VRML AS AN EFFECTIVE CONSTRUCTION COMMUNICATION TECHNIQUE

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Abstract : During the project life cycle, several communication channels among stakeholders (designer, owner, contractor, subcontractors, etc) will be established in order to transfer needed data. These data are for examples memos, transmittals, requests, change orders, project progress, schedules, etc. Therefore, these parties need an effective communication procedure/tool to assure effective communication of project information. Currently, project stakeholders have turned to handle communication management using computer systems, but still depending on paper-based communication. Using Virtual Reality Modeling Language (VRML), engineers are now looking for electronic ways to distribute the required information, which can significantly minimize the paper-based communication. A VRML model is designed to convert the available 2D drawings to 3D drawings and then, generate VRML files using “Autodesk Design Review” software. The aim of this paper is to implement the designed model to a case study project in order to examine its effectiveness and efficiency using seven different communication channels during project life cycle. It is concluded that VRML technique leads to a better communication in construction projects.

1. INTRODUCTION

The process in which engineers design and describe the proposed buildings is complicated. This process is critical to their role in the Architecture/Engineering/Construction (AEC) industry. They need an effective communication technique to transfer project data among different project stakeholders. The communication media among engineers varies, although it is dominated by a text-based system accompanied by 2D drawings. The 2D graphical drawings are supported by Computer Aided Design (CAD). When the design phase of a building is completed, the whole project document will be distributed to contractors for bidding. These documents constitute of hundreds of CAD drawings to describe the project. Moreover, series of revisions and comments will accompany this process (Campbell et al 1994). With the commencing of the construction phase, the level of complexity and development of the project increases for engineers and executers. This complexity necessitates a communication management system that can handle the project requirements. A lot of Requests for Information (RFI) and Field Work Instructions (FWI) and orders will progressively be elaborated during the construction phase. Usually, the technical language used in such transmittals and the various frames of reference increase conflicts and misinterpretations between different stakeholders. For example, if the engineer wants to change a material specification, a certain amount of paper FWI must be sent to many subcontractors to describe the updated materials. Thus, by the time a project is complete a considerable amount of paper transmittals and revised drawings will be evolved. These paper-base documents make it difficult for project analysis as well as future revisions. Another disadvantage of paper-based communication is the large volume of paper necessitated during project execution phase which is considered to be the main
factor of office and site overhead since it consumes time and money. With the use of World Wide Web (WWW), new concepts of communications in constructions are being evaluated. Throughout the WWW text-raster based images, vector based graphics and 3D models can easily be distributed and exchanged. One of the technologies available is the use of Virtual Reality (VR) to model buildings. VRML (Virtual Reality Modeling Language) is a draft specification for the design and implementation of a platform-independent language for virtual reality scene description; VRML 1.0 was released on 1995-05-26. In other words, it is a realistic simulation of an environment, including three-dimensional graphics, by a computer system using interactive software and hardware. Developers of VRML and researchers in the AEC industry believe in the benefits of exchanging project documents using 3D models and web technology. Engineers tend to rely on 3D models to clarify their designs more than 2D drawings. Using the VRML technology, engineers are looking forward to use new communication technique where they can eliminate the use of paper-based documents and reduce time and cost. Thus, the benefits of moving towards a “paperless” design in construction industry are clear.

2. PREVIOUS AND RELATED WORK

Recently, a number of researchers have been investigating the use of digital models as a way to communicate design ideas. Researches at the University of Washington described a need for a new approach for architectural presentation where they can apply geometric links and multi levels of detail to their models (Campbell et al 1994). Such hyperlinks and multiple levels of detail were eventually implemented in the first VRML specifications. In addition, researchers have investigated the use of immersive, distributed virtual environments along with other electronic media as a means of communication and critique design intentions (Davidson and James N 1995). Hyperlinks and multiple representations of a design made the study of new building construction drawings seem easier than before. The symbolic system “detail bugs” which architects use to reference their detailed drawings in construction documents is modified in VRML as hyperlinked geometry (Mitchell and William 1995). Professionals outside of the AEC industry have already begun to advance the notion of communicating graphic and model data electronically to automate the construction process. Perhaps the most famous project is the design and production of the Boeing 777. The airplane was designed and optimized by the help of a digital model where all of its components were manufactured and extracted from the model. All communications to fabricators were referenced with respect to the digital model. In fact, entire systems have been implemented which enables manufacturers and suppliers can partner with designers electronically (Varney et al 1996).

3. HOW VRML WORKS

Generally, VRML relies on WWW technology. Three main components designate the system: a web server, client server, and the user interface as shown in Figure 1. The web server contains a central storehouse or repository which controls two databases: ‘project specific data’, and ‘project general information’ databases. The project specific data store information that is directly related to the project, such as architectural drawings, change orders requests; project activities’ progress, etc... Project general database contains information that is general to similar kind of projects. Examples of general information are site paper documentation, building regulation codes, health and safety regulation, etc. In case the client had certain specification standards, these specifications will be found in this database. We will use “Autodesk Design Review” as our database software which will generate a DWF (drawing web format) files which can be generated as VRML files and can be used in the internet. In this case study we will only generate DWF files without using an internet web server.
The client side consists of a computer workstation plugged (connected) with a continuous internet access with display software to view the delivered electronic information as shown in Figure 2. These softwares may be Computer-Aided Drawing (CAD), project planning and scheduling or quantity take off packages. The user interface plays the role of a link between the main server databases and the project stakeholders' computer network. Moreover, it plays an important role in organizing the data transfer from database servers and client computers by displaying web pages with specific menus and buttons. The interfaces, through these menus, enable the project stakeholders to easily receive, modify, archive, send or request information (Hang Li et al 2003).

Figure 2: VRML Path between Stakeholders and CAD Drawings
4. METHODOLOGY of VRML MODEL BUILDING

This study will focus on the major benefits of moving towards a “paperless” and an effective communication process in the construction industry by studying seven different communication channels during construction project life cycle using the VRML technique. The procedure to reach this aim is conducted by the following sequence: Step 1- Analysing required information. Step 2-Transferring the whole PAPER BASE DATA into a VRML BASE DATA. Step 3-Examining the model using VRML technique by applying 7 different communication channels in a construction life cycle.

4.1. Information Requirements Analysis (IRA)

The process of IRA phase starts with the selection of a specific construction project which covers the basic information of the model. The selected example for this case study is a commercial retail building (Bank). The reasons for this selection are: The nature of the project which contains rich information concerning different construction aspects, and the availability of necessary data. The resources for the design documents will be the architectural, structural, electrical, mechanical, and spot details drawings. Other project documents must be presented to link them with corresponding 3D objects. These chosen documents are: Bill of Quantities (BOQ), project specifications which are detailed description of all materials used in the project, and project Manuals which contains detailed procedures for installation and operation for certain technical systems used in the bank like alarm, safe, security. In addition it is advantageous to have access to pictures of the already executed project for the same bank as these graphical documents will be helpful to show the theme of the whole project. The modeling information and development phase of the research starts with identifying specific exchanged information during the life cycle of a construction project. Exchanged information from one engineer to another may be categorized into one of the following criteria: Revised Shop drawings; which will include architectural (floor plans, sections, elevations and details), structural, and services drawings. Transmittals during construction, contract document exchange will include change/variation orders, architect instructions, valuation and measurement, etc.

4.2. Converting to VR Model

The 2D drawings taken from project documents are converted into a single 3D model using CAD software. The next step was to convert the 3D model into a single VR model using ‘Autodesk Design Review’ software. As the model was generated in its final form; the first benefit of computer base models is substituting all 2D drawings in the previous section with 1 model (Figure 3) showing all details of the architectural, electrical, mechanical and structural details. Additionally, text-based specifications can now be implemented to the corresponding 3D objects. For instance, if a contractor wants to know the finishing material of any drawn object, one “click” on the desired object will open a pop-up window, which will show all the needed specifications. Thus, the VR model had eliminated the use of a number of 2D separated drawings and a set of specification booklets which will definitely reduce time and cost.

4.3. Implementation of Different Communication Channels

To test the effectiveness of the developed model, different scenarios of communication channels taken from a normal construction project are implemented. Autodesk Design Review (Computer Aided Software Engineering) tool is used to simulate each of the scenarios within each stage. To describe each of these stages, a drawing document exchange scenario is used as an example. These scenarios are described in Figure 4. This diagram shows 7 possible communication channels between Owner, Designer and Site Engineers. As an alternative to traditional paper Base Exchange data technique, the VRML can be used to interpret the same purpose. By coordinating the exchange of these information documents, it will be possible to record their history such as origin and revision. Each number in the diagram will represent a communication channel in a project life cycle. The direction of the arrow shows the path of the channel “Sender and Receiver”. For example channel #1 means that the Owner (Sender) would ask the Designer (Receiver) to change some items in the project.
5. DIRECT APPLICATION OF VRML

After identifying all the inputs to the VR model, the VRML technique will be applied to communicate between the previously mentioned 3 stakeholders. The presented snapshots in Figure 5 are the outputs of the VRML software which will replace the traditional paper-base exchange material. Figure -a- shows a change order request that can be sent from owner to designer or from designer to site engineer. Using a paper-based method, a significant number of transmittals must be sent to explain the changes needed and change or modify the specifications of an object. While using the VRML technique one layout sent by www can clarify the point to all stakeholders at the same time with no misunderstanding and eventually reducing the time and cost of the exchanged information. Similarly to Figure -b- a clear project progress.
can be sent to the owner showing all the finished items in the site in a graphical form. Owners with no technical construction background can easily visualize the progress since each drawn object represents a finished item in real life. Figure -c- shows a change order sent from the designer to a subcontractor. Figure -d- shows a request from site engineers to designers requesting consultation for a specific problem found on site. In this case the site problem is described in a very clear way eliminating the need for detailed paper-based description to explain the situation. Figures -e-, -f- will replace traditional daily reports sent from the site engineer to designers. One of the main benefits of applying VRML technique in construction communication can be found in daily site reports since they will save exact time and information for future revisions or claims. VRML can be very efficient in sending revised drawings and modified information to all stakeholders Figure -g-. Since all the data exchange is done via web servers, updated information will automatically replace the old data eliminating any kind of conflicts between engineers.
6. ANALYSIS OF THE VRML RESULTS

Results are represented in Table 1 to show the main benefits and advantages of VRML technique versus Paper-Based technique.
Table 1: Analysis of VRML results

<table>
<thead>
<tr>
<th>Channel #</th>
<th>Paper-Base System</th>
<th>VRML-Base System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select and photocopy the specified drawings</td>
<td>All drawings are found on one layout. No need to spend time on searching for a desired area.</td>
</tr>
<tr>
<td>1</td>
<td>Writing notes</td>
<td>No need to write text scripts since all information will be explained graphically with clear drawings.</td>
</tr>
<tr>
<td>1</td>
<td>Use additional information to clarify certain points</td>
<td>Use the markups provided by VRML software to write all needed information on specific item without causing any misunderstanding.</td>
</tr>
<tr>
<td>2</td>
<td>Specify in details the progress of each finished activity</td>
<td>Each markup note attached to a 3D object in the VRML file will show the activity progress</td>
</tr>
<tr>
<td>2</td>
<td>Provide pictures taken from site</td>
<td>No need to send any pictures. Each 3D object in the VRML will correspond to a fully executed item.</td>
</tr>
<tr>
<td>2</td>
<td>Email, fax or by hand distribution for all involved parties</td>
<td>Once the file is updated all stakeholders will receive the new project in no time. VRML file can handle as many subcontractors as it takes in the project.</td>
</tr>
<tr>
<td>3</td>
<td>Print the whole set</td>
<td>The VRML file will summarize the whole set (architectural, electrical, mechanical...)</td>
</tr>
<tr>
<td>3</td>
<td>Print the whole BOQ and project documents</td>
<td>Each 3D item will contain information concerning specifications and quantities</td>
</tr>
<tr>
<td>4</td>
<td>Print the selected drawing to show the specified area</td>
<td>The VRML file will clarify the problem by highlighting the corresponding 3D item</td>
</tr>
<tr>
<td>5</td>
<td>Use additional information to clarify certain points</td>
<td>Use the markups provided by VRML software to write all needed information on specific item without causing any misunderstanding.</td>
</tr>
<tr>
<td>6</td>
<td>Email, fax or by hand distribution</td>
<td>Once the file is updated all the project stakeholders will receive the updated project in no time.</td>
</tr>
<tr>
<td>7</td>
<td>FWI, RFI and many letters to explain new change orders</td>
<td>Updated VRML file will specify exactly the time and date of change and explains changes graphically</td>
</tr>
</tbody>
</table>

7. CONCLUSION

The developed system offers many advantages compared to the conventional communication method. The system provides storage and immediate access to all project documents with exact time and date. All technical data are categorized according to their revision date and modification status, which can be very useful in case of project revision or contractor claim. New or revised drawings are immediately supplied to all project stakeholders without any delay. One of the main system advantages is that the system can save a significant man-distribution time from issuing, printing and delivering revised drawings to a correspondent subcontractor. Regardless of stakeholders number, they will receive the latest revision of all project documents by a single click in the internet browser. In this case all previous
data will automatically be replaced with the modified version. The system eliminated distribution copies of the drawing which will clearly save money for the contactor. The drawings, when issued, are immediately uploaded on the internet for viewing and printing, which will in turn save many copying bills. The system proves to be efficient in time and cost reduction due to the decrease in data repetition. Overall using graphical illustrations to exchange data are much appreciated to all engineers than using text scripts data. Main disadvantage of the system is that an IT specialist must be present on site to cover any web problem and qualified CAD operators must be working under the designers’ supervision to update the VR model daily.

8. REFERENCES