Location and Activity Recognition Using eWatch: A Wearable Sensor Platform

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Abstract. The eWatch is a wearable sensing, notification, and computing platform built into a wrist watch form factor making it highly available, instantly viewable, ideally located for sensors, and unobtrusive to users. Bluetooth communication provides a wireless link to a cellular phone or stationary computer. eWatch senses light, motion, audio, and temperature and provides visual, audio, and tactile notification. The system provides ample processing capabilities with multiple day battery life enabling realistic user studies. This paper provides the motivation for developing a wearable computing platform, a description of the power aware hardware and software architectures, and results showing how online nearest neighbor classification can identify and recognize a set of frequently visited locations. We then design an activity recognition and monitoring system that identifies the user's activity in realtime using multiple sensors. We compare multiple time domain feature sets and sampling rates, and analyze the tradeoff between recognition accuracy and computational complexity. The classification accuracy on different body positions used for wearing electronic devices was evaluated.

1 Introduction

The eWatch is a wearable sensor and notification platform developed for context aware computing research. It fits into a wrist watch form factor making it highly available, instantly viewable, and socially acceptable. eWatch provides tactile, audio and visual notification while sensing and recording light, motion, sound and temperature. The eWatch power management was designed to operate similar to a cellular phone, requiring the user to recharge overnight. The eWatch needs to be small and energy efficient enough to allow for multiple day user studies by non-technical participants. Given these energy and size constraints, eWatch should provide the most computation and flexibility to allow an assortment of applications. The goal was to move beyond simple sensor logging and

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allow for online analysis that could query the user for feedback while collecting data or provide services to showcase context aware applications.

eWatch can be used for applications such as context aware notification, elderly monitoring and fall detection, wrist PDA, or a universal interface to smart environments. The ability to sense and notify allows for a new variety of enhancements. For instance, much work has been done on fall detection for the elderly [11]. Existing systems do not function appropriately when a patient loses consciousness and cannot press a button. Current automatic systems have a high rate of false positives. An eWatch system could sense if the user was in distress and then query to confirm that it is an emergency. If the user does not respond, then the eWatch could use its networked abilities to call for help. The use of online learning could profile a patient's daily activity and notify a caretaker if a patient no longer performs their daily routines. The eWatch can also notify a patient when they should take certain medication. In order to achieve these goals, we need to accurately classify user location as well as activities.

2 Related Work

Several groups have developed wearable computing platforms and wearable sensor recording and processing devices [4, 2, 12]. However, most of these devices do not interact directly with the user, have insufficient battery life, or are too cumbersome for a long-term study with non-technical subjects. The idea of a smart wrist watch dates back as early as the 1930s [6] and first took a functional form with the IBM Linux Watch [10]. In its original form, the Linux Watch was a PDA on the wrist, and did not possess sensors. Later revisions of IBM's Linux Watch added acceleration and audio sensors; however, they lacked light and temperature sensors and have not targeted user context or location tracking applications. The power consumption of the Linux Watch is too great for day long operation.

Current location tracking systems offer high accuracy [14, 9] using triangulation methods; however, they require infrastructure support. In this paper we demonstrate a simple, coarse-grained location tracking method to show how eWatch can use sensor information to reason about the environment. Our method relies only on sensor samples from the environment in order to categorize the user's location.

In [1], the authors used multiple accelerometers worn on a person's body to recognize their physical activity. Sensor data from multiple body positions was combined for classifying the activities.

In [2], a low power sensor hardware system is presented, including accelerometer, light sensor, microphone, and wireless communication. Based on this hardware, a design method for a context recognition system is proposed. It evaluates multiple feature sets and makes the tradeoff between power consumption and recognition accuracy. A system that classifies household activities in realtime with a focus on low power consumption is presented in [3].

In [8], a system using an armband-based sensor array and unsupervised machine learning algorithms was able to determine a meaningful user context model.