Virtual Reality Applications in Project Management Scheduling

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ABSTRACT

This study concentrates on management of construction projects and how the spatial aspects of project development can be visualized. This research paper presents a case study of using virtual reality in project management, particularly scheduling and reporting. The concept employed in this VR application is to visualize any schedule changes in the execution order through applying these changes directly into the VR model. The research concern is the visualization processes of the project development rather than the automatic link to the schedule. The complementary use between different software programs in order to benefit from their potentials was the main research motivation, rather than the integration of these different uses in one application. The market applications represented in 4D CAD and currently used programs, are presented regarding to their potentials. The research highlights the contribution introduced by the virtual reality use to this field of project management.

1 INTRODUCTION

In general, it can be stated that project management is one of the poorly understood areas of management. "Delays and cost overruns are the rule rather than the exception in construction, defense, power generation, aerospace, product development, software, and other areas" (Sterman, 1992.) Customer design changes during construction are frequent, generating costly ripple effects which create delay. The during-construction changes are resulted from many factors which are not included into the research concern. Of these factors is the full, clear understanding of the construction processes and the spatial links between them, which can be provided by effectively visualizing these spatial aspects. Projects often appear to be going smoothly until near the end, when errors made earlier are discovered, necessitating costly rework, expediting, overtime, hiring, schedule slippage, or reductions in project scope or quality (Sterman, 1992.)

This study concentrates on management of construction projects and how the spatial aspects of project development can be visualized throughout the processes of scheduling and reporting. In this research area concern, the area of scheduling and reporting, an observation which forms the motivation of the research can be phrased as: bar charts and the critical path method (CPM), the traditional scheduling and progress control techniques, fail to provide information pertaining to the spatial aspects of a construction project (Poku and Arditi, 2006.) Forming the graphical representation between the construction activities and the 3D project model offers visually detailed images/insights

of construction information whether it was previously included in the schedule or recently modified during construction.

2 SCHEDULING

Schedule is a list of a project's terminal elements with intended start and finish dates. Those terminal elements are often estimated in terms of resource requirements, budget and duration, linked by dependencies and scheduled. Once the resources and dependencies are assigned, schedule can be made.

One of the most common purposes is to schedule a series of events or tasks and the complexity of the schedule can vary considerably depending on how the tool/method is used and what the details are included. Some common challenges are:
- Events which depend on one another in different ways or dependencies
- Scheduling people to work on, and resources required by, the various tasks, commonly termed resource scheduling.
- Dealing with uncertainties in the estimates of the duration of each task.

2.1 Schedule Methods

The main schedule methods are Critical Path Method, Linear Scheduling Model and Repetitive Scheduling Method. Critical Path Method CPM, the well-known method, is a mathematically based algorithm for scheduling a set of project activities. Linear Scheduling Model and Repetitive Scheduling Method are graphical scheduling methods focusing on continuous resource utilization in repetitive activities.

2.1.1 Critical path method

The CPM with linear scheduling techniques is a mathematical approach.

2.1.2 Linear scheduling model and repetitive scheduling method

Linear Scheduling Model and Repetitive Scheduling Method are graphical approaches. The productivity scheduling method is based on singularity functions that provide a flexible and powerful mathematical model for construction activities and their buffers that are characterized by their linear or repetitive nature.

The steps used in these methods are formulating initial equations, stacking and consolidating them, and deriving information about their criticality. The mathematical approach of these methods allows an integrated treatment of activities regardless of the number of modifications in productivity within the activities, and in the same time this approach does not depend on the graphical representation of the schedule (Poku and Arditi, 2006.)

3 VISUALIZATION AND 4D TOOLS

The visualization of construction progress through using a CPM schedule and a graphical representation of the construction, in order to synchronize with the work schedule, was the main concept behind many applications. In general, the architectural design is executed using a computer-aided drafting (CAD) program (AutoCAD), the work schedule is generated using a project management software, and the design and schedule information (including percent complete information) are plugged into a GIS package (ArcViewGIS). The project update is viewed in a generated bar chart alongside a 3D rendering of the project marked for progress. The GIS system developed effectively a representation function to communicate the schedule/progress information to the parties involved in the project. The output is to see in detail the spatial aspects of the project alongside the schedule, Figure 1.

The next development in this field was the 4D tools which introduce more potentials as most of the commercial 4D tools allow to build up a 4D model of the project which facilitates a comprehensive visualization process. However, 4D tools lack features such as generation and manipulation of developed 4D model on a single platform, Figure 2.
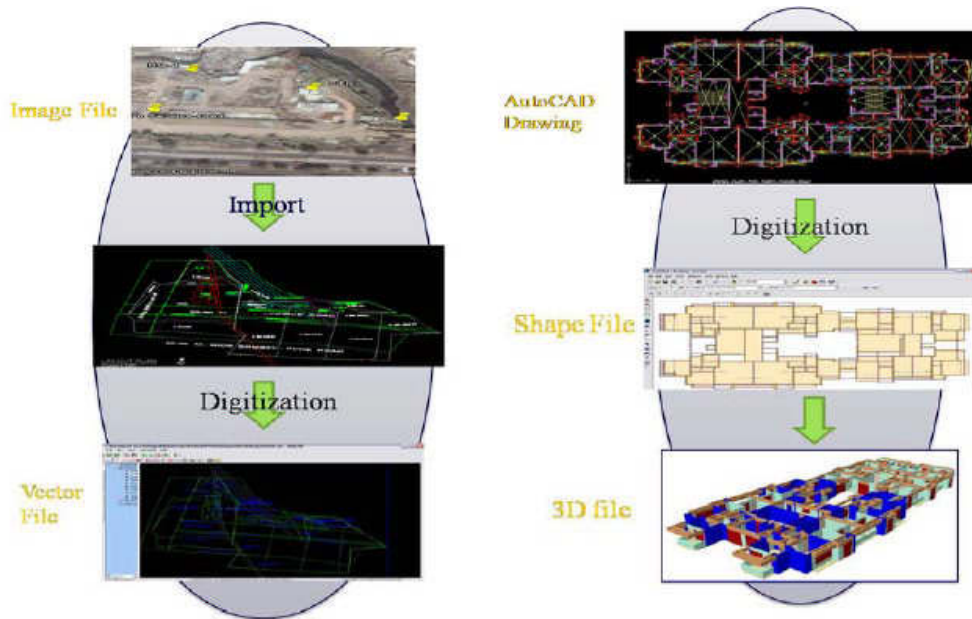
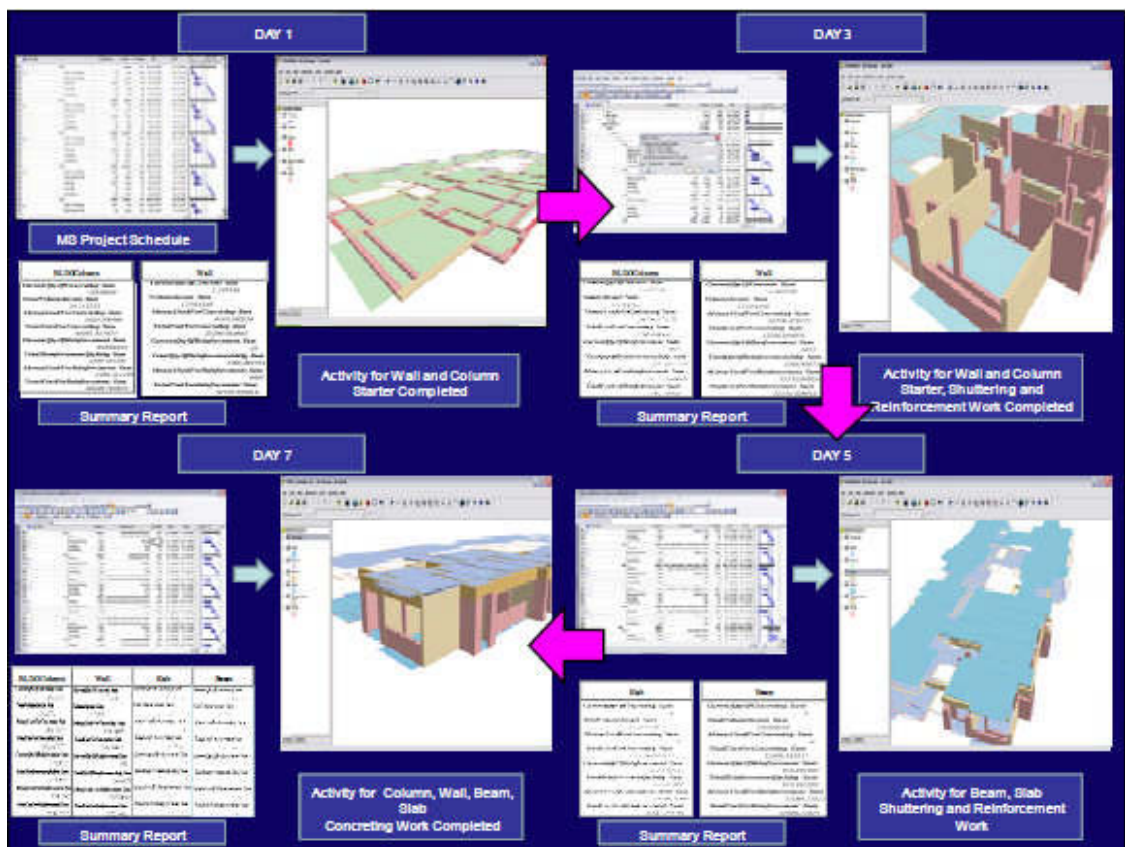Fig. 1: Migration of raw data in GIS format (Kolagotla, 2009).

Fig. 2: An example of a link between MS project management and GIS (Kolagotla, 2009).

3.1   Concept and Applications

Navigable 3D animation to visualize and review a construction project schedule is an alternative to the existing 4D CAD tools and other programs' visualization functions, for example ArcViewGIS and Revit. Most of the existing 4D technologies are usually used for planning and design phases of a project. To facilitate the 4D model manipulation, both 3D model and the project schedule can be developed within GIS. Models generated by using popular commercial tool and the schedule generated in Primavera or Microsoft Project can be also utilized. The animation of the project activities utilizes dynamic linkage between activities of the schedule and the corresponding 3D components, therefore, allowing detection of activities and errors in the project schedule. The database management capabilities of GIS can be utilized to maintain and update the construction resource database to facilitate the project planning.

The link between project management capabilities and GIS at any stage of the project, through a navigable 3D GIS based animation conveys 'where' in the space, along with 'what' is to be built 'when' (Bansal and Pal, 2009.) This link offers powerful schedule visualization, planning and querying capabilities. The main contribution of this application is the querying and analyzing potentials

In a different respect, VR application in project management would offer a contribution to the previous applications, which is not related to query or analysis, but manifests itself in having a VR model of the project rather than an animation. The VR model introduces more powerful visualization as the VR environment potentials offer more effective navigation inside the model and its components. The construction project development can be visualized stage by stage from different viewpoints. The spatial connections between different project components at different project stages can be tested and analyzed.

The concept employed in this VR application is to visualize any schedule changes in the execution order through applying these changes directly into the VR model. The research concern is the visualization processes of the project development rather than the automatic linkage to the schedule. The complementary use between different software programs in order to benefit from their potentials was the main research motivation, rather than the integration of these different uses in one application.

4   VR APPLICATION

The VR application introduced by this research paper does not apply the automatic linkage between the schedule and the VR model, in order to visualize any changes might be made in the schedule; however, this linkage can be built up through SDK programming if it is needed. The research concentrates on another respect that is VR visualization for changes in the schedule.

The research uses a project, university hospital building, to introduce the VR application. The VR environment used is the VR Studio, a VR program developed by the Forum8 Company. The research does not concentrate on the construction details of the project although the main structure system is presented in Figure 3 to highlight possible changes in the schedule. The VR Studio program and its main functions also are not explained or presented although they offer powerful visualization navigation inside the VR model.

The project structural elements are grouped and defined based on their construction decencies and execution order in the schedule. Each group is modeled separately in 3ds max program. Each group can be divided into parts to have more flexibility to apply any changes in the schedule. Material can be also added to introduce more realistic visualization. These groups, and subgroups if any, are imported separately into the VR Studio. The project site plan and the surroundings can be also modeled in the VR program that introduces many functions to form the surrounding buildings and to shape roads and control each road traffic flow with car per hour.

4.1   The Construction Project

The project consists of three units of nuclear medicine therapy, along with a four-story building of the radiology department and two operation rooms. The project, therefore, has five separate structural parts. Two structural parts of the building are column and beam structures, while each nuclear

medicine therapy unit has a separate reinforced concrete structure with least three meter thickness, Figure 3.
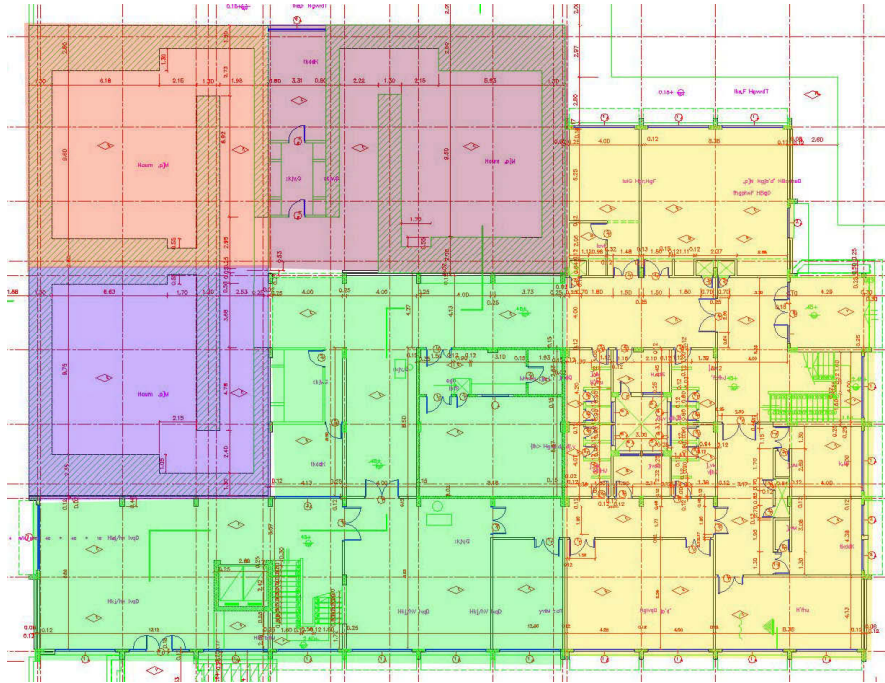

Fig. 3: The five structural parts of the project used in the VR application.

Figure 4 shows the structural parts based on the proposed schedule of the project. The construction elements and their dependencies are executed in the five structural parts. Figure 5 shows the structural parts after changes made in the schedule to have a priority for the department building of two structural parts.

The schedule changes are easily applied into the VR program, through different methods and techniques that are not into the research concern. The MicroSim function of the VR program associated with the use of XML language was employed in this case study in order to apply the possible schedule changes. The next part of the research discusses the VR environment potentials.
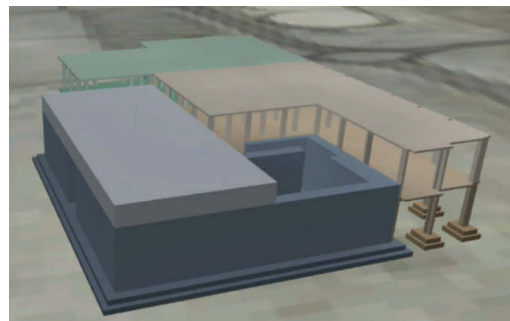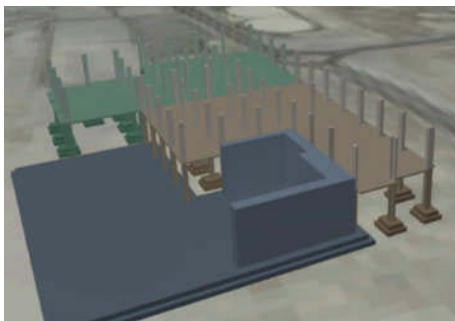

Fig. 4: Two images of the proposed project schedule.

Fig. 5: Two images of the changed project schedule.

4.2   VR Potentials

The powerful navigation introduced by the VR program help stakeholders visualize the project interior, Figure 6; the project exterior, Figure 7; and the project surroundings, Figure 8.

The surroundings and site plan with their details can be also added to the VR model in order to visualize the spatial relationship with the project components. The site circulation and construction materials storage can be also visualized and included inside the model for more evaluation and decision making processes.
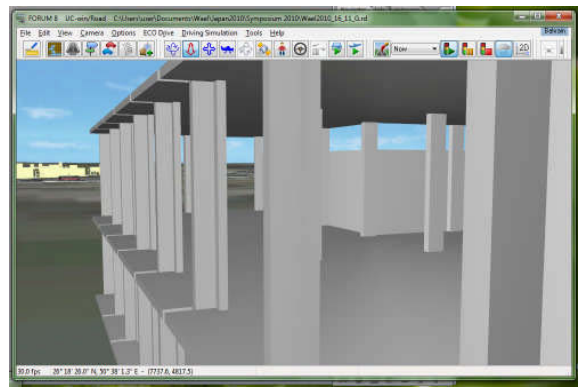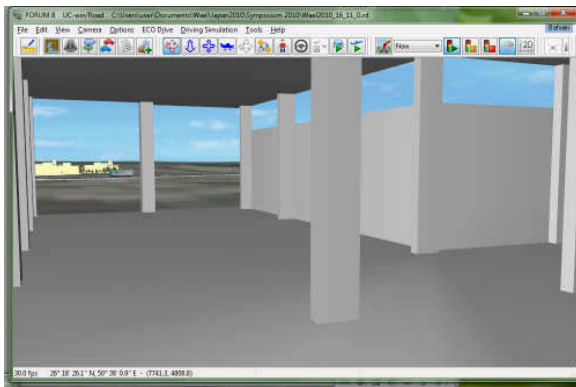

Fig. 6: Two interior images show spatial relationships of different project structural elements.
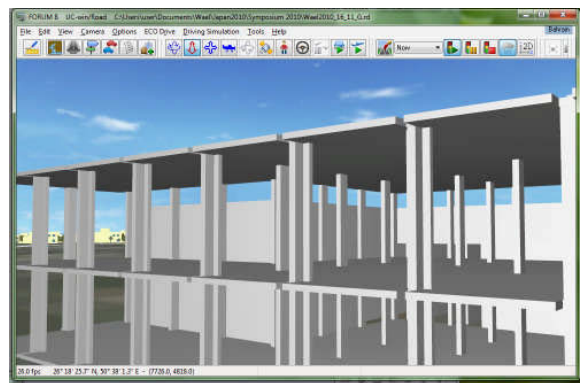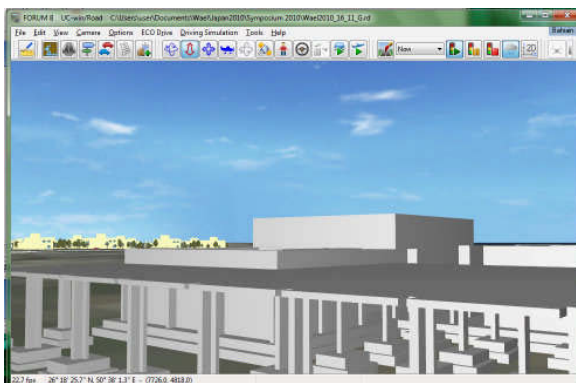

Fig. 7: Two images show different exteriors of the project during construction processes.
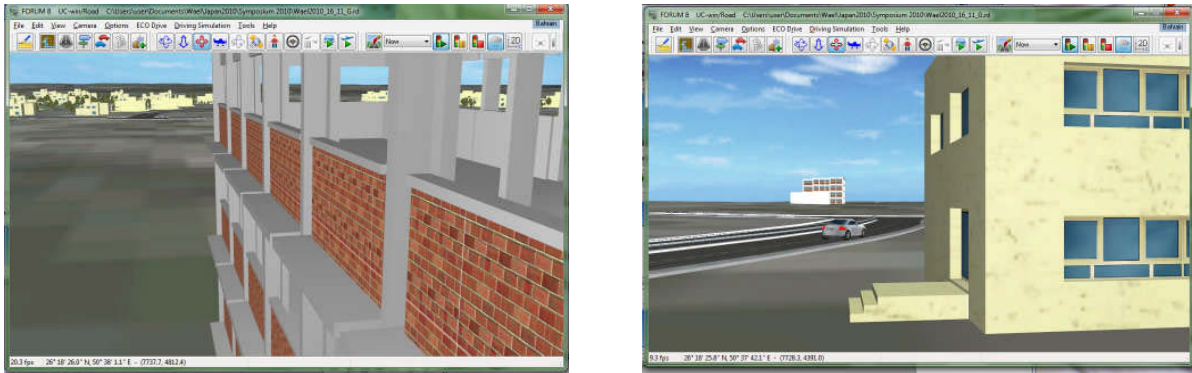
Fig. 8: A VR image shows a nearby residential neighborhood, and another image from the neighborhood shows the project exterior.

5   CONCLUSION, DISCUSSION AND FUTURE WORK

The research concentrated on presenting a new VR application in project management, scheduling in particular. The functions currently offered by famous market software, for example GIS and Revit, and used in the construction process visualization of scheduling have many advantages and contributions, particularly in analyzing and querying. The introduced VR application aim was to add the powerful navigation of schedule construction stages to these existed advantages; however, the integration of the current programs' functions inside the VR Studio, or any VR environment, can be applied through programming.

The advantages of the VR visualization can be used with other structures that are a part of the development project. The project site plan details presenting the proposed improvements to the given lot can be part of the model according to the schedule. Many details beside the project itself, therefore, can be modeled, presented and evaluated, for example walkways, roads, parking, drainage facilities, sanitary sewer lines, water lines, lighting, and landscaping.

Construction stakeholders may use this application to visualize improvements to the property site plan, employing their own specialization areas, such as design consultancy, mechanical/electrical engineering, urban design, urban plan, or even surveying. In another respect, authorities can use the VR application to verify that land use and building codes are being met, or to keep records as a historical resource.

The sets of construction materials may be included into consideration with the same order in which they will be utilized inside the construction processes. This gives another dimension to the proposed application for a more wide use range of project management in general. These construction materials along with their required store spaces and their timing of consuming in the project add more respects of who may benefit and what will be added.

Moreover, the introduced application may be employed in other project management areas related to scheduling, such as presenting a report or a risk plan. A risk plan is a list of all risks that threaten the project, along with a plan to mitigate some or all of those risks, which may result in project schedule alternatives. During project construction process, a regular report is required on different time period basis daily, weekly, monthly, etc., in order to present details of the project development and to compare it to the planned schedule processes. In this regard, the VR application can have great importance especially for those stakeholders, who are not professionals in architecture or engineering area.

The previous discussion opens various paths for practical researches and real applications in the area of project management in general, and for software development and VR applications in particular.

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