are actually driven by the goals to enhance interactive experiences in practice. User input and feedback for the design experiments are seldom integrated in the design process.

Supported by interface design theories, interactive space design can be considered communicative activity by which designers try to convey concepts through design products, to express certain values to the users, and provide users experiences intended in the use and perception of the product. Yet the relationship between designers and users in digital culture does not show an equal degree of contribution for decision-making in design from these two groups. Designers and researchers are in

a more proactive position to propose the technologies available to users, with their vision of future environments. The users are comparatively passive in their ability to inform decision-making process.

Another point to notice is the ineffectiveness in achieving a common ground of design ideologies and expectations of interactive space design between the designers and users is observed, due to different points of view and focus of interest, a lack of communicative tools for describing the design practice with a common "language", and ambiguity in designers' conveying of design intentions and loosely defined criteria for users' articulation of their experiences within interactive spaces. Reference of studies of human-computer interfaces may bring into account the importance of designer-user communication in designing interactive systems.

The key findings of the research summarizes some fundamental reasons for discrepancy in design descriptions, and consequently suggests a need for better communication between designers and users in order to drive evolution process of interactive space design.

8.2 Revisiting the research questions

The goal of the research study is to articulate a general understanding of digital culture in environmental design, in the scope of interactive spaces. The main objectives to identify topics of interactive space design and investigate design ideologies of designers have been achieved through the analysis of projects, research articles, designer activities and designer interviews along with their perspectives of looking at environmental design now from post-digital perspectives. Supplementary objectives on involvement and experience of users were significantly attended to in the study of user behaviours, psychology and communication and interaction strategies. Here the main research questions are revisited, addressing the key knowledge achieved:

1. **Generally on the field of design**

- *What is the current situation of interactive environment design under digital culture? What types of interactive spaces are observed? What are their characteristics, design strategies and values?*

Interactive space design is considered as the design of communication interfaces combined of environmental and computer interfaces. Through the communication of

conceptual models shown by the design of the system image, designers can convey their ideas through the interface, and project its intended spatial experience for the users.

As a multidisciplinary subject, interactive space design requires knowledge and contribution from architects, interface designers, engineers and media designers. The new design process is horizontal and even bottom-up, while design inspirations are expanding to include more cross-disciplinary areas of knowledge with shared design outcomes since boundaries are broken by digital information and workflow.

Still under development for application, experiential spaces in particular are considered experimental apparatus by the designers to find out more about the interaction experience and behaviours of the users. The practice of interactive spaces is also conceived as a learning-by-doing method of carrying out research on digital technologies and environment design.

Common typologies of interactive spaces are observed and can be categorized by fitting design products into a matrix according to the common environmental interface formats and modes of user involvement (fig. 5.1). These are related to the experience of interaction and its strategies, by their different levels of architecture and body orientation, and the ways users communicate with the computer and other participants. The interface formats have different orientation of the interface on the architecture to the body, that present different characteristics, design strategies and values in space definition, portability, site specificity and uses of representations (fig. 5.2).

2. **On users' point of view and interactive experience**

- *In what ways are users involved in interactive spaces? What are the modes of involvement and the respective experience of users? What are the significant areas to consider when designing interactive interfaces of such spaces for user interaction?*

"The user" is a common concern of designers in interactive spaces; many design projects are grounded on human psychology and behaviour as the design context. They are interested in the design of mediated experience for users by overlapping the virtual environment onto the physical environment. The study of user behaviour revealed that

user experience is greatly linked to, or even judged by the cognitive process, sensory perception, and emotional effects in interaction. These are important in interaction since they are descriptions about the actions and psychology involved (fig. 5.4).

Modes of involvement of users are categorized as individual users, multiple collocated users and community users in interaction. The different modes of interaction may engage different experiences on its focus of interaction, purpose of interaction, system feedback, feedback time and the contribution to database of the system (fig. 5.3). Communication activities include communication with physical or virtual representations through observation, command and control, with computer agents or collocated users through social interaction and pseudo-social interaction, and with community users through observation, broadcast and social interaction (fig. 7.8).

The descriptions from the user's experience reflect the user expectations for interactive space design. Based on research findings on kinds of description and support theories, a set of ten evaluation criteria of user experience in interactive spaces can inform the user-centredness of the design projects (fig. 5.5). The evaluation criteria were: familiarity, accessibility, coherence, predictability, responsiveness, diversity, continuity, appeal, arousal and freedom of interactive experience, which can be applied by evaluating the levels of these factors with user description (fig. 5.6). The criteria pay attention to psychology, actions, sensory stimulation, participation, interactive opportunities, social communication, preference and emotions that users may encounter in spatial interaction.

3. **On designers' point of view and design ideologies**

- *What are the post digital inspirations and approaches towards environment design in research and practice? How do designers "look at" design now as reflected by their ideologies and explorations in interactive environment design practice? What are the roles of "designers" now?*

Nine major topics conclude designer's ideology based on design context, design theory and design practice. The topics are: design and technology, digital architecture, dynamic tectonics, psychology and behaviour, hybrid spaces, mediated experiences, computer and informatics, ubiquitous computing, and interaction information structure (fig.

6.4). The grid of topics and subtopics of ideologies encompassed the major areas of concern for designers of digital environments. By arranging design projects in this grid of ideologies, the thinking process trend, starting from the context, theory and practice of design can be observed (fig. 6.5).

A more focused analysis of designer interviews and ideologies of topics showed that the major ideologies for interactive space designers come from human-oriented design context, but more technology-based theories and practice (fig 6.9). The result means that human psychology and behaviour is a popular topic explored by interactive space designers, but the execution of design does not always put the user experience as the highest priority, rather it is on the design of physical and virtual structures, which may be able to give designers more control and exploration in the design process.

Many designers consider interactive spaces as tools for exploration or expression of ideas and vision. A good example is their interest in designing new spatial experience for users. Designers' employment of digital technology and their views on digital culture are reflected by their experiment or application in design nature, and their defined and adaptive design approach.

According to their design approach and design nature, four types of designers in interactive space design were observed – the types are the designer type, the developer type, the researcher type and the artist type (fig. 6.8). Though these types are not unique in interactive space design, they reveal that in digital culture, new technologies and media have inspired many in their practice to bridge physical and virtual environments.

8.3 Contribution

The main topics of design ideology of interactive spaces are typical, common characteristics of the interactive space design niche owing to its close relationship with human psychology, information structures and physical space design that are all embedded into the knowledge base of environmental interactive interfaces. It is expected that these main topics, and the other related subtopics explored by research and development, will continue to influence ideologies in this evolving design discipline.

However, we should be aware of the situation that ideology in interactive disciplines are cross-references and cross-fertilizing; particularly in the design of spatial interactivity, it embraces other types of designs that are present in the physical environment, all interconnected and acting on similar grounds for human-scale interactions. For example, user involvement models, interactive psychology and interface strategies are believed to apply to other types of design in a more general sense. Apart from the value of the research findings, this document contributes to design research in the following aspects:

- **Demonstration of gaps and misalignment in situation by contrasting descriptions**

This research demonstrates a human-oriented approach to assess the interactive space design discipline, with the view that human interactivity within design environments will become more integrated in future design spaces. It brought together the user's perspective to analyze a practice dominated by designer opinions. For instance, issues about user behaviour and psychology, human-computer interaction modes, conceptual models and social interactions brought into discussion in this research actually have high significance to inform experiences of users in interactive environments, and these topics are easily overlooked by technical-centred investigation usually emphasized by designers.

Illustrated is a research method that contrasts designers' description on intentions and users' descriptions on experiences of interactive spaces. A major finding is the discrepancy between users' and designers' descriptions of the same subject and the gap between points of view and expectations from design products of interactive space design. By demonstration of misalignment in a situation, we now have the general idea of the current nature of this design practice, and a need for mutual understanding and further discourse between different parties involved is suggested to drive design evolution.

- **Methods for conceptualization and visualization of the field of practice**

Some conceptual methods for description, evaluation and analysis employed in this research paper seek for better articulation and understanding of design ideologies within the current interactive space design discipline. In the data analysis of user and designer

descriptions, these methods for conceptualization and visualization are proposed and demonstrated on empirical data – for example, the taxonomy of interactive space projects (fig. 5.1), criteria for user experience evaluation (fig. 5.6), the grid of designer ideologies (fig. 6.5), and different types of designers (fig. 6.8). The diagrams or categories presented suggest meaningful visual tools, while they are accompanied by terms defined, articulated in design context for more precise communication of ideas engaged in discussion of this practice.

These methods aim at improving the effectiveness of conveying ideas for both designers and users, in the view that better use of language is needed for clarifying meanings in communicating ideas, and that designers should convey design intentions and users should realize and express expectations from design; "interactivity" is believed to be about communication and exchange between people after all. If ambiguity of terms can be avoided and mutual understanding achieved between different parties, designers will be able to evaluate design process by analyzing their own design approach and intentions, justify them, and convey meanings to users through effective descriptions.

8.4 Implications for design

The current situation that experimental work of interactive spaces as the mainstream of practice by practitioners, with the emphasis of explorations without further analysis of implications and values of their work, contributes to an object-based approach dominantly found in the discipline. While designers do not have well-defined "problems" or "goals" in many of their design experiments, and lack of effective tools or methods for designing their spaces in a user-experience-centred way in new design contexts of interactive spaces, users can be easily lost in the fictional environments produced for designers' own manifestation.

Overlooking follow-up evaluation and revision of design shows missed opportunities to learn about possible further development and to solve latent problems to achieve "new adaptive qualities of spaces" and "new user experiences" as claimed by many designers. Though investigated projects are more about experiential values, interactivity has its purposes, as laid out in the foundation achieved by many who study and develop interactive interfaces. By scientific observation of user behaviour,

designers can benefit from acknowledging the relations between the realization of environmental interfaces and psychology in user participation, and direct works to a problem solving based practice and further apply to real life situations for enhanced experience of everyday environments.

It is essential for designers and developers to well understand the current situation of this emerging practice, and equip themselves with the ability to analyze and evaluate the results achieved and the groundwork established by realized experiments, for example by structured methods such as those proposed in this research. Using these methods to understand ideological and technological implications as datum reference, designers may be able to drive future design ideas in applied execution. It may be also beneficial for designers to appreciate the roles of different types of designers, in order to understand their own perspectives within design and their own contributions to the bigger picture of this cross-disciplinary practice.

8.5 Future directions

Conclusions lead to possible further investigations around the topic of interactive space design. Firstly, research on scientific methods for user observation techniques for evaluating interactive space design is believed to provide practitioners a review of issues, which may pose significant values for them to integrate useful user comments and expectations in varied stages of design process; especially when the practice is considered one of problem-solving nature. Relevant areas of investigation also include participatory design methods, and scenario based design planning – areas that have been attended to in traditional human-computer interface design but not well-defined for application on experiential spatial interfaces.

Secondly, it is also observed that larger scale environmental interactive systems are as well explored by many designers, in the probe of new experiences in urban environments using different sets of interactive media, such as communications technologies and location based media. They are not within the scope of this research; nonetheless, further research may reach a more integrated examination of the human-environment interaction design practice, as connected spaces compose a highly relevant pool of data, whereas interactive space design tends to show overlapped or mixed attributes when technological feasibility is continually explored by practitioners and the practice reshaped accordingly in this still evolving field of design.

8.6 Concluding remarks

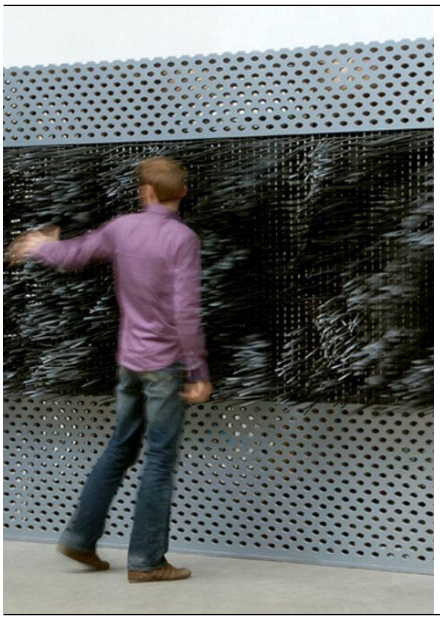
The research of digital culture in interactive space design addresses only a small proportion of influences on design ideologies on architecture and environmental design from the technological and social development of the post-digital times. Observing the limited number of references from a vast amount of interactive space projects, this research hopes to achieve a way of identifying and discussing the design discipline and its practice, among several other ways of discussion with very different propositions such as "interactivity" and "architectural responsiveness". For a manageable scope of research, the study is limited to the bodily interaction of humans with physical environments, but it may have overlooked other important areas in remote user participation, environmental interactivity and information-augmented environments. However, the research project has developed a linkage among relevant knowledge and theories immediately connected to designing spatial interaction and environmental interface system, and more importantly getting the insiders from the design community to talk about their projects and conceptions in making ideas possible.

Appendix A
Project Information of the Matrix of Core Projects

A-1 Reciprocal Space Ruairi Glynn Plymouth, 2005
www.interactivearchitecture.org

Interactive Architecture as a field of research has key characteristics. These interactive spaces must feel / experience its inhabitants and respond in a way that challenges the inhabitants to reciprocally respond. If it fails to challenge their cognitive perception of the space, then it fails to engage the inhabitants of the space and a reciprocal relationship will not be created. Interactive video and audio installations have explored these relationships exploring how moving image and sound can have real impact on our sense of space. These are being investigated in my Virtual Space Projects but as my major investigation in 2005 I built a physically reconfigurable and responsive environment to assess how moving physical spaces could have a distinctive and potentially more reciprocal affect on the inhabitants challenging neglected modes of cognition. The installation was also intended through the act of constant responsive reconfiguration to make inhabitants to reciprocally respond and reassess their preconceived ideas of architectural space being fixed.

Environment	**Format**	Tectonics	**Input**	Motion sensing camera
	Represent.	Physical	**Output**	Robotic controlled surfaces
Interaction	**Users**	Individual	**Actions**	Body movements
	Strategies	Space Navigation	**Feedbacks**	Robotics



A-1 Wind 3.0 Daan Roosegaarde Rotterdam, 2006
www.studioroosegaarde.net

Wind 3.0 exists out of 8000 fibers which, through a merging of techniques, interacts with the visitor. Microphones and sensors detect the human interaction around the object. According to the intensity of behavior large amounts of fibers are (dis)positioned by ventilators. Wind 3.0 moves with you; when there is a lot of activity the object makes large fluid motions while in other circumstances it turns into a soft breeze. This way a direct relation is made between human behavior and the dynamics of the sculpture. Wind 3.0 plays with the relation and differences between nature and technology; sometimes being very sensual but also being aggressive. The hundred of ventilators stimulate this sensation straight to the skin; prepared to be blown away!

Environment	**Format**	Tectonics	**Input**	Mic, motion sensors
	Represent.	Physical	**Output**	Ventilators
Interaction	**Users**	Individual	**Actions**	Body movements, make sounds
	Strategies	Manipulation of object	**Feedbacks**	Air currents, wall surface change

A-2 Audio Grove Christian Moeller Tokyo, 1997
www.christian-moeller.com

The installation consists of a circular wooden platform 12 metres in diameter, on which 56 vertical steel posts extend 5.5 metres up toward the ceiling. Each of the steel posts is connected to a touch-sensitive sensor system. This forest of vertical steel posts is an interface through which light and sound can be physically experienced and controlled. Visitors touching the posts can evoke a soundscape which always results in a harmonic whole whatever the conceivable combination of interactions. To accomplish this, the acoustical structures were perfected within a physical modeling system.

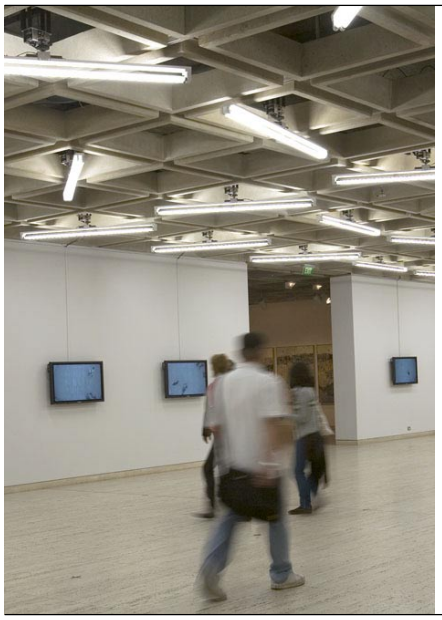
The visual component of the installation is a lush, composable texture of light and shadows. Spotlights placed in a circle around the installation project through the structure of steel posts onto the floor of the installation. According to the visitors' interaction with the poles, the spotlights illuminate different positions on the floor and draw shadow line textures onto the installation's "carpet of light".

Environment	**Format**	Tectonics	**Input**	Touch sensitive posts
	Represent.	Physical	**Output**	Speakers, lighting
Interaction	**Users**	Multiple Users	**Actions**	Touching
	Strategies	Manipulation of sounds	**Feedbacks**	Mixed audio and light patterns

A-2 Bubbles Michael Fox, Scott Franklin, Axel Kilian, Miao Miao, Juintow Lin — Los Angeles, 2006
robotecture.com/bubble/

Bubble is an adaptable spatial pneumatic installation at an urban scale. The installation will consist of large pneumatic volumes that inflate and deflate in reaction to the visitors coming to the site. If unoccupied the volume of the site is slowly filled by the spatially distributed sacks creating a translucent bubble translucent infill. If approached the section the visitor is closest to deflates offering a pathway into the installation. More activity opens up the space more making it navigable. The installation aims at bringing the sense of an adapting volumetric sense of architecture to the installations site that is compelling for its ever-changing form and response to visitors. The changes suggest a life like yet somewhat mechanistic space creature occupying the space. The installation tackles volume over surface, interaction with space over static geometry and pushes the scale of interactive architecture. Specifically, as the occupants enter and move through the installation, they bump the bubbles ranging from 6' to 8' in diameter that fill the lower layer of the space. Sensors in the bubbles cause a fan in the manifold to transfer air to the bubble directly above. Single manifolds connect pairs of bubbles.

Environment	**Format**	Tectonics	**Input**	Motion sensors
	Represent.	Physical	**Output**	Fans
Interaction	**Users**	Multiple users	**Actions**	Body movements
	Strategies	Space Navigation	**Feedbacks**	Robotics



A-2 Homographies Rafael Lozano-Hemmer — Sydney Biennale, 2006
www.lozano-hemmer.com

HOMOGRAPHIES is an interactive installation featuring 144 robotic fluorescent light fixtures controlled by 7 computerized surveillance systems. As people walk under the piece, the light tubes rotate to create labyrinthine patterns of light that are "paths" or "corridors" between them. In Homographies the "vanishing point" is not architectural, but rather connective, i.e. it is determined by who is there at any given time and varies accordingly. This gives a reconfigurable light-space that is based on flow, on motion, on lines of sight, an intended contrast to the modernist grid that currently organizes the court. With the assistance of Conroy Badger, Matt Biederman, Sandra Badger, Natalie Bouchard and Will Bauer.

Environment	**Format**	Tectonics	**Input**	Motion sensing camera
	Represent.	Physical	**Output**	Robotic controlled lighting
Interaction	**Users**	Multiple users	**Actions**	Body movements
	Strategies	Space Navigation	**Feedbacks**	Robotics, lighting

A-3 URBANforest Markus Appelbäck, Staffan Björk, Håkan Carlsson, Linus Lundahl, Eddy Svensson — Ars Electronica Festival, 2006
televatr.org/urbanforest/

It's a forest! It's an urban forest. Shaped to create a place for people to experience, to interact, to communicate, to relax, to annoy, to find new excitements, enemies or friends. Unshaped to its content, uncontrolled, free of interpretation, and able to have its own language depending on the setting it is located in and the users interacting with it. While being a forest it is also an instrument, able to play the sounds of the surrounding environment. Each tree triggers different sounds according to how they are being touched, and every tree is one part of a big instrument which sounds have been given to it through the users themselves. Each tree of the forest is a gigantic microphone and recorder. The users are free to take a tree with them, collect sounds of the environment around the forest to add to the sounds of the instrument. The sounds could then be played in sequences added by previous users or played through wandering the forest touching the objects. While sound is the main response from this forest, the lighting is also changed according to the music being played, and not least the tactile interaction with all objects. You really have to engage yourself as a user, first of all, through walking into the forest, and then through the touch based interaction with all the objects.

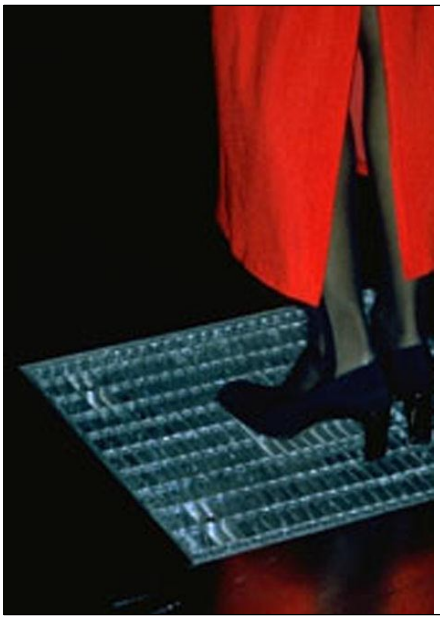
Environment	**Format**	Tectonics	**Input**	Mic, touch sensitive tubes
	Represent.	Physical	**Output**	Speakers
Interaction	**Users**	Community	**Actions**	Touching and voice recording
	Strategies	Manipulation of sounds	**Feedbacks**	Mixed audio

B-1 Tune Me Stefano Mirti, Line Christiansen, Stefano Testa — London, 2005

projects.interaction-ivrea.it

Tune Me is an immersive conceptual radio based upon tactile features. The sound (as well as the visual) is triggered by a number of 'touchy' interfaces. The visitors enter the ellipse-shaped space, immersing themselves in a new world where to listen to the radio waves. In this extent 'Tune Me' is a representation of the ambient radio of the near future. As well as the sound, each channel provides light features as well as vibrating and pulsing experience. When choosing the different FM stations, the overall space changes, defining different moods upon the nature of the different content. News, sport, classical music and international pop. Each of them triggers a different visual experiences, the space vibrates, pulses and interacts with the visitors .

Environment	**Format**	Ambience	**Input**	Touch sensors
	Represent.	Physical	**Output**	Speakers, lighting, actuators
Interaction	**Users**	Individual	**Actions**	Touching
	Strategies	Manipulation of controls	**Feedbacks**	Audio, lighting, vibration



B-1 Insound Out Christian Moeller — London, 2001

www.christian-moeller.com

The installation allows visitors to experience the generation and perception of sound with as much physical immediacy as possible. The sound is generated by a computer system tracking the visitor's own physical movements in front of a video camera. Embedded in the floor are square gratings, mounted on springs and set in motion by computer-controlled actuators, vibrating in a frequency between 0 and 200Hz. Unique loud speakers consisting of hemispherical Plexiglas domes project the higher sound frequencies right onto the head of the visitors. In this location, visitors are not so much doing something to sound as have something done to them by sound.

Environment	**Format**	Ambience	**Input**	Motion sensors
	Represent.	Physical	**Output**	Speakers, actuators
Interaction	**Users**	Individual	**Actions**	Body movements
	Strategies	Manipulation of sounds	**Feedbacks**	Audio, vibration

B-1 Dune 4.0 Daan Roosegaarde — Rotterdam, 2006

www.studioroosegaarde.net

Dune 4.0 is an interactive landscape which reacts on the behavior of people. This hybrid of nature and technology exists out of large amounts of fibers which are brightened according to the sounds and motion of passing visitors. Dune 4.0 investigates nature in a futuristic relation with urban space by means of looking, walking and interacting.

Environment	**Format**	Ambience	**Input**	Motion sensing camera
	Represent.	Physical	**Output**	Lighting
Interaction	**Users**	Individual	**Actions**	Body movements, make sounds
	Strategies	Space navigation	**Feedbacks**	Lighting

B-2 Subtitled Public Rafael Lozano-Hemmer Madrid, 2005
www.lozano-hemmer.com

SUBTITLED PUBLIC consists of an empty exhibition space where visitors are tracked with a computerized infrared surveillance system. As people enter the installation, texts are projected onto their bodies: these "subtitles" consist of thousands of verbs conjugated in third person and they follow each individual everywhere they go. The only way to get rid of a subtitle is to touch someone else: the words then are exchanged between them. The piece invades the supposed neutrality of the space that museums and galleries set-up for contemplation, underlining the violent and asymmetric character of observation. Subtitled Public also highlights the danger of surveillance systems that typecast and try to detect different ethnic groups or suspicious individuals, as in the latest computer-vision devices that are being deployed in public spaces around the world. Finally, the installation is an ironic commentary on our era of technological personalization, literally branding all spectators and converting them into "thematic individuals".

Environment	**Format**	Ambience	**Input**	Motion sensing cameras
	Represent.	Virtual	**Output**	Projectors
Interaction	**Users**	Multiple Users	**Actions**	Body movements, touching
	Strategies	Space, social navigation	**Feedbacks**	Visuals

B-2 The Layer Andrew Shoben Dublin, 2000
www.greyworld.org

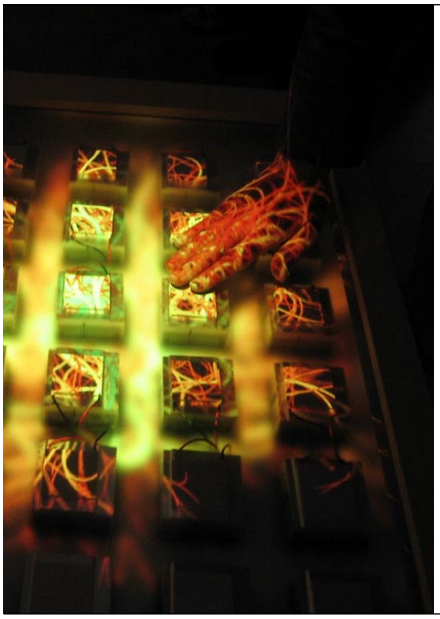
The work of art was installed along the Millennium Bridge that runs across the Iffey in Dublin, Ireland. It gave pedestrians crossing an opportunity to create and interact, simply by passing through the space. We installed a bright blue carpet along the bridge, to signify that something was different in the centre of Dublin. We then embedded sensors in the carpet that responded to each footstep across the bridge, generating unexpected sounds and melodies - a plaintive piano phrase or the sounds of footsteps crunching through snow or splashing through puddles.

Environment	**Format**	Ambience	**Input**	Touch sensors
	Represent.	Physical	**Output**	Speakers
Interaction	**Users**	Multiple Users	**Actions**	Body movements
	Strategies	Space navigation	**Feedbacks**	Audio

B-3 Deep Space Yasuhiro Santo Hong Kong, 2006

An existing café and multi-functional space at the School of Design of the Hong Kong Polytechnic University has been linked to a "twin" in the form of an online-accessible environment. Using arrays of sensors, displays and other interfaces, channels of communication are established between the virtual space and the physical space, enabling on-site visitors to the café and online visitors to the project website to participate in a shared spatial experience. The project explores ways in which digital technologies can serve to enhance and enrich the experience of spatiality and human social communication in space(s).

Environment	**Format**	Ambience	**Input**	Motion sensors, sound sensors
	Represent.	Virtual	**Output**	Display units
Interaction	**Users**	Community	**Actions**	Body movements, make sounds
	Strategies	Space navigation	**Feedbacks**	Visuals

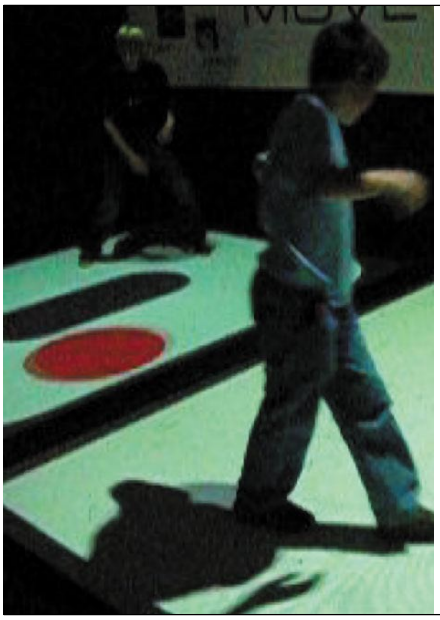


C-1 Thermoesthesia Kumiko Kushiyama Ars Electronica Center, 2006
www.aec.at/en/center/project.asp?iProjectID=13613

Is it possible to feel the temperature of a virtual object? “Thermoesthesia” is a new way to experience the world through the sense of touch. “Thermoesthesia” features an innovative display that lets visitors feel the different temperatures of a wide array of graphics (from icicles to heat waves) directly through the sense of touch. But this isn’t just a pure touch-and-feel experience; by touching the graphic elements, visitors can interact with them directly .

The surface of the monitor screen displaying the images is warmed and cooled by 80 Peltier modules. A PC controls the electrical circuits feeding current to the modules. The thermographic displays can read out temperatures ranging from 5° to 45° Celsius. A photosensoric touch-pad system registers the position of the user’s hand via infrared light diodes and thus enables the visitor to actively interact with the thermographic images. The interactive real-time program was written in C and OpenGL-Library.

Environment	**Format**	Projection	**Input**	Light sensors
	Represent.	Physical and Virtual	**Output**	Projector, speakers, cooler
Interaction	**Users**	Individual	**Actions**	Touching
	Strategies	Manipulation of visuals	**Feedbacks**	Visuals, sounds, temperature



C-1 MOVE Andrew Hieronymi Ars Electronica Center, 2006
ahieronymi.net/works/move.html

MOVE is an installation using computer vision and full body interaction allowing participants to experience six different types of actions usually performed by avatars in videogames. It is divided into six distinct modules, JUMP, AVOID, CHASE, THROW, HIDE and COLLECT. Each module offers a single-user interaction, based on a verb corresponding to the action the participant is invited to perform. Each verb corresponds to a common procedure acted out by avatars during videogame play. Each module offers an interaction with abstracted shapes (circles, rectangles) behaving according to simplified rules of physics (collision, friction). Each module is color-coded with consistency, where the color red is used for the graphical element that poses the core challenge. Each module increases in difficulty in a similar linear manner .

Environment	**Format**	Projection	**Input**	Motion sensing camera
	Represent.	Virtual	**Output**	Projector, speakers
Interaction	**Users**	Individual	**Actions**	Body movements
	Strategies	Virtual agent interaction	**Feedbacks**	Visuals, sounds

C-2 Messa Di Voce Golan Levin Ars Electronica Center, 2006
tmema.org/messa/

Messa di Voce (Ital., "placing the voice") is an audiovisual performance in which the speech, shouts and songs produced by two abstract vocalists are radically augmented in real-time by custom interactive visualization software. The performance touches on themes of abstract communication, synaesthetic relationships, cartoon language, and writing and scoring systems, within the context of a sophisticated, playful, and virtuosic audiovisual narrative.

Tmema's software transforms every vocal nuance into correspondingly complex, subtly differentiated and highly expressive graphics. These visuals not only depict the singers' voices, but also serve as controls for their acoustic playback. While the voice-generated graphics thus become an instrument which the singers can perform, body-based manipulations of these graphics additionally replay the sounds of the singers' voices – thus creating a cycle of interaction that fully integrates the performers into an ambience consisting of sound, virtual objects and real-time processing.

Environment	**Format**	Projection	**Input**	Video camera, mic
	Represent.	Physical and Virtual	**Output**	Projector, speakers
Interaction	**Users**	Multiple Users	**Actions**	Body movements, voice input
	Strategies	Manipulation of visuals	**Feedbacks**	Visuals, sounds

C-2 Body Movies Rafael Lozano-Hemmer Rotterdam, 2001
www.lozano-hemmer.com

BODY MOVIES transforms public space with 400 to 1,800 square metres of interactive projections. Thousands of photo portraits taken on the streets of the cities where the project is exhibited are shown using robotically controlled projectors. However, the portraits only appear inside the projected shadows of local passers-by, whose silhouettes measure between 2 to 25 metres high, depending on how far people were from the powerful light sources placed on the floor of the square. A custom m-made computer vision tracking system triggers new portraits as old ones are revealed. With the assistance of 6 developers.

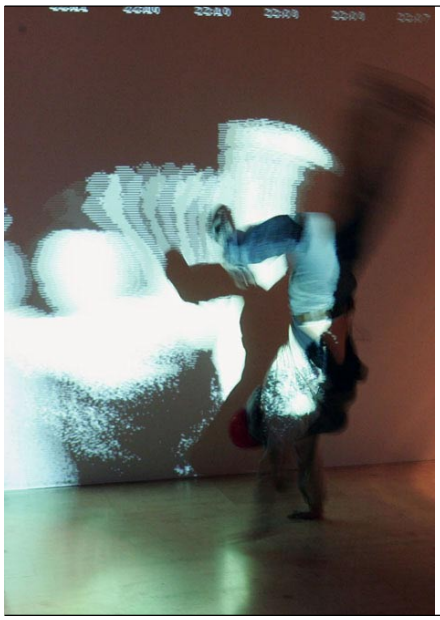
Environment	**Format**	Projection	**Input**	Video camera
	Represent.	Virtual	**Output**	Projector
Interaction	**Users**	Multiple Users	**Actions**	Body movements
	Strategies	Manipulation of visuals	**Feedbacks**	Visuals

C-3 Deep Walls Scott Snibbe 2003
www.snibbe.com

Deep Walls creates a projected cabinet of cinematic memories. Within each of 16 rectangles, the movements of different viewers within the space are projected, played back over-and-over, and reduced into the space of a small cupboard. Initially, when a viewer or viewers move into the larger rectangle of the entire projection, their shadows begin to be invisibly recorded, and one box within the projection (the eventual destination of the current movements) is cleared out. When all of these viewers leave the larger frame, their shadows are re-played within that smaller, single box, looping indefinitely. Thus the work presents records of the space, organized and collected into a flat cinematic projection. By collecting the viewers' own shadows, the piece reveals how individual objects gain in symbolic meaning, while losing literal meaning, through organization, repetition and display.

Rhythmically, the work presents a complex temporal relationship between cinematic loops. Each smaller collected shadow-film has the precise duration of its recording. A single item in the collection might anywhere from a few seconds to several hours.

Environment	**Format**	Projection	**Input**	Video camera
	Represent.	Virtual	**Output**	Projector
Interaction	**Users**	Community	**Actions**	Body movements
	Strategies	User contribution	**Feedbacks**	Visuals



C-3 Memento Ulrike Gollner and Jeldrik Schmuch Ars Electronica Festival, 2006
memento.smugo.com

Each person who visits our installation leaves a small part of itself to let future visitors be aware of his/her appearance. Memento will steal your shadow! While interacting with memento, sound is played and manipulated to the shape of your shadow. Meanwhile you see your shape among all the former visitors walking through the room. The world of memento limits our four dimensional world (space + time) down to only two! Time is no longer existent .

Shapes of people are calculated with background subtraction. Their positions are calculated and the amplitude of the music, that is played, changes to the size of the shapes. The shapes are transformed into binary images and are merged to a one minute-movie together with former shapes. After each minute all shapes dim so that a shape only remains in the movie for 7 loops. If no movement is detected the whole process stops and a screensaver is shown until someone steps into the image.

Environment	**Format**	Projection	**Input**	Video camera
	Represent.	Virtual	**Output**	Projector, speakers
Interaction	**Users**	Community	**Actions**	Body movements, voice input
	Strategies	User contribution	**Feedbacks**	Visuals, sounds

Appendix B
Transcripts of Designer Interviews

Below are the transcripts of interviews with five designers in the research of designer descriptions of interactive spaces in Chapter 6.

The interview questions are as follows:

1. Why have you chosen to work in the field of interactive spaces? How would you describe your approach to the design of interactive environments?

2. Please comment on the inspirations and intentions of this project (specified in each interview). What did you want to achieve or demonstrate with this project?

3. How did you achieve these intentions in the project? What are the strategies of choosing specific types of interaction?

4. What do you see as the implications of this project within the greater design field? What can be learned from it by designers or architects? How can these ideas be taken further?

5. If there is no limitation on budgets and workforce, what would be your ideal project to work on? Can you describe it and explain why?

Interview with Yasuhiro Santo

1. I was studying architecture, and then I started working as a computer analysis student. The work on the computer originally was to design using CAD. Then I started to think, instead of using computer as a drawing tool, you should be able to use it to do more. So that I started thinking about how I can use the computer and the internet as part of architecture, especially around that time that internet started.

--- Can you further explain your approach of using digital technologies and the Internet on physical spaces?

My main interest has always been to introduce more than one space to the existing space, connected through network or other means. Within a building, you have many rooms connected with corridors and they are considered as one unit of spaces that you call a building. As soon as they are individually located they don't become one building as you lose immediate communication and contact. Now using internet or even telephone you can connect these rooms. At this moment they're still considered as separate entities, but with more and more technologies come up, and especially the possibility of what the internet can do, my approach is how close we can bring all these together, so that you feel it is one space.

Another thing I am interested in is perceiving the sense of coexistence. In deep space there are all sorts of these elements too. In the sense of coexistence you don't need to have phone connection or video connection, that when you feel something is moving within the space then you know it is moved by some other people somewhere else; you know somebody exists in the other side, and the users don't have to interact with the virtual system at all. Another thing I'm interested in is tangible interface.

--- Would you refer deep space as a tangible interface?

No. It is tangible to a certain extent because it's visual and somehow abstracted like the icons people can draw on the physical interface. It is not the kind of one to one interaction but it suggests somebody's existence. And it's not intrusive. It's kind of tangible since you can "feel" the existence of somebody. Of course with the camera and the video and voice you do actually recognize people's existence by, kind of like, you also need to face the virtual things. Deep space is like half-done in terms of what I want to do; the ideal is a physical interface to exist somewhere else - and there is a way for physically existing people to produce some icons by their behaviour, and they go to the other side. That's much closer to what I want to achieve, but right now without the existence of web people it won't work. The other cube project that I'm working on is totally physical only, it also introduced the web interface too, but my interest in to produce all physical and tangible and architectural interfaces connect two spaces that way.

2. I don't have that much intention in deep space, it is more about experimental things that I want to see the possibilities. To see whether people can communicate with the physical and online interfaces. At the moment this interface means nothing. I think more have to be done. It's a beginning of further development. I tried because I can try. But I had great fun working on this.

Deep space is a great experiment in a way, because we have a very specific site, so you need to think about how to build in the site and what to put in the site. I have to also think about the server space to store the information, so I have already made a common platform, then I can easily hook it up to the cube interface with the software multi-user environment I made. Another dream I have is to make this protocol easy enough for everybody interested in this kind of communication and environment to use, then start building their own interface and hooking up these environments. I don't need to design everything.

--- So you'd like to find out new possibilities of linking up physical spaces by new types of technology?

Probably not new types of technology, since technology could already exist, but new ways of utilizing this technology. Sometimes in order to do something specific you need to invent, even work with somebody else, a new technology, just to be able to do something. More and more architects are starting to invent custom-made technology, not only digital things; architects are not like technologists, but most of them understand a certain degree of technology, and think of how it can be useful.

3. I'm basically working on the product, install this product onto any existing space. Now it's the cheapest way of doing it. If I have an empty room with nothing designed yet, if I install everything as part of interior architecture design, then it becomes a very specific "tangible interface ready" space.

--- It's like an adaptive system that can be put on any environment or in any design?

It is the case now, but I would like to move forward to think about how a space can be designed that way, instead of attaching something to the existing space, though both are interesting.

There is no specific type of interaction. It relates to existing technology and financial, technical and time constraints. The project is also kept to basic interaction types of motion and sound input, it is open to an experimental level rather than usage to explore new ways of utilizing existing technologies. Sound and motion is appropriate for the first try out, but I as well work on all sorts of other modules of sensors for interaction, and in essence all of them can be combined together as a mega unit capable of sensing all sorts of information. I think it's more about getting them to work, we observe how they work, and we find out different things and try out next things.

It would be really nice if motion detection can also detect how far away, for example. Then you will start thinking about all sorts of other scenarios - what can be introduced to detect what, and if you detect this specific behaviour, what type of information you can find out, and how you can utilize this information to do the next thing, like what output should there be, what can be transferred to other systems, what can be displayed... there's a huge amount of combination of things. Even the deep space interface, there are hundreds of ways to utilizing this information already. I think you just need to keep on thinking what will be the most interesting, or useful types to have.

--- Do you prefer that spatial interaction and usage changed by the action of people should be in random, or in a predefined scenario?

Unless it's an art piece, or it will have to be a scenario. Though it's always nice to think of spaces, that you can create up to a certain part of a context scenario, but beyond that it's out of your imagination. But clients like to have scenarios to predict what's going to happen in the space. That's why it is hard to design a totally random space which nobody knows how it will respond. But it's also too boring to have very predictable predefined responses. You have to decide where to put the line between too crazy and too boring. I have no answer for this, as I'm still thinking about what would be the most interesting way of introducing this thing.

--- Any past experience that you can share about these unexpected interesting results?

A historical example is that one time a building is designed, maybe it was a church, but later the function of the church may not be suitable for the time and then it became a restaurant and nobody predicted it, or a parliament that later people move out but the building stays to become a monument or a gallery... it happens all the time, nobody intended that to happen, so it's totally outside the planned usage of the building; then why do you have to plan ahead? Maybe there's a building, started as a plain building, with all sorts of computer controlled whatever, and all the time the way people use it determines what it is going to become. That is what I want to achieve with all sorts of technologies. It's part of what architects should consider. Maybe designers should think more about adaptive environments. Only up to a certain proportion it is predetermined, but the last proportion is totally adaptive.

4. Architects think of spaces as physical entities, but now it is not enough, we should start to think about how more than two or more different physical spaces can be considered as one architecture entity, when they are connected with the Internet or other networks.

--- Can you talk more about the integration of this kind of system in spatial design?

You know about evolutionary space, which the space learns and evolves all the time? John Frazer's evolutionary space has two things: one is you evolve something within the design stage, and apply that to design a fixed space. Right now we also try to design spaces that evolve as people use them. It is more expensive but doable now. It is to me the evolutionary space in long term. I'm also interested in evolutionary space in real time, which is more like an interactive environment. When you combine the two things together you get a real time interface and with a long term evolutionary space. It's like a living organism which responds to human needs. If these spaces are networked together, when one person needs something in one space, and another space evolves, and somebody else do something else in some other place, in the interactive and evolutionary way, it would be far more exciting to design the whole space and system than just attaching things.

--- What would you like to see the future development of "deep space"?

Now I have already developed a tangible interface - before deep space I wanted to develop different kinds of interfaces, all connected to the same internet website and they all start working together. For example in Hong Kong the deep space interface in the cafe area, and in Japan probably other interfaces with the same protocol, so if I do something in Japan something else start to happen in deep space, or

if somebody do something in deep space maybe an entire building in Los Angeles something starts doing something. You can keep on increasing the scale. The greatest thing is to have a whole building especially designed for this interface, that the information of your existence is broadcast.

5. I would like to build a building, right in the middle of a public space where a lot of people pass by and use it, it can be like a public park where people lay around and sit down, in different parts of the world, to try my ideas out in an architecture space. It's like an art project.

--- *Would you like to see your experiment projects leading to something for fun or functional?*

It doesn't have to be us to develop something out of it, somebody outside may think the system can be something really useful that they want to have and start developing something functional out of our idea. I think that's great. We suggest possibilities in design end up just being artists.

Interview with Stefano Mirti

1. It happened by chance. I studied architecture in Italy, I did work as architect there, then I went to Japan, scholarship at Tadao Ando Lab in architecture department at Tokyo University. 18 months of scholarship within the most traditional idea of architecture. After that, I had an offer to teach at Tama Art University, information design department.

I was the only non-geek in a world where everyone seemed to live into the computer. I found that very interesting too cross and overlap brick and mortar architecture with the new digital tools. 18 months at Tama, and I was ready to go back to Italy. I was then hired by Interaction Design Institute Ivrea (idii), where the whole thing was about new technologies, interaction, etc. So, finally, I never chose to work in the field of interactive spaces, it happened a little by little in a natural way.

I do have an approach to design. Sometimes this implies interaction and new technologies, sometimes it does not. It depends upon circumstances. Bottom line my attitude is: a) Get a good client, b) Make him happy and satisfied, c) Go back to "a". All the thing is about getting the "good" client. No good design without good clients. This is the trickiest. Also, very important to notice that there is a structural difference between traditional architecture and more experimental (involving new media) one. Traditional architecture is the product of a vertical system: the architect - pharaoh on top, with a ladder of people/slaves under him. New technologies imply a horizontal system. You have the architect, the software engineer, the electronic engineer, a couple of people with administrative/ financial background and so on. The system here is horizontal, completely different than the usual one. This implies a great deal of communication, dialogue, ability to negotiate, deal, and come to shared goals. Design as a highly social and communication-oriented (internally) activity.

--- *How do you comment on such digitally mediated experiences in your design approach?*

To me "user experience" means: a) We want to design something nice & relaxing, b) We ask 1000 people what they would like, c) Because of their answers we move to design. As a general, I do not believe in part "b", and I never do.

2. Nothing. I am a designer like someone else is a doctor, a taxi-driver or a shopkeeper. The world around asks for some of the things I am able to do, and I try to respond at my best. I do not see any mission or things to demonstrate. I like to work nicely, to make myself (and therefore other people) happy. Finally, my achievement is demonstration is mostly about myself. I like very much to experiment, to push forward, to see what's happen if... how to stretch things the most without breaking them.

--- What has inspired you to produce this kind of immersive environment?

"Tune-me" was designed by a group. It was Line Christiansen, myself, Stefano Testa. The inspiration came from: a) The brief from V&A (exhibition name: "touch me"), b) Line's final thesis at interaction Ivrea (I was her mentor): "re-lounge": http://www.interaction-ivrea.it/en/gallery/relounge/index.asp.

3. The types of interaction are not the cause they are the effect. When you work you have a set of given constraints. Financial, cultural, relational, and so on. You map them and upon such a map you try to define a design strategy. A key element is to sharply understand when do you need the new media and/or interactive tools, and when do you not. I do not see a clear split between new and traditional media. They are media. Technology is not high or low, is rather appropriate on inappropriate.

How to choose the specific types of interaction? Again, it is a matter of external constraints. How much time do we have? Do we have enough money to experiment this and that? Would the client understand? Would the people understand? Can we take a risk here or not? Is it better to develop something completely new, or it is rather an issue of fiddling with already existing solution? The (hypothetical) quality of what we do, it doesn't come out from a single project, but when you have them altogether. The "one shot" project, is generally bound to disaster. You have to take a mid-long term attitude.

--- In the "tune me" project there are a few feedbacks triggered by the tangible interface that users interact with to control lighting and sounds and vibration in the environment. Do you think interface design, especially tangible ones, is getting a bigger part in environment design?

Not necessarily. Mart Stam designed the prototype for a chair with metal pipe in the early 20's (of the last century). It took about 50, 60 years to get it as a mainstream product in our lives. The same goes for tangible interfaces. I do not think that they are getting a big thing in contemporary environmental design, still, the direction to go is that one. Let's say we do work thinking to the long term.

--- Using "Tune me" and some of your exhibition designs as example, is "user experience" a keyword of the designs?

Eventually yes, not in our case. "User experience" means to make a lot of studies about users before you actually design your new things. This I never do. I was trained as an architect, and traditionally in architecture there is not such a thing.

4. What do you see as the implications of the project within the greater design field?

I do understand I am working on some edges of the discipline. Quite nice, also with some attached difficulties. In each period you have people working on the traditional and well-established areas, and some other more keen on experimenting. What can be learned from them by designers or architects? Mmmhh.... not much I guess. These are things you don't teach and/or learn. Simply you do. My work is there. If you find it useful, take it and bridge it further... How can these ideas be taken further? Making them working for real in the everyday world. Till now, all the experiments with interactive space are experiment. Next step is to seed them into real life on a mass scale.

--- From your experience, what aspects in interactive design do you think are most important?

A very broad question. In this extent I do not think that interactive design is different than "traditional" design. You have a client, you have to design something worth the money he pays, eventually making him happy and moving on to next project. The interactive design, has to work, has to fulfil the promises you make to be technologically feasible, financially viable etc. But this is the same recipe you would use to do not-interactive design as well.

--- How do they influence traditional ways of design thinking?

Think to this. In the 1960's the only possible design was the industrial one. Of course, you could do crafts, still, given the period and the world around you, the main challenge was about "industrial" stuff. Nowadays we are in a similar condition. If the thing has a plug, therefore it will have some buttons (or some kind of interface)

If it has some buttons, then it is very important the way we interact to them... there we go... today, design implies "interactive design". Interactive design is design (and vice versa). I do not believe in a specific features of interactive design compared to traditional one. Nowadays "Bluetooth" is an advanced technology. 100 years ago, steel (or concrete) was an advanced technology. To make a chair out of a pipe of steel (by then) was a technological challenge. To make a lamp with a Wi-Fi system (now). It is a very similar challenge.

--- Since you're also a teacher in interactive design, what advise will you give architecture or design students if they would like to work on interactive spaces in the future?

To get a very strong knowledge on traditional design. Get your 5 years of traditional design school. Become an architect, a graphic designer, a product designer... learn the basics. Learn the masters, composition, structural engineering, mathematics, colour theory, all those very boring stuff. Then, once your backbone is very strong, then you are ready to inject new stuff into it. If you want to fly into the future, you must know perfectly the present and the past. If you only know about the future, you will surely crash into some thick walls.

5. This would be a nightmare not an ideal condition. To have no limitation, I die. I need limitation and constraints. I hook to limitation and constraints to develop the design process. Without them I froze. Mmmhh... I don't know... it would be lovely to have a commission from some kind of religious entity. To design a temple or a church or a cemetery using new technology, modifying the actual interaction... this would be nice. I am Christian by culture. I think that a church (or even more a cemetery) would be a stunning ground for experimental work. Because it would link the blink-blink universe (interaction based on tiny time bit) to the eternal. Average interaction goes something like: touch this, and immediately this other thing happen. That is fine. The whole process goes in a wink. Can we link this to the other end of the line? When I die, I am dead forever. The wink and the forever. This would be interesting.

Interview with Ruairi Glynn

1. Well my background is littered with various attempts to find the medium I most enjoyed working in creatively. At the same time I have been trying to use materials that reflect the world around us. I started to explore my interests using digital multimedia but realized that the most interesting application of digital interfaces was physical space rather than just on screen. My approach is to work both virtually and physically on the same project. In other words prototype possible interactions of the built installation using software and basic inputs devices like keyboard, mouse etc. At the same time I work on finding materials and learning how to use them effectively. It all starts to fall into place and the eventual physical construct is always a compromise between my imagined ideas and the realities of the materials and technologies available within my budget. I always begin by reading a great deal. I usually get inspired by something and then I read around the subject and then focus in on what really captures my imagination. Sometimes looking at a site and working up from there can be a useful exercise rather than always looking at an installation as just a space in a gallery context. With Reciprocal Space I looked into the writings of Stephen Perrella, Kas Oosterhuis, dECOi, NOX and Neil Spiller. I'm very lucky to have Neil as tutor of mine now at the Bartlett.

2. What is most interesting for me is how we can start to communicate with our built environment through exchanges of simple gestures to build up a history of interactions that generate new possibilities, new goals and new shared outcomes. My installation, 'Reciprocal Space' explored these ideas by creating a dance like performance between the inhabitants and the boundaries of the installation. I hope to achieve with this project, an understanding of the principles of physical computing and the practicalities of building on an architectural scale. Up till that point I had never built anything so big.

3. Interaction as I explain above is a series of exchanges and I believe the design process of interactions should be the same, working in a 'bottom up' design approach. I obviously have my pre-conceived ideas of how I imagine the interactions will be played out but I usually find that the most interesting ideas come once you begin to exchange interactions with the installation and you mutually develop the final behaviours with the system itself.

4. Well for a start, I don't believe that our houses will ever morph and change shape as much as I suggest in the installation. However in tightly packed cities like Hong Kong where whole families occupy small housing units in large apartment blocks, the ideas of living spaces that are in constant reconfiguration from bedroom, to kitchen, to living room to office is nothing new. What some of interactive architects are exploring are the ideas that our environment could begin to spatially transform and optimize its efficiency in response to human needs in ways that as yet we cannot imagine. I was more interested in expressing the idea that architecture is becoming increasingly fluid and responsive and that our environment is becoming more in aware of our physical and emotional needs. The idea of creating a dance like performance examines how we see architecture as a servant to our needs and perhaps how a responsive architecture could become more of a mutual player to us in the built environment. In terms of taking things further I have explored how to build these transformable surfaces into more flexible constructs such as my Angels project where if architecture was lighter than air, it could reconstruct itself to infinite differing conditions. Reciprocal Space was always limited to the fact that it had a fix frame behind it. I'd like to imagine transformable architecture being able to move around not just move on the spot.

5. Good question :) I have no idea, but I'd like to work with more engineers and dancers. I enjoy their fascination with precision and creativity. I think they are both important contributors to the future of interactive architecture.

Interview with Andrew Shoben

1. We want to create art that encourages people to play with their environment, to unlock a magical experience that only exists with their interaction. In essence to transform the viewer into a catalyst for a unique creative experience and challenge their perception of a public space. Our aim has always been to create installations that articulate these spaces, allowing some form of self-expression in areas of the city that people see every day but normally exclude and ignore. By establishing special intimacies through the unexpected, magical, articulation of the objects installed in these spaces, we want to 'short circuit' both the environmental and social expectations supplied by the surrounding urban environment. We create spaces that offer the passers by an opportunity to join an unexpected 'community of presence', initiating an intimate communication which often leads to a personalization of the environment.

2. The Layer is simply an "art system" that articulates transit spaces through a series of contact sculptures. Sound is a powerfully evocative medium and we wanted to create a heightened sensory

environment that encouraged people to navigate their way through a particular part in the city using sound rather than sight. We wanted to illustrate that you did not need to alter the look of a place, to transform people's experience of their surrounding environment. Public art is often a static imposition into people's environment, "the bronze man on a horse" for example is set at both a physical and psychological distance from the public who are meant to engage with it. We wanted to create public art that responded to and reflected the diversity of life living in and passing through a particular space, empowering them with a key to unlock a unique creative experience.

3. The Layer was born directly from this desire. We had been experimenting with different ways to articulate these transit spaces, from purely analogue methods of sound capture and distortion, to more complex means of digesting movement and form. "The Layer" translates people's passage through a space into a unique, rich, sound environment based on their speed and gait. We developed the art system further to allow for both a wider range of inputs to be used, such as colour and shape as well as a large range of expressive outputs, such as light and generative display. Essentially it is the legibility of the installation to a broad public that remains paramount to us.

We are never bound to any particular form of interaction. Our ideas always stem from the same desire to transform the city into an unexpected playground full of illusion, intrigue and surprises. Although technology plays an important role in our work it does not drive how we conceive any interactive experience. The idea always comes first and we then have to find the technology to realize it. In this way we differ from many new media artists and designers who often find inspiration in emerging technologies. Our inspiration always comes from the City.

4. I guess The Layer illustrates that art can be embedded into the fabric of a building – in its walls, floors, furniture etc. – rather than sit alongside it as a static object. Traditionally art has been allocated a specific location within a building and limited to a visual experience. We hope that our work challenges this convention and offers an alternative understanding of the role of art in a specific environment, unleashing art from lobbies and boardrooms to roam free in a building without altering the look of a building. We want to challenge many people's preconceptions about the esoteric nature of a lot of contemporary art by rooting our installations in their own, familiar, lexicon of experience. In many ways we want to democratize the creative experience and open it up to wider audience.

We hope that designers and architects will embrace our desire to see art as an integral part how people understand and experience their surroundings rather than a decorative add on.

5. (The designer did not answer this question.)

Interview with Daan Roosegaarde

1. I was trained as a sculptor at the academy of Fine Arts. During this period I made sculptures such as "22beds". What disturbed me that the whole process of making was completely dynamic; the reading, the drawing, the building, getting the materials but somehow in the end the sculpture would not be able to incorporate this process. It would be finished; as wind in a glass bottle which is not wind anymore. Therefore I started to work on the series Liquid spaces in which form would never be finished; always on the way with new input of the visitor.

2. Wind 3.0 is the sensual sister of 4D-Pixel; a human-machine interface which reacts to the sounds and motion of the visitors. The idea is to define an architecture which is not a sum of doors, walls and windows but, in this case, exist out of hundreds of fibres which move along with you. By reacting to human behaviour the work becomes an extension of our skin.

3. We always try to work with different types of interaction since human behaviour is one of the most varied things present. So for example we always work with several moods. When someone enters near the work it will give a signal so you know it is there, when you give a loud signal the work will echo this but if you keep on doing this the work will start to ignore it. It is the idea of a conversation in which you say something and I say something and together you build up a story. All sculptures are wild, electronic animals which sometimes can be quite dangerous (liquid 2.0) or more sensual (such as Dune 4.0) but in the end should be this all-in-one.

The more intelligent the system is behind it (via software, electronics, mechanism) the more the work will be capable of handling several inputs at the same time and therefore become more sensual, more adaptive and more dangerous.

4. Well, it is based on a fundamental difference that design is not based on a single brilliant idea of an designer but that form or space is generated via input from its visitors. There will always be the role of the designer/architect as a mediator but at the same time there is an undefined area in which new forms of communication can occur (during the process of making with software engineers, material producers but also when it is "finished" with its inhabitants). So it is time to let go of the hierarchical model and dive into the wide world (of technology) and see where it takes us!

5. I have stopped believing in making objects and started to believe in landscapes. Creating landscapes is something amazing since you can really surrender to it since it is so much larger than yourself. A sculpture such as Dune 4.0 has this capacity in which, when you walk through it, you make the landscape but the landscape also makes you. This dialogue will be put into a next step when implemented or infiltrated into existing public space and architecture. The context would give it its final 'sense'; reacting and interacting to the people differently in the morning as in the evening. It would be great to do something with a music or cinema centre somewhere in L.A. or Mumbai where people are accustomed to dynamics. So if I would have endless budgets I would probably do the same time as I am doing now but it would speed things up into a next mode of working.

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