# INTERACTIVE FRAMEWORK OF 3D MODEL GENERATOR FOR WALKTHROUGH VISUALIZATION

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## ABSTRACT:

In this paper a framework of building a model generator for interactive walkthrough visualization is presented. The design includes simple graphical user interface, model generator, interactive database as well as display management which can be used for visualization system. The paper describes how to input data by interactive framework from a user and bi-directional interaction between a user and an application. A technique to manage data through dynamic array, link-list and serialization is implemented. The authors also present a technique to generate 3D model data and saving data with binary and text format for retrieval to synchronize the visualization algorithm. The implementation of a prototype algorithm of visualization system produces insight visualization of three-dimensional geometric data through effective interactive display of virtual 3D virtual environment.

## INTRODUCTION

Interactive visualization is useful for evaluating, design and training in virtual environment, such as those found in architecture and mechanical CAD (Funkhouser, 1996; Airey et. al., 1990,). The visualization technique requires an interactive framework of large and complex model with many geometric primitives to reduce the visualization pipeline complexity. Visualization technique with object-oriented programming approach is recently proposed by Dixit et. al. (1999).

In this research, we design and implement a visualization framework for translating abstract objects and their relations, typically represented in visualization object forms, into realistic-looking representations and describe a general visualization interface. This paper focuses on framework design and implementation of interactive visualization for walkthrough activity (Brooks, 1986, Funkhouser et al. 1996). The approach is based on interactive windows

message passing and user interaction between a user and the system. A new PC-based CAD system for creating model visualization namely Simple-Architecture (S-Arc) was developed. All aspects required for visualization system were identified. The system includes a model and geometry database management, a new approach to generate 3D building model and a method to manage database and visualization technique with an interactive framework architecture. The most important contribution of this paper is the technique and algorithm of improving the S-Arc system for 3D graphical representation and visualization of large and complex building model with interactive task in virtual environment.

## SIMPLE-ARCHITECTURE (S-ARC): AN OVERVIEW

The Simple-Architecture (S-Arc) is a system of Computer-Aided Drafting and Design (CADD) (Yuwaldi et. al., 2000) that was developed by CAD research group in the Faculty of Information Science and Technology National University of Malaysia (UKM). S-Arc has a CADD application that helps student design, draft, visualize and learn 3D building model. It is a system with minimum user interaction aimed at high school or first year university students in creative design field (Abdul Rahman et. al., 1996).
S-Arc system uses object-oriented programming approach with windows platform and designed to suite minimum hardware facilities. The system consists of functions of standard CAD system with 4 modules: drawing, model generator, rendering and visualization, and printing. It automatically generates the corresponding three-dimensional geometrical model from 2D drawing data.

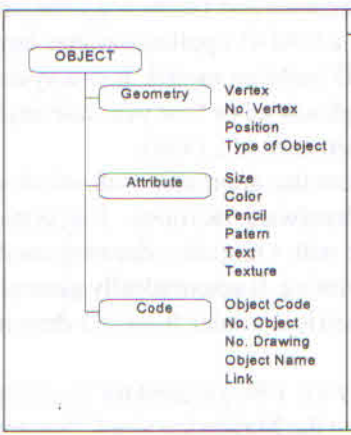
A "S-I-M-P-L-E" approach (Yuwaldi Away, 1997) is used for the design process. The acronym S-I-M-P-L-E represent the Malaysian word "Senang" (simple), "Interaktif" (interactive), "Mesra" (user friendly), "Pengajian" (education), Lengkap (complete), and "Ekonomi" (economic). Under this approach a technique to manage the data input and database to visualize 3D model with rendering is used.

## DATABASE MANAGEMENT

We designed and implemented interactive technique to handle data input from drawing module of S-Arc system. The data input, for example floor plans and their attribute, is a set of geometric data with binary and text format. The geometric data saved to database are passed through an algorithm that

perform symbols locating doors and windows. The database used to map data sets into visual media for the purpose of assisting users in exploring these data sets or visualizing them to user. The objects are shown in Figure 1.

Database management operation is activated while the user drawing the object. The activation takes place at real time during mouse interaction and display function. The view-doc interaction records the data passed through serialization. The serialization technique already use in object-oriented programming. The idea of serialization is that the objects can be buffered before it is saved on disk when a program exits and then can be restored when the program is restarted or framework is activated. The class CTypedptrList is a good example for implementation. CTypedPtrList is a template class that can be used to create a list of any pointers to objects of any specified class. The templates of this class are a relatively new C++ language element, introduced by Microsoft in Visual C++.




| Object Data | Type | Variable |
|---|---|---|
| Vertex (x,y,z) | Double | m_titikObjek |
| No of vertex | int | m_jumlahTitik |
| Type of Object | char | m_bentukObjek |
| Object name | char | m_namaObjek |
| No. of object | int | m_noObjek |
| No. of Draw | int | m_noUrutObjek |
| Position | int | m_posisiObjek |
| Object code | int | m_jenisPoligon |
| Size | float | m_saiz |
| Color | COLORREF | m_warna |
| Pencil | LOGPEN | m_Pen |
| Pattern | LOGBRUSH | m_Corak |
| Text | String | m_Teks |
| Texture | BMP image | m_Tekstur |
| Link | int | m_Link |

Figure 1: Structure of Database

## MODEL GENERATOR

We implement a simple approach for design process as a building model tool that offers design, generation, visualization, and walkthrough of model. The system allows user to perform various design set-up and analyze functions interactively. Our approach on construction processes is shown in Figure 2. It shows that once the building model is created, the S-Arc module lets user create object graphically with rendering. The model generator module is a graphical model generator for the S-Arc system. The graphical user interface

allows fast generation of building model and creates 2D and 3D layouts suitable for building analysis.

Based on result of need analysis using SIMPLE approach, we found that there are combinations of three approaches to construct 3D model from floor plan. They are elevation, surface generation, and cloning process. The algorithm is a pre-processor to the S-Arc building design modeling system to generate floors, portal (doors, window, etc), and roofs on top floors. The algorithm provides instant response and calculation for the object paths, as well as primary floor plan object and developing portal, thus the data saved using hierarchical geometric approach (Clark 1976). Construction of a 3D model of the floor is possible once the floor plan has been corrected and analyzed. Floor plan is extruded to form the walls of the 3D model. A floor and ceiling polygon is generated for each space. Doors and windows consist of holes in the walls of the connected spaces, plus polygon that connects the adjacent spaces. The most essential of the properties of resulting 3D model is height information, which is absolutely necessary for constructing the 3D geometry. Clearly, height cannot be extracted from a 2D drawing such as a floor plan. Therefore, the user must specify the proper heights of ceiling, door openings and window openings (h1, h2). Figure 2 shows technique of 3D building generator using S-Arc.

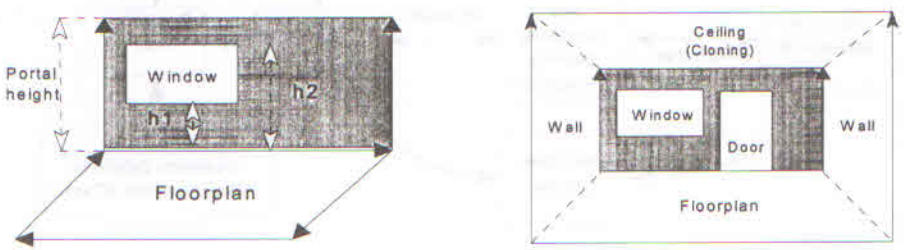



Figure 2. 3D building generator in S-Arc.

## THE FRAMEWORK OF VISUALIZATION SYSTEM

The fundamental idea in S-Arc interactive framework is to render objects with real time interaction between database and display algorithm. The rapid transfer of 2D data input among database or 3D display algorithm is of crucial importance for the acceleration and reduction in the number of iterative steps for visualization processes. In our framework, abstracted objects in 2D and relations are mapped to 3D graphical objects and relations by interactive object mapping rules. The focus our visualization process is to determine a

3D model of graphical objects under geometric modeler with interactive framework task.

S-Arc system is an event-driven programming of object optimized for various phases of visualization data flow (Yuwaldi et al. 2000). S-Arc databases deliver fast turn around time during visualization, high performance rendering during visualization and capturing model-level for filing with most major various file formats (src, txt, bmp). S-Arc also provides powerful walkthrough environment through its graphical user interface and mouse interaction. We design and implement a technique to manage geometric data through typically dynamic array, link-list and serialization (Abdul Rahman et. al., 2000). Then the data are saved with binary format and text format. The text format can be retrieved using other visualization system. The framework of visualization in S-Arc system is described in Figure 3.

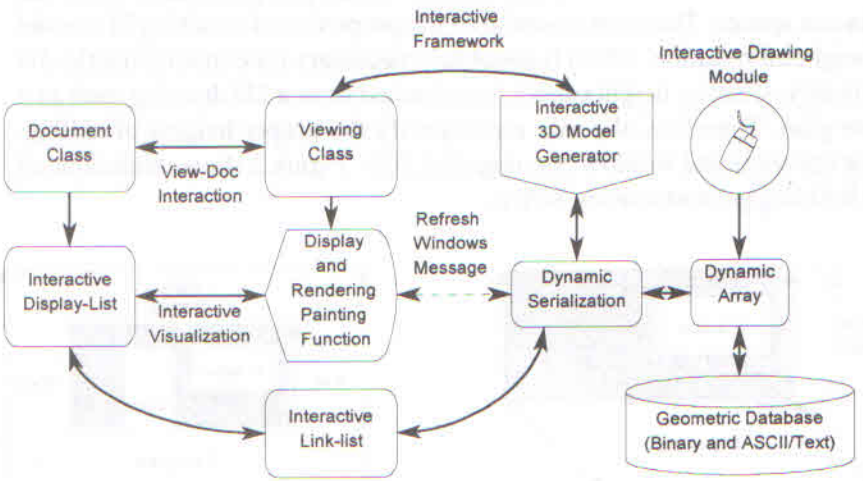



Figure 3: The Framework of Visualization in S-Arc System

The visualization framework of S-Arc is demonstrated from beginning to the end by a simple approach. Model generator creates 3D models from inputting database through dynamic array. The 3D model is a set of geometry that covers the entire surface of the object. It iteratively creates model from these geometry and add them to the visualization system through link-list. This requires each patch to be entirely visible in a given view. When all the range of data has been accounted, the model is completed and ready to display by display-list. The final model can be written out as a set of polygon in the binary and TXT file format that can be read by a wide variety of CAD

systems. S-Arc provides a WYSIWYG (What You See Is What You Get) environment by capturing visualization system and export to BMP file format. We are investigating this methods to accelerate rendering using efficient storage and retrieval of large amount of data with interactive display algorithm.

The process to generate the building model (model generator module) begins from input data of S-Arc system via object of floor plans. The 2D geometric data, which is saved to database, are passed through an algorithm that performs topological correction and semantic analysis. Symbols locating doors and windows are located. The gaps and incorrect intersections are fixed, and edges are grouped into contours representing each space on the plan. Ceiling heights of different spaces are determined through examination of a "reflected ceiling plan" corresponding to each floor. The building generator module is fully interactive with all other S-Arc modules i.e. drawing module, database and visualization managed through a view-doc mechanism. The model generator module can be used to build a polygonal based reliability model of the system. The S-Arc allows the user to build hierarchical levels of detail model. This makes complex models much more manageable.

A symbolic data representation of three-dimensional model is represented by vector projected into 3D buffer scene in this visualization framework. However displayed information are not saved in database, it is projected from three-dimensional information onto a two-dimensional view plane. Interactive visualization allows direct transformation of model with manipulating vertex of object through link-list and display-list. Building models to be provided through S-Arc visualization module with walkthrough capability. S-Arc allows viewers to walk around, then walk through building. The viewer is able to change with interactive zooming, direction and move sources around by hand. The scenes are composed of ray-traced imagery and dynamically rendered geometric surfaces. S-Arc added the capability to produce a walkthrough-viewable model without leaving the S-Arc program. Another facility that walkthrough viewer can perform is to allow the user to navigate the building. It is guided by hand, which influences the visualization of the models for the initial model and by walkthrough activity, which is used to assess the interior models.

The framework of S-Arc visualization implemented with object-oriented programming, windows platform, and design are used to suite minimum hardware facilities. S-Arc is currently fully supported in the Windows 95/98 environment. S-Arc was developed using visual development studio Microsoft Visual C++ (Kruglinski, 1996). All algorithms are written in C++, to optimize visualization performance the system implement OpenGL and GLUT libraries (Dirk et. al., 1999). An OpenGL display-list has been implemented with clear

selected buffers and enables them for visualization. The OpenGL allows controlling of parameters of the scissoring, alpha, stencil, and depth-buffer tests that are applied to pixels. OpenGL also perform dithering and logical operations and finally use the accumulation buffer for such purposes as scene anti-aliasing. S-Arc at this stage gives fixed lighting, materials, and textures. The projection (perspective or parallel), point of view, scale, rotation, and translation are variables. The value of projection parameter is dynamically depending on mouse movement interaction by user. Fast rendering speeds using double-buffering, 3D geometry, and texture mapping techniques now common to current visualization efforts extend the power of graphic transformation.

## CONCLUSION

The effort to design and implement the interactive framework for visualization with accurate z-buffer for object drawing with Simple-Architecture (S-Arc) has been completed. At present not all visualization problems have been solved. However, this technique has been applied to S-Arc to manage the drawing, database management, model generating, and interactive visualization. In the case of complex model with large number of geometric primitive, interactive maintain rate is so slow. The performance is considerably improved if only the visible object is rendered.

## REFERENCES

Abdul Rahman Abdullah, Azlina Ahmad, Marini Abu Bakar, Seah Boon Keong, and Siti Mariyam Shamsuddin. 1996. S-CAD: A School CAD software For Malaysian School. *IASTED Int. Conf. on Modeling, Simulation and Optimization.* 6-9 May 1996. Gold Coast. Australia.

Abdul Rahman Abdullah, Yuwaldi Away, and Riza Sulaiman. 2000. Database Management for Graphics Application Development (in Malay). Technical Report FTSM (FTSM/Mac 2000/LT 88). Universiti Kebangsaan Malaysia, Malaysia.

Airey, J., J. Rohlf and F. Brooks. 1990. Towards image realism with interactive update rates in complex virtual building environments. In *Proc. of ACM Symposium on Interactive 3D Graphics* : 41-50.

Brooks, F. 1986. Walkthrough: A dynamic graphics system for simulating virtual buildings. In *ACM Symposium on Interactive 3D Graphics*, Chapel Hill, NC.

Clark. J. 1976. Hierarchical Geometric models for visible surface algorithms. In: *Communications of the ACM*, 19, 10 : 547-554.

Dirk B., Michael Meibner, and Tobias Huttner. 1999. OpenGL-assisted occlusion culling for large polygonal model. *Computers & Graphics,* 23 : 667-679.

Dixit, D. S., Shirish H. Shanbhag, S.P. Mudur, and Kurien Isaac. 1999. Object-Oriented design of interactive mechanism system –Clodion. *Computer & Graphics*, 23 : 85-94.

Funkhouser, T. 1996. Database Management for Interactive Display of Large Architecture Model. *Graphics Interface'96*, Toronto, Ontario : 1-8.

Funkhouser, T., S. Teller, C. Sequin, and D. Khorramabadi. 1996. The UC Berkeley System for Interactive Visualization of Large Architectural Models. In *Presence*, 5,1.

Kruglinski, D. J. 1996. *Inside Visual C++: The Standard Reference for Programming with Microsoft Visual C++ Ver 4*. Washington: Microsoft Press.

Yuwaldi Away. 1997. Software Engineering Process for Conceptual Design of the Simple Computer-Aided Drafting and Design (S-CADD). Ph.D colloque, Universiti Kebangsaan Malaysia, Malaysia.

Yuwaldi Away, Abdul Rahman Abdullah, and Riza Sulaiman. 2000. S-Arc: a System of Computer-Aided Drafting and Design for Drawing 3D Building Model (in Malay); Technical Report FTSM (FTSM/Feb 2000/LT 85). Universiti Kebangsaan Malaysia, Malaysia.