Chapter 3.2
Visualizations of Wireless Sensor Network Data

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ABSTRACT

Wireless sensor networks can provide large amounts of data that, when combined with pre-processing and data analysis processes, can generate large amounts of data that may be difficult to present in visual forms. Often, understanding of the data and how it spatially and temporally changes as well as the patterns suggested by the data are of interest to human viewers. This chapter considers the issues involved in the visual presentations of such data and includes an analysis of data set sizes generated by wireless sensor networks and a survey of existing wireless sensor network visualization systems. A novel model is presented that can include not only the raw data but also derived data indicating certain patterns that the raw data may indicate. The model is informally presented and a simulation-based example illustrates its use and potential.

INTRODUCTION

Wireless Sensor Networks are quickly realizing a potential to support large and ultra-large scale data sensor, gathering and processing applications. Applications suitable for such wireless sensor networks include ubiquitous and quickly deployable systems that can meet the anytime and anywhere demands for quickly obtaining information about the environment, processing that information and then presenting that information to human communities to facilitate better understanding about the environment. The latter includes the visualization of the sensor information and is the main focus of this chapter.

There are many types of user communities that may be interested in the information obtained via sensor networks. Very broadly, these would

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include scientists, policy and decision makers, educators and general public interests. The first two types of communities are often involved in modeling and seek to understand the sensor obtained information as observations in the context of these underlying models; or, as in the case of the policy and decision makers, base professional decisions upon this understanding. Educators are primarily interested in facilitating the learning process and may use visualizations in two ways, either by considering the sensor acquired information singularly, or as combined with the underlying models. General public interests however would often be satisfied by merely the sensor acquired information. The visualization model described here incorporates both of these visualization levels and therefore suggests its wide-scope application potential.

There are many issues involved in the visual presentation of wireless sensor network acquired information to broad audiences. Some of data related issues include: large and ultra-large scale deployments, high frequency data acquisition rates, and, multiple imagery and multimedia streams. The presentation of information will also depend upon the needs of the user communities and in particular the selection of the information level appropriate for those needs. In particular, the decision makers may require presentations to afford sufficient depth of understanding in time-critical applications. Since the latter imposes additional requirements, the focus of this chapter emphasizes the visualization of wireless sensor network information for presentation to decision makers to facilitate understanding leading to effective decisions in time-critical situations.

The objectives of this chapter are three-fold. Firstly, to discuss issues about the potential large data set sizes generated by wireless sensor network. Secondly, to survey existing wireless sensor network visualization systems. And, thirdly, to present a new visualization model that can accommodate large data set sizes and address the limitations of existing visualization systems.

BACKGROUND

The primary purpose of sensor networks is to acquire information about some environment. Sensor data is obtained both spatially and temporally, and for purposes of this chapter, is assumed to be transmitted to a computational base station for pre-processing and visual displaying. The first part of this section discusses the significant large data set sizes that wireless sensor networks impose upon visualization systems based upon a simple analysis. The second part discusses several wireless sensor applications in context of current day realistic data set sizes. And the third part discusses several existing sensor visualization systems.

Characteristics and Properties

The ideal maximum amount of information available for a visualization is limited by the sensor communication bandwidth. Two communication technologies can be used. Radio Frequency based systems have bandwidths in the 40 kbps and 250 kbps ranges (Polastre, 2004), although, newer systems may be capable of somewhat higher rates. Free space optical based technology is newly emerging and can support data rates in the order of 10 gbps or higher (see d'Auriol et al., (2009) for further discussion). The kilo bits per second range is sufficient to support typical environmental data sensing such as acceleration, temperature or humidity; but not high definition imagery nor video; whereas, the giga bits per second range can support both. Assuming an eight-bit short word representation for environmental type data; then, a 40 kpbs data rate can deliver 5120 values per second, a 250 kpbs data rate can deliver 32,000 values per second and a 10 gbps data rate can deliver over 1.3 billion values per second. And, assuming a 1280 by 720 pixel, 24-bit color image (without compression); then, a 10 gbps data rate can deliver 485 images per second.

It is unlikely that the ideal maximums truly represent the realistic maximum information