25 INTEGRATING VIRTUAL REALITY WITH CAD SYSTEM

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Abstract

The main issues that significantly contribute to problems and delays on construction sites are changing client's view, incomplete design information, and poor site monitoring and control. Although experienced designers and construction managers control or minimise such problems during the design stage, the complexity and amount of the information in construction project make such a task very difficult to accomplish effectively. This paper presents a conceptual model for an integrated system which aims at presenting construction activities in 3D using virtual reality. Firstly, the technology enables construction managers to walk-through the proposed building perhaps at different time intervals-giving a vivid appreciation of the whole situation. Secondly, its enables the users to interrogate the building elements to present its details progress thus giving total conceptual of the project. Finally the system enable virtual models to be shared and thus facilitates collaborative global design and construction.

Keywords: *Virtual reality, integrated construction environment, project model*

INTRODUCTION

The construction industry has been criticised for being slow to accept and apply modern management methods, for the planning and execution of projects, and this is said to explain, in part, poor construction performance (Oglesby, 1989). Advance has been hindered by the fragmentation of the construction industry, which has forced a large number of researchers to look for some alternative means to tackle the problem (Alshawi, 1994), and by the legal and liability considerations intrinsic to the industry. In particular, questions of ownership and use of design documents are a significant obstacle to the further integration of design and construction activities (Oloufa, 1994).

The developed data and process models have been implemented in an object oriented environment as part of a single integrated construction environment in which the main functional module is InteVAC (Integrated Virtual Reality for Building Construction).

The development of InteVAC has resulted in the implementation of a system that embodies the intuitive responses, judgements and experience of experts in its knowledge-base. The system will dynamically display the building in 3D environment using virtual reality. Virtual Reality (VR) is usually based on graphic world, and has three basic characteristic: inclusive, interactive, and happens in real time. In other words, the user of VR becomes part of virtual world where he/she can interact with and make real time changes.

THE PRODUCT MODEL APPROACH

For any construction project, project manager requires information from planners, designers and estimators. Once a design drawing has been completed, the construction planners prepare a schedule of work, identify temporary facilities, equipment, plant, etc (Alshawi,1995). The estimators, meanwhile, work out the total costs of the construction according to the information supplied by the planner. A project programme can then be produced using this information, along with other relevant information.

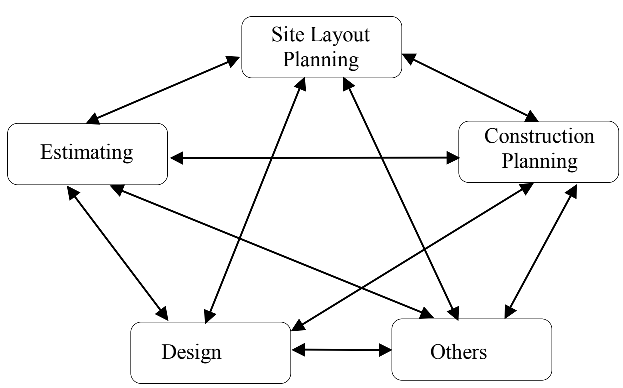


Figure 1 Project Life Cycle of Building Construction

Figure 1 shows the traditional interaction between the different applications which is necessary for the construction planning process. In this approach, construction planning is performed by obtaining the information from other parties in an informal procedure, which means, in practice, that every time a new application is added, new interfaces are required. Furthermore this approach often leads to data duplication as each application requires its own representation of the project data. This problem can be overcome by having a central model (Figure 2). The ‘central model’ referred to in this study is a *Product Model*. Aouad (1993) highlighted the fact that a full integration can only be achieved if a product model which contains all the data describing a particular building, can be established.

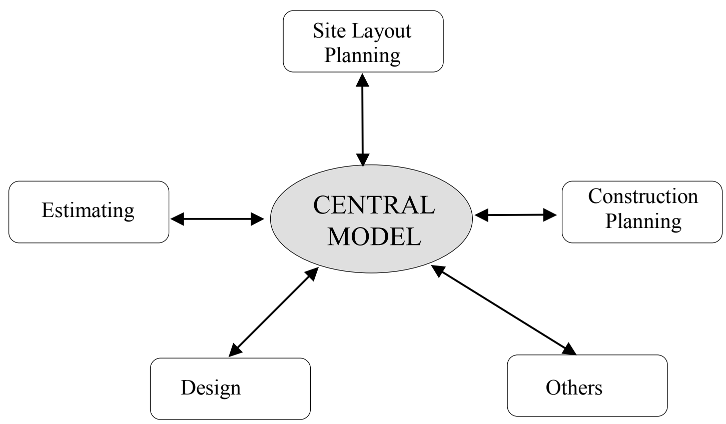


Figure 2 Central Model Approach

A PROPOSED INTEGRATED CONSTRUCTION ENVIRONMENT

A framework has been proposed for the integrated construction environment (ICE) in which all information about a project is controlled and manipulated by a modularised project model, from which all integrated applications can access their relevant information. A project model is a model that combines both project and process views (Froese, 1993).

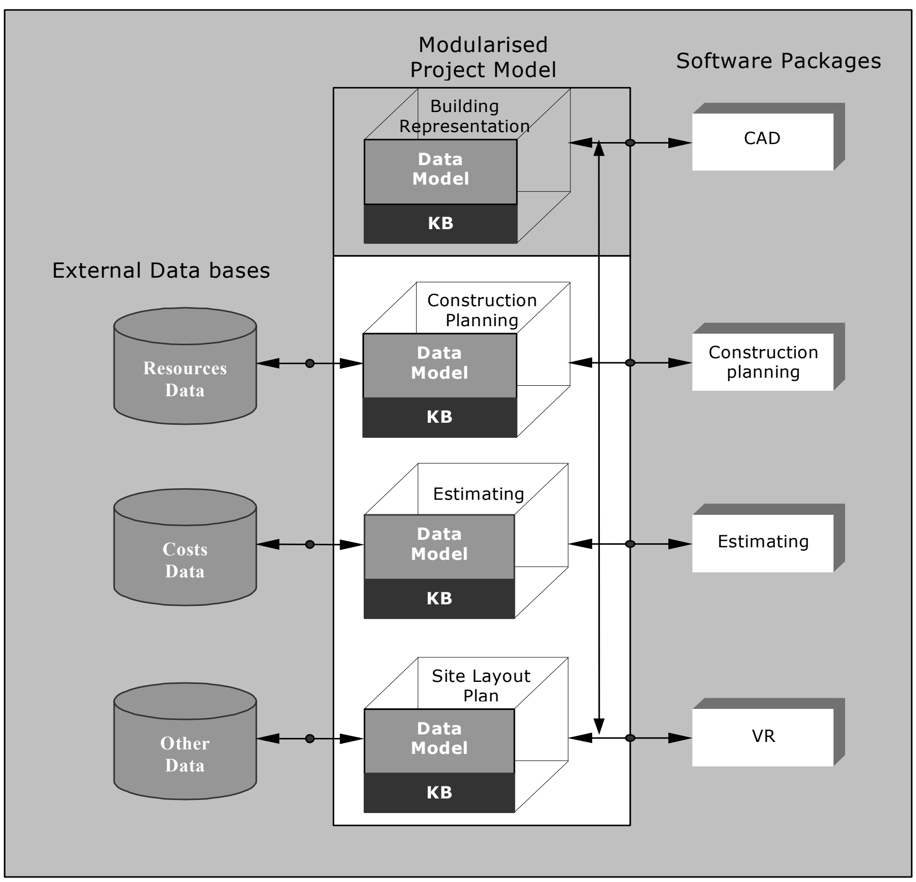
The proposed framework shown in Figure 3, consists of three main parts; (i) the modularised project model, (ii) software packages including interfaces with the project model, and (iii) external data bases.

A modularised approach has been adopted in the development of the project model where each stage of the project's life cycle is represented by a module. These modules are supported by methods/events which are necessary to describe the modules' behaviours and relationships with each other and with the external world (i.e. application software packages and external databases). Moreover, each module is underpinned by a knowledge-base which adds intelligence to its behaviour.

The Modularised Project Model

The project model comprises a building data module and other application data and process modules. The building data module mainly describes the building's components and their behaviours. The extent and structure of this module depend on the scope, the context, and the main objectives of the ICE. For example, an environment for concrete-framed buildings may have a different structure from one of steel. Other application data modules, on the other hand, represent data required by other stages of the building's life cycle, such as specifications, estimating, construction planning, site layout planning, etc. Each of these modules must be developed to fulfil the need of a particular construction application. For example, a construction planning application requires an application data module to support the information required by the planning process. For example, generic construction activities, resources available, construction methods, and so on.

The modules are designed to complement one another and to maintain and share data in the most efficient way. In this approach, data relating to a particular stage of the project's life cycle is maintained separately from other data, but makes use of other modules' data as and when required.



❑ Figure 3 Conceptual representation of the ICE

For example, the construction planning data module contains generic information about construction activities, methods, resources, etc. When it is activated, it refers to the building data module, where information about the current project is stored, to generate the project's specific construction activities.

Software Packages

The second part of the ICE represents the construction applications packages such as CAD, construction planning, estimating and virtual reality. Such application software packages can either be external (stand-alone applications packages), or internal (developed within the environment of the ICE). In either case, each application has (i) its own user interface to manipulate the information, and (ii) a specially developed two-way communication channel to transfer information between the application and its related application data module in real-time. In Figure 3 the interfaces are represented by bullets/large dots on the communication line. These application packages are completely independent of the project model.

External Databases

The third part of the ICE environment comprises the external data bases. The project model can retrieve external information from these as and when it is required by the various modules involved. This process can be discrete to the specific module or shared by a number of application modules. For example, estimating, site layout planning and construction planning applications may all need to share cost data which can be retrieved by any of these applications from the on-line database (Figure 5).

RUNNING THE ICE

ICE’s point of departure will be the input of project-specific information through a design package, a CAD package for example, from which a large proportion of the project's information can be extracted. As the design progresses, design information is dynamically transferred to the building data module in a high-level format, that is design elements (Alshawi, 1994). Once the building data module is populated with the project-specific information, users can run any other application package at any stage of the design. For example, the cost of the so far developed design can be dynamically determined by running the estimating application package. The estimating data module, in this instance, transfers the design elements along with their specifications and quantities, to the estimating software package, in order to produce either the total cost or a cost break-down of the current design. The generated costs can be altered in the estimating software package, if required. This alteration is then transferred to the estimating data module, where actions are triggered if the altered information is not feasible or does not comply with regulations, standards, the in-house database, etc.

Users can switch between various applications at any stage, and at any time. Software applications packages respond to requests from the project model, with the output of these software packages being limited to the information supplied by the project model. Objects in such an integrated environment are populated with different types of information and knowledge, at different stages of their life cycle. In this proposed ICE, an object can go through four phases during its life cycle.

Clients with limited ability to visualise 2D design tend to misinterpret the design that leads to design amendment at late stages of the construction process. VR can alleviate this misunderstanding by allowing designers to explore alternative design quickly and effectively. VR can also be used in visualising the buildings by obtaining the completed building elements at a particular time and generate the virtual objects that correspond to them. VR can support the whole life cycle of the projects, more details on VR and it role in supporting construction tasks can be found.

InteVAC is capable of building a virtual environment from the design and other construction applications interacting with them, to obtain all the data needed to generate the virtual environment that corresponds to the application's view of the data (Figure 6). It also maintains the integrity of the design in the virtual environment by maintaining the relationships that exist between objects in the project model in the virtual environment.

InteVAC, which is supported by the project model, enables intelligence to be incorporated in the virtual environment and makes it possible to obtain any information about any object, write newly-generated data or update data in the project model.

THE PROPOSED VR SYSTEM

Worldup is Windows-based real time 3D graphics developing system. Objects are created using other modelling tools such as AutoCAD Architecture Desktop, which generates DXF files. Worldup is capable reading these files, displaying the objects, and allowing the user to interact with them in real-time. In the current implementation of the prototype environment, created objects are mapped to the virtual environment as they are created by the design system. Figure 4 shows an overview of InteVAC prototype environment where the data flows to InteVAC, i.e. from the graphical file (DXF or 3DS) to the project model (Figure 8). The data in the project model is populated by the design application AutoCAD Architecture Desktop. While the DXF or 3DS files mirror the instances created in the 'Building Elements' data module. For example, a solid wall with a brick texture in the 'Building Elements' is displayed in the virtual environment as a solid wall.

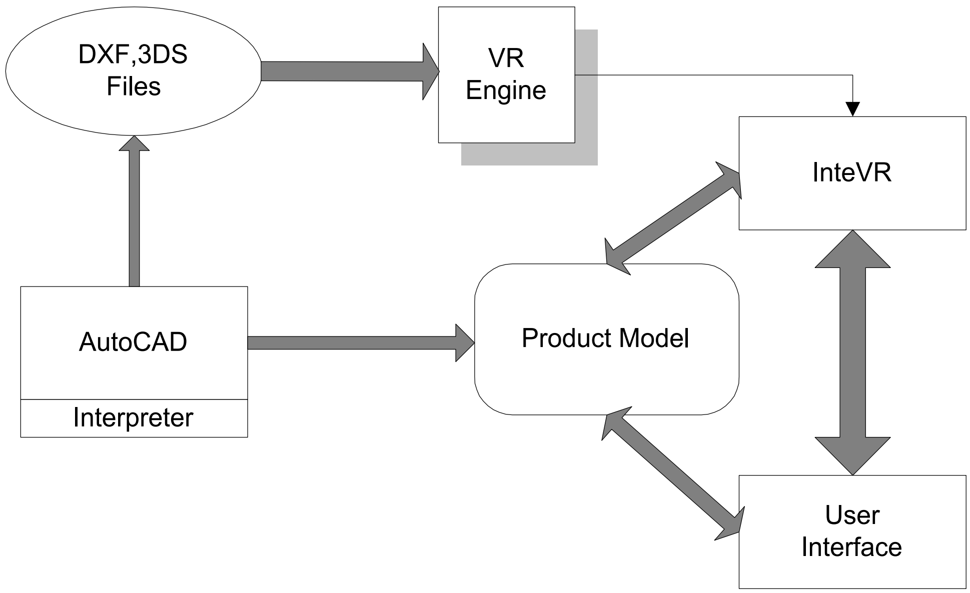


Figure 4 An overview of InteVAC prototype environment

CONCLUSION

This paper has discussed the approach and benefits of integrating CAD with other construction applications. One of the main benefits is the sharing of data at real time, thus helping to improve decision-making when evaluating the planning at the early stage of construction. The traditional approach-that of obtaining information from other parties in an informal procedure-has many disadvantages, such as data inconsistency and redundancy. New interfaces need to be developed when new applications are to be integrated with existing applications, the result of which will be a confusing multiplicity and diversity. The product model approach, on the other hand, enables applications to exchange data effectively and efficiently.

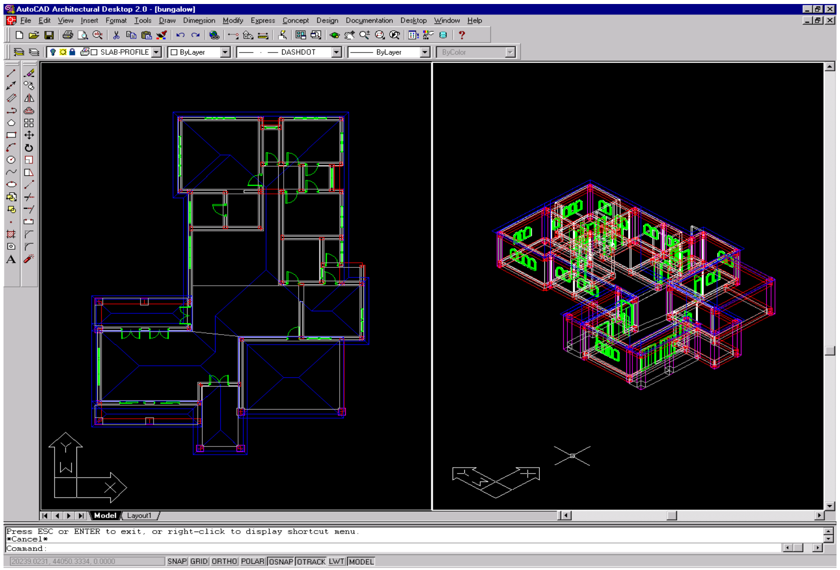
In this project, the user can generate the virtual building elements that correspond to the design produced by traditional CAD systems. The user then walkthrough and navigate in the virtual building (Figure 7), and interact with the individual virtual objects such as chair, door, wall, etc. giving the illusion of moving through a real building.

Finally, the proposed framework of integration has been found to be a great success in the attempt to produce a prototype which adopts the project model approach for data exchange between the construction applications.

Figure 5 Real time changes for building elements textures

Figure 6 Display Residential area in Virtual Reality

Figure 7 Using Virtual Reality to visualise space constraint



■ *Figure 8 CAD or 3DS file to be exported to VR*

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