

VIRTUAL REALITY APPLICATIONS IN THE UK'S CONSTRUCTION INDUSTRY

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ABSTRACT: A survey has been conducted to investigate the use of Virtual Reality and its applications within the construction industry in the UK. It surveyed the general perception of the new technology and its potential in improving design and construction processes as seen by practitioners in the industry and reviewed the work being undertaken by researchers in the academics' field.

In recent years there has been attempts to apply Virtual Reality to various sectors of the construction industry, however due to the high cost of the new technology in terms of hardware and software most of these applications, as shown by the survey, remain unknown by the construction practitioners. The survey also showed that there is a lack of understanding of the new technology that is not surprising in an environment where even some more traditional aspects of IT are still to be improved to achieve the intended purposes.

The survey first traced the history of Virtual Reality applications and its developments during the last forty years and then reviewed the different systems available in terms of hardware and software. It discussed the level of sophistication offered from desk top to fully immersive comparing and contrasting them with traditional visualisation techniques.

A review of current and potential applications of VR in the construction industry was also undertaken covering those sectors likely to benefit the most from it. Design applications were found to be at a more advanced stage due to the fact that computer visualisation and modelling techniques have always been an important part of building design. However attempts to use the technology as a tool to improve construction processes have been made but most of them are still at the development stage.

The results of the survey are presented and discussed in this paper and the future role of VR in the construction industry is debated in the light of the current and proposed work by researchers in the field.

Keywords: Design, Construction, Virtual Reality.

INTRODUCTION

Virtual reality is not, strictly speaking a new technology. It is more accurately a set of older technologies merged together. These technologies are essentially computer graphics/displays, human computer interfaces and simulation. Virtual reality is also referred to as Virtual Environments. There are numerous definitions for virtual reality, some of them are stated below:



- A computer generated simulation of the real world
- The illusion of participation in a synthetic environment rather than external observation of such an environment.
- A computer-generated simulation of three-dimensional environment, in which the user is able to both view and manipulate the contents of that environment.

Virtual reality can also be described as the science of integrating man with information. It consists of three-dimensional, interactive, computer-generated environment. These environments can be models of real or imaginary worlds.

VIRTUAL REALITY SYSTEMS

Virtual Reality systems can be divided into two main categories :

- i) Desktop Virtual Reality
- ii) Immersive Virtual Reality

Desktop Virtual Reality

PC based virtual reality systems are usually classed as Desktop systems. Desktop virtual reality has emerged from animated computer aided design. With these systems the user views and interacts with the computer represented image on a traditional computer graphic screen.

Immersive Virtual Reality

The main difference between immersive virtual reality systems and desktop systems is that in immersive virtual reality the computer screen is replaced with a head mounted display unit. Immersive virtual environments can be described as a system which "immerses" or surrounds the participant in an environment. With this system the user (viewer) feels as in a natural environment. Hardware and software for this system are more expensive and more sophisticated than immersive virtual reality. This system requires hardware such as super computers, High resolution Silicon Graphics screens, position tracking devices, power gloves and head-mounted displays. Software can be purpose made. For instance a flight simulator which is situated in a room surrounded by wide angle projection screens

VIRTUAL REALITY APPLICATIONS

Virtual Reality concepts have been around for many years, it is often referred to as a recent description of a technology that had for many years been known as visually coupled systems. The roots of these can be traced back to the aerospace and defence industries with the development of the most known Virtual Reality application which is the familiar flight simulator. More recently, advances in electronics enabled the use of the VR technology to spread to areas such as: scientific and product visualisation, medical applications, training, maintenance systems and CAD/CAM.

In the construction industry, recent attempts to use Virtual Reality concentrated on the process of design and construction. The first use of VR in the construction sector was the development of walkthrough systems. Other possible applications have been identified although at different stages of trials and developments:

in design

- Space modelling
- Interior design
- Lighting design
- Heating Ventilation and Air Conditioning design
- Ergonomics and functional requirements
- Space selling
- Fire risk assessment
- landscaping

in construction

- Site layout and planning
- Planning and monitoring of construction processes
- Evaluation of construction scenarios

RESEARCH IN VIRTUAL REALITY

The department of Information Science and Civil Engineering at the University of Strathclyde, in Glasgow, carried out research projects to develop an approach to share collaborative visual planning of the construction process. This research involves a non-immersive virtual reality interface allowing, visual monitoring of, and interact with, the progress of the simulated project and allows users to : (i) investigate interactively in a collaborative manner several alternatives for both the construction sequence and site organisation; (ii) verify and refine the construction plan, integrating dynamically the construction process with on site activities and plant (1).

A design team which consists of researchers from The Bartlett School of Architecture and The department of Computer Science at University College London, developed a system called Pangea, a 3-D sketch package for early prototype testing of architectural and urban designs. This focus on one of the main attractions of modern IT, allowing the user to see things that are not immediately apparent to system - social, economic, structural - many of which are invisible (2).

A team of researchers from Salford University are using Virtual Reality to tackle problems such as: maintenance evaluation, submarine compartment design, visualisation and space planning for supermarkets' design (3)

CADCentre Ltd. and the Advanced Interface Group (AIG) at the University of Manchester launched a collaborative project to explore the applications of virtual reality techniques to the task of creating , and subsequently using, CAD models of complex process plants, such as oil rigs , oil refineries or power plants. The main objectives were to understand and overcome the

problems of applying such techniques to large, real-world systems and to research software architectures and algorithms which will underpin future developments in the design and applications of virtual reality (4).

A Company called Colt Virtual Reality Ltd. based in the United Kingdom, developed a virtual reality software for the visualisation of risk to life assessment for fires in buildings. The system is called Vegas and enables users to experiment in real time with evacuation scenarios long before any concrete is poured (5).

Communication through virtual reality also hold a considerable part in the construction industry. S. Sugawara et. al. a research team at NTT Human Interface Laboratories at Yokosuka-shi, Japan, developed a network system called InterSpace which is a multi-user system and also transmits the image of the user into the virtual world. In the InterSpace system, users inhabit the "real world" and drive their images in the "virtual world," their "virtualselves." To meet by plan or casual encounter in the virtual world is equivalent to meeting in the real world through visual communication (6).

A research project called Naive is under way in the University of Dundee (7) which allows the users to visualise the deflection or stress of a structural element in any direction. Naive users can pick up a complex piece of software and in relatively short period of time produce an immersive set of output. The pictures produced are carefully designed to be understandable so the engineer may quickly pick out the critical points in his structure and the critical values of the parameter under consideration. The researchers believe that they can offer a novel form of solid mechanics analysis approach but wish to provide as part of it a system for visualisation of the results which:

- 1 Allows the designer to walk through his structure observing aspects of its behaviour and assimilating the implications of that behaviour as quickly as possible; and
- 2 in the process to be reminded continuously of the information which he/she is observing.

THE QUESTIONNAIRE SURVEY

The survey concerned 120 of the leading construction companies in the United Kingdom and was based on questionnaires targeting different sectors of the industry supported by interviews which included IT system developers. The main objectives were to determine the level of use of IT, current understanding and use, and the present and future prospects of the new technology in the industry.

Objectives of the questionnaire

- Frequency of non users who are considering using virtual reality in the future.
- Frequency of non users who are not considering using virtual reality in the future.
- Reasons for not considering virtual reality.
- Applications of virtual reality under consideration and already in use.
- Investment towards virtual reality technology.
- Current design systems in-use in the industry.
- Information from current VR users:

Time period of use
Type of VR system
Advantages of using VR systems
Investment on this technology

Targets of the questionnaire

It is very important to know the targets that are aimed at, before the preparing the questions and the model answers. The targets that the questions aimed at are listed below:

- Nature of the respondent:-
 - IT manager
 - Architects
 - Engineering managers
- Nature of the company:-
 - Civil Engineering
 - Housing Development
 - Building Construction
 - Road and Highway Construction
 - Estate Development
 - Design and Build
- Position of the company in the construction industry :-
 - Annual turnover of £50 million and over.

The results

The main findings of the survey were:

- In general there was a lack of understanding and awareness of the new technology.
- The potential improvements that the technology can offer were generally recognised by those who are aware of its existence.
- The high cost of VR was the main reason why it has not been tested by most of the companies involved in the survey.
- Larger companies dealing with big projects and having well-established IT working patterns seemed to favour the idea of developing new VR applications.
- The areas in which VR is thought to have the most contribution, in the majority of practitioners' views, were space modelling and visualisation of design proposals.
- It was also shown that most companies interested in VR were willing to spend between 10 and 60 thousand pounds to invest in the new technology.

The Future

Integration has been the focus of much of the research work in construction, it is influencing the industry at two levels: the integration of enabling systems or toolsets in both the design and the construction processes; and the integration of the two processes, design and construction. An both levels Virtual Reality will play a key role, it will be the testing and

modelling medium in both design and construction. In addition, it will also enable the construction process to be considered at concept design stage assessing the design for buildability. VR will then be seen as the technology which will help abolish the traditional demarcation which exist between design and construction.

From the results of the survey it is apparent that much of the work being undertaken by researchers in this field is still not fully disseminated and exploited by practitioners in the industry. The survey showed a general lack of understanding of new enabling technologies such as VR partly due to the cost and partly to the level of involvement of practitioners in the research and development process. This should drive the focus of the work in the future by encouraging more industry led research to reduce the lime lag between research and practice.

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