Poster: 3D Virtual Disaster Management Environment using Wireless Sensor Networks

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Abstract

The integration of wireless sensor networks with 3D virtual environments contribute to a vast array of applications in several areas such as disaster management, emergency preparedness fire, complex military training, and virtual health. Collected sensor data can be mapped to a virtual controlled environment in order to produce a real live 3D virtual environment that reflects exactly the real situation. The virtual environment can be used and analyzed by rescuer professional team to come up with a rescue plan scenario and with an appropriate effort management in an acceptable response time whenever there is a need. In this paper, we provide a general framework for 3D Virtual Disaster Management Environment Using Wireless Sensor Networks.

Keywords

Internet-of-Things, Wireless Sensor Networks, Disaster Management, 3D Virtual Environment

1 Introduction

Recently with the advent use of wireless sensors, new opportunities are opened to explore 3D virtual environments (VEs) for disaster management applications. In such applications, different team members need to collaborate with each other in order to accomplish a common goal. The integration of wireless sensor networks with 3D virtual environments provide a 3D true-to-life scenario based on the received sensor data such as fire, earthquakes and enemy attacks from the real environment.

The objective of this paper is to design and implement a 3D collaborative virtual environment application for disaster management to visualize the monitored physical environment in a 3D remotely virtual environment based on the data received from a WSN deployed in the physical environment. We aim at making it easier for the rescue team supervisors to understand the situation and decide about the workforce needed including firefighter, medical staff, and policemen, before heading to the accident site. In case of a severe disaster, a number of autonomous agents such as ground and/or aerial robots are remotely sent to the disaster site (location already known) to investigate the disaster and to send more details to the central station about victims gravity, pattern of fire spread etc. A new representation must be created in the virtual environment to reflect the new situation based of the observation of the agents/robots.

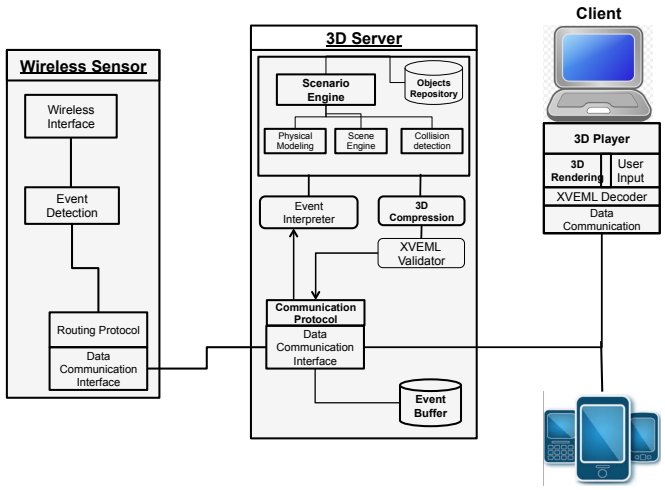

Figure 1. 3D Virtual Disaster Management System Architecture

One of the motivating applications of this proposal is to deal with disastrous situations that may occur during Al-Hadj (Pilgrimage to Makkah) season where more than three million of Muslim people gather every year to perform the rituals of Al-Hadj. Critical disasters like stampedes or fire may happen, and require an effective and prompt action plan to quickly overcome the situation. The proposed system is intended to provide a contribution in this respect.

2 3D Collaborative Environment Design

2.1 System Architecture

Figure 1 shows the overall architecture of the proposed system. Three layers are identified: (1) the WSN layer, (2)

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Figure 2. Fire scenario Implementation

the cloud-based virtual environment layer, (3) The client-side 3D player.

We propose a cloud-based system, where the processing of the complex scene is performed on a 3D server and the resulting data is streamed to the client side as shown in Figure 2. In order to cope with the large and complex 3D environments that require a great deal, the server sends only new data that represent sensor events in an XML format file using a new script language called eXtensible Virtual Environment Markup Language (XVEML) rather than sending a complete 3D content to avoid delay and system interruption. Any coming events need to be reflected in the graphical environment momentarily to provide a live interactive virtual environment with augmented reality, and thus make avatars capable to collaborate and finding their way around the accident site in the VE. Such requirement is vital for critical virtual environment application like military training, and emergency preparedness scenario. A Virtual Reality Modeling Language (VRML) client web browser with 3D graphics rendering capabilities is used. Compared to traditional approaches [3], this idea does not require the complete knowledge of objects or structures in the scene from the client side. Most of existing game engine systems block the system from users, and their features are coupled with the proposed game characteristics. In addition they require advanced programming skills which complicate the virtual environment modification task.

2.2 Protocol And Algorithms Design

We addressed three main problems. First, we focused on communication protocols in WSNs to collect and exchange data between autonomous agents such as ground and/or aerial robots and mobile sensors. We proposed extended versions of RPL, namely OF-FL a fuzzy-logic based objective function [1] for RPL in static networks that combines a set of metrics in order to provide a configurable routing decision based on the fuzzy parameters, and Co-RPL that extends RPL to support mobility using the Corona mechanism[1]. We are also working on an adaptive RPL objective function based on the operational status of the network, whether it is normal or critical operation. The idea consists in using multiple objective functions in a RPL network where an objective function promotes energy-efficiency in case of normal operation, and an objective function that optimizes the quality-of-service and real-time constraints in case of a disaster. Second, developed a highly efficient mechanism that interprets sensor data into 3D XML context representation which, can be displayed in the client side without system interruption. This representation is simple enough for real-time display. It is based on the concept of atomic action with real-time interactive rendering capability. Third, we considered the cooperation of agent autonomous (e.g. robots and drones) to perform a collaborative mission in case a disaster, such as visiting the points of interest and reporting data back to the VE server.

An initial 3D representation of the location is created and stored in 3D server. Users may download the entire 3D environment before they start using it. Collected sensor data are transferred to the central server through a communication mechanism. A scenario engine module with 3 submodules is integrated in the 3D server to handle the 3D rendering and VE environment modification when new sensor events are received. Events should be interpreted in a 3D context.

3 Discussion and Ongoing Work

A deployment of real-scenario is planned inside Prince Sultan University to integrate different modules in the project. Sensors events are collected and transmitted to a cloud-server through the Co-RPL protocol that we implemented in ContikiOS. Sensor events are interpreted into a 3D data context, and then incorporated in an XML file format using new script language called eXtensible Virtual Environment Markup Language (XVEML). We adopt two scripts levels called Class and Instance to benefit a fast creation of large-scale VE applications. In the Class level, we incorporate the atomic simulation concept [2] to model all possible simulation scenarios in Scenario Simulation XML (SCXML) file. In Instance level we incorporate the atomic behavior and action concepts to manage entities behavior and avatars facial animation in an Instance XML (IXML).

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4 References

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