Demo Abstract: SATIRE: A Software Architecture for Smart AtTIRE

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Algorithms, Management, Measurement, Performance, Design, Experimentation

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Personal Monitoring, Smart Attire, Human Activity Identification

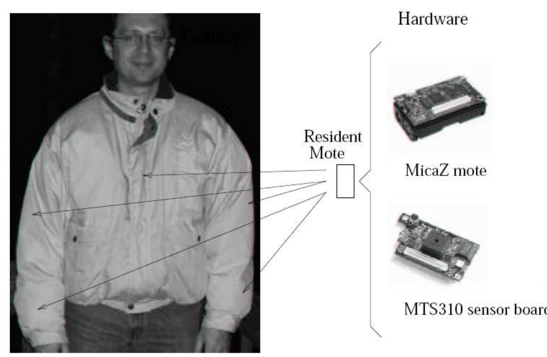

Figure 1: A typical user wearing the SATIRE jacket

1. INTRODUCTION

Personal instrumentation and monitoring services that collect and archive the physical activities of a user have recently been introduced for various medical, personal, safety and entertainment purposes. SATIRE is a software architecture, implementation, and preliminary evaluation of a wearable personal monitoring service transparently embedded in user garments. It allows users to maintain a private searchable record of their daily activities as measured by motion and location sensors, which are two of the most popular sensing modalities in personal instrumentation.

A typical operational scenario of the SATIRE jacket is as follows - an everyday user wearing the SATIRE jacket goes about his/her daily activities as usual over the course of a day. During that time, the jacket records sensory data pertaining to the owner's activities and whereabouts. When the system comes in the vicinity of an access mote (a base mote connected to a PC), the logged data is uploaded reliably to a private repository associated with the person. Further, this data can be used to reconstruct the activities and locations of the person. A typical user wearing the SATIRE jacket is shown in Figure 1.

Our current prototype records human activities and location information using 2-axis accelerometers and GPS respectively, storing the measurements locally until they can be uploaded. This is achieved using a network of a few MicaZ motes [1] woven into the lining and padding of a winter jacket. MicaZ motes are off-the-shelf devices of the size that is roughly half that of modern cell-phones. These devices have sensing, processing, storage, and wireless communication capabilities. This data collected is uploaded to a PC through an access mote connected to the serial port of the PC. This data is then used to identify various human activities using discrete alphabet based Hidden Markov Models (HMMs). Accelerometers are devices that measure acceler-

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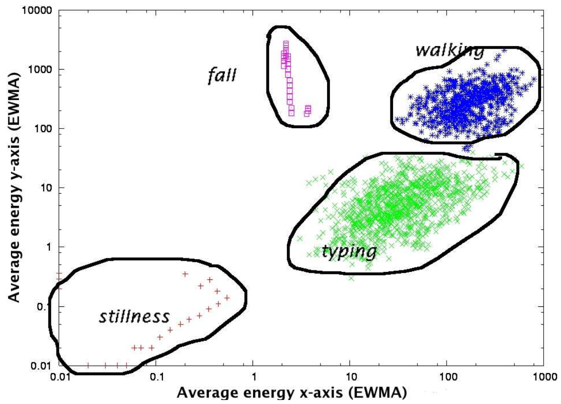

Figure 2: Map of X vs Y EWMA values for certain activities (Data obtained by performing specific experiments)

ation and can be used to identify human activities. As a proof of concept, Figure 2 shows a map of the EWMA (Exponential Weighted Moving Average) filter values of average energy of x axis of the accelerometer versus average energy of y axis of the accelerometer. We observe from this figure that different activities have clearly identifiable regions.

To accommodate a heterogeneous system that changes rapidly (e.g., due to introduction of new hardware, new system software, new sensor modalities, or new applications), we developed a layered architecture that advocates modularity and transparency, where the user involvement is kept to a minimum. Figure 3 shows the architecture of SATIRE. As we notice from this figure, the architecture is two-dimensional, the first is the *PC/laptop* and the second is the *motes*. On the motes side, the application, operating system and the hardware layer abstractions have been well developed by the sensor network community. TinyOS [2], a widely used operating system for sensor networks, provides the necessary abstraction to enable introduction of new sensor modalities. We developed data collection and storage, upload, and data synchronization protocols at the operating system layer. We also introduce the sensor specific protocols layer, *layer 3*.

On the PC side, data is uploaded at *layer 1* and is parsed and stored in appropriate data formats at *layer 2*. For example, the accelerometric data is stored as *(time,sample)* value pairs, whereas the GPS data is stored as *(time, latitude, longitude)* values. The data collected at layer 2 is passed on to *layer 3*, the data interpretation layer, which interprets the data collected using various data mining or statistical and signal processing techniques. Different algorithms for reconstruction of the type of human activity can be plugged into this layer, thus enabling easy upgrade of garment functionality. Finally, the application layer (*layer 4*) is presented with the results in a standard format from layer 3 for the user to view it.

2. DEMONSTRATION

SATIRE is a next-generation wearable personal monitoring service that is transparently embedded into user's garments. It records the owner's activity and location information using 2-axis accelerometers and GPS for subsequent automated uploading and archiving. This personal archive is

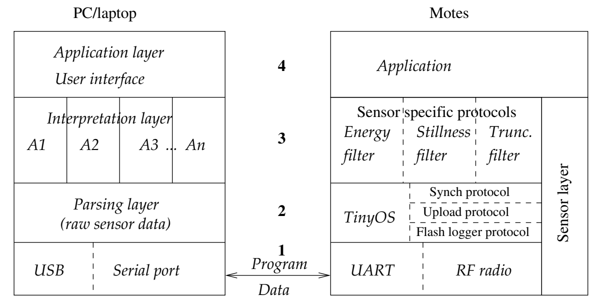

Figure 3: SATIRE architectural framework

used to identify various activities, such as `sitting, reading a book, walking and typing` and the location information of the person. Our demonstration consists of three stages. In the first stage, a user will perform a few activities, during which time the jacket will record the activity and location information and store it in the flash memory of the MicaZ motes. In the second stage, we will show the transparent data upload. When the user comes in the vicinity of the access mote, the data collected is uploaded transparently to the PC through the access mote connected to the serial interface of the PC. Finally, the data collected over the course of the demonstration will be used to identify the user's activities during that period of time. We use discrete alphabet based Hidden Markov Models (HMMs) to identify human activities. Our current implementation requires that the HMM be trained for each user separately for it to be accurate in identifying activities.

3. REFERENCES

[1] Crossbow technologies, http://www.xbow.com/.

[2] Tinyos, http://www.tinyos.net/.