GEO-FENCE DESIGN IN AN ONLINE VIRTUAL GEOGRAPHIC ENVIRONMENT WITH VIRTUAL SENSORS

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ABSTRACT: This paper describes an implementation of geo-fence in an online Virtual Geographic Environment platform, which is based on OpenSimulator with detailed geo-models to represent the real scene. Virtual sensors are used to get its position and estimate its relationships with geo-fence. Geo-fence is visualized to give the users an intuitional feeling. Some preliminary experiments were done to test the virtual sensors in the virtual environment. The overall motivation is to provide an exploration for simulating and testing sensors in a 1:1 reconstructing virtual world of the reality for research purposes.

1. INTRODUCTION

Location-based services (LBSs) are recently experiencing a massive shift in popularity (Bareth *et al.* 2010). Such as the user is in close proximity to a point of interest (PoI) or to another user, the position information should be tested for the location events. Recently, the concept of geo-fence, which represents a subset of LBSs (also can be called Zone-based LBSs (Küpper and Treu 2005)), is gaining momentum (Bareth *et al.* 2010).

A Geo-fence is defined as a virtual perimeter for a real-world geographic area, which can be dynamically generated in a radius around a store or point location, or can be a predefined set of boundaries, like school attendance zones or neighborhood boundaries. When the location-aware device of a LBS user enters or exits a geo-fence the device receives a generated notification. This notification might contain information about the location of the device. The geo-fence notice might be sent to a mobile telephone or an email account (Geofence 2011, Houseblogger 2011). There is plenty of applications for geo-fence, such as tracking senior citizens with Alzheimer's disease; tracking mobile employees, children and pets, or a certain object, e.g. vehicle is stolen; also notifying rangers when wildlife stray into farmland; etc. So the geo-fence is very useful in our daily life.

On the other hand, the implementation, testing and evaluation of new sensor systems in a real environment are laborious works. A lot of time and effort has to be spent on designing and testing prototypes and simulators in order to avoid unforeseen problems, such as regarding optimization, before the system is actually installed (Brandherm *et al.* 2008).

Because of these requirements, we propose an online virtual geographic environment (VGE) (Hui and Jianhua 2002) for the simulation, testing and evaluation of geo-fence scene using virtual sensors. In recent years, as three-dimensional (3D) virtual worlds like SecondLife (SL) (SecondLife 2011) and OpenSimulator (OpenSim) (OpenSimulator 2011) become more mature and technically advanced, they can be used for serious applications that are driven by research (Anette von Kapri 2009, Prendinger *et al.* 2009). OpenSim is an open source multi-platform, multi-user 3D application server. It can be used to create a virtual environment (or world) which can be accessed through a variety of clients, on multiple protocols (OpenSimulator 2011). Both SecondLife and OpenSim depend on user created content and have programming interfaces to create new functionality. The networked virtual environment allows for intuitive interaction.

In this paper, the VGE system is based on OpenSim and it can be regarded as the corresponding implementation of the real world, so the virtual sensor based geo-fence simulation and testing is significant; besides, the users of the VGE system can interact with the environment in the form of an “avatar” (a human-controlled graphical representation of the user) very easily based on the online 3D platform.

The remainder of this paper is structured as follows: Section 2 introduced the online Virtual Geographic Environment, which is the platform for simulation and testing the virtual sensors. Section 3 gives the design of the geo-fence using virtual sensors. After that, work on some experiments and first experiences are described in Section 4. And finally this paper concludes with a summary and an overview of future work.

2. VGE BASED ONLINE VIRTUAL CAMPUS

VGE is proposed as a new generation of geographic language that is characterized by "feeling it in person, knowing it beyond reality" (Hui and Jianhua 2002, Hui *et al.* 2009). It lies in its ability to provide virtual environments that not only correspond to true nature but also in the real world to communicate about geographic phenomena, and further to help understand human behavior taking place in the physical environment. Unlike the traditional data-centered GIS, VGE is a human-centered environment that represents and simulates geographic environments (both physical and human environments). It allows geographically distributed multi-users to visually explore spatial information, design models, implement complex computation, and to provide support for decision-making (Zhu *et al.* 2007, LIN *et al.* 2010).

In this paper, we propose the online Virtual Geographic Environment of OpenSim as a promising environment for the simulating, testing of the virtual sensors and geo-fence. The Chinese University of Hong Kong (CUHK) is selected as the case to study, and the virtual campus environment is defined as an avatar-based, explicitly geographical, immersive, and sharable 3D visual platform (Figure 2). The virtual campus server is deployed as a HTTP request and response application from a UserServerURL with all the required components for virtual scene construction and application extensions. The whole virtual campus scene is based on the OpenSimulator server, consists of the 'grid' in which the terrain domain is divided into regions of meters (Hu *et al.* 2010). And it's a realistic virtual campus of the real campus in networked virtual worlds since the scale 1:1 reconstruction and the coverage of 36 (6*6) regions by using SL-like virtual world technology (Chen *et al.*). Based on detailed models (buildings, trees and indoor space), we will implement the geo-fence to simulate the scene of realistic problems.

Figure 1. Snapshots of Virtual Campus Environment

3. GEO-FENCE DESIGN USING VIRTUAL SENSORS

According the definition, Geo-fence is designed as the following figure (Figure 2) in this paper, firstly, we define the boundaries of a certain region using the phantom prims (so that the avatar can cross it) with highlighted color by defining its position and shape in the VGE system, and then tag a virtual RFID device on the body of the avatar and when he/she exits the region, or when a strange avatar enters the region, the virtual RFID triggers an event (send a message, or sound alarms, etc.) to warn the avatar.

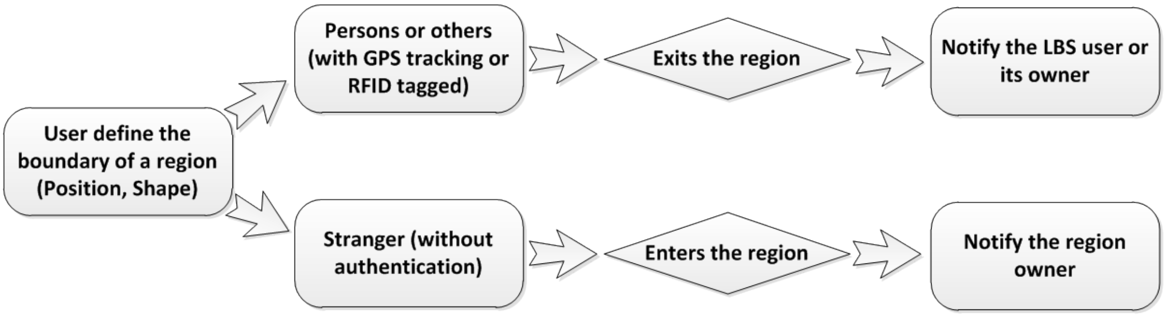

Figure 2. Geo-fence Design

The advantage of the geo-fence in this paper is, it can be easily defined using the VGE system and the area and position can also be revised very conveniently. For the primitive which is used to represent the geo-fence, can be defined and revised in very simple ways by controlling the parameters with the chat text or dialog box, and the shape of the primitive can be various, such as rectangle, triangle, circle or others. Also, the notifications can be in different ways, such as sending text warning, emails or SMS to the real users, etc. Besides, based on our VGE system, the geo-fence can be defined both indoors and outdoors.

4. PRELIMINARY EXPERIMENTS

In the preliminary experiments, we implemented the geo-fence in the virtual campus environment using virtual RFID (Figure 3) to track the avatar, and further to augment the reality by tracking the LBS users in reality by linking the avatar and the real person using GPS or other positioning device, because our VGE system is 1:1 reconstruction of the real campus and we can map the real positioning coordinates to the virtual campus and drive the avatar automatically when the real users moves.

Figure 3 shows an avatar with a virtual RFID wore on his waist, and the virtual RFID is designed with Linden Scripting Language (LSL, which allows one to assign scripts to in-world objects. With over 300 library functions and different data and message types, scripts can control the behavior of virtual objects and communicate with other objects and avatars (users of SL)) to estimate its position. Figure 4 gives the visualization of geo-fence. In the real world, geo-fence actually exists, but cannot be seen by our humans; while in the VGE system, we can represent it intuitively with different colors; besides, when the position and size of the geo-fence are defined, it will be listening to the virtual RFID, if there is any virtual RFID enter its area, virtual sensors will be triggered and warnings will be showed to the user. So finally, with the geo-fence defined and Virtual RFID programmed, when the avatar passes a classroom where is giving an open seminar, he will be notified by text tips (Figure 5).

Figure 3. Virtual RFID wore by the avatar

Figure 4. Geo-fence define by visualization (area, position)

Figure 5. Text notifications

Then the avatar (controlled by the user) may be interested in the topic of the seminar and he will enter the classroom to attend it (Figure 6).

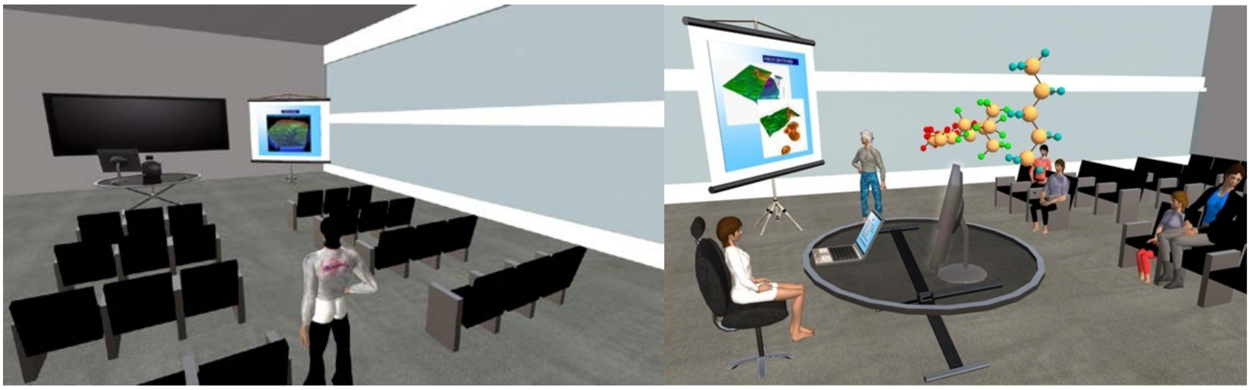

Figure 6. Open Seminar in Virtual Campus

Another important application of geo-fence is tracking some certain persons or some items to restrict them in a predefined region. The tracking targets can be the citizens with Alzheimer's disease, children need of care, and other disabled persons, or even the pets, cars or other public properties. Figure 7 and figure 8 shows this scenario of geo-fence application. These persons or items should be restricted in the geo-fence for their safety or facilitating management, and when he/she/it exits this are, the relevant person will be warned by Emails or SMS immediately.

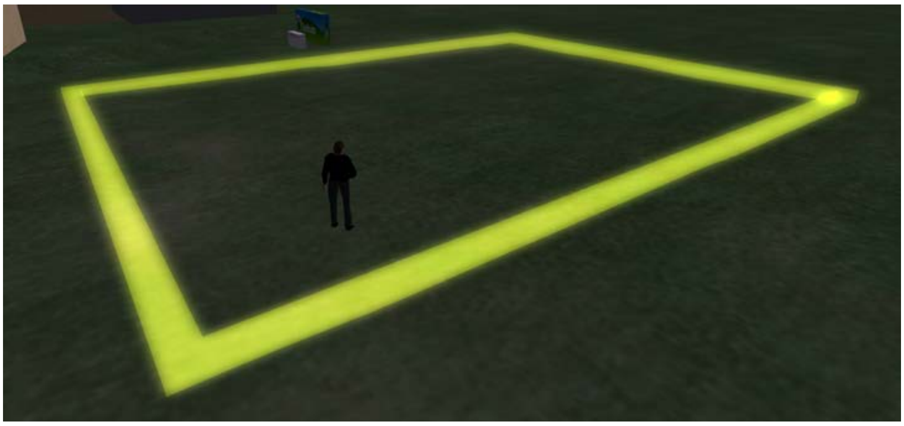

Figure 7. Geo-fence define by visualization (area, position)

Figure 8. Text warning when the avatar exits the geo-fence

5. DISCUSION AND CONCLUSION

The paper proposes a simulation framework based on the online Virtual Geographic Environment of OpenSimulator, which can be used as an evaluation testbed for sensor-based systems. A core feature of our approach is the implementation of virtual sensors in the VGE system, which is the reflection of the real world and then the simulation and testing of virtual sensors can be significant. With the example of geo-fence design we have illustrated how our simulation works can be used and how the virtual environment can be utilized for implementing to the real world.

However, this paper is only a preliminary exploration. In long term consideration, we are planning to link the physical world and virtual world with LBS users tracked by real sensors. Then the researchers, managers or other related staffs can have collaborative works in our VGE system and know the position of the concerned person such as the senior citizens with Alzheimer's disease or other disabled ones by the avatar, define the appropriate geo-fence in the system according to the situation and then notify these persons or take other proper measures. Then the geo-fence in the VGE system will be of great importance.

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