EXPLORING THE POTENTIAL OF MASSIVELY MULTIPLAYER ONLINE GAMES FOR INFORMING CONSTRUCTION DESIGN DECISIONS

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Traditional 2-D contour models, Computer Aided Architectural Design (CAAD) and the latest virtual reality models have greatly enhanced the design process by enabling designers to visualise buildings and the space within them prior to their construction. A recent development in immersive virtual environments is Massively Multiplayer Online Games (MMOG) such as Second Life (SL). These offer users the opportunity to interact with other players in real time on a global basis, and so offer an excellent opportunity to experience virtual buildings and structures within them. However, the effectiveness of such applications to some extent depends upon how realistic the interactions of those using virtual space are in relation to interaction within the real world. This paper presents a literature review of the potential of SL as a visualisation and interaction tool. It examines the potential of this technology for enhancing the building design process and describes a study which is exploring how SL might be used to inform building design in the future. A methodology is described in which virtual copies of buildings are being created in SL in order to examine the extent to which users reflect the real behaviours of users of the actual building. It is hoped that this will reveal the strengths and limitations of such applications and hence, this should inform how they might be applied in the future.

Keywords: visualisation, simulation, game engine simulation, second life, MMOGs.

INTRODUCTION

Various Information and Communication Technologies (ICT) have been developed to solve communication problems in all industrial sectors including construction. These include traditional models, such as 2-D contour models, Computer Aided Architectural Design (CAAD), Virtual Reality, Augmented Reality and Multi-user Virtual Environment, Game-engined models and Nd modelling. However, whilst these have all enhanced the design process by enabling designers to visualise buildings and the space within them prior to their construction, all of them have limitations. The latest innovation in this area is the use of MMOG (Massively Multiplayer Online Games) to simulate large scale human interaction within the building environment, which may hold significant benefits. In comparison with traditional architecture, engineering and construction (AEC) simulation tools, the great value of MMOG, such as Second Life, lies in its autonomous simulation of real world human interaction and global reach. However, in comparison with traditional architectural modelling tools

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mentioned before, the visualisation in these applications is somewhat limited. A question arises, therefore, as to whether these limitations outweigh the advantages afforded by the real-time interaction possible within MMOG arenas.

The purpose of this research is to evaluate the possibility of using MMOG, and Second Life (SL) in particular, as an instrument to enhance the building design process. This paper is a literature review of the potential of SL as a visualisation and interaction tool. It describes a study which examined the extent to which SL might be used to inform building design in the future. A digital building model of an existing building has been created within which existing users are being asked to interact. The research concludes with the future empirical work at the end of the paper, describing a methodology based on ‘critical realism’, and combines offline interviews and online participant observation to assess the extent to which the human interaction in SL reflects that in real space. This will also enable the relative advantages of SL to be evaluated against other forms of visualisation.

LITERATURE REVIEW

The AEC industry is known to be ‘fragmented’ (Mohamed *et al.* 2008). It is fragmented in both participants and information. Participants in AEC projects are from various sectors and even the simplest construction projects involve huge numbers of stakeholders from various industries. The stakeholders include individuals and organisations who ‘develop, design, construct, occupy, manage and live in the buildings’ (Aouad *et al.* 2007: 3). The diversity of participants from various industries also leads to an intermittent information flow between them. It is easy for information to become ‘misinterpreted, lost, incomplete and inaccurate’ (Mohamed *et al.* 2008:110), and thus hamper an effective decision-making process. With the growth of ‘Information and Communication Technologies (ICT)’, ineffective communication in construction projects can be improved.

From Traditional 2-D contour models to Visualisation

The limitations of traditional 2-D contour models include a lack of ‘spatial relationships’, which makes the design process ‘arduous for even the most dextrous mind’ (Bulmer 2001: 7). As such, architects have turned to computer-aided design (CAD) for solutions. The first CAD programme was installed in the 1960s, to help architects design more effectively. However, as a computer programme to aid the general design process, traditional CAD application cannot offer the necessary construction tools and fully meet the needs of architects. Therefore, Computer Aided Architectural Design (CAAD) has been developed to cater to architects’ specialised requirements (Kalay 2004).

CAAD

CAAD can support the construction projects from the initial pre-design process, to the actual design stage, and to the realisation and management of the construction project post-design. However, some argue that the application of CAAD in the AEC industry remains fairly primitive and limiting, this despite some 30 years of development (Reffat and Beilharz 2003: 2). Architectural design is a ‘search activity’ to explore all possible solutions and ‘subsets of feasible candidate, or constraint satisfying solutions’ (Turk, 2001: 158). With limited computing resources, it is difficult to achieve the complex cognitive goal of architectural design (Salman 2004).

Virtual Reality

Virtual Reality is a technology aimed at creating an illusion of reality using a computer generated digital environment. The advantage of VR is that large models can be visualised with high quality, in real-time (Wickman and Söderberg 2003: 9) while still including all necessary physical attributes of the building simulated. Although this is a powerful visualisation technology, it has two key limitations. Firstly, the development, installation, and application of Virtual Reality systems are expensive. In the past 15 years, the use of VR has mainly been pushed by big manufacturers in the automobile industries, and more recently by the technology of Computer-Generated Imagery (CGI) in the film industry. The majority of small companies in the AEC industries cannot afford them (Santos *et al.* 2008). Secondly, Virtual Reality can only provide limited interaction between users and the virtual environment. Many virtual cities constructed by VR technology have been made available online, but technological limitations mean participants cannot explore these virtual cities interactively with other participants (Day 2005).

Augmented Reality

A development of Virtual Reality is Augmented Reality (AR). Augmented Reality is a digital environment constructed by 'computer generated sensory inputs' (US Air Force 1994). The greatest value of Augmented Reality lies in their integration of the real physical world with which people are familiar, and the digital world. However, AR systems also have limitations. Firstly, the development and application of AR systems is time-consuming because 'the rationale of AR can be 'difficult or impossible to understand without sufficient means for accessing and communicating the interlocking knowledge'. (Aouad *et al.* 2007: 290) Secondly, quantifying the actual value of an AR tool in various contexts is problematic due to the complexity of individual projects (Leicht *et al.* 2008: 102).

Multi-user Virtual Environments

By integrating VR and AR technologies, researchers have developed Multi-user Virtual Environments. A multi-user Virtual Environment is a programme designed to simulate multiple average user's responses to building environments at the same time. (Kalay 2004). It is often driven by goals (Lam and *et al.* 2008). In these simulation models, virtual users can interact with one another and the environment according to predetermined behavioural rules. Limitations of this approach include that it is not easy to define appropriate rules in more complicated behaviour models. Real social interaction within building environments is autonomous where fully researcher-controlled goal models cannot be applied. Secondly, the users cannot fully explore the building environment according to their own interest. With the predefined schedules, the users have to follow preset goals and fulfil the tasks. If there are no choices of actions, they cannot fully interact with the environment or other users (Lam *et al.*, 2008). Thirdly, the movement of the users are controlled by 'programmed algorithms' or by 'human operators' (Aouad *et al.* 2007: 290). This does not have many 'degree of flexibility' (Aouad *et al.* 2007: 294). Accordingly, the human interaction in this virtual environment still lacks the interactivity of the real world.

nD Modeling-one model to include all building information

Simulating all construction dimensions in one building system has become known as the nD modelling concept. The nD Model is based on the Building Information Model (BIM), a computer database of all the design information of the building. nD Models are based on BIM, but with the further ability to create and manage all project information in one consolidated data repository, representing the whole life-cycle of the building (Lee *et al.* 2003). Whilst nD nodels offer advantages over other forms of visualisation, there are challenges to be addressed. Firstly, there is currently no standard to evaluate what constitutes an additional n dimension. Space, time, management attributes, colour, and acoustics are considered pertinent, but due to the complexity of the AEC industry, there is ongoing debate on which additional dimensions to be introduced for best performance of building projects (Lee *et al.* 2005). Secondly, it is not easy for one system to accommodate many potentially conflicting dimensions. Finally, as with other technologies, the wide application of nD modeling is not yet possible. Due to the massive work involved, the ‘global nD uptake’ only ‘presents itself as a research agenda’ at this moment. (Aouad *et al.* 2007: 342-343)

Game Engine Construction Models

Construction engineering solutions are also being developed which act as interactive environments (Aouad *et al.* 2007: 287). Interactive graphics such as games are increasingly affecting all ICT applications in how the applications are used, their purposes and the people using them (Aouad *et al.* 2007). However, gaming simulations in the AEC industry have only been used for training rather than for design and decision making. This is mainly due to ‘the complexity in defining behavioural patterns tailored for the storyboard’ within the computing resources required (Lam *et al.* 2007: 60). Like the multi-user virtual environment, autonomous agents are seldom used in these gaming environments.

MMOG and Second Life Architectural activities

MMOGs are persistent three-dimensional online virtual worlds where millions of users can play simultaneously, interacting or competing with each other globally. MMOGs fall into two broad categories – scenario games with goals to finish, and open-ended games with no preset missions. The most successful MMOG to date is SL which belongs to the latter group. SL was opened to the public in 2003 and is based on the users’ own imagination. With free choice of avatar (the player’s digital identity) and task to finish, participants can experience something entirely different from their everyday lives. In the past years, the number of residents of this virtual world has grown to over 11 million.

For some of its inhabitants, SL has ‘eclipsed real life as the place to work, shop, socialise and create’ (Braddock 2007: 56). Since the beginning of 2007, there has been an explosive growth in the use of SL for educational purposes; more than 200 universities have a presence in SL and are beginning to use it for various academic research, including architectural studies. For example in the past 2 years, Second Life has been used by Salford University for various academic studies. In 2007, SL was used to educate young people on practising safe sex (Powell *et al.* 2008). In June 2009, SL was used to train students to identify various issues on environmental health and safety through a ‘virtual kitchen’ (Salford University 2009). With an interactive public video added to SL, some researcher is currently developing a project in SL named 'Peace Games' to converge people's real life and virtual life experiences on the topic of global politics (Sermon 2009). As a 3D immersive virtual world SL offers excellent opportunities for architectural design (Ondrejka 2006). With a range of simple tools, architects can ‘build items with a limited palette of primitive objects’ (“prims”) including cubes, spheres, cones, and etc (Kemp and Livingstone 2007:13).

These geometric objects can be manipulated to provide a powerful modelling tool for architects who can rearrange the whole place overnight without incurring extra expenses or consequences (Rose 2007:23). Moreover, with highly immersive 3D interaction on a global scale, SL can greatly enhance the collaboration between architects and their stakeholders. Real life architects such as Jon Brouchoud have been using SL to simulate real building designs for real life clients. They think that SL has provided clients with an unprecedented level of visualisation and immersion into the design before construction starts (Brouchoud 2006). Academics have gone even further than traditional architectural design. Firstly, the works of architectural students in SL demonstrate more originality, which challenge the traditional architectural practices in reality. However, the extent to which the interaction with the virtual built environment, within SL, reflects reality remains unclear. Many academic researchers have attempted to introduce external databases into SL to enhance its adaptability to the AEC industry. For example, Salford University introduced the 'Whole Life Costing Application' they developed to SL to realise more advanced analysis of human behaviour in the building environment. However, it is argued that there is still a long way to go to develop more complicated application to fully monitor group interaction within the built environment (Pathmeswaran *et al.* 2009).

Real-time, Real Life Human Behaviour

The greatest academic value of SL over previous AEC simulations lies in its provision of the real-time, real life representation of human behaviour. As a parallel universe, SL globally connects 9 million people, who spend large amounts of time immersed in these digital worlds (Williams 2007). It is a completely autonomous game environment with no specific task to finish. There are no preset human behaviour rules to conform users' activities with other users and the environment. Everything is about free imagination and creativity. As Aleks Krotoski, University of Surrey put it, the social networks of the virtual world are 'unique, emergent social properties reflective of offline social life' (see Kirriemuir 2007: 5). The residents of SL imagine, learn, create and interact with each other, to form complex social networks where reality has become hard to define (Ondrejka 2006). For the majority of users, 'the generation of Millennials' (those born after 1980), SL is no less important than the real world. This generation has grown up with the increasingly interactive and visualised communication technologies of the network society. This social experience shapes them in trusting technology as an ultimate tool to enrich their lives. Therefore, as research shows, for them, there is no difference between friendship developed in the real world and online; and they would prefer the virtual world to manage their social network (Bray and Konsynski 2007).

According to a member in SL NMC (the new media consortium, 'a nonprofit higher-education technology group'), 'I do not see any major difference between the life I experienced in SL and my first life'. 'They are so similar, that I sometimes find it really hard to tell what is real, what is not. But I do not care because they are both important to me. This is my life'. In this sense, things going on in SL can become real representations of real social events and movements. This provides unprecedented opportunities for social and behavioural research. It can be used to test government policy. For example, in August 2003 when Linden Lab wanted to 'levy taxes' (Irwin 2007: 9) on virtual objects created by residents of this new world, a virtual revolt similar to the famous Boston Tea Party took place. Outraged residents hoisted boxes of Linden tea into a virtual Boston harbour. They denounced Linden Lab as 'Mad King George Linden', while wearing T-shirts that stated 'Born Free, Taxed to Death'

(Weir 2005: 27). This makes SL a perfect medium to analyse the interactivity between real social life and virtual social life. Because of this potential, many universities have conducted or are currently conducting social and behaviour research in this world (Kirriemuir 2007). Paisley University has found it beneficial to use SL to explore Multi-User Virtual Environments for teaching and integrating them with traditional Learning Management Systems (Kemp and Livingstone 2006).

Global Reach

Within the global network of the SL virtual world, architectural academics can reach out to a new demographic as SL provides ‘a space where researchers can meet, socialise and interact with each other on a global basis without being physically together (Yong 2007). With SL, this highly interactive and visualised communication channel (Tossell 2007), researchers can be liberated from the shackles of time and space, and become truly interconnected in a parallel world. Academia with similar research interests can be found via the SL’s educational mailing list, education group list, or researchers’ personal profiles. Instant messaging and the fully voice-enabled environment also provide a perfect platform for international academic conferences, events and training.

Limitations

Despite this potential, there are also some limitations that architectural researchers need to consider.

Firstly, SL is not the exact representation of real life architecture. The powerful construction tools in this digital universe enable the easy and vivid incarnation of architectural design. However, unlike the real world, there are no physical rules to follow. Architects do not need to consider the problems of physics, gravity, and weather in SL design. According to real life architect Lester Clark, the owner of the virtual replica of Farnsworth House, ‘I don't have to bleach the decks every couple of weeks, nor worry about the ventilation or flooding’ (Rose 2007:23). This poses difficulty in transforming virtual world designs into real life architecture, and also rises doubts within the architectural community on the value of virtual building design. Is it worthwhile to invest time and money in SL, if the virtual world designs cannot be applied to reality? This is one reason that the architectural experiments in SL are mainly conducted by individual architects, rather than big construction companies. As a possible solution, many architects are working on introducing CAD models into SL to supplement this limitation. This is basically what Jon Brouchoud, the leader of SL Architecture has done.

Secondly, researchers need to think of ways to attract enough visits to their virtual architecture. With easy access, SL has the potential to attract people from around the world to experience and improve the design. However, as residents in SL can simply ‘teleport’ to wherever they want it seems as if ‘there is no need for streets, paths, motorways, signposts, tunnels, and transportation such as trains, cars, air planes or any of the things that order the real-world landscape. (Rose 2007:23) For architects who are involved in a variety of construction projects, how to design a possible visiting route and attract enough feedback on their design becomes a challenge.

Thirdly, it will take time to explore the best use of SL to help better decision making in the architectural industry. As this area has only begun to emerge, it takes time to persuade academic members to join and play an active part in SL. Some university members are sceptical of the digital world's value due to the popularity of cybersex in the virtual world (Hogan 2007). Some scholars argue that SL is ‘primarily a platform for adults to realise their sexual fantasy’ (Foster 2007: 24). The most popular places in SL are ‘sexually oriented regions,’ such as strip clubs and nude beaches. This overtly sexual nature of SL makes it more difficult to persuade academic staff, architects, and clients to join this virtual world and use it for architectural development.

RESEARCH METHOD PROPOSED

Drawing on this existing literature and research, we have identified the need to examine social interaction in a virtual world with the corresponding actual social interactions in the physical environment. A methodological approach is therefore required which can begin to explore the nature of such interactions as a starting point for examining the potential of such applications for informing future design decisions. Accordingly, the methodology for this study is based on ‘critical realism’, which can help to 'deconstruct common sense' by collecting data, from both real interviews and online participant observation (Houston 2005: 7). To this end, an immersive 3D model of the recently constructed Civil and Building Engineering Department of Loughborough University has been created in SL (see Figure 1). Researchers from the department and various design professionals are to be invited to use the virtual department building regularly, engaging in some of the activities which they would do within the actual space. These users will be interviewed in a semi-structured way to enable them to elaborate on points upon which ‘further investigation’ can be undertaken (Yin 1994: 98).

The interviews will be supported by data collected through participant observation. This is a method which aims to gain first-hand research materials of social actors (Ezey 2003) and their practices through an intensive involvement in their natural environment (Nandhakumar and Jones 2002). It can be conducted openly or secretly - strategies known as overt and covert participant observation respectively. The difference is whether the observed know they are being studied by the participant researchers or not. If it is overt, then those observed are informed of the purpose of the research, while research permission must be obtained (Bowen 2002). Each of these methods has their advantages and disadvantages, but in this case overt participant observation will conducted in SL. The initial observation period will last for two months, during which time the researcher will observe the users interacting with the virtual building. Seminars will be held in the SL virtual department to help all participants to become more familiar with the virtual department and its features.

The second stage of will involve architects and other designers experiencing the space and exploring its utility as a design tool. Together, these analyses will begin to reveal the efficacy of SL as a design decision support tool and for examining the ways in which users might utilise and appropriate designed space.

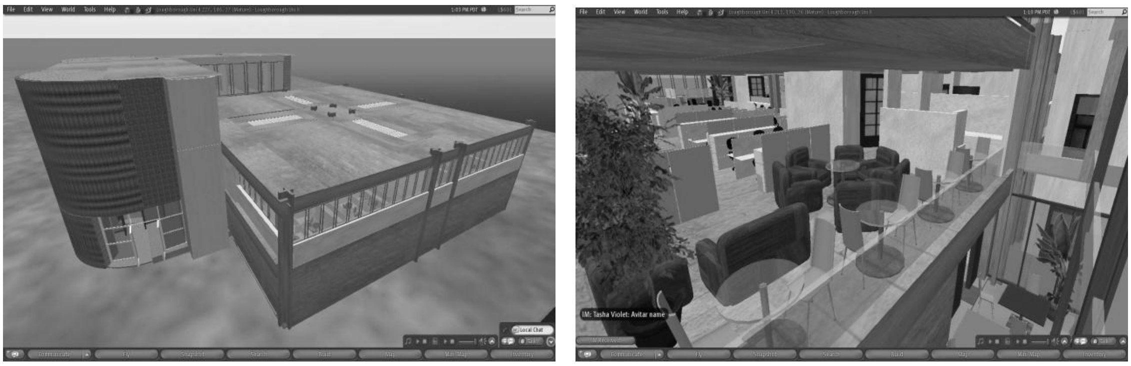

Figure 1: Screen shots of virtual CCCR building within SL construction

This paper has reviewed the literature around visualisation and has explored the potential of MMOG to address some of the shortcomings of existing visualisation applications. The aim of the study is to more fully understand whether MMOG such as SL can be used to enhance architectural design decision making by examining the social interaction in a virtual environment with the corresponding actual social interactions in the physical environment. It would seem from this review that in comparison with traditional AEC design tools, SL has the potential to offer real world human interaction and globally easy access. However, there are some problems that researchers must address in order to use SL for better architectural design, such as there being no real-world physical rules attached. It is hoped that by employing the method of participant observation that the extent to which such technologies undermine its potential as a design tool can be established, and ways of overcoming such deficiencies determined.

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