Localization System for Outdoor Wireless Sensor Networks

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1. INTRODUCTION

We demonstrate a localization system, called Spotlight [1], for Wireless Sensor Networks (WSN). The system, developed at the University of Virginia, has been tested in an outdoor, realistic, environment and has shown a very high accuracy (e.g., tens of centimeters). Our contribution to the area of localization in WSNs is two-fold: develop a novel scheme for localizing sensor nodes, and implement the system on real sensor nodes and common-off-the-shelf (COTS) hardware.

2. SYSTEM DESCRIPTION

The Spotlight localization system employs an asymmetric architecture, in that all the complexity associated with the localization is embedded in a single device, called the Spotlight device. In our system, no hardware changes are necessary to the existing line of Mica sensor boards.

The Spotlight device is a sophisticated, powerful device, capable of producing controlled events (e.g., light events) in the deployment area of a sensor network. A visual depiction of the Spotlight device, is a helicopter equipped with a search light.

The sensor network is time synchronized. Its sensor nodes execute an event detection algorithm, and report back to the Spotlight device, through a base station, the time stamps of the detected events. Using its knowledge of the distribution (in space and time) of events, and the time when a sensor node detected an event, the Spotlight device is able to compute the node's location.

3. DEMONSTRATION

For our indoor demonstration, we use the following hardware: a computerized telescope mount, three very low power (less than 1mW) diode lasers, able to produce circular and linear beams, an LCD projector, a laptop and a sensor network of 10 MicaZ motes. The setup is shown in Figure 1.

The sensor nodes are attached to a vertically positioned Veltex board (attached to an easel). The Spotlight device, comprised of the telescope mount and laptop is positioned 3-4 meters away from the sensor network. A Localization GUI, running on the laptop, controls the orientation of the computerized telescope mount and the communication with the sensor network, through a base station. The Localization GUI displays, through the LCD projector, an aerial image (map) of a real outdoor environment, called deployment area.

During the demonstration, the system goes through the following phases:

- Time synchronization phase, to synchronize the clocks of all sensor nodes and the PC. This phase executes only once, at the beginning of the demo. The following phases execute in a loop.

- Event Generation phase, during which the laser will scan the deployment area. We demonstrate two different Event Generation schemes: a Point Scan and a Line Scan. In the Point Scan scheme, the deployment area is scanned by a laser with a circular beam. In the Line Scan scheme, two lasers, with linear beams, scan the deployment area, on the horizontal and vertical axes. One run of the demo will exhibit one of the two Event Generation schemes.

- Reporting phase, initiated by the Localization GUI. In this phase all sensor nodes report back to the Localization GUI, the time stamps of the detected events.

- Localization phase in which the Localization GUI computes and displays on the map the position of sensor nodes.

- System reset phase, initiated from the Localization GUI, in which all sensor nodes clear the set (i.e. empty set) of timestamps for the observed events.

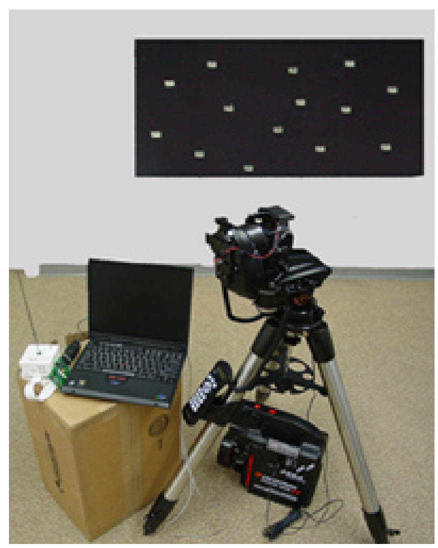

Figure 1. Indoor demonstration setup.

The error in localization of the system is represented by the distance between the position of the photo-sensor, on the MTS310 sensor board, and the position of a sensor node, shown as a red dot through the LCD projector.

4. REFERENCES

[1] R. Stoleru, T. He, J. A. Stankovic, "High-Accuracy, Low-Cost Localization System for Wireless Sensor Networks", in International Conference on Embedded Networked Sensor Systems (SenSys), 2005