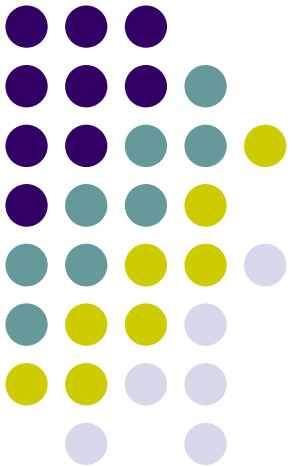
BeWell: A Smartphone Application to Monitor, Model and Promote Wellbeing

CS 525: Mobile and Ubiquitous Computing

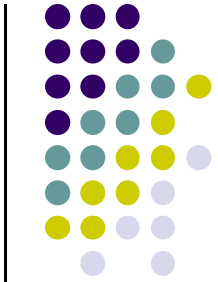
Alec Mitnik

Computer Science Dept.

Worcester Polytechnic Institute (WPI)

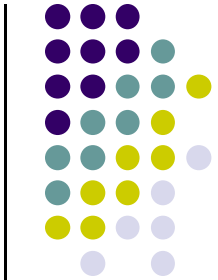


Introduction/Motivation



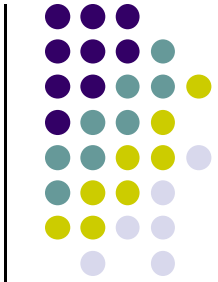
- BeWell: A smartphone app that focuses on personal wellbeing
- The aspects it measures have been shown to affect both mental and physical health
- Easy to get and easy to use
- Provides easily interpretable feedback

Introduction/Motivation



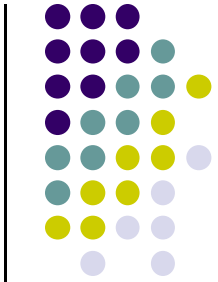
- Uses Android phone sensors to monitor exercise, social interactions, and sleep
  - Other health aspects can be manually recorded on the web portal
- Converts the data into a measurement of wellbeing
- Presents the results so that users can effectively manage their behaviors

Related Work



- Existing wellbeing apps have focused on just one aspect of health
- Many require manual input and upkeep that hinders the likelihood of mass adoption and long-term use
- Others require specialized external devices
- They don’t focus on interpreting the data for the user

Methodology



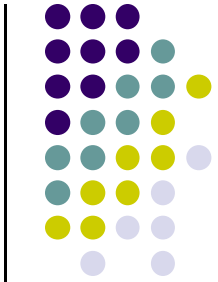
- Uses an initial model for interpreting wellbeing that can be improved later
- Calculates three individual scores from 0 to 100 based on professional recommendations
- Provides a web portal for detailed results and editing, along with an ambient mobile display

Sleep

- Poor sleeping patterns can result in numerous illnesses
- Only measures duration for now, but quality of sleep is important too
- Identifies sleep based on phone usage and charging
- Accepted range is 5-9 hours, ideally 7
- Uses a Gaussian function for daily score:

$$sleep_{day}(\mathrm{HR}_{act}) = Ae^{-\frac{(\mathrm{HR}_{act}-\mathrm{HR}_{ideal})^2}{2(\mathrm{HR}_{hi}-\mathrm{HR}_{lo})^2}}$$

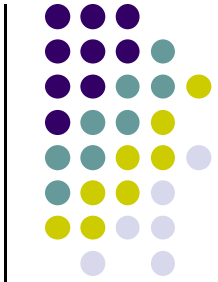
Physical Activity



- Measures physical movement (walking, running) with sensors
- Calculates daily metabolic equivalent (MET)
- Ideal values vary, but uses generic range of 150 to 300 minutes of moderate aerobic activity
- Cannot reliably sense muscle- strengthening activity yet
- Uses linear regression to calculate score:

$$physical_{day}(\mathrm{MET}_{act}) = (\mathrm{MET}_{hi} - \mathrm{MET}_{lo})\mathrm{MET}_{act} + \mathrm{MET}_{lo}$$

Social Interaction



- Social support allows people to better cope with stress
- Measures social isolation with the portion of time that ambient conversations are detected
- Empirically determined that acceptable range is 0 to 0.35
- Uses linear regression to calculate score:

$$social_{day}(\mathrm{DUR}_{act}) = (\mathrm{DUR}_{hi} - \mathrm{DUR}_{lo})\mathrm{DUR}_{act} + \mathrm{DUR}_{lo}$$

BeWell Infrastructure

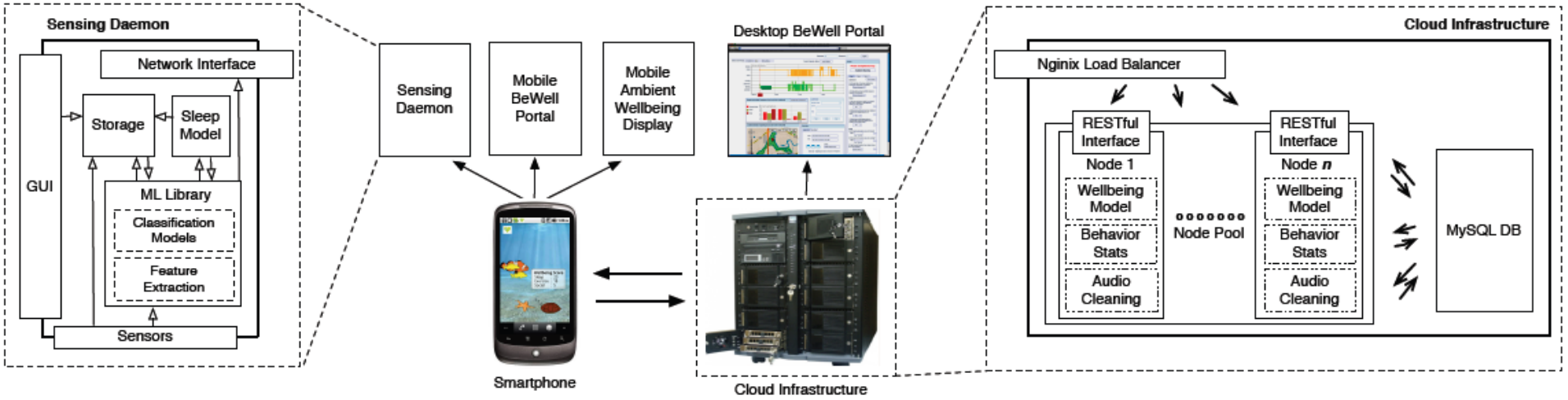
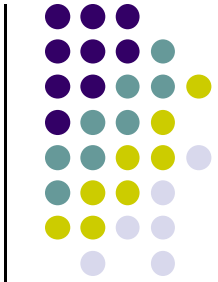


Fig. 2. BeWell implementation, including smartphone components supported by a scalable cloud system

Sensing Daemon



- Responsible for communication, storage, and the user interface
- Uses the GPS, accelerometer, and microphone to extract data
- Uses classifier models to make inferences about the data
- Sends this information to the cloud infrastructure

BeWell Web Portal

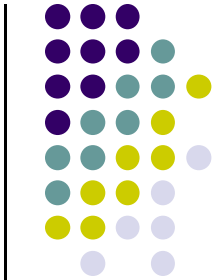
- Allows manual input to adjust data and scores

Fig. 3. The BeWell web portal provides access to an automated diary of activities and wellbeing scores.

Mobile Ambient Wellbeing Display

Fig. 4. Multiple wellbeing dimensions are displayed on the smartphone wallpaper. An animated aquatic ecosystem is shown with three different animals, the behavior of each is effected by changes in user wellbeing.

Cloud Infrastructure



- A pool of Linux-based servers
- RESTful interfaces
- Stores data and responds to queries for data
- Runs daemons to update scores and clean the audio to protect privacy

Results

- Performed a 5-person user study to assess BeWell's viability
- Accuracy of classification:

	Voicing	Walking	Stationary	Running
Accuracy	85.3%	90.3%	94.3%	98.1%

TABLE II
BEHAVIOR CLASSIFICATION ACCURACY

	RMSE	MAE
Linear Regression	2.18 hrs	1.54 hrs
Logistic regression	2.254 hrs	1.56 hrs

TABLE III
SLEEP DURATION ESTIMATE ERROR

CPU and Memory Usage

- BeWell's resource usage is comparative to other smartphone applications

BeWell Sensing Daemon		
	CPU Usage	Memory Usage
GUI only	0%	13511K
Audio sensor only	2%	14373K
Accel sensor only	2%	13917K
Audio classification	25%	14778K
Accel classification on	11%	14736K
Both Accel and Audio classification	31%	15357K
Benchmark Applications		
	CPU Usage	Memory Usage
MP3 Player	16%	27056K
Web Browser	5%	62376K

TABLE I
ANDROID NEXUS ONE CPU AND MEMORY USAGE FOR BEWELL AND BENCHMARK APPLICATIONS

Battery Drain

- An extended life battery can sustain BeWell usage all day given a brief charge during the day and full charge at night

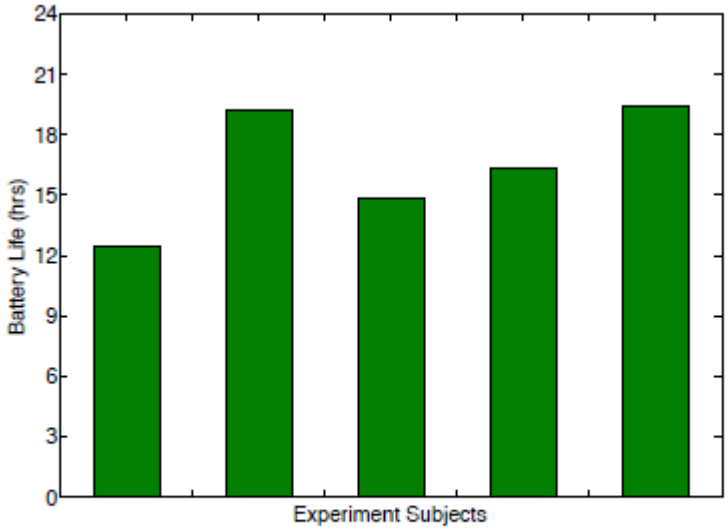


Fig. 6. Smartphone battery life for subjects during experiment

Data Usage

- A 4 GB microSD card is sufficient for BeWell's data generation

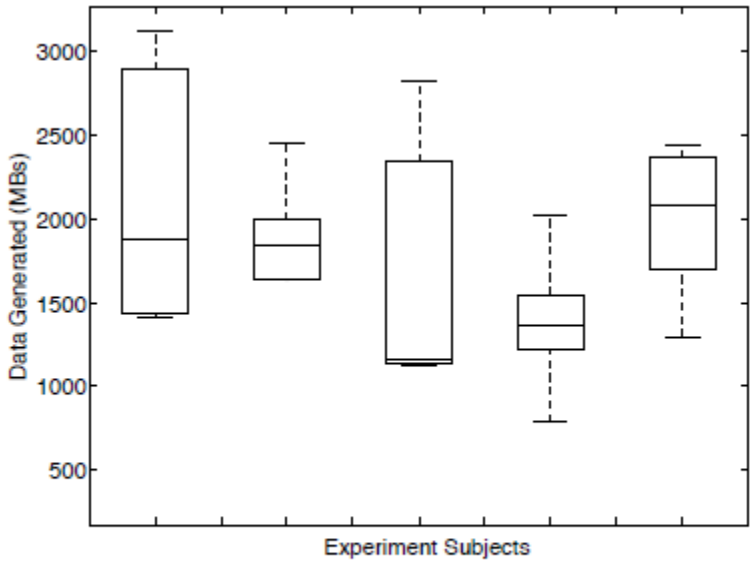
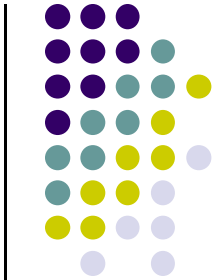


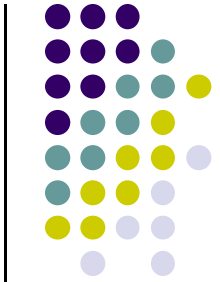
Fig. 5. Daily data generation by subjects during one week experiment

Conclusions/Future Work



- BeWell is a relatively easy to use application that promotes wellbeing
- Demonstrated the viability of an application for an off-the-shelf smartphone to monitor health
- Will work on more accurate sensing and comprehensive health profiling
- Intends to have a large-scale deployment and user study

My Thoughts



- Very rough so far, but can improve
- I imagine people are already quite aware of how much exercise, social interaction, and sleep they are getting
- Needs to better connect the benefits of these to the results so it doesn't just come off as nagging
- Lack of personalized guidelines can provide inaccurate feedback