A Cooperative Engineering Environment Using Virtual Reality with Sensory User Interfaces for Steel Bridge Erection

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Abstract. In this research, a product model for representing steel girder bridges was developed, based on IFC of IAI. In order to control 3D objects in the CAD world effectively, first, a virtual reality (VR) CAD system was developed for engineering of steel girder bridges by using the developed product model, Java 3D, liquid crystal shutter glasses, infrared emitter unit, etc. Then, to improve the user interface, an electro-magnetic sensor system was added for controlling 3D objects in the virtual world. This system can be used for interference checking between moving girders and surrounding structures during erection. In order to enable multiple users to view the 3D bridge model from different locations and angles, a cooperative engineering environment was proposed. In this environment, each user wears a head mounted display (HMD) instead of liquid crystal shutter glasses. A prototype system is being developed for verification of the proposed methodology.

1 Introduction

Product models represent the geometry and attribute information of products and facilities based on the object oriented paradigm. 3D CAD systems are usually used to view, control and modify the product model as a major user interface. However, it is hard for most engineers to acquire the ability to use 3D CAD systems, and they feel difficulty in controlling 3D objects when many objects are laid out in a complex manner. Although a perspective view image on a flat display monitor, generated from a 3D model, can be viewed as a stereoscopic image, most viewers cannot feel immersed in the virtual world because the image lacks true cubic effect. Thus, the virtual reality (VR) technique with a stereoscopic vision should be used to enhance the user interface of 3D CAD systems.

Virtual reality is a realistic simulation by a computer system using interactive software and hardware. The requirements for virtual reality usually include virtual world, immersion, sensory feedback, and interactivity. The virtual world can be realized as a three-dimensional space by using computer graphics. The user can feel immersed in

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 83 – 90, 2006.

the virtual world by using a special display system. Feedback and interaction can be realized by using a sensor system connected with the virtual world and the user.

In this research, a product model has been developed for representing steel plate girder bridges by expanding Industry Foundation Classes (IFC) of International Alliance for Interoperability [1]. A VR-CAD system was developed to view, control, and modify this product model effectively. In this system, graphics are generated by using Java3D. To generate stereoscopic views, liquid crystal shutter glasses and an infrared emitter unit were used.

Although the developed VR-CAD system demonstrated its feasibility and effectiveness, the mouse operation of the system had a problem and needed improvement as a user interface with the 3D virtual world. Therefore, sensor systems including an electro-magnetic wave transmitter and receivers were used to realize sensory feedback and interactivity. The sensor system allows the user to grab, move, and control each member of a steel plate girder bridge by moving a magnetic sensor in a 3D manner. We applied this VR-CAD system with the sensor system to check the interference between the member which the user is moving and the surrounding objects such as other members of the bridge, buildings, trees, construction machines, etc., for erection planning. This application showed the effective use of the VR-CAD system.

The next step was to develop a framework that allows multiple users to view the virtual world from different directions and to move the steel girder for erection planning. The system based on this framework allows engineers and construction workers to plan the erection work cooperatively.

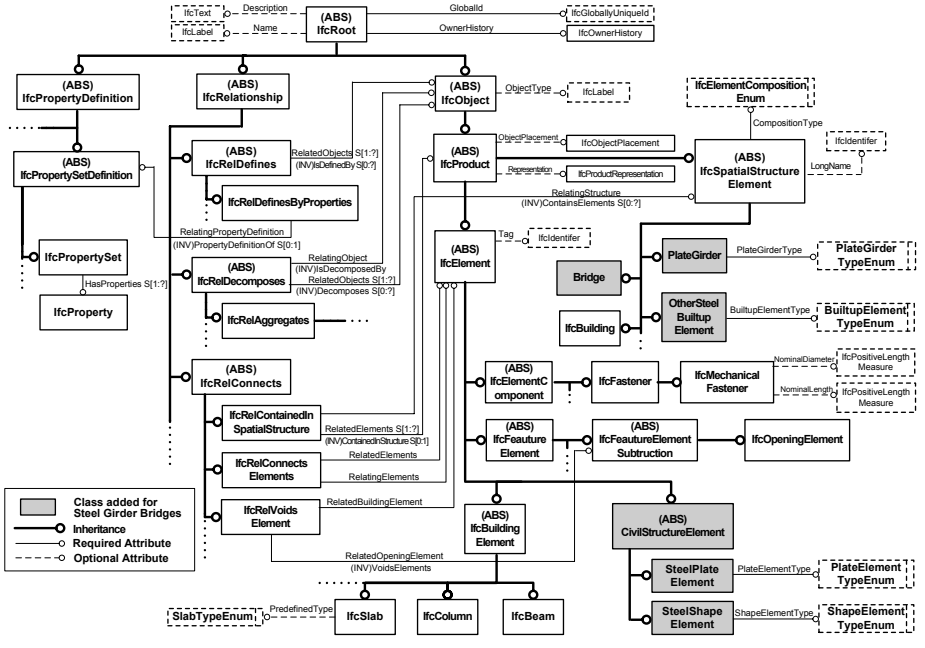

Fig. 1. A Part of the developed product model for steel girder bridges