Using Mobile Devices Coupled with Intelligent
Real Time Analaysis for Increased and Better Patient Care.
Thesis Proposal, 6.199

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Overview

Advanced computer technologies have an opportunity to improve the health of humans. For years most medical equipment has been found only with the confines of a hospital or medical practicioners premises. Yet opportunities exist to bring these devices to the homes and work places of individuals. In fact, an area of research is using devices to monitor in real time basic vital signs and analyze this information. Although these devices are significantly less powerful than the medical devices in hospitals, the proper analysis of vital signs such as movement or heart rate can serve as a source of significant information.

Real-time monitoring of vital signs is especially important for elderly people whose fundamental organ systems may not function reliably. Heart failure is a chronic condition that is a major cause of death and disability. Over 2 million Americans suffer from Coronary Heart Failure (CHF) and around 400,000 develop it annually. Pervasive and patient-centric medical care can save lives by actively monitoring the patient. Around one million hospitilizations a year result from heart failure, many of which could be avoided if there were early indicators. Such a decrease in hospitilizations could save significant money for the health care system.

Imagine a scenario in which the movement of an elderly woman with a forrm of heart disease were constantly monitored by devices in the patient's house. Certainly too much physical activity may increase the chance of a heart attack. However, if the movement sensors were to determine that the patient's activity was too high, it could

warn not only the patient but also a doctor, relative, loved-one, or neighbor. In addition to serving as an alerting system, the activity monitors could archive the behavior and movement patterns of the person. These patterns could then be analyzed to provide some insight into the person's lifestyle and potentially suggest changes that would be needed.

Group Description

This research project will be conducted with the Clinical Decision Making Group (CDMG) in the MIT Laboratory fo Computer Science. The research group is focused on exploring applications of technologies and artificial intelligence for clinical decisions. Additionally, the group works on securely and accurately gathering medical information.

Project Description

This project aims to create a system of monitoring a patient's movements across a variety of sensors, sending this information to a network server, archiving the data, providing a basic analysis of the person's movement, and a notifying system.

Since patients with chronic diseases such as heart failure can suffer from an attack relatively quickly and unexpectedly there is a need for real time information monitoring. To support correct and detailed clinical decisions accurate information is needed. A system of archiving the data and rich algorithms are needed to analyze this archived data.

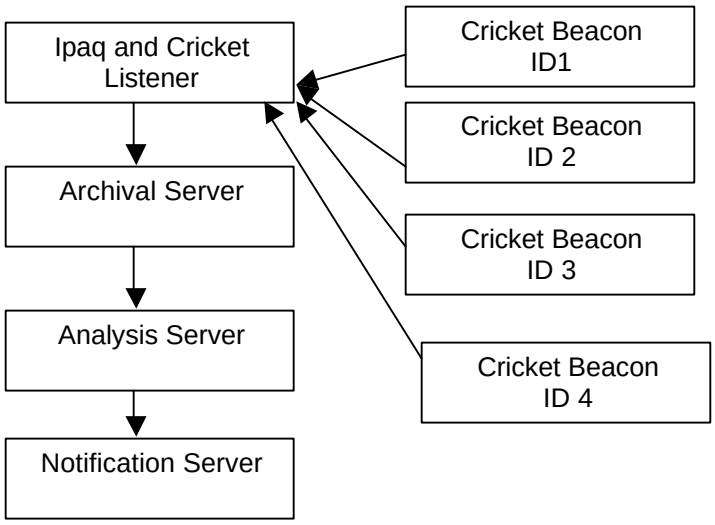

Figure 1: Overall System Design of Monitoring Network

User Device

In order to determine the movement of a person, MIT LCS Cricket technology will be used. Crickets provide indoor location information. They consist of Beacons which transmit a concurrent RF and ultrasonic pulse and Listeners which listen first for RF signals and upon finding one examine a corressponding ultrasonic pulse. The listeners use a series of estimates between the RF and ultrasonic samples to determine the location.

For this project, several Cricket Beacons will be placed in a room and each will be assigned a name while the patient will wear a Cricket listener and an Ipaq. The Ipaq will be connected to the Cricket Listener and must have the MIT Oxygen distribution of linux for the Ipaq loaded on it. The Ipaq and the listener are together referred to as the *Listener.*

Client Software

Since there will be multiple Becaons in the house, the software will need to build a map of the house containing all the Cricket Beacon names and their physical world locations including the distance separating the beacons. Once the location is determined by the

Cricket Listener, software will need to be written for the iPaq to collect and send the data to the archival server. This software involves first connecting to the listener device and examining the location of all the becons it can contact. The software will then parse raw data that comes from the cricket listener into a smaller array of information consisting of the time of sample, distance to the Beacon, and the Beacon ID number. The client software will then send this entire set of location information to the network server every second.

Archival Server

An Activity Monitoring Server will need to be designed such that it can receive the set of location information from the client. This server will also need to analyze the raw set of data to determine where in fact the closest beacon is to the person. Once it has determined the closest Beacon to the person, it will need to retain state of the person's previous location and the time. For each new trial of data sent to it from the user device, it can calculate if the position has changed and over what time period this change has occured. Since the Activity Monitoring Server will have the map of the beacon name and its physical location, it can calculate the physical distance that has been covered by the patient. In addition, the rate of movement of the person can be calculated as follows:

Speed=Distance/Time [Eq. 1]

which leads to:

{Distance between two Beacons}/{Time of sample 1}-{Time of Sample 2} [Eq. 2]

Analysis Server

Various algorithms will need to be developed and implemented to interpret the physical activity data of the Archival Server. This system should understand if the patient is physical exercise is sufficient.

Notification Server

The Notification Server generates monthly, weekly, daily, and emergency reports for both the doctor and patient. The notify server will send these reports via email and

wireless alerts to pagers and cell phones using WAP Push.

Resources

This project will require a Cricket Listener and several Cricket Beacons deployed throughout a room. An Ipaq with a wireless card connected to the Cricket Listener is needed to serve as the user device.

Scheduling and Milestones

A timeline is displayed below in Figure 2.

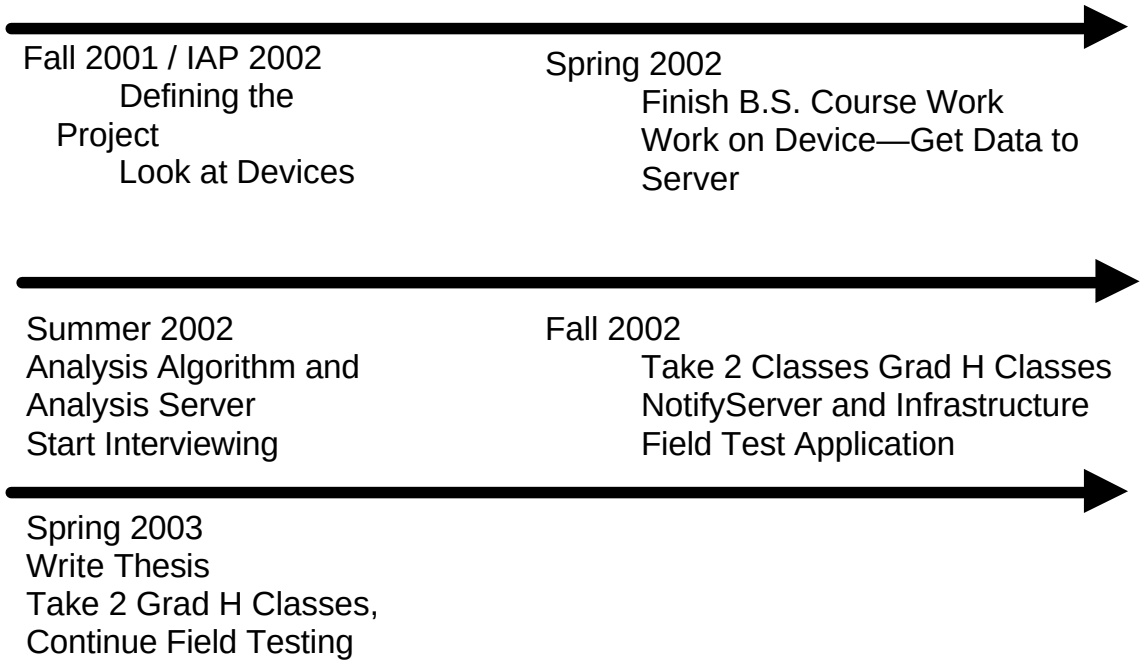

Figure 2: Projected Timeline of Meng Project.

An analysis of Cricket technology has already begun and will continue through IAP 2002. In the Spring of 2002, the archive server should be able to receive and store movement information. During the summer of 2002, work will center around developing and imlepenting the analysis algorithms. By the end of Fall 2002, the notification server will be complete, the system will be integrated and field testing will begin. Spring 2003 will be devouted to further field tests and writing up the thesis.

Risks

Cricket technology has not been widely used and is an emerging technology from LCS. This research relies upon the Cricket ability to properly determine location information. This could require other hardware devices such as a pedometor or other device to be built.

Conclusions

This project aims to use pervasive location based technology to gather data on an individual's physical activity. In addition, it will be built using rich analysis methods to analyze this data and a system of notifying the patient and doctor of this analysis. This real time effective monitoring can ultimately increase a patient's life expectancy and their quality of life.