CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: WearWare Study Manager	
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Project Overview:

In the United States (US), the prevalence of cardiovascular disease (CVD) among adults under age 60 is approaching 40% and nearly one-third of CVD deaths occur between 55 and 64 years. Physical activity (PA) is one of the most potent modifiable behaviors for the prevention and treatment of CVD.

Traditional intervention approaches typically hinge around personalized human-delivered health coaching, which costs both time and money and is often not covered by health insurance plans. This has led to growing popularity of wearable activity tracking monitors, such as Fitbit, which claim to offer motivational feedback to help improve both fitness and sleep. Unfortunately, there has been very little clear scientific evaluation of these claims. To what extent can devices like Fitbit and their automated "smart" coaching really elicit meaningful, sustained health behavior change? The only way to answer these questions is through large-scale studies in which hundreds or thousands of participants are recruited, outfitted with wearable devices, and monitored and managed during the study execution. After a study period of weeks or months, the physiological data collected by the Fitbits or other wearable devices can be paired with health outcome data (e.g. weight loss, BMI, etc.) and analyzed by the researcher to reveal key insights into the relationships between the design of various wearable devices, the physiological data they have recorded, and the health outcomes.

A major obstacle in this research area is the incredible effort and complexity involved in managing these large scale fitness studies. Participants for the study must be identified and recruited, the must all be fitted with Fitbits (or whatever the device being studied), those devices must all be registered to record their data, incoming data must be monitored to keep an eye out for problems, and of course, data collected must be downloaded.

The WearWare Project: a powerful fitness study manager

What is desperately needed is a powerful, robust, cost-effective study management/deployment platform that can support a wide variety of fitness and wearable device studies driven by data from cheap off-the-shelf activity monitors like Fitbit. In particular, the platform would allow researchers to set up studies, select and enroll participants, register their devices, record/monitor their activity behavior, and allow configuration/deployment of a broad range of "study protocols" that monitor activity of subjects in near-real-time for certain events, which then trigger various messages to the participants and/or researchers. A previous Capstone team explored a powerful database substrate for the project. This project will be focused on the GUI front-end: a power web application that will allow researchers to set up, configure, and execute studies with wearable devices. Although the product should ultimately support studies of any wearable device, we focus on supporting studies built around Fitbit devices for this project. Key features of this product will include:

Level 0, Bare Basics: Minimum viable product (MVP). A secure Web2.0 web application that:

- Allows researchers to create accounts on the system
- Allow researchers to create "studies" that represent all relevant aspects of a study. Studies can be edited over time, can be populated with experimental subjects, and can be made active/inactive to start/stop data collection.
- Has a backend relational database for storing physiological data collected by study Fitbits
- Allows researchers to upload csv (or similar) files with info on study participants to a particular study.
- Allows researchers to upload csv (or similar) files with info on study participant contact information, and then simulate enrollment with Fitbit, i.e., create a link (IRB and related Fitbit) that is emailed to participants.
- Allows researchers to download collected data at any point in study for further analysis.
- Functions with simulated data access to Fitbit device data, i.e., grabs it from a database rather than Fitbit Inc.

Level 1: A Competent Solution. A truly usable product will add:

- A well-designed "dashboard" as login landing page. Allows researchers to easily see active/inactive studies they own, access/edit those studies, and gives indication of how active studies are going.
- Supports more robust, editable user profiles, access management, and other configuration controls.
- GUIs for monitoring active studies, e.g., easily see what data has been downloaded, which participants have issues (e.g. not wearing their device)
- Permissions. Allows multiple users (e.g. lab aides, collaborators) to be given varying levels of access to studies by the lead researcher.
- Able to connect to Fitbit (via API provided by Fitbit) and download actual physiological data collected by participant Fitbits periodically or on-demand.
- GUI to allow researchers to define, select, and download specified subsets of collected data, e.g., "retrieve heartrate and step (only) data from females over 50 from <this> time range within the study".
- Attractive GUIs refined and tested for usability by average researchers.

Level 2: Stretch goals. Really nice but peripheral additions would include.

- Provides tools to communicate with participants in active studies, e.g., easily send messages to individuals or subgroups.
- Provides GUI tools (e.g. graphing) to do "quick views" of data coming in from one or more participants, i.e., a way to take a quick look without downloading data and processing in Excel, Matlab, SciPy or other tool.
- An "event monitor": Can define various "triggers" (e.g., "if heart rate in last 12 hours dips below 60") that can be attached to a study to notify the researcher of some event in the data.

The entire WearWare system will be implemented in a cloud infrastructure on AWS to support robustness, accessibility, and expandable compute resources.

This project, once successful, will be key to operations in the Wearable Informatics Lab. As a secure web application, it will also allow WearWare to host (for a fee perhaps!) fitness/sleep studies based on wearable monitors for researchers from across the entire world; it could become the de-facto platform for doing wearables-based fitness and sleep research.

Knowledge, skills, and expertise required for this project:

- Understanding of cloud-based computing; deploying/managing DB and compute instance on AWS
- Understanding of APIs and module-based software design.
- Will need to research and build advanced knowledge of DB design and optimization.
- Basic understanding of modern web2.0 web application technologies for building development GUI interface, including "get" and "post."
- Understanding of big data science: how studies work, how data is collected, large scale data management.

Equipment Requirements:

- Access to Amazon Web Service (AWS) account and products; will be provided.
- A Fitbit for each team, possibly each team member, will also be provided for dev purposes.

- No other specialized equipment should be needed, outside of standard (free) IDEs and a development station.

Software and other Deliverables:

- The study manager software module as described above, deployed and tested successfully with real data. Must include a complete and clear User Manual for configuring and operating the software.
- A User Manual for end-users, i.e., health and fitness researchers. Details how to create and manage studies.
- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development of the product.
- Complete professionally-documented codebase, delivered both as a versioning repository (client provided bitbucket); and as a physical archive on a USB drive