Simulation of Sensor-based Tracking in Second Life (Demo Paper)

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ABSTRACT

This paper describes "Second Life" as a novel type of testbed and simulation environment for sensor-based applications. Second Life is a popular virtual online world that provides a free networked multi-user three-dimensional (3D) environment. The overall goal of our work is to support the development, testing, and deployment of sensor-based applications. In particular, pervasive systems like smart environments make heavy use of wireless sensor networks. However, the development of such systems requires much effort and the success of a system relies heavily on good planning and testing. Many different factors have to be taken into consideration and the environment has to be modeled carefully to foresee potential problems or to be able to perform changes before actual implementation. Until now, only custom-made solutions exist whereby technical limitations restrict adequate testing. By contrast, our approach introduces a flexible architecture for an extensible testbed for sensor-based applications. It employs Second Life to model an easily customizable three-dimensional environment with various interaction possibilities.

Categories and Subject Descriptors

I.6.7 [**Simulation and Modeling**]: Simulation Support Systems—*Environments*

General Terms

Design, Experimentation

Keywords

Simulation, testbed, Second Life, sensor networks

1. INTRODUCTION

Smart environments and multi-agent system based sensor networks are highly active fields of research. The number of powerful and versatile sensors is rapidly increasing through the advances in embedded systems and technological evolution. We can already observe many interesting new application scenarios. However, similar to older trends (e.g., virtual reality in the 90s) the technology is far advanced, whereas the development tools are still in an early stage.

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Figure 1: Example of a developer avatar adjusting simulated sensors in our testbed in Second Life.

Currently, the development and testing of new systems is realized in different ways, ranging from real-world testing and miniature mock-ups for prototyping to software-based simulators [1]. Some of the existing testbeds make use of emulators for the sensor devices to support the development.

Real-world testing of sensor networks is impractical because it requires significant resources and appropriate infrastructure. Miniatures, e.g. made of wood or Lego [1], provide a possible solution. However, they still rely on real sensors and have limitations in terms of fixed spatial structure and given equipment.

For those reasons, we favor a software-based approach to simulation and testing of sensor networks. The advantages of this approach include: (1) Emulation of sensors, (2) flexible setup, and (3) fast prototyping of new environments. Two recent examples of testbeds are MoteLab [4] for wireless sensors, and eHomeSimulator [1] for smart environments. While these software-based testbeds are far more practical than physical models, both of them are limited to testing in two-dimensional space.

Besides the provision of similar functionality as conventional testbeds, the key novelty of our approach is the simulation, visualization, and interaction in three dimensions, using the 3D environment of Second Life [3] (see Fig. 1). In

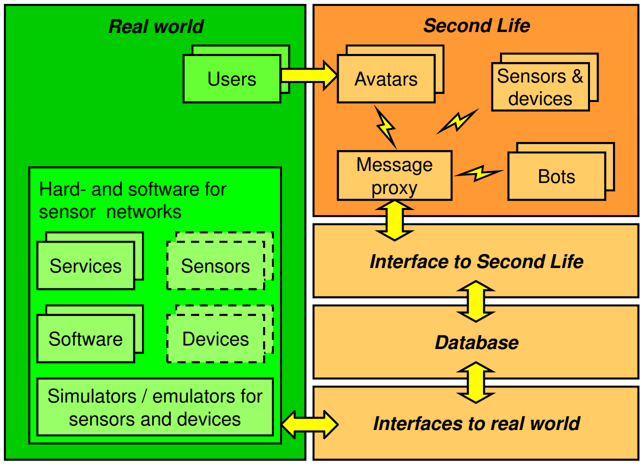

Figure 2: Architecture for the sensor simulation testbed in Second Life.

Figure 3: Visitor avatars are being tracked to gather statistical data while visiting the poster session.

Second Life, 3D content including buildings and props can be created easily, and anyone can interact with the environment in the form of an 'avatar' (a human-controlled graphical representation of a person). Benefits of 3D simulations in Second Life include:

- Spatial characteristics of sensors and sensor networks can be modeled more accurately;
- The testbed can be experienced immersively;
- Sensor models and other objects can be moved easily and intuitively by 'direct' (avatar-mediated) manipulation (Fig. 1);
- 'Bots' (computer-controlled visualizations of persons) can be programmed to simulate inhabitants of sensor based-based environments.

2. DEMONSTRATION

To demonstrate the versatility (and feasibility) of Second Life as a simulation environment, we have initially chosen the simple scenario of a poster session with sensor-based tracking. The motivation for this scenario is to track visitors in order to gather data for statistical evaluation, such as number of visitors and time spent at each poster. While available tracking systems appear to be easy-to-use in real life, the setup of the sensors is certainly a non-trivial task as it depends on several factors such as the infrastructure, the amount and type of available sensors, etc.

The testbed architecture implements a flexible framework for integrating sensor simulation into a customizable, interactive, 3D virtual environment (Fig. 2). Extensible interfaces support (1) the communication with any kind of sensors (real or emulated), and (2) access to the full functionality of Second Life, including APIs that allow us to run scripts and program new applications.

Our example scenario uses RFID tags attached to visitor avatars (Fig. 3). Since RFID sensors can only sense RFID tags in their vicinity, the (simulation) task is to position a RFID sensor network that would allow us to track the positions of visitor avatars. A simplified version of the system described in [2] is used for user tracking (here visitors).

The existing tracking software is used for simulation, whereby the sensors are replaced by simulated counterparts that are positioned within a modeled poster session room in the Second Life environment. In this way, simulated tracking is employed to collect statistical data about visitor avatars (Fig. 3).

3. CONCLUSION

The described architecture for simulating sensor networks can be used as a testbed and for demonstration purposes, but also for conducting principled user studies in 3D sensor-based environments. In our demonstration, Second Life is used to simulate and test a RFID sensor-based tracking system. Because of the flexibility of the proposed architecture and its extensible interfaces, any kind of sensor network can be integrated into the simulation. In the near future, we plan to start experimenting with wireless sensor networks. The scale of simulated environments in Second Life is not limited to single rooms, but can be extended to buildings, and in the future maybe even to whole cities.

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