

Demo: Activity-aware Heart Sensing in Mobile Healthcare

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Abstract

This work designs, implements, and evaluates an activity-aware heart sensing framework based on mobile devices, called AA-Heart, which consists of two major components: the front-end mobile platform collecting user's heart and context data, and the back-end web server where the data can be visually displayed, screened and analyzed, and shared with user's permission. Using the mobile devices, AA-Heart can monitor heart continuously and send the heart data to medical staff in a real-time way. Specially, AA-Heart enables doctor to make a positive diagnosis of user's heart conditions. Since mobile devices are very constrained in energy resource, we design a semantics-based model to achieve balance of energy efficiency and application fidelity.

Categories and Subject Descriptors

C.2.4 [Computer-communication Networks]: Miscellaneous

General Terms

Design, Implementation, Experimentation

Keywords

Mobile Healthcare, Heart sensing, Activity recognition, Energy efficiency

1 Background and Motivation

Continuous heart monitoring is very critical to detect the seizure of heart disease and then to find proper, timely treatment. So medical staff often advises patients to wear a Holter during their daily life. However, three disadvantages of Holter make it undesirable for patients. First, the patient has to wear a box (recorder) on his belt to receive the electrocardiac signals from two up to twelve electrodes attached to his chest. This may make patient feel uncomfortable. Second, the heart data stored in the box can not be sent to doctor's office in a real-time manner, i.e., the patient must take out the storage card containing heart records, and give it to doctor for analysis, right at hospital. Thus the heart monitoring with Holter needs regular interventions of the patient and the doctor, and may not be able to report to medical staffs in time dramatic variation of heart state. Third, the most important point is that Holter [1] as well as other heart monitoring techniques can not well reflect the heart condition when the

patient is not in clinic, because his activity in daily life significantly affects the heart states. For example, when a user is jogging for physical exercise, as advised by doctor, his heart rate is exactly higher than the average. Consequently a heart-alarm may be improper when user starts jogging. In summary, it is a new challenge for heart monitoring in mobile healthcare environment to provide doctor more informative heart status such that positive diagnosis can be made in time. Computing and sensing technologies enable mobile devices to form a mobile sensing platform, which can extract more user-centric information, including user's call/message contacts, physical activity, favorite apps, and even their interests or health status. In our work we use mobile phone or laptop as a sensing platform to collect user's health and activity information and forward them to web server for further management. A critical problem is to enable the feasibility and efficiency of on-device sensing.

In this demo, to address the above problems in mobile heart monitoring and on-device sensing, we propose a heart sensing framework based on mobile devices to improve the real-time performance, and we consider jointly heart sensing and activity recognition of user, which will make medical staff understand user's heart condition more accurately. We design and implement an activity-aware heart sensing system, called AA-Heart, which can be used to real-timely, remotely monitor user's heart conditions in daily life covering, say, working on desk, physical exercise in gym, heart rehabilitation program, and so on. Specially, AA-Heart records location information of user, which is very helpful and practical to localize user himself and the nearest hospital in emergency. Since mobile devices are often powered by battery. We therefore design a semantics-based model to achieve balance of energy efficiency and application fidelity. According to the model, AA-Heart employs user's activity to dynamically control the location sensing task in terms of rate and duration, almost without any hand-operated overhead.

2 Overview of AA-Heart Platform

The objective of AA-Heart is to provide medical staffs or software with an information group of user's heart status, activity, and location, such that not only more accurate profile of heart can be achieved before diagnosis, but also user's location can be provided in time when emergency occurs. As shown in Fig.1, AA-Heart consists of two major components: the front-end mobile platform collecting heart data

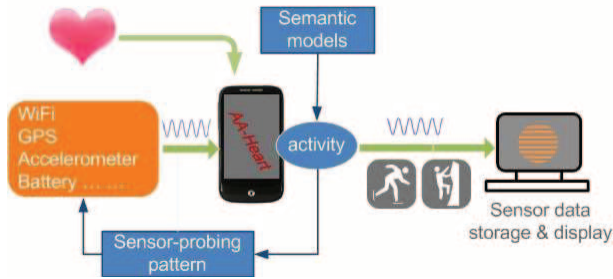


Figure 1. Architecture of AA-Heart

and user's activity and location data, and the back-end web server where the data can be visually displayed, screened and analyzed by medical staffs or software, and shared with user's permission.

In the mobile platform, mobile phone, laptop, tablet, or other mobile device can be used as a gateway to relay sensory data to web server through IP connection. In our system an Android mobile phone is used as the gateway. The heart data is collected with a regular period, in order to guarantee the fidelity of medical application. As for the activity-related data collection, we design an adaptive scheme to probe the on-device sensors such that the application fidelity can be met with as less energy as possible.

The web server can either be deployed in hospital or be maintained by some authorized agency. On the web server side, the heart data as well as the contextual information of user is stored. Therefore, any registered user can not only access his data, such as heart rate distribution, visiting place, etc., but also take back diagnosis and advice from doctor.

In addition, AA-Heart can be extended in functionalities, by deploying on the web server side more powerful analysis software, which aims at achieving excellent diagnoses and predictions.

3 Design

In this work we consider only heart rate and its variation the metric for heart condition. It is one of effective, reasonable references for heart seizure detection. One challenge in designing AA-Heart is to accurately identify and update users activity as well as his location, while minimizing the energy consumption.

Activity Recognition and Localization. We use a series of semantic models [2, 3] to map the acceleration data into deterministic activity, and then we design an activity-driven localization scheme, which adaptively records and updates user's location according to the dynamics of activity, reducing the energy cost of AA-Heart considerably. Semantic model is to transform raw sensor data to the semantic information that is easily understood and lively for users. The semantic models we use includes: activity analysis, WiFi fingerprint, place detection, and place handoff. Sampling location sensors (WiFi channel and GPS) continuously and with a high, fixed rate is very energy-hungry to mobile device, because starting and reading those sensors both consume significant energy. To address this problem, we use semantic-driven model, which adaptively collects data with a low average sampling rate to save energy, while guaranteeing the application fidelity.



Figure 2. Wireless heart rate monitor in our system

Wireless Heart Monitor. In this work we consider only heart rate and its variation the metric for heart condition. It is one of effective, reasonable references for heart seizure detection. But, note that ECG or other more complicated heart sensors can be connected to AA-Heart platform, directly or by wireless interfaces, and that we can use hybrid wireless connections in AA-Heart only if the gateway device supports them. We use eZ430 Chronos [4], a development kit of Texas Instruments, and BMi chest strap [5], a BMi heart monitor, to construct a testbed to monitor heart rate.

The Chronos watch can act as a central hub for on-body BlueRobin sensors such as pedometers and heart rate monitors. As shown in Fig.2, a Chronos watch relays heart rate data from an BMi chest strap to a gateway device, a PC or a mobile phone, where the data can be stored, displayed, or even uploaded to some web server through IP networks. In our system we use such an architecture to collect heart rate data. Since the heart data is very critical, we sample the BMi heart sensor with a regular period, without using the automatic control logic for other on-device sensors.

4 Demonstration Proposal

During the demo stage, we will present the wireless heart monitor and the context data collection of AA-heart, with user's real-time heart and his activity data. User should wear the eZ430 Chronos, BMi chest strap and the Android phone with the context data collection module. User can browse his heart data as well as associated activity and location traces in the Website [6].

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6 References

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