TOUCHING THE UNTOUCHABLES: VIRTUAL-, AUGMENTED- AND REALITY

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Abstract. This paper brings forth an overview of design and interaction within realms stretching from reality to virtuality. In recent years, architects have been exploring creative technologies and potentials using a variety of interfaces ranging from real and virtual to augmented reality (AR) and mixed reality (MR) media. The process of design and method of communication are becoming increasingly imperative for inter-disciplinary work. This highlights the need for a structured review of successful effective adoptions and settings of those realms and technologies. This paper critically reflects on lessons learned from architectural design research, which employ virtual, augmented, mixed and real environments, and address rising issues in these areas.

Keywords. Reality; Mixed Reality; Augmented Reality; Virtual Reality; Design Conversing.

1. Introduction

Architects use a variety of tools to bridge the rift between the imagination of a design and its representation–linking communication and realisation. Each tool places different demands on the designer, and each introduces reinterpretations of the design idea through inherent characteristics and affordances, thus imposing a divergence between the idea and its expression. In this paper, we present research findings in design and interaction within realms reaching from reality to virtuality. In recent years, architects have been exploring creative potentials and technologies using a variety of interfaces that range from real and virtual to augmented and mixed media. Design and its communication occur increasingly in multiple domains (Schnabel, 2005). This highlights the need for a structured review addressing effective adoption and settings of those realms and technologies. This paper critically reflects on lessons learned

from architectural design research that employ virtual, augmented, mixed and real environments and put forward research issues arisen from the study.

The exploration of the relationship between human beings, the natural and the artificial world and the subsequent implication on interaction has deep roots in philosophy. Husserl and Gibson (1931) describe the connection of reality and action with the terms 'noesis' (consciousness about an object) and 'noemata' (direction in which a conscious observation is made). Schutz (1967) developed this notion further by investigating the social components. Later, Gibson (1979) introduced the term of 'affordance' which includes the social and physical implications of objects and their relationship to us. Norman (1988) combined the theory of affordances with concepts of cognition and further categorises affordances into the 'actual' and 'perceived'. All these theories have in common the fact that there is an intangible connection between real and virtual objects.

Depending on their definitions of real and virtual, architects establish a relationship with the environments in which the design is created and communicated. With this relationship, consciousness establishes a sense of (mixed) presence. From an architect's perspective, the connection between the real and the virtual is a natural one, as the development of a design includes thinking in virtual realms about real objects. The perceivable complexity of the social, emotional and sensorial richness can then be exposed (Seichter, 2005). Subsequently the paper reviews recent design experiences that transform an idea from virtual to real environments and back (Wang and Dunston, 2003). The paper shows how reality is expanded into new dimensions without being duplicated, while the various forms of virtuality become their own reality complimenting physical realms in its own right.

2. Virtual Environments

Virtual Environments (VE) were originally embraced by architects for design concept presentations. As computing advances, increasingly sophisticated interaction and design possibilities are needed and supported (Hendrickson and Rehak 1993). According to Maze (2002) however, VEs are seldom used for creation, development, form-finding and collaboration of architectural design. Likewise Immersive-VE (IVE), which enables active and real-time interactions with design, has not yet been used widely in the design process. Schnabel and Kvan (2002) report that IVE offers new opportunities and solutions to architectural design problems through involvement in a three-dimensional (3D) medium. They argue that via employment of VE to envision and realize ideas, the architect is challenged to deal with perception of solid and void, and navigation and function, without translations to and from two-dimensional (2D) media. Furthermore, they suggest that VE empowers designers to express, explore and convey their imagination with greater ease. For these reasons, the very different nature of VE allows architects to create designs that reflect the three-dimensionality of architectural design to a greater precision than 2D realms. Virtual Reality (VR) is a constructive tool which supports the design and communication process (Davidson and Campbell, 1997). Compared to conventional computer-aided design (CAD), designing within IVE does not present itself with the typical lack of collaboration and communication as noted by Kvan et al. (2000). The exploration of space, volume and location is enhanced and site-specific problems are not only better recognized, but possibilities are also better investigated, both of which a normal design process cannot offer (Campbell and Wells, 1994). Users of IVE can change their viewpoints and escape gravity, all the time remaining 'inside' the model without having to translate scales or dimensionalities. Designers prefer to work three-dimensionally because every creation within IVE is a place experienced directly through movement and interaction parallel to real world familiarity.

The research findings of a design studio held in an IVE show that this realm produce different architectural expressions and exploration of form and gestalt from those explored with 2D tools (Schnabel, 2004). The design proposals illustrated that the 3D space is explored

and used extensively in order to create innovative schemes. This proves that designers can successfully use the medium to create and communicate architectural structures within a normal studio setting. Thus, the process of collaboration and design is enhanced and communication between designers is more focused on the subject itself.

In his research Schnabel demonstrated that employing VE as medium for the design process it enhances the designer's perception and understanding of 3D form, volumes and space. This is true not only for purposes of presentation or simulation, but also for the different stages of the design process itself. From the results, it was also identified that a direct translation of information from VE into other real media is potentially problematic. However, similar to the conclusions of Yip (2001), re-representation and translation into other realms actually contribute to the quality of the overall design process.

A VE offers designers an instrument that allows conceptualization of design ideas in a finer way, whereby digital 3D models are generated with immediacy similar to physical models, constructed to improve the perception of designs developed by drawings. VE provides through its involvement an immediate feedback to its users, which is not possible within CAD or traditional design media. Subsequently, architects can negotiate their own design despite the technology used and the abstractness of VE. The process of design converses the idea and the design intention closer to a normal interaction with 3D media, and in that sense it relates to a 'human' interaction.

Schnabel and Kvan (2002) also point out that despite the advantages of VE, a re-representation within other media–or a mixing of realms–will lead to deeper understanding of spatial design. Hence, a Mixed Reality (MR) will intersect properties of real and virtual realms and allow designers to interact within this MR to create, explore and communicate their designs.

3. Tangible Augmented Environments

The current generation of architects are able to generate renderings of a crowded space or animations filled with the lurking twitter of birds at their fingertips. The question is whether these multimedia enrichments cater to the purpose of the design process or the final product.

2D graphical user interfaces offer functions accessible in a number of ways, such as command-lines, menus and toolbars. Legacy modes of access are retained, accumulating redundancy and subsequently compounding into ever-steeper learning curves for the user. The designer and the designed object are separated by interfaces loaded with visual metaphors of real objects. However, the actions do not follow these visual or otherwise perceptive implications. An essential attribute of design – tangibility – has been detached in favour of more flexibility and interpretation by the user. Furthermore, the physical quality of touch makes tangible interfaces more suited to a participatory experience.

Tangibility in this section refers not only to the sensation of touch, but the whole concept of direct access and manipulation guided by the sensation of touch, weight and collision. In order to achieve awareness of an object, the senses must be able to create a plausible mental image. Focillon, a French art theorist and historian, argued that tangibility is an essential attribute to give cues about space and matter (1989). Though these attributes can be simulated, it can inflict a loss of perceived plausibility. This trade-off has moved design towards a more intellectualised discipline of product and process (Dewey, 1938). With Augmented Reality (AR) and tangible interfaces in particular, this disparity might be reunited to a new meaning. As a sub-mode of MR based on the definitions by Milgram and Colquhoun (1999), AR can add virtual elements into the physical real world, which can be associated with tangible interfaces and provide great benefits in architecture and urban design (Seichter and Schnabel

2005). Thus, the real elements in AR could potentially place certain constraints on the shared imagination. Major advantages of AR include ease of collaboration, intuitive interaction, integration of digital information, and mobile computing.

AR can also provide an alternative medium that allows groups of people to share the same work and communications space (Wang 2005). The desired benefit would be a reduction in time and cost. Developing computer support for the collaborative team in architecture and construction industries means creating systems that amplify the effectiveness of the collaboration team as a whole. Wang (2005) developed a tangible AR prototype for solving issues involved in architecture and construction industries. This prototype was applied into two scenarios: face-to-face conferencing and remote space conferencing via network.

The seamless blend of real and virtual objects facilitates collaboration between the partners, who can each see the same spatially aligned 3D virtual model but can control their own individual viewpoints independently through their head mounted displays. Social roles are well supported as coordinators may locate themselves in central positions around the table.

Virtual space conferencing is based on the notion of a shared workspace, a joint storage facility that may contain various objects such as 3D virtual models, 2D CAD drawings, databases, etc. Each member can not only have individual view, but also a common view, in which discussion can proceed without further orientation/location confusion. This allows one to view and fully-interact with all members of the group and to be aware of each others' relevant activities, increasing the sense of reality for the virtual collaboration in the shared workspace.

Wang (2005) investigated how AR can change or enhance the traditional nature of work. He studied the efficiency improvement for review collaboration gained from the enhanced and augmented cognitive and collaborative activities involved. His findings were similar to the ones of an IVE. This suggests that designing in MR enhances the understanding of space and improves the design decision making and performing spatial task compared to a paper based, 2D realm. Users working in the MR (or IVE for that matter) environment engaged in a deeper discussion about design and engaged in more intense collaboration than in a conventional face-to-face environment. This outcome correlates to Kvan et al's (2003) findings. A design environment that employs a text-based communication or a MR, VE or IVE is superior to conventional design realms. Conversing with a design using an AR allows the designer to interact with spatial issues that relate directly to reality, but at the same time include additional new design elements. An interplay of realms ranging from reality to virtuality leads to a deeper involvement with an enhanced conversation with the design.

4. Mixed Environments

MR, applied in visualization and entertainment, is attracting more attention for collaborative work. Examples of applications have included collaborative web space (Billinghurst and Kato 1999) and scientific visualization (Schmalstieg et al. 1998), etc. MR can provide an alternative medium that allows groups of people to share the same work and communication space.

Developing computer support for collaborative teams in architecture means creating systems that can amplify the effectiveness of the collaboration team as a whole. By merging a range of digital and physical media, the architectural design process can be enriched by different perceptions, comprehensions, and conceptions of spatial volumes within both physical and virtual environments. The use of pure digital media predominantly confines the creative design process to only the digital realm; yet designers need more freedom to move smoothly back and forth between digital to physical realms using digital and physical tools in both conventional and unorthodox ways. The variety of different media transformed the design process from a tangible portrayal of architectural design to a virtual portrayal, and vice versa. As a result of interchanging and crossing-over ranges of design environments from reality to vitality, the limits of each are dismantled, and both realms can be linked together into an overall process

leading to alternative form findings and resulting designs – following the tradition of artists who push media to explore new interpretations in application and artwork.

As Seichter (2007) reported in his research of AR in urban design, the differences between AR-interfaces have implications for the integration of this technology in a praxis relevant design work flow relating to a perceived object presence, performance measures, perceived performance and variations in the communication patterns. His findings reveal that using an AR system, designers gain a more complex understanding of relationships of their design and are engaged in a richer communication with their partners about their design proposals. AR contributes to urban design in an innovative approach thus enabling new forms of design expressions. He also argues that new opportunities arise for architectural design as by utilizing digital instruments to reconnect to the designer's original idea. The sharing of ideas is related to the perceivable and tangible existence of design items as well as the sensation of applying them. Therefore, the application of AR and MR in a design setting contributes to digital and tangible sensation within the architectural design context. As Schnabel (2005) reports a diversified, open-ended, and critical approach of architectural design that mixes and interplays with a variety of media and realms communicates and converses with innovative new spatial solutions.

5. Summary

This paper reviewed the current status of architectural design within MR and VR. A next step is to establish a framework and taxonomies that allow these new design realms to become standard for further research and application. Subsequently this review helps to classify and draw conclusions about the effect these realms have on the design development and outcomes.

It has been found that MRs and VEs are effective instruments in conversing with design and communication processes (Davidson and Campbell, 1996), establishing co-presence in both realms for a shared experience in spatial interaction. Design studios not employing the full potential of IVEs or MRs have exhibited a lack of collaboration and communication (Kvan et al., 2000), and hence do not effectively communicate the deign intentions. Digital 3D models are generated with an immediacy similar to physical models, and constructed to improve the perception of designs developed by drawings. Thus through its involvement, MRs and VEs provide immediate feedback to its users, which is otherwise impossible within CAD or traditional design media. Designers can therefore interact with their design three-dimensionally as each and every object within the AR and VR is experienced through movement and interaction. This possibility offers a different method for designers to 'converse' with their design, and spatial issues are addressed in a manner akin to the real world.

However, it appears not to be as simple as merely placing a designer in a VE, augmented environment or any other MR environment. The technology itself will require further investigation. Assumptions about what works and what does not work need to be challenged. A large body of research in AR is dealing with issues of usability, however, mostly only in a constrained lab environment. Architectural design provides a natural test bed for MR and AR technologies and the application and usability needs to be evaluated on a case by case basis. Technology issues such as usability, interface, and navigation have to be further developed to reach the same ease of use and familiarity as any alternative two dimensional media. Problems with the working environment clearly limit what the designers can do. In particular, clumsiness of gesturing and limited field of vision constrains the way we use those realms. The presentation format of digital information can be dictated by the features of workspaces.

This paper highlighted the possibilities of a new generation of interaction possibilities. Tangibility and, in turn, transparent access across users in remote or local settings seem to have the largest impact on effectiveness for collaborative designing using the aid of digital media. This ongoing effort will lead to an evaluation of the effectiveness of tangible interfaces in a design studio setting.

The above review of current MR and VE design realms show the advantages these media have over other design environments. However, compared to conventional design methods, AR and VR are still in its infancy. It is in the early as well as in the final stages that architectural design can embrace the use of these realms as an opportunity to converse with designs in novel ways. The potentials go beyond visualisation and drafting. The combination of real and virtual elements forms an ideal context for a design team to communicate and interact with spatial ideas. Boundaries between real and virtual are pushed further than we can predict today, but it is necessary to remind the designer that the equipment should be utilised as an aid and not a push-button solution. Creativity needs to be paramount and in control for the designer. The design realms need to provide the designer with a maximum of freedom and a minimum of pre-programmed logic in order to maintain rather than restrict creativity during the design process.

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