APPLICATION OF COLLABORATIVE SUPPORTED FRAME ACCURATE ANIMATION FOR BRIDGE CONSTRUCTION PROJECT

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Abstract

During a civil engineering construction process many types of professionals are involved, such as engineers, constructors, designers, clients and so forth. To provide mutual understanding among construction workers and unify their ideas is necessary the creation of an effective presentation. In addition, the construction process have to work relatively in harmony with the situation of the construction site. Moreover, the use of Computer Graphics (CG) can help to visualize clearly sequences of the construction process, simulate changes in the execution of the project and make it possible to be carried out smoothly before the construction begins. The paper introduces the application of Frame Accurate Animation (FAA) as an important implement for the construction management. Also explains the use of FAA in an illustrative example of the Sashiki Bridge (provisional name) construction project in Kumamoto. Our main expectation is for the work environmental become more cooperative, efficient and safely.

Key words: Collaborative Work, Frame Accurate Animation (FAA), Presentation

1. Introduction

In phases of the public investment process, the construction work has to be shared and subdivided among construction workers. For this reason, exchanging design drawings, ideas and information about the construction project becomes not so simple to be done. The positive use of information technology can be observed trough the introduction of CALS/EC in the construction business area. CG Animation (CGA) is one of these types of information technology, and has been reported with many practical uses on design drawing processes. The authors has applied Frame Accurate Animation (FAA), one of the CGA technologies, on different sequences of several construction projects so far, and distilled the application requirements and issues as follows:

(1) purposes of use and objects were not clear during the use of FAA;
(2) according to each purpose of the applications, FAA was not well expressed; and
(3) specific role and usage of FAA were not well informed to the evaluators.

In this research, FAA reproduces construction sites’ condition, attempting to support the construction collaboratively. The possible usage of FAA during the construction process as a presentation tool has been observed through our second pilot project, Sashiki (provisional name) Bridge, the first extra-dosed bridge in Kyushu region in Japan, introducing the concept of the collaborative supported FAA application for construction management practice.

2. Presentation of Construction Process with FAA

By using FAA during the construction process, two specific forms of the use have been verified. They are presentation and simulation. Whether it is presentation or simulation depends on the exact purpose of the usage. Strictly saying, however, users can adopt simulation as a tool to make presentation.
Depending on each specific purpose of the use, FAA scenarios must be created for the effective presentation. In this paper, the presentation with FAA for expediting communication during the construction management process is called "Collaborative Supported FAA."

As the FAA application impacts so many people related in public works, applications of Collaborative Supported FAA have to be categorized, and subjects and purposes have to be made clear to obtain an effective presentation. According to Kunishima, important matters and issues on the construction management process and its condition can be observed. Examples of specific uses of the Collaborative Supported FAA have been illustrated. Three main processes of the use are considered as follows: (1) acceptance of an order, (2) construction work planning, and (3) construction management. In each stage of the construction process stated above, audiences are specified and considered: They are engineers, construction workers, clients, and local community. The Table-1 explains each position of the use. Engineers can use Collaborative Supported FAA when they seek authorization or confirmation to execute his task.

In the phase of acquiring orders, the first step engineers involve in the construction project, engineers have to make a proposal in tenders with value engineering, promoting in-house technologies. In the phase of construction, thanks to the FAA's persuasiveness, the construction work sequences can be understood without enough construction management expertise or the presence of an expert. Therefore, a group of technical workers and engineers are able to carefully and easily analyze the construction work plan, making a successful decision in studying proposals of construction work plans.

The Table-1 also presents the possibility of

<table>
<thead>
<tr>
<th>Table-1 Usage of Collaborative Supported FAA</th>
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<tbody>
<tr>
<td><strong>For Engineer</strong></td>
</tr>
<tr>
<td>Main Objective</td>
</tr>
<tr>
<td>Explanation</td>
</tr>
<tr>
<td>(Confirmation, Consensus Making)</td>
</tr>
<tr>
<td>To decide construction method and sequence for tender price estimation</td>
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<tr>
<td>Planning</td>
</tr>
<tr>
<td>To help examine construction planning;</td>
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<tr>
<td>To examine alternatives for change order;</td>
</tr>
<tr>
<td>for example construction method site layout</td>
</tr>
<tr>
<td>Management</td>
</tr>
<tr>
<td>To get agreement on change order</td>
</tr>
<tr>
<td>To inform construction plan</td>
</tr>
<tr>
<td><strong>For Worker</strong></td>
</tr>
<tr>
<td>Main Objective</td>
</tr>
<tr>
<td>Explanation</td>
</tr>
<tr>
<td>(Confirmation, Instruction)</td>
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<tr>
<td>To instruct work conditions for subs;</td>
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<tr>
<td>To instruct construction activity;</td>
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<tr>
<td>for example safety instruction coaching</td>
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<tr>
<td>traffic control</td>
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<tr>
<td><strong>For Client</strong></td>
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<tr>
<td>Main Objective</td>
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<tr>
<td>Persuasion</td>
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<tr>
<td>(Recognition, Suggestion)</td>
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<tr>
<td>To get agreement for construction plan</td>
</tr>
<tr>
<td>To inform construction plan</td>
</tr>
<tr>
<td><strong>For Local Community</strong></td>
</tr>
<tr>
<td>Main Objective</td>
</tr>
<tr>
<td>Persuasion</td>
</tr>
<tr>
<td>(Understanding, Agreement)</td>
</tr>
<tr>
<td>To publicize construction activity for example site surroundings from start to finish completion status construction outline construction method environmental impact</td>
</tr>
<tr>
<td>To mitigate complaint</td>
</tr>
</tbody>
</table>

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FAA applications in decision making process in proposals for the client. Clients expect to hedge risks and get their project done faster. To let the local community go through the construction work plan and construction site management processes enables collaborative relationship between engineers and local community. Moreover, it is necessary to give details of construction management process to all construction workers. Thus, FAA provides the capacity to explain the contents of the construction work process, gives safely directions to the workers, and allows engineers to share data and information with others.

3. Collaborative Supported FrameAccurate Animation:

To make Collaborative Supported FAA, the following two points should be considered. They are entire reproduction of construction site and visualization of the model creation content. Entire reproduction of the construction site is very important for simulation. Forecasting construction site condition is also very important during the construction process. Collaborative Supported FAA can be expressed in two dimensions. They are spatial expression, which provides enlargement, reduction, and visual effects, and temporal expression, which is flexibility of time scale. Collaborative Supported FAA enables to reproduce both huge amount of information such as whole construction site surroundings and detail expression such as re-bars arrangement depending on the specific size of enlargement and reduction at the same time. Collaborative Supported FAA also makes it possible to visualize impossible situations as if it were in reality, simulating virtual conditions inside of the structure that a naked eye can not observe. In terms of the flexibility of time scale, Collaborative Supported FAA reproduces not only the whole work schedule from the beginning to the completion of the construction work activities but also certain complicated work schedules. Thus, what Collaborative Supported FAA can realize and forecast is summarized as follows; (1) condition and relative position of the structure through the spatial expression, and (2) construction process and any relevant activities to the work through temporal expression. Moreover, the advantage of using Collaborative Supported FAA is the faithful reproduction of the construction site circumstances and is the ability to forecast the construction site condition precisely.

Repeating a series of still images makes collaborative Supported FAA. In this way, the project participants can visualize construction in three dimensions and different sequences of the construction process by just turning on and off. Also, selecting a certain frame of the animation can easily print out a still image.

AutoCAD r14J and 3DStudioVIZ 1.0J were used for the modeling and each FAA’s still frames, and both are from Autodesk Inc. Director 5.0I, a MACROMEDIA product, was used to script each command of action. CD-ROM was used for the distribution of Collaborative Supported FAA.
4. Case Studies

Sashiki Bridge (provisional name) is situated at Ashikita area in Kumamoto Prefecture, Japan. The bridge is being constructed as the second route in a wide agricultural area of Ashikita (alias: Orange Belt). Details of the Sashiki Bridge construction project can be observed as follows:

Description: Construction of 3 clear span extra-dosed pre-stressed concrete bridge;
Length of main span: 225m,
Width of Bridge: 9.25m - 12.25m
Duration of Work: March, 1998 ~ November, 2000 (Estimated Completion)

The agricultural road projects of the second route in the wide agricultural area of Ashikita intend to improve the circulation and transportation systems of the district. The district of Ashikita is a prosperous area in the southernmost Kumamoto Prefecture. The project aims at the development and stability of the agricultural work by improving logistics access. The extension of the road is around 25km, and the road system is called the Orange Belt. The Orange Belt will be alternative route for the Route 3.

The construction process of the Sashiki Bridge, the first extra-dosed bridge in Kyushu region, was relatively unfamiliar. The extra-dosed bridge has the normal girder bridge structure whose upper floor slab is arranged with pre-stressed cables to support the diagonal member arranged outside of the slab. The structure is an alternative solution to make use of pre-stressed concrete in the main girder and to stand the bending moment. Applications of Collaborative Supported FAA are illustrated as follows.

(1) Simulation of Re-bar Arrangements of a Pier

FAA visualized the re-bar arrangements of a bridge pier and helped site engineers for examining better installation processes. The animation was used to facilitate communication with re-bar placers and site engineers, allowing them to examine various ways of the re-bar arrangements. In general, re-bar arrangements of the bridge pier were designed independently among its base, column and beam. (Figure-1) Through regular designing process, the thickness of re-bars in the same part such as a base or column is taken into account although not taking others parts into consideration. Therefore, the re-bars of each part are always interfered each other. In this situation, site engineers usually redesign re-bar arrangements beforehand, and redraw re-bar arrangement drawings before making decisions in changing positions, cutting or reinforcement.

Figure 1. The CAD drawing
Figure 2. Study of Arrangements
Figure 3. Re-Arrangement of a Pier
However, the engineer often find the presence of re-bars interfered each other at the actual construction site, only to find that the re-arrangement is needed. For this reason, the engineers decided to place all re-bars of three parts altogether in advance on the computer to see where the interference was observed and how they can re-arrange them. (Figure-2) Then, they re-arranged interfered re-bars so as to interfere with each other (Figure-3).

(2) Overall Construction Schedule

It's important for project participants, such as engineers, workers, clients and local community, to grasp the whole process of the project in the earlier stage of the construction. For example, the FAA can be used for the engineers to support the rational construction planning by grasping the whole story of the project intuitively. For local community, it can be used to improve the image of the construction project. Thus, in this specific application, the FAA was created with the function of the bridge structure turned on or off, showing the major work schedule from start to completion (Figure-4). Through the application, the whole process of the project including the geographical features was visualized. The objects created for this application can be used for other FAA applications.

(3) Simulation of Cantilever Erection System

The Figure-5 shows the erection process of moving wargen in Cantilever System. The FAA can be used for the working explanation and for pointing out the dangerous part in education for inexperienced workers. Captions in each figure help understand the
complicated erection process. It may not be effective for well skilled workers, but the complex construction which is difficult to grasp a situation only from the information of the still images.

(4) Change Order Approval for Main Tower

For explanation of changing scheme on construction sequence of the main tower and cantilever construction, FAA was created by showing both original and changed designs side by side. (Figure-6) On the process of the main tower construction, constructing main tower in advance and construct cantilevers later was the original sequence. However, engineers decided to change the order. In the proposed alternative plan, three blocks of cantilevers have to be erected before the main tower construction begins for ease of working. It would be critical if engineers found any problem on the construction site with everything set up, such as working space shortage. FAA should be used to rehearse several site layout of construction by comparing the working space in advance.

(5) Completed Structure and CG Photo-Montage:

It seems important for residents what kind of structure is going to build and how the view changes rather than the way of construction. So the animation was made which have several viewpoints such as from the sky, ship, and car. (Figure-7, 8) The contractor has to improve the image for residents, because their cooperation is needed to carry forward the construction. For example, to explain the outline of construction, it is considered that all of the processes and the completed structures help enhance
their understanding. Furthermore, it is possible to use CG photomontage. A cut of animation scenes is combined with a site photo. (Figure-9)

5. Conclusion

In this paper, authors tried to help support construction management process by reproducing the construction site and virtually performing construction activities on the computer, proposing Collaborative Supported Frame Accurate Animation. Case studies on an actual bridge construction project in Sashiki have been performed and the results from the studies have been examined. Through the case studies, the evaluation method for the Collaborative Supported FAA application in construction projects found to be necessary not only by the cost and the period of production but by some other performance evaluators such as the value chain analysis method which can expect synergy of each application.

In this research, designers mainly produced the data of FAA. It will, however, be important for clients such as the Ministry of Construction in Japan, to deal with FAA by themselves since the keyword "Accountability" has been look at to carry out their duties and to explain how the public works projects are needed.

References

