Chapter 4.25
A Data Visualization and Interpretation System for Sensor Networks

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ABSTRACT

With the increase in applications for sensor networks, data manipulation and representation have become a crucial component of sensor networks. This chapter explores an implementation to process and interpret the data gathered by sensor networks. In a project supported by SensIT program at DARPA, we have built wireless sensor networks deployed to monitor rare plants or other endangered species. The environmental data, such as temperature, rainfall, and sunlight, around the plants are sent by the wireless sensor networks to a base station. The system presented in this chapter combines database management technology, geographic information system, and Web development technology to visualize the data gathered by the wireless sensor networks. The integration of our data visualization tools and the online collaborative discussion environment makes the system useful to different communities of potential users.

INTRODUCTION

Of all the global problems in the biosphere we confront today, few would argue that the extinction of species and destruction of ecosystems have the most serious consequences, and they are irreversible. Worldwide, the preservation of rare species presents a major challenge. In Hawaii, there are numerous species of plants and animals. Many of them are found only in Hawaii and are currently threatened or endangered.

In order to monitor the ecological environment and events around rare plants, the Pods project at the University of Hawaii has started to build wireless ad-hoc sensor networks (Biagioni & Bridges, 2002). A *sensor network* is a computer network made up of many spatially-distributed sensors which are used to monitor conditions, such as temperature, sound, vibration, pressure, motion, or pollutants. These sensors are usually small and inexpensive, so they can be deployed in large numbers. In a wireless ad hoc sensor

network, the sensor nodes are self-contained units consisting of a battery, radio, sensors, and other accessories. The nodes self-organize their networks, rather than having a pre-programmed network topology. Every node in this system can transmit data of its own and also forward data from other nodes (Bose, Morin, Stojmenovic, & Urrutia, 2001; Nagar & Biagioni, 2002). In our project, we call these network nodes pods. Each pod contains a micro-computer which is needed for collecting and transferring the weather data, micro-sensors, and other accessories. Currently the pod is designed to measure sunlight, temperature, wind, and rainfall. Some pods are also equipped to take high-resolution images of the plants periodically. In addition, the pod is designed and constructed to be inexpensive and easily camouflaged to avoid damage by curious visitors. The pods are deployed every few hundred feet, thus form a wireless ad hoc sensor network. A new wireless routing protocol (named multi-path on-demand routing protocol [MOR] has been designed for the network to provide energy conservation and routing efficiency. This network constitutes a monitoring system for scientists to observe the rare plants. On the Big Island of Hawaii, we have already made preliminary deployments of pods to monitor a rare plant species, Silene Hawaiiensis. Figure 1 is the picture of this rare plant which was taken automatically by a pod sensor, and is believed to be the first ever picture of a Silene Hawaiiensis in flower in the wild.

In this wireless ad hoc sensor network system, the collected data and images are transferred from one pod to another. They eventually reach a special pod — the base station. At the base station, the data are stored for further manipulation and accessible via the Internet.

It needs to be pointed out that field sites where the rare plants live are sometimes in harsh environmental condition or in remote areas. With the help of the data sent back by the wireless sensor network, the ecologists and botanists can observe the plants and their environmental conditions from

Figure 1. A Silene Hawaiiensis plant in flower