UBIQUITOUS COMPUTING AND ARCHITECTURE (6B)

INTERACTIVE SPACE: SEARCHING FOR A DUAL PHYSICAL - VIRTUAL WORLD

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Abstract. This paper discusses embodied interaction followed by a survey of examples in installation art and research projects that attempt to fuse physical space and digital technology. From studying the examples, we propose a categorization of types for a better understanding of interactive spaces. Design attributes are also identified from the examples. We hope this will be useful to designers in designing engaging interactive spaces.

Keywords. Architecture, interactive space, embodied interaction, human computer interaction, virtual space.

1. Introduction

The last few years saw a distinct escalation of mass development in interactive digital media, portable gadgets, communication devices, network and online sharing that encouraged the growth of many virtual communities. People are consuming more and more smart technologies. Various online media (i.e. Twitter, Wikis, Blogs, Chat rooms, forums, Auctions etc) are becoming ever-greater knowledge sharing and social networking resources.

The popularity of online communities such as 'Second Life' or 'Face Book' is an indicator of the shift of the masses to the virtual world. This affection of digital culture is provoking users to be disinterested towards the real world. A lack of the full range and breath of interaction with the environment can lead to psychological and pathological disabilities (Grusser et al, 2006). The phenomenon known as 'Hikkiomori' or 'social withdrawal syndrome' is one such indication in recent years among male gamers in Japan who spend majority of their time at home shutting off interaction with the outer physical world (Jones, 2006).

Creating embodied interaction in physical spaces imbued with digital technologies can be a way to draw the digital culture crowd back to physical built environment. Such a space, which we term interactive space, is a blend between physical and virtual space. How do we approach the design of such spaces? There are very few built architecture examples and little literature on typology or framework of interactive spaces. But there are many experimental art installations that give us clues to how we can approach the design of interactive spaces in architecture design. From studying the examples, this paper attempts to categorise interactive spaces and to understand its associated design attributes for a meaningful interactive space. Our definition of interactive spaces excludes smart spaces that deal with human comfort by changing physiological conditions of the environment. Section 1 discusses concept of interactive space and embodied interaction. Section 2 includes a description of the case studies, a proposed categorization of interactive spaces and the design attributes that are found in the case studies, followed by conclusion in section 3.

1.1. ARCHITECTURE AND THE CONCEPT OF 'INTERACTIVE SPACE'

Architecture is the art and science of the built environment. It is an act of creation through material understanding and representing the establishment of a cultural order. It is a social product, a mimesis of society's intentions and etiquette; thus it reflects what a society holds important. Architecture is about permanence and materiality while digital culture is virtual, dynamic, real time and transient. But there often prevails some unwillingness in architecture to accept digital culture, which possibly can lead towards replacing material by the virtual. These fears of replacement are however misplaced as digital culture is not engaged in assaulting the essence of materiality. Rather, interaction design reinforces materiality and becomes a defence of architecture (McCullough 2004, p63).

Digital technology promises the possibility of transforming space and modes of representations to meet changing needs and desires. Architecture by rejecting digital culture misses out the potentials of this new tool to renew and reinvent itself. According to Bullivant (2005, p5) architecture in the information age faces two challenges: the need to reconcile materiality with the image and practices of a digital culture; and overcoming the limitations of the built environment through flexible digital technologies.

New evolving design technology promises the possibility of transforming space and modes of representations to meet changing needs and desires. So now designers are thinking about 'fusion' of digital media with physical space. Pervasive computing as a catalyst emphasizes interactive media and network technologies as key ingredients to design of a dynamic 'third space' or 'interactive space', which mediates between the immaterial and the material.

According to McCullough (2004, p154) architecture and interaction design can overlap and escalate social consequences. He described it as 'operable inability' systems where two disciplines converge on the design and shift from foreground object to background experiences. Among some other technical issue McCullough (2004) mentioned certain properties of such spaces: *(i) User-centric:* physically situated and support user's intention, actions and etiquettes (p 101). *(ii) Participative:* should support multi-user participation for richer experience (p101) and *(iii) Transformative:* Open systems for extensible places and this extensibility must be casual and learning, nor burden the user with technology (p114).

This attitude of design thinking thus reflects a 'paradigm shift' from building virtual worlds towards embedding information technology into the ambient social complexities of the physical world. This shift poses advantages in making technology more intuitive by means of embodiment; although it inherits unwanted annoyances such as extra surveillance.

1.2. WHY EMBODIMENT?

Dourish (2001) coined the term 'embodied interaction' which, refers to interaction with computer systems that inhabit our world – a world of physical and social reality – and that exploit this inhabitation in a way they interact with us. Based on a platform of phenomenology, he defines embodied interaction with artefacts and places at the intersection of tangible interfaces and social computing. So, embodiment plays a key role of designing interaction as user's response to the environment, their engagement and understanding of the space and enjoyment depends on it.

"For much as the body imposes a schema on space, architecture imposes a schema on the body" - Tuan, Y. (1977). The proportions, image and embellishments of the body are reflected in the proportions, image and embellishments of the buildings. Both of the disciplines of architecture and interaction design address how context shapes actions. Architecture frames intentions while interactivity primarily connect those mental states to available opportunities for participation (McCullough, 2004).

According to Dourish (2001, p126) embodiment is the property of our engagement with the world that allows us to make it meaningful and embodied interaction is the creation, manipulation and sharing of meaning through engaged interaction with artefacts. For a successful embodied interaction Dourish suggested three common elements. *Participative:* Embodiment is a participative status, a way of being, rather than a physical property. *Task accomplishing:* Embodiment directed toward the accomplishment of practical tasks. *Practical Action:* Embodiment as a source for intentionality, rather than as the object of it.

2. Case Studies

"We experience buildings not as objects but as boundaries of space" – Day (2004). Today many designers are adopting new technologies as means to create smarter and smoother environments. Few are trying to enhance the experience of space for people. Through specialized moments, stating narratives and event designs, architects can directly influence the emotional state of users through participatory acts (see references for related websites).

(a) Dune 4.0 (2006-07): Dune 4.0 (figure 01) by Daan Roosegaarde, an interactive landscape that changes its appearance based on human presence.

(b) UVA (2006-07) (figure 02): In this LED grid of 46 columns, each plays its own piece of music, the notes generate changing colours in real time according to human presence.

Figure 01. Dune 4.0
(Source: http://www.studioroosegaarde.nl/
work_html.php?id=3: May 2008)

Figure 02. UVA, volume
(Source: http://www.polaine.com/
bauhaus/wp-content/uploads/2006/12/
volume17.jpg: May 2008)

(c) Mirrorscape (2003): Enabling remote participants to look into each other's eyes, the work has a screen and mini camera at its centre. This setup is repeated in a second installation, so people who look into the mirror can communicate with each other (Bullivant, 2007).

(d) Antenna Design (2004): Based on a 'hub' and 'spokes' system that visually embodies the notion of a tree-like gathering place. The information system is an open platform with an interactive map allowing for community participation, with an LED column serving as a public announcement screen (Bullivant, 2007).

(e) Hole in the Earth (2004): Hole in the Earth linked the Netherlands, with Indonesia by creating a video 'hole' in the planet through which people could see and hear each other in real time (Bullivant, 2007).

(f) Tactical Sound Garden Toolkit (2006): Open source software platform to cultivate public "sound gardens" in contemporary cities (Bullivant, 2007).

(g). RemoteHome (2003): Two spaces in London and Berlin were designed with matching elements, to relay tactile, evocative communication between the two via furniture and wall surfaces (Bullivant, 2005).

(h) Meta L Hyttan (2002): By re-animating the steel industry hall using site-specific interactive media the historic blast furnaces in Avesta is being transformed into an interactive environment for visitors to learn and experience history, science and art (Bullivant, 2006).

(i) EnterActive Carpet (2006): A luminous field of red LED lights embedded into the entry walkway at the Met Lofts apartment building, Los Angeles; responds to the moves of visitors. When triggered, the impact is mirrored on an eight-story grid of LED panels on the building facade.

(j). The KidsROOM (1996): A fully automated and interactive narrative play-space for children developed at the MIT Media Laboratory.

Figure 03. The KidsROOM
(Source: http://www.research.ibm.com/
people/p/pinhanez/cp_medialab.htm:
June 2008)

Figure 04. The Intelligent Stage
(Source: http://people.brunel.ac.uk/
dap/dai.html: May 2008)

(k) Blur Building (2002): This project by Diller and Scofidio is an architecture of atmosphere. Water is pumped from the lake, filtered, and shot as a fine mist through 31,500 high-pressure mist nozzles. A smart weather system reads shifting climactic conditions of temperature, humidity, wind speed and direction, and regulates water pressure.

(l) The intelligent stage: Dance and the digitally mediated environment are combined to explore new means of communicating immaterial concepts through audiovisual displays (figure 04).

(m) BlogWall: Extends the short message service (SMS) to a new level of self-expression and public communication by combining art and poetry.

(n) Age Invaders: A novel social physical game which allows the elderly to play harmoniously together with their grandchildren in physical space, while parents can participate in the game play in real time through the internet from their workplace.
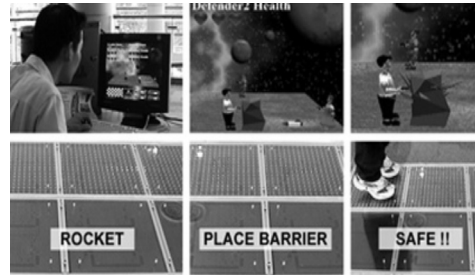
Figure 05. BlogWall
(Source: http://www.mixedreality.
nus.edu.sg: May 2008)

Figure 06. Age Invaders
(Source: http://www.mixedreality.
nus.edu.sg: May 2008)

(o) The AmbientROOM (1996): A Tangible Bits platform which explores the use of ambient media as a means of communicating information at the periphery of human perception (Wisneski and Ishii, 1998).

(p) The Saltwater/Freshwater Pavilion (1994-97): Conceived by NOX, it joins together physical and digital spaces to create a topological space of emergence, liquid architecture. The central idea of the projects was to establish an interaction with the users as though the building was alive.
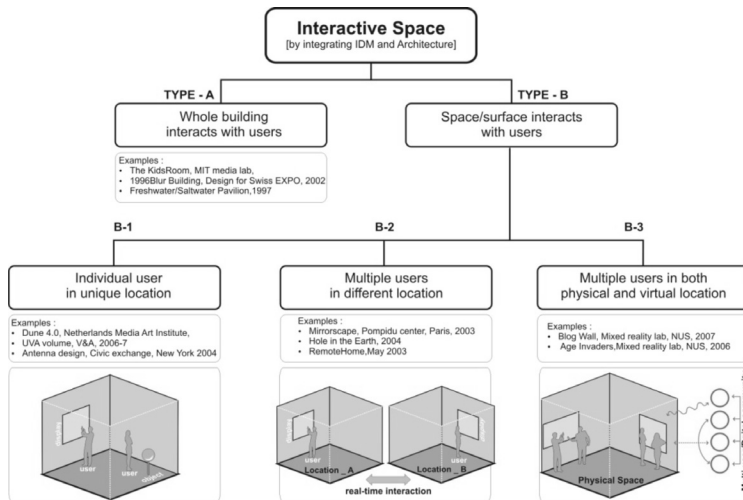
2.1. DEFINING TYPOLOGIES

Figure 07. Typologies found from the cases.

Our study shows that attempts at making interactive architectural space by

means of integrating digital media/installation can be categorized into certain typology (figure 07). We propose two basic typologies: Type A: Whole space interacts with users and responses; Type B: Partial space/art installation that interacts with users situated in architectural space.

Again from the point of interaction with user; the second category (type B) may also have three sub-categories: Partial space/art installation that interacts with individual user within or around the space (B1); Partial space/art installation that interacts (synchronous or asynchronous) with different user in different physical location and enables the different users to interact with each other in real-time (B2); Partial space/art installation that interacts with users located in both physical and virtual space (in virtual community) and enables the different users in different spaces to interact with each other (B3). This is explained in the above diagram.

2.2. COMMON DESIGN ATTRIBUTES FOUND

The need to connect architecture and interaction design comes from overlapping subject matters and escalating social consequences. The path toward this connection involves a shift from foreground object to background experiences – thus developing embodied interaction through creation, manipulation and sharing meanings. Although, Dourish (2001, p9) has defined three components - participation, task accomplishing and practical action as the basis of an embodied environment, we have also identified some other attributes from the cases (explained in Table 1).

(a) Participative/ Agency: 'Agency' refers to the degree of which we are able to interact in a meaningful way with our environment. Thus the more meaningful the interactions and the more involvement within a context, the higher the interactivity is. All cases are found to have some inherent characteristics of participative manner depended upon user agency. However, high interactivity does not always mean a higher proportion of meaningful interactions; rather the criterion for successful interactivity is depended upon the level of desire by which the individual wishes to interact.

(b) Task accomplishing: Although most cases are not task based, some environments like KidsRoom, Meta L. Hyttan and Age Invaders are designed with built-in objective of task accomplishing narrative. User gets new experiences while accomplishing certain task and advance to new level.

(c) Practical Action: Engagement with such interactive environment must pose some practical action to have meaningful real-time interaction. Environment creates embodied interaction by creating, manipulating and sharing-meaning through engaged interaction with artefacts. All case studies

TABLE 1. Common attributes/design strategies used in different case projects.

Typology	Project title	Defined by Dourish			Other common design attributes						
		Participative/ agency	Task accomplishing	Practical action	Desired context	New experience	Embodied learning	Transformative	Visual Identity	Interface	Shared experience
A	KidsRoom		√	√	√	√	√	√	√	√	
A	Salt/Fresh water pavilion	√		√	√	√		√	√	√	
A	Intelligent Stage	√		√	√	√	√	√	√	√	
A	Ambient ROOM	√		√	√	√		√		√	
A	Blur Building	√		√		√		√	√	√	√
B1	Dune 4.0	√		√	√	√		√	√	√	
B1	UVA volume	√		√	√	√		√	√		
B1	Antenna Design	√		√	√	√	√	√		√	√
B1	EnterActive Carpet	√		√	√	√		√		√	
B1	Meta.L. Hyttan	√	√	√	√	√	√	√	√		
B2	Hole in the Earth	√	√	√	√	√				√	√
B2	Remote Home	√		√	√	√		√		√	√
B2	Mirrorspace	√		√	√	√		√	√	√	√
B2	Tactical Sound garden	√		√	√	√			√		√
B3	Blog Wall	√	√	√		√		√		√	√
B3	Age Invaders	√	√	√	√	√	√	√		√	√

have practical action based on user response either in an implicit or explicit manner. It seems that user finds meaningful experience and enlivens sate of awareness through practical action.

(d) Desired context: Context is a major issue in designing interactive environment. Context provides the basis of interactivity. Like in KidsRoom, elements of a child's room are included within the augmented reality as agents, in Blur building within the misty environment users interact in a different way by tracking the colour of the coat. In addition context also determines the degree of interactivity which is desirable.

(e) New Experience: New experience makes people more interested about the environment, enrich engagement and interaction. New experience provokes delight and highlighted states of awareness too. However, delight is dependent on the creativity that is injected within the experience. Like KidsRoom or Interactive stage, users experience a mediated non-physical immersion that is quite different from the daily life or daily experience. Sometimes, even when old technology (video conferencing) is presented in a new way (e.g. 'Hole in the earth'), there is the same objective of assuring new experience.

(f) Embodied Learning: Interactive design affirms the need for embodiment. Study shows that, some cases like Meta L Hyttan, Intelligent stage, KidsRoom etc. are designed intentionally for embodied learning to take place – especially where experiences are based on accomplishing a task. However, most of the cases are developed for pleasure or excitement rather than task-based learning.

(g) Transformative Space/Element: The case studies show that for new experience through agency, transformation is essential. Transformation can take place through/within form, space, shape, colour, sound or even motion. Examples like Dune 4.0, UVA volume, Enteractive carpets etc all are designed to respond user's movement through transformative elements.

(h) Visual Identity: Visual identity is mainly understood in terms of cognition. As computing becomes pervasive, the identity of either user or systems goes beyond the appearance of screens. New forms of ambient, haptic and multiuser interfaces promote a shift from objects to experiences. Most of the projects are designed for universal user and instead of emphasizing the visual identity of an object – importance was given to the process of identifying with an experience. Meta L Hyttan is designed in such way to give user an environment to learn and experience - history, science and art through exploring the space. Remote home on the other hand provide a communicative mediated environment through interactive furniture, wall surface etc for different users located in different space.

(i) Interface: Interface is the most important part for bridging the user with the environment. Interactive environments are found to be smart and reconfigurable. The design of such smart systems in interactive environments is likely to be event driven, motion sensitive, decentralized and senses the activity. Like Dune 4.0, UVA, Interactive stage, Ambient Room, Enteractive carpet, Water pavilion, etc are all embedded with hidden sensors to provide uninterrupted interaction with users.

(j) Shared experience: Interactive technologies can be both private and social. In the public sphere, interactive technologies can serve as social capital to energize the urban scene through the creation of shared meanings and representations e.g. Blog wall or Tactical sound garden is built within this concept of shared common interest. As in Antenna design, interactive environments can create meaningful dialogues within the urban context by creating situations that can serve as meaningful places for socialization.

3. Conclusion

As interactive space in architecture is a relatively new area with little literature on framework and classification, this paper attempts to categorise interactive

space by reviewing case studies and identifying some common design attributes. We did not find any set of attributes associated with a particular typology; common design attributes are not exhaustive. More research with a larger sample size of case studies is required to see if certain design attributes are essential for each typology. We hope this paper has contributed to understanding interactive spaces and offers designers a palette of design attributes to inspire them when designing interactive spaces.

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BlogWall: http://www.mixedreality.nus.edu.sg: May 2008

Age Invaders: http://www.mixedreality.nus.edu.sg: May 2008

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