Harnessing the power of Virtual Reality- The potential for VR as a Virtual Integrated Environment for Project Development in Construction

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Research Vision

The overall aim is to improve the competitiveness of the construction industry by developing a flexible, customer focused, efficient and reliable system of working throughout the design and operation cycle of a project. We believe that Virtual Reality techniques can be used interactively and can interface intelligently with other key existing IT systems for CAD, structural design, environmental design, costing and scheduling.

Objectives

The objectives of research in this area should be:

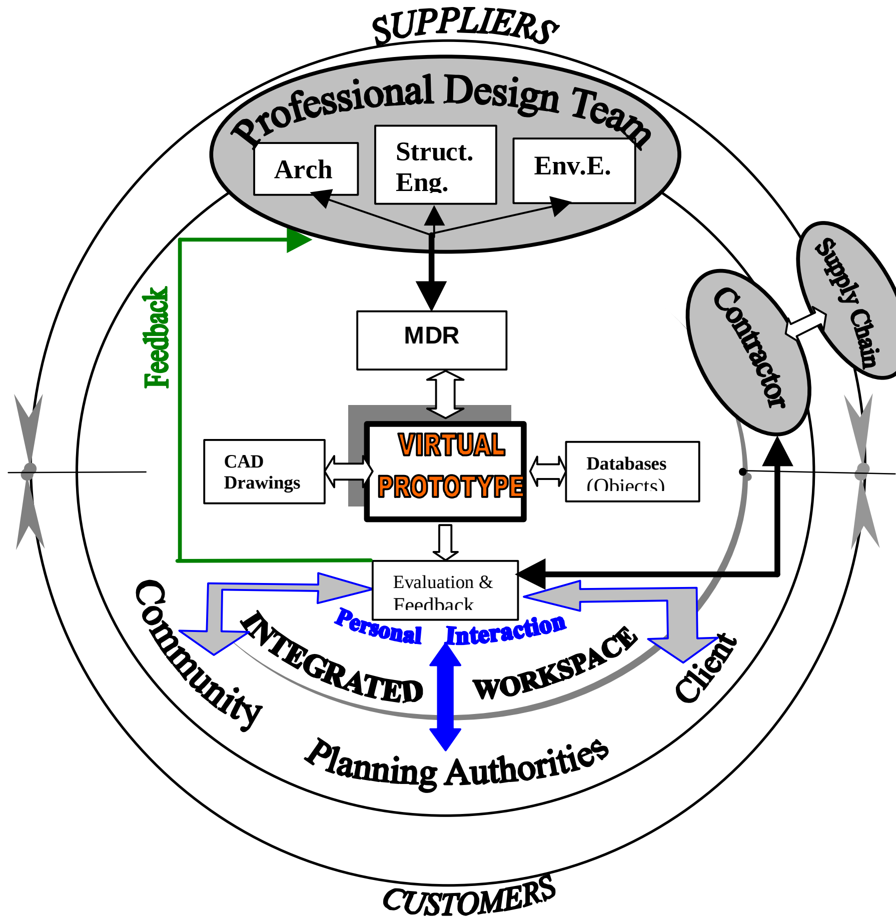
- a new project modelling paradigm, based on “virtual prototyping,” in which a three-dimensional, visual representation of the new building is used as the central project model
- a flexible and accessible system integrating existing ICTs
- multi-platform, user focused capability for VR representations
- a VR model for rehearsing construction schedules within the construction team, and provide a platform for visualising the spatial and temporal distribution of tasks for the whole building including specialist trade.

This project model can then become the collaborative “workspace” for all participants in the planning, design and operation of the constructed facility. The key to its effectiveness lies in improved communication, between all parties and at all stages. Figure 1 shows the concept of the project model.

Construction projects involve a large number of direct stakeholders (clients; professional design teams and construction companies) and indirect stakeholders (local authority; residents; workers and customers). An effective communications tool for these groups must be visual and must present the design information in a 3-dimensional way, which is as close as possible to the finished project. A Virtual Reality based system can meet these needs and enable client and user involvement in design.

Previous work, e.g. the European Union funded ESPRIT CICC project, demonstrated efficiency gains of up to 30% from using VR and other techniques to improve communication in construction. The need now is to develop systems to enable the CICC concepts to be embedded in work practice and extend them to the initial conceptual proposals, detailed design development and handover/operation. Early stage communication is of particular importance in providing a competitive advantage for project bidding, and will be of major significance in emerging international markets.

Figure 1: the concept of the model



MDR: Multi-discplinary Design Review tool

Research Needs

- Business process mapping and re-engineering through formal interviews of clients, architects, structural and building environmental engineers, contractors and facilities managers, from large organisations and SMEs.
- Development of an adaptable "Virtual Workspace" system to suit a range of process maps; based on a central, open source, web compatible software platform with a range of specific "add-on" modules. These will enhance the functionality of the core platform to include a user interface and interfaces to a wide range of software systems and industrial standards (CORBA, STEP, IFC, DXF etc.).
- Use of flexible "open systems" approach to allow the "Virtual Workspace" core to interface with the "best available systems at appropriate cost" for each participant at any time.
- Evaluation of system functionality, efficiency, user friendliness, technical stability and effectiveness of a range of VR platforms for communicating the building design to different stakeholder groups.
- Software applications to facilitate integration (translation) between propriety applications and the VR model.

Literature Review and Background

A series of factors are currently forcing change in the way that construction projects are initiated, designed, developed and managed. There is increasing pressure both to perform more efficiently and to reduce construction programme times, whilst the UK industry is criticised in terms of its performance against international competitors. At the same time there is increased regulatory pressure to improve health and safety and employee conditions (e.g. CDM and the working hours directive). In response to these pressures a number of structural changes have taken place in the UK industry over recent years. It has moved from main contracting to construction management, and now most medium and large-scale projects are procured in this way and therefore the project stakeholders are in the increase. For a typical £5 million project, the average number of direct stakeholders (subcontractors) is in the range of 100. It is therefore new ways of working should be emerged.

Dealing with the programming and management of activities on and off site and the proliferating numbers of designers and trade contractors has therefore become of critical concern just as the staff with appropriate experience and skills are becoming scarce. New forms of procurement such as public private partnerships and design/build/ finance/operate are compounding the issue by shifting the appreciation of risk for satisfactory operation and maintenance to the construction industry, and allowing contractors a greater say in design and construction methods. Significantly more intelligence needs to be brought to bear in the issue of communication and planning of the construction process if the industry is to achieve a sustainable growth.

It is intended to learn from the manufacturing experience - the results of the application of VR to various sectors of engineering have so far been tremendous (Boyd 1998; Wilson 1996). VR modelling (VM) has been shown to avoid costly mistakes, and enable planners and managers to envision the whole manufacturing process from design and assembly to product shipping. Factory simulation has helped to make substantial savings on tooling, design, construction and installation. Compared to the use of conventional methods, VM has also been shown to dramatically reduce the amount of time it takes to analyse new design concepts and incorporate them into the production process. It has enabled decision-makers to make last minute changes and eliminated the need to build prototypes. The application of VR has made it much easier for factory workers to accomplish complex and error-prone tasks, and has also offered a safer environment for testing various manufacturing techniques.

Some of the approaches and principles developed for an engineering context may find construction applications, for instance for the visualisation of building layouts (Bridgewater and Griffin, 1994). However, construction sites vary in terms of their size and complexity and are therefore inherently different to manufacturing processes. In particular whilst for manufacturing it is possible to optimise a process within the controlled environment of the factory, in construction the product and the environment used to create that product occupy the same space.

There are a number of methodologies/systems being developed in the UK and USA to tackle the problem of prototyping of information. (see Mackinney and Fisher 1996; Pierrette Zouein 1995; Hendrickson 1997; Soh et al 1993; Tommelein et al 1992; Williams 1996 and work within the VRCBE). These methodologies/systems were developed to facilitate automatic production of construction schedules from 2D or 3D drawings. All of these systems use heuristic/knowledge rules encapsulated in a prototype computer model. One approach has been to develop the use of object technologies and VR interfaces to aid in the communications aspects of construction projects (Penn et al, 1995, 1996). The approaches have been applied to construction site processes by Williams, 1996 and Retik 1996 who have developed 4D Planner (a graphical simulation tool which allows the user to electronically relate the 3D model to the time dimension in the project schedule), and a VR model for visual planning by simulation of processes respectively. Researchers at Georgia Institute of Technology have developed an Interactive Visualiser allowing the exploration of geometric primitives and operations on a virtual construction site (Ribarsky et al, 1994). Although, this system has great visualisation capabilities, its main weakness is its lack of power of analysis and simulation. It is apparent that the gap between current research and the real construction process is wide.

Conclusions

Virtual Reality techniques has the potential to be used to enhance the efficiency and effectiveness of all stages of a construction projects, from initial conceptual design, through detailed design and the construction process itself through to hand-over of the completed project and its management in service. The key to its potential lies in its power as a media for communicating the complex 3D information that defines any construction projects. Current limitations to its effective use due to its high demand on computing power will disappear as desktop systems develop over the next few years. The challenge is to develop business processes and accessible and affordable implementation tools, including web based systems, which will make the power of VR available to distributed project teams and organisations of all sizes, from the smallest architectural and engineering design practice to the largest construction companies. This is an exciting and extremely valuable area of research, which has the potential to transform the methodology of working in the design, construction and operation phases of a project.

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