Animation for Computer Integrated Construction
Application to Elevated Highway Reconstruction after Great Hanshin-Awaji Earthquake

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ABSTRACT

Computer graphics animation systems provide the ability to integrate on-site engineers’ expertise into design systems as well as construction management processes. Computer graphics animation improves coordination and communication among engineering, construction and client organizations. The expedited communication leads to a substantial improvement of quality and productivity in the AEC industry. Computer graphics animation makes it possible to move through the design objects and view the proposed facility interactively in virtual environment. In this way, all participants can work as a team beyond their specific interests. A collaborative work environment is created.

The paper introduces the application of computer graphics animation as a tool for the construction management in terms of computer integrated construction, evaluates the role and proposes recommendations for the application. In order to verify the effectiveness of the application, a case study was performed in a highway reconstruction project in Kobe, Japan, where much of its infrastructure suffered from severe damages due to the Great Hanshin Earthquake in 1995. The study showed its superiority as a communication tool to the common paper-only tool.

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INTRODUCTION

A great earthquake, the Great Hanshin-Awaji Earthquake, hit Kobe area and damaged much of its infrastructure in January, 1995. Some elevated highway-bridge girders fell down. Some piers shows fatal clacks. Some piers leaned. Most of the damaged structures had to be repaired or even be completely reconstructed.

A route of elevated double-deck bypass road bridges for Route 2, Hamate Bypass, is one of the vital national arteries, which passes through the middle of the city of Kobe known as an international seaport. The bridges suffered from severe damages in their piers and girders. Some of them had to be reconstructed and aseismically reinforced. Engineers in the government, contractors and regulatory services have been working very hard to let the artery be in service as early as possible.

A section of the artery reconstruction projects, Hamabe-Dori section (Figure 1), is located right in the middle of the cross section among the elevated highway, Hanshin Expressway, elevated railroad, Port Liner, and the artery, where the traffic beneath these structures is very busy. All of the structures had to be reconstructed or repaired as soon as possible in the same period. Collaborative work environment was essential to the quick recovery.

Figure 1: Aerial View of Hamabe-Dori Section (All Girders Removed)

Computer graphics animation has been implemented to the reconstruction in order to
minimize conflicts among the projects in the same area and expect the support of general public by promoting the importance and sequences of the project.

COMPUTER GRAPHICS ANIMATION

Computer graphics animation is categorized in two basic functionality. Those are real-time animation and frame accurate (frame-by-frame recorded) animation. A difference exists in how animation should be applied to solve a specific problem, which is interactivity.

Real-time animation (Figure 2) is dynamic and interactive. Interaction requires significant graphics processing power. Real-time animation is created by complex four step process. First, three-dimensional models are created using either external CAD software or a similar aspect of the animation software. These models are then loaded into the animation system. Second, a user supplies a real-time animation controls parameters such as camera position, view parameters such as perspective angles, and object positions in the model. Third, the objects and the camera are moved based on the input provided by the user. Fourth stage is the rendering stage. The most important feature of real-time animation is the ability to provide complete, interactive control over the motion of the objects and the camera. The size and complexity of the model and the power of the graphics hardware influence performance.

Figure 2 : Snapshots of Real-Time Animation (Redevelopment Site in Osaka, Japan)

Unlike real-time animation, frame-accurate (frame-by-frame recorded) animation (Figure 3) is not interactive. This method is less effective for interactive applications such as design review and construction simulation. Since the rendering time is no longer dependent on an interactive bottleneck, more sophisticated rendering techniques such as multiple reflection and shadow can be used.
The process of frame accurate animation is similar in many ways to real-time animation. As in real-time animation, the creation of three-dimensional objects is the first step. The motion of the objects and a camera in a key frame is saved in a script file. The system then renders the scene. Once the rendering process is complete, the scene is recorded on video-tape or digital media. Once a scene is rendered and recorded, the system moves to the next frame. This process repeats until the objects and camera motions defined by the motion script file are completed.

![Figure 3: Snapshots of Frame-by-Frame Recorded Animation](image)

(1) cooperative business relationships as opposed to competitive ones;

(2) integrated computer systems that allow concurrent design and construction as well as
sufficient field access;
(3) ability to provide both owners and operators with information required for operations and maintenance;
(4) ability to communicate electronically with major project participants such as clients, vendors and subcontractors.

The goal of CIC is the vertical integration of data, design decisions and knowledge through all phases of a construction project in order to improve the productivity and quality of design and construction. In this way, constructed facilities can better meet the cost, schedule and technical performance objectives of their owners. Moreover, enhanced integration and automation of the decision-making process in all phases of the project can provide a machine-readable and machine-usable knowledge environment in which computerization of the construction management processes can be accomplished more efficiently.

Among the technologies for CIC, computer-aided design (CAD) systems perform a variety of design, engineering and managerial tasks. In addition, computer graphics animation is now seen as an emerging CAD-related technology in the AEC industry.

APPLICATION FOR AEC INDUSTRY

Most personal computers available today offer enormous power and speed which only expensive mainframe computers were capable of several years ago. In the AEC industry, personal computers have become capable of using new and emerging computer technologies such as computer graphics animation. Expensive mainframe computers are no longer required for such applications.

The AEC industry can improve efficiency and gain benefits resulting from the use of the computer graphics animation systems. Communication among participants can greatly improve the construction process. Computer graphics animation can play a key role in this process. However, as construction projects become more complicated and more technologies become available, efficient communication becomes essential. The ability to quickly and accurately convey the physical configuration of a construction project is desired. Computer graphics animation allows construction project participants to exchange ideas and to interact with three-dimensional geometry without any ambiguities or misunderstandings. Animated images require less interpretation than static images or drawings.

Application of computer graphics animation for AEC industry provides strategic and operational advantages:

(1) the ability to quickly and effectively present concepts in a form which resembles physical and real images allows designers to identify an owner's needs and to provide solutions to these needs;
(2) the ability to directly and interactively develop a program of conceptual design for a client on the computer screen with three-dimensional animated images;
(3) the capability for training and rehearsing complex construction operations to help manage construction safety; and
(4) the ability to disseminate newly developed in-house technologies to prospective owners with wide range of technical background, allowing them to consider the technologies for their new facilities.
These advantages provide a strategic benefit and an increased edge over competitors. A firm's improved image as a client-oriented, advanced technology company catches the eye of a prospective owners and could thereby increase its market share.

In addition to the image advantages, productivity improvement can be expected by:

1. the ability to construct a project and detect obscure flaws on the computer screen before actual field construction;
2. the ability to involve more people from design, management, construction, operations and maintenance during the detailed design phase for exploring options that might lead to design improvement;
3. the ability to create instant snapshots of the current state of the design, which does not suffer from construction delays associated with plastic models; and
4. the ability to facilitate immediate and unambiguous communication of the spatial relationships among all design objects within the facility for better installation sequencing.

CASE STUDY IN HIGHWAY RECONSTRUCTION

As stated in the previous section of the paper, the reconstruction site is located in the difficult condition. Not only collaboration among the project participants is required, but cooperation of general public is essential to the successful completion of this fast-track reconstruction project. In this regard, some specific applications specified previously were expected to be applied and their applicability was studied.

![Figure 4: Animation Selection Menu displayed at the Information Booth](image-url)
Contractors of the project jointly set up an information booth to familiarize residents and others with the project. It is to provide people with general information about the AEC industry as well as reconstruction methods chosen and reconstruction sequences and status. (Figure 4 and 5) Computer graphics animation about the reconstruction process, such as removal and reinstallation of damaged girders and piers (Figure 6 and 7), has been displayed on a personal computer at the booth and is regarded as an exciting and effective guidance.
On the other hand, computer graphics animation has been used in a bridge girder removal process, where three huge track-crane (360 ton lift capacity) were required, to check clearances and interference between giant cranes and bridges prior to actual construction. (Figure 8, 9 and 10) The animation worked, showing on-site engineers its removal process on the computer screen.

Figure 7: Animation Scenes of Demolition Process of Damaged Bridge Pier (P12)

Figure 8: Crane Setting Layout

Figure 9: Actual Girder Removal
CONCLUSION

Visualizing demolition and reconstruction sequences with computer graphics animation has been performed and evaluated through the case study. Due to the increased complexity of construction methods and rapid advance of construction related technologies today, clients have experienced more trouble in evaluating designs by looking at only site plans and elevations than they used to have. Computer graphics animation allows the clients to communicate the designs much better and to help make better decisions. From the client’s point of view, prompt and appropriate decisions could be easier to make and tough judgments could be made earlier in the project.

During the construction stage, computer graphics animation could be used to evaluate the constructibility of a number of bridge demolition processes on the computer screen by actually performing construction simulations and by graphically displaying work status and physical interference at any given time. It allowed the client to feel comfortable with the process. In this way, all construction participants can understand each other and work as a team beyond their specific interests.

Animating and visualizing the highway reconstruction sequences and methods with a widely familiarized personal computer at the information booth caught the eyes of not only participants of the project but people who live near by the construction site. It has contributed to improve public awareness of the AEC industry activities.
REFERENCES

