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Ultrasonic sensor + 4D virtual reality simulation environment for safety training

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The term "4D" is used to refer to time-sequenced three-dimensional environments or scenarios. The 4D plus Virtual Reality (4D-VR) has been studied and used as game environments because the combination of 4D and VR can capture and reveal the ever-changing feature of the real world. The proposed study will bring ultrasonic sensor into the 4D-VR simulation environment as a measurement, a boundary sensor, and a testing tool for trainer reaction. It may be OK for users to jump from floor to floor in a computer game. But it sure is dangerous for construction safety trainees to take it as granted or think it is safe to jump between floors, walk through walls, or fall off beams or scaffoldings. Therefore the authors propose to use ultrasonic sensor or radio frequency identification (RFID) technologies in VR Cove to test the direction-control capability, which provides the VR safety training with game environment and sound reflection, as well as boundary detection.

The Occupational Safety and Health Act (OSHA of 1970) has made it a rule that employers provide health and safety training. In the research done by Xie and Tudoreanu (2006), the design purpose, visualization feature, user interface, and game engine used of VR construction safety training systems have been compared.

Figure 1 is the detail ultrasonic sensor + 4D VR safety-training system. In this system, safety database for equipment safety and site work safety are separated and selected. Figure 2 shows the safety control system in the ultrasonic sensor + 4D VR safety-training system. A designed sensor location system has readers sited on required positions. Special sensor tags were attached on equipment and workers' hardhat or helmets. In an intranet environment, sensor location system can arrange a distance for safety control and locating riskily locations, such as hoisting area, flammability area, falling zone, and heavy equipment path, then making a warning system for danger movement or possible safety violation. For the learner with sensor goggles or headset on, if he or she entered any of these virtual danger locations, he or she may receive an alert or a reflecting alarm. Also it may have different frequencies to zoning the safety.

The use of the ultrasonic sensor is together with a transmitter, helmet-mountable receiver and control box. It is typically mounted into head mounted displays or into eyewear for Virtual Reality and Simulation applications. The interface of the proposed system is responsible for communicating actions and feedback from and to the user. Geometric representation and physical properties of the modeled objects are described in the database. The system engine is responsible for creating time dependent events and synchronizing the simulation processes. The system processor is responsible for responding to the system events based on the objects' properties specified in the database. To achieve scalability in this system, the authors proposed to separate out modules which depend on special requirements that highly vary from one user environment to the other. A virtual clock is established between the server and the client to synchronize between the incoming client commands and the

server command processing. When the time stamp of the client commands fall behind the server clock, the server will ignore these commands- there is no need to process old data.

One task of the core processor of the proposed is to calculate the response of the system users or trainees to events coming from the engine and the interface module. This task is done by the server side. The processor receives the data from the sensors and updates commands from the interface, and accordingly will update the database of the entire system.

The ultrasonic sensors used in the 4D-VR Safety Training system help the users or trainees to recognize environment around them. In particular, it is essential function to detect the distance and direction of obstacles around a person in the 4D-VR world. Using ultrasonic sensor costs is low but is highly efficient.

This paper presented to use ultrasonic sensor in the 4D-VR Safety Training System, in particular, for construction workers. This system allows user to experience the very complicated or extremely dangerous construction situations without the need to physically visit the place. Ultrasonic sensors are used in virtual reality training. The proposed system allows for future extensions to new sensors.

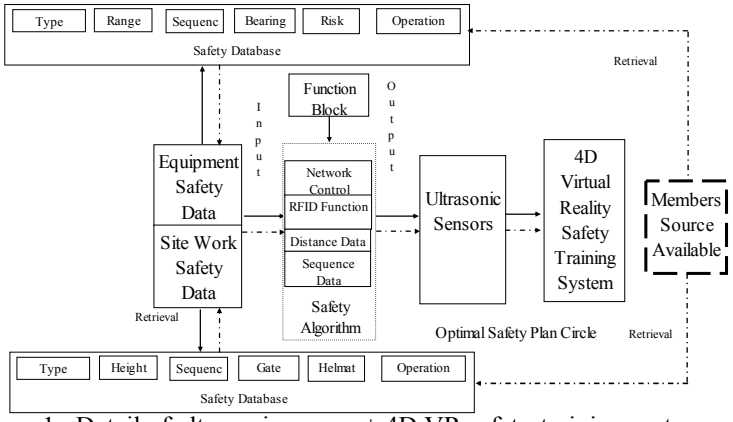

Figure 1. Detail of ultrasonic sensor + 4D VR safety-training system

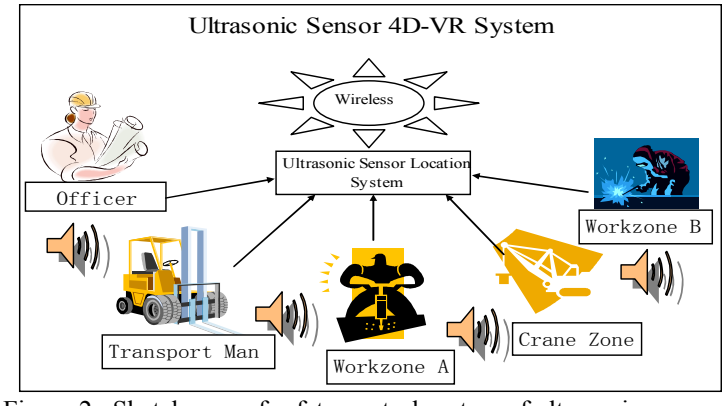

Figure 2. Sketch map of safety control system of ultrasonic sensor + 4D VR safety-training system

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