Cooperative Reinforcing Bar Arrangement and Checking by Using Augmented Reality

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Abstract. In this research, a bridge product model named New IFC-BRIDGE was developed to represent entities of various types of bridges in a standardized manner. To solve problems identified in planning and design of reinforcing bar works, a cooperative reinforcing bar arrangement support system using Augmented Reality technology was developed. In this system, multiple users can move tangible markers that represent entities of reinforcing bars and that are linked to computer graphics images represented from the New IFC-BRIDGE product model data. A prototype system was developed by deploying head mounted displays with video cameras. Furthermore, to enhance the reinforcing bar checking task at construction sites, a cooperative reinforcing bar checking support system was developed by using AR technology. The test of the prototype system showed the practicality of the system, and some problems were identified for future study.

Keywords: Product Model, Reinforcing Bar, Augmented Reality, IFC, IFC-BRIDGE, Collaborative Work.

1 Introduction

Reinforcing bar arrangement and checking are very important because they are directly related to the strength including earthquake resistance of concrete structures such as buildings, bridges, tunnels, etc. Currently, reinforcing bar arrangement is done by construction site workmen based on 2D drawings which can show only minimal information of reinforcing bars. Thus, workmen usually draft many large drawings and discuss with their colleagues how to arrange reinforcing bars sequentially if the reinforcing bars are complex or to be laid out densely. Otherwise, they will be in trouble at construction sites. However, it is often difficult for inexperienced workmen to visualize the reinforcing bar arrangement and sequence in their minds. Furthermore, inspectors often find it difficult to check whether reinforcing bars are arranged correctly in accordance with the drawings by using tape measures because it is almost impossible to measure all distances and spaces of reinforce bars in a short time. In addition, it is also difficult for inspectors to find time to visit the construction site from their distant offices by car or on foot for checking.

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Therefore, in this research, a cooperative engineering environment for reinforcing bar arrangement using augmented reality (AR) is proposed. In this environment, multiple workmen wear head mounted displays (HMDs) with video cameras, which are connected with their computers. They grab and move markers, each of which is linked to 3D model data of reinforcing bars, and represented by newly developed IFC-BRIDGE product model schema. By using an AR tool called ARToolKit [1], users can view the virtual reinforcing bars represented by computer graphics on their HMDs. They can discuss how to arrange reinforcing bars by moving the markers in a virtual 3D world. A prototype system has been developed, and students used it for review. The prototype showed the feasibility of this methodology.

In addition, a new framework consisting of an AR system at a construction site and a viewing and controlling system at a remote office, connected via the Internet, has been developed. This framework intends to facilitate the inspection process more efficiently so that inspectors do not have to visit construction sites.

2 New IFC-Bridge Product Model

Much effort has been seen in developing product models for building design and construction in order to enable the interoperability among heterogeneous application systems and software packages such as CAD, analysis, conformance checking, cost estimation, construction scheduling, for more than two decades. Recently, Industry Foundation Classes (IFC) of International Alliance for Interoperability (IAI) [2] seems to be considered as a de facto standard for building product models. However, as for bridges, each CAD and design software company, nation, or organization has been developing its own product model, and there is little interoperability among those models and application systems.

The authors have developed a bridge product model for prestressed concrete (PC) bridges by expanding IFC in collaboration with Japan Prestressed Concrete Contractors Association [3]. In parallel, a steel girder bridge product model was developed by the similar method [4]. These two bridge product models were merged into one, which is called J-IFC-BRIDGE.

Around the same time as this model was developed, IAI French Speaking Chapter developed a bridge product model called IFC-BRIDGE based on the IFC and OA-EXPRESS, which is a bridge product model developed by SETRA, French governmental technical center for roads and highways, and it has been open to public since 2002 via the Internet web site [5].

Both Japanese and French groups did not know their efforts in developing bridge product models each other by 2002, although their approaches were quite similar. Both Japanese and French groups decided to integrate the two product models and have proposed New IFC-BRIDGE by merging their product models by the support of IAI. Reinforcing bars of bridges can be represented by using the New IFC-BRIDGE product model.

3 Augmented Reality Technology

Augmented Reality technology provides a facility to overlap real video images with virtual computer graphics images. This can be done by showing a special marker to