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TECHNIQUES TO UNDERSTAND INDUSTRY VISION FOR VIRTUAL REALITY IN CONSTRUCTION

Vaibhavi.N.Gawai
Dr. N.W. Ingole
Prof. R.A. Dahane
PG student, Construction Engineering and Management, Prof. Ram Meghe College of Engineering and Management, Badnera.
Prof. & Dean (R&D), Department of Civil Engineering, Prof. Ram Meghe College of Engineering and Research, Badnera – 444701
Assistant Prof. Department of Civil Engineering, Prof. Ram Meghe College of Engineering and Management, Badnera.

ABSTRACT
Recently, VR has started to be adopted as an enabling technology in construction projects. Even though VR today is primarily used for visualizing the final product, the potential as a universal interface application is high. For example, VR can be used to explore design options, simulate construction activities, support design reviews, communication of the design intent, clash detection and much more. This paper includes the methodology adopted to understand the industry vision for virtual reality in construction. The questionnaire show the factors which affect most for the adoption of VR in the construction industry. Analysis of survey is done after collecting the data.

Keywords:
Virtual Reality (VR), Visualization, Construction Management, Organizational Health and Safety (OHS), Virtual reality in construction.

INTRODUCTION

Virtual reality refers to an immersive multimedia or computer-simulated life, replicates an environment that simulates physical presence in places in the real world or imagined worlds. Virtual reality can recreate sensory experiences, which include virtual taste, sight, smell, sound, and touch (Luo, 2015). People gain 70 percent of information by vision, resulting in systems like HMDs that provide the visual component of immersion has been widely used to develop virtual environments. VR provides one of the best tools for accident reconstruction, training and hazard identification by immersing the trainee in an environment that is as real as possible. The use of high-quality three-dimensional graphics, sound and dynamic simulation combine to form a uniquely engaging experience (Kizil and Joy, 2001).

Although the numbers of injuries in the construction industry have decreased significantly since the passage of the Occupational Safety and Health Act in 1970, several hundred workers still face fatalities every year. Addressing safety challenges remains a priority in every construction project as a result of this legislation. Safety managers now constantly attempt to enhance the effectiveness of training materials provided to workers (Bhoir and Esmaeili, 2015).

Current Virtual Reality (VR) technologies build upon ideas that date back to the 1960s and earlier. In 1968, Ivan Sutherland created the first head-mounted display that rendered simple wireframe models for the viewer's changing pose. This invention laid the foundations for the technologies we now call Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), as defined by Milgram et al. in their reality-virtuality continuum. The term denotes a continuous scale ranging between the completely virtual and the completely real. VR is commonly described as computer-generated environments or realities that are designed to simulate a person's physical presence in an immersive and convincing environment. The purpose of VR is to allow a person to experience and manipulate the environment as if it were the real world. The VR subject experiences “hypes” at regular intervals, and they disappear shortly thereafter. With the advent of more powerful graphics hardware and innovative tracking technologies, the

topic has been revisited in recent years. According to Gartner's hype cycle, VR has finally reached the “plateau of productivity”. The first applications can be found in the areas of gaming, marketing and advertising. For industrial applications, VR offers great potential that goes beyond just looking at virtual models. The idea of “Virtual Prototyping” (VP) or “Virtual Design Review” allows users to examine prototypes in a realistic way starting in the earliest design stages. Many companies conduct design reviews to detect errors in their products early on before the physical product is manufactured. Today, the classic design review process is often performed directly on the PC with the support of CAD software packages (Koskela, L., Ballard, G. and Howell, G.2003).

LITERATURE REVIEW

General

The literature review has been done by referring to various research papers and by gathering all the important information and findings required from those research papers. Aim of literature review was to identify and shortlist factors of VR in construction sector, current flows, and to find future scope of VR. In this section we studied literature review to understand different techniques and methods used for virtual reality in construction.

1. Safety participation with virtual reality in construction

This paper solve problems by providing a framework for systematic personal safety performance assessment and then developing a practical approach for personal safety participation assessment. This involved the development of a supporting multi-user platform to sharing safety-related information and also protecting the workers from danger sources through obtaining real-time locations (13).

The framework consists of the following three modules: Safety Knowledge Dissemination (SKD), Safety Knowledge Reflection (SKR), and Safety Knowledge Assessment (SKA). The system prototype was developed and evaluated with case studies to identify the system’s benefits and limitations. The results concluded that using mobile based VR+AR would improve construction safety & health effectively (14).

The paper provides a method of BIM based virtual environment with an intent to improve the safety training programs currently in practice in the construction industry. Through BIM models and VR tools a more proactive approach has been proposed to tackle safety issues (5).

2. Virtual reality in Education

This paper has focussed on the importance of teaching CAD systems at school, not only as a good instrument for “drawings” but mostly as a helpful tool to be used to develop research work and, as a professional support in their activity as engineers(8).

In this paper, we argue and present evidence from vast research that VR is an excellent tool in engineering education. Through our review, we deduced that VR has positive cognitive and pedagogical benefits in engineering education, which ultimately improves the students’ understanding of the subjects, performance and grades, and education experience(26).

The researchers collected student perceptions of the experience, and comparison of the two VR viewing options are analyzed and discussed in this paper. Overall, students’ attitudes were favorable about the use of VR as a substitute for the construction site visit and the data indicate that they preferred more immersive form factors for viewing the 360° panoramic photography. Lastly, students offered, through open-ended feedback, some ways in which the experience could be made more authentic(25).

3. Adoption of Virtual Reality for Site Layout

The purpose of this paper is to assess traditional practices for site layout planning and introduce the application of VR in construction jobsite organisations for site layout planning, collision detection, and evaluation of construction site layout scenarios. In this paper, two different construction jobsite scenarios for the structural phase of a construction are created and for optimisation purposes, Autodesk Revit software, SketchUp, and Lumion are used to develop the three-dimensional (3D) model(29).

The main objectives of this paper are to understand the industry trends in adopting AR & virtual reality technologies and identifying gaps within the industry. The identified gaps can lead to opportunities for developing new tools and finding new use cases. To achieve these goals, two rounds of a survey at two different time periods (a year apart)

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were conducted. The findings demonstrate that older generations are significantly more confident about the future of AR & VR technologies and they see more benefits in VR utilization (30).

4. Analyzing the potential of Virtual Reality

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 (27).

This paper presents a result of an experiment to integrate three different types of AEC digital modeling data and proposed workflows for IVR applications in construction, visualization and building performance analysis. The experiment deals with construction simulation, rapid generation of the VR scene for existing building and airflow visualization. Several workflows investigated game engine and VR tools have been used (28).

5. Investigating virtual reality Applications

This study revealed limited ability to interact with all the objects in the game. Future research intends to address this issue, expanding on the current research. Areas may include ability of the user to select the location of jobsite objects, i.e. the crane, materials, and tools. Additionally, giving the user the ability to operate operable objects such as the crane (31).

The research papers briefly describe the diverse avenues that have the scope of development or improvement under virtual reality. Collaboration and immersion are two aspects that are being explored in the field of design. With the complexities in design introduced by evolving time it becomes essential to manage this data in an efficient manner to seek maximum output (32).

METHODOLOGY ADOPTED

In this study, a quantitative approach was used to get factual information about the awareness of virtual reality use in the construction industry. The data is collected from the data an online questionnaire survey. The whole process is shown in below figure.

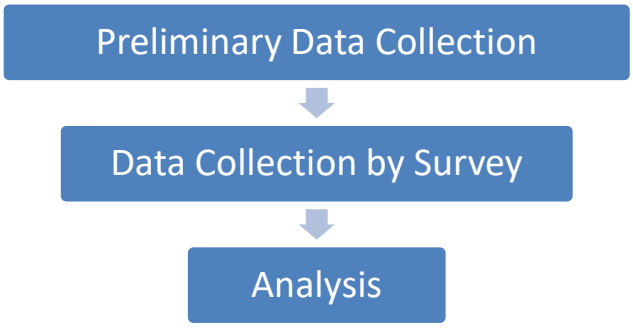

Figure 3: Methodology process chart

1. Preliminary Data Collection: The preliminary data for questionnaire design was taken by study current available literature review of research articles, paper published in various publications regarding VR in construction industry and understanding current scenario of technology enhancement and practicality in construction industry.

2. Data Collection by Survey: As mentioned earlier data collection was done by collecting data from online questionnaire survey using Google Forms. Prime focus of questionnaire was to take response of mainly construction professionals to understand and derive conclusion of the research. Professional Included in the study was in field of Architecture, Engineering, Developer and contractor and professors.

3. Data Analysis: After the data collection by the questionnaire survey, the analysis is to be done. In data collection, the opinion of professionals was collected through questions listed out in questionnaire form with help of Google forms. Here data analysis is accomplished with the data collected. Collected data is compared with one and all, and

the percentage of responses is found out. Data analysis is done to determine the most affecting factors for use of VR in the construction industry.

SURVEY FOR VIRTUAL REALITY

Since the implementation of virtual reality technologies is still relatively new in AEC industry, there is not much empirical data on these topics. In order to gather data, the authors came up with a number of research methods. The authors designed a detailed online questionnaire. The detailed questionnaire was reviewed by the expert field of construction engineering and management to ensure questions are clear and not misleading. Finally, by further analysis on the survey results, the authors were determining the industry trends and visions over VR technologies. The questionnaire is formulated to gather the information about the industry's adoption of VR technologies. Moreover, the questionnaire investigated the opportunities for VR technologies to improve stakeholders' communication and identify experts' predicted return on investment. The questionnaire is designed to analyze the growth of these technologies. The survey conduct online with the help of online survey forms. This survey only includes those responses which are properly completed. The excluded responses were mainly from the respondents who didn't complete the survey so that the authors could not accredit their credibility for the goals of this research.
The survey questions were divided into four sections:

i. General information,
ii. General virtual reality related information,
iii. Visions for future of virtual reality.
iv. Use of virtual reality.

Description of target areas and objectives with respect to different parts of the survey describes the main sections, gathered data, and the objective of each section in more detail.

Table No: 1. Description of survey

Section Name	Gathered Data	Objectives
General information	age, gender, occupation, and professional experience	To determine how respondents responds in different parties to envision the future of VR
Knowledge and understanding of VR	Virtual reality understanding and used VR tools	evaluate how respondents with different VR knowledge
Visions for the future of VR	opportunities of VR in the industry	represents the industry future on VR
Use of VR	Majority usage	Determine how respondents use VR

The first and second rounds of the survey had 94 and 64 respondents, respectively. Survey members are from different parties such as owners, architects and designers, general contractors, and construction managers. The surveys were distributed in two rounds to measure the impact and growth of VR within the AEC industry and identify trends and visions for future adoption of these technologies. The first section of the survey attempts to identify the general information of the respondents, such as age, gender, occupation, and professional experience.
In the next section, the respondents answer several questions about their companies, such as location, size, and type of projects (e.g., residential commercial, institutional, etc.). The third section examines the respondents' competency in VR applications (i.e., quality control, progress monitoring). In the next two sections, the survey results assessing VR utilization in the industry, as well as the future opportunities for virtual reality applications, are presented. First, the respondents are asked what types of virtual reality devices they have used and how many VR experts they have in their companies. Through these questions, the authors were able to evaluate the respondents' familiarity with VR tools and their companies' effort in integrating these technologies with on-going and future projects. In the last section, the respondents were asked to answer a few questions about their vision for the future integration of VR technologies within the AEC industry. The questions in this section were designed in a way that demonstrates VR

potentials for future developments. For example, the respondents were asked to identify the sectors (i.e., education and healthcare facilities) and the project size that can best leverage VR technology. The last section evaluated the visions for cost and time saving through integrating VR technologies in construction projects. The last two questions evaluate how the respondents predicted the increase in end-user satisfaction when virtual reality technology is used and their limitations in industry. By understanding the potential and maturity of VR technologies, industry leaders can better understand the potential use-case of these tools. The identified industry trends can help industry leaders make better investment decisions on these technologies.

In this section, the survey responses are analyzed to

i. Understand the current state and growth of VR in the industry over the past year
ii. Identify opportunities of VR development in improving communication and visualization
iii. Understand the benefits.
iv. Limitations of virtual reality

The surveys did not ask for any personal information such as, name, company name, and etc. from the participants.

CONLUSION

It is concluded that the,

i. Virtual reality will diversely enrich revolutionize our world in many areas. It offers new possibilities to understand and experience history, cities or landscapes. In the other area such as marketing there are countless fascinating virtual reality solution, which inspire others.
ii. Virtual reality helps enhance learning and experience it in a different ways.
iii. It offers tangible benefits for individual learners, streamlining workflows through teams training together and contributing to a safer and more productive workplace.
iv. Virtual reality is commonly used for training because people can have a safe environment to make mistakes and learn. It can also be a cost effective way of delivering training in an agile way.
v. By using this methodology it is concluded that this method is effective and acceptable.
vi. This methodology provides an exact idea about the trend of virtual reality in construction industry.
vii. The benefit of this methodology helps us to find factors that are most important in terms of improvement in the construction industry.
viii. This method have minimum errors.
ix. This method is less complicated as compared to other methods.

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