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

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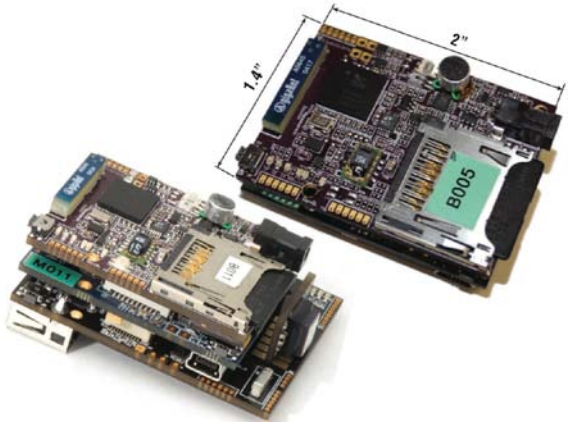
Overview

- First (bigger) part about „BeWell“

- Second part some extracts from „The Mobile Sensing Platform: An Embedded Activity Recognition System“



BeWell

- Introduction
- Architecture
- Monitoring & Modeling Wellbeing
- Implementation
- Evaluation

Introduction

- The way we live has a impact on our health.
- Nutrition, sleep, physical activity, socialization have an influence on high-blood pressure, stress, diabetes, depression.

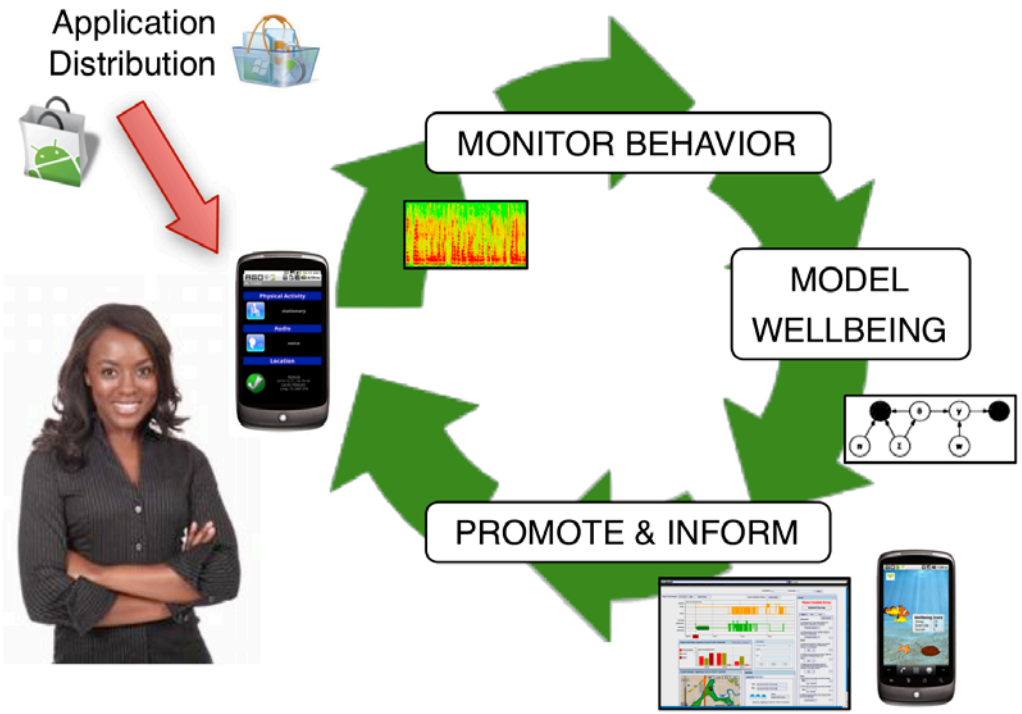
- No tools available to support the busy user in self-management, wellbeing and health.

Introduction

- Introducing **BeWell** – “A real-time, continuous sensing application for smartphones, that provides easily digested feedback that promotes healthier lifestyle decisions.”

- BeWell runs on off-the-self smartphones and uses the on-board sensors of the device (no external sensors needed).
- Uses multiple dimensions of behaviors and (almost) all data is acquired automatically.

Architecture



1. Monitor Behavior
2. Model Wellbeing
3. Promote and Inform User

Monitoring & Modeling Wellbeing

- Three user activities are monitored:
- **Sleep**, **Physical Activity**, **Social Interaction**.
- Every activity is assessed independently and a wellbeing score between 0 and 100 is calculated. (0 poor health, 100 meets guidelines)

Sleep

- Quality and quantity of sleep have influence on wellbeing.
- BeWell only measures quantity (i.e. Sleep duration).

- Done by measuring mobile phone usage (recharging, movement and ambient sound)
- Error about +/- 1.5h (!)
- Wellbeing score calculated by a gaussian function.

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

Physical Activity

- Impact on heart diseases, cancer, depression, self-esteem, mood, sleep, stress.
- BeWell distinguishes driving, walking, stationary and running by using the accelerometer and GPS. Muscle-strengthening activities are entered manually in the webportal by the user.
- “Metabolic Equivalent of Task" (MET) (measures energy coasts of physical activities) MET values are between 0.9 (sleeping) and 18 (fast running).
- Score is calculated as a linear regression.

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

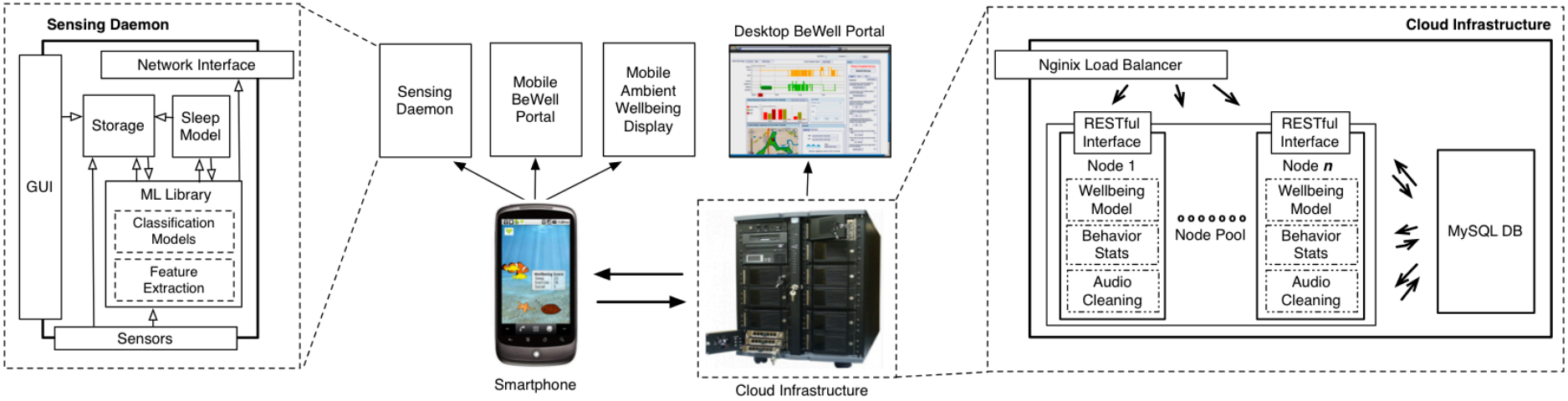
Social Interaction

- Impact on psychological wellbeing, more resistant to stress, mental illnesses and chronic diseases.
- BeWell measures duration of ambient conversations through the microphone.
- Score is calculated as a linear regression.

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

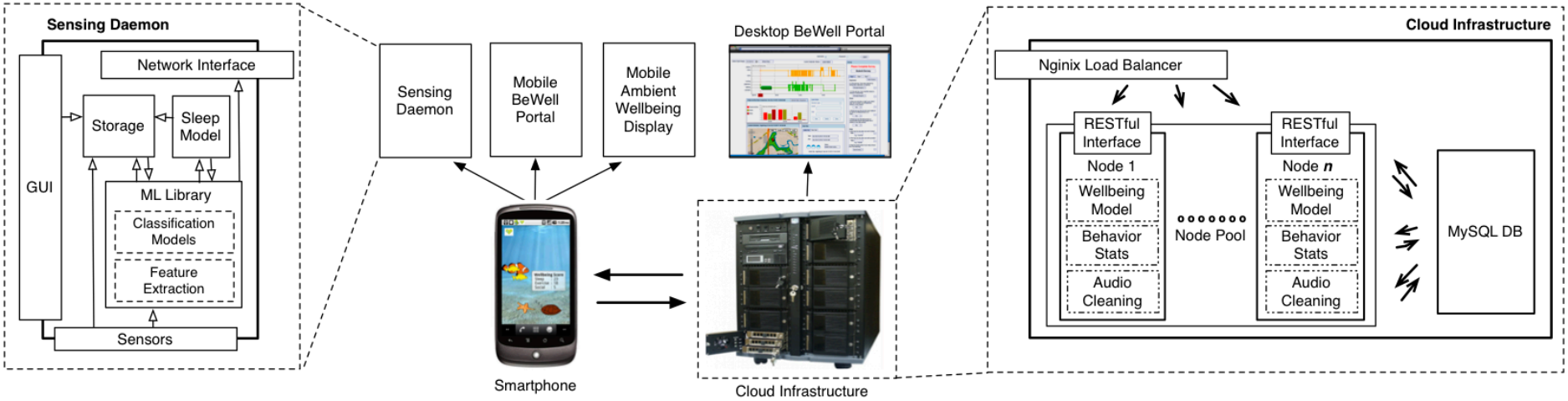
- DUR_{hi} is empirically determined and DUR_{lo} is simply set to 0.

Implementation



- Sensing Daemon
- Mobile BeWell Portal
- Mobile Ambient Wellbeing Display
- Desktop BeWell Portal
- Cloud Infrastructure

Implementation



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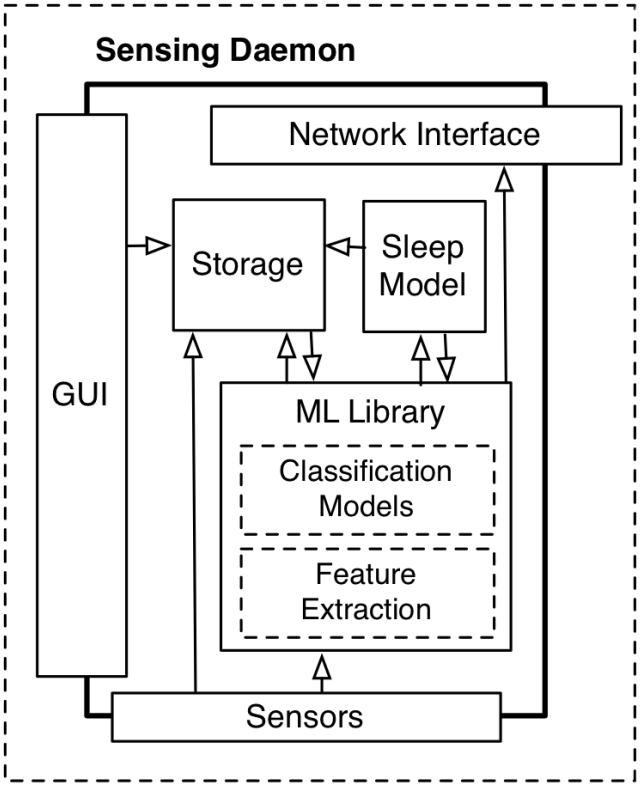
Sensing Daemon

- Data from three sensors is gathered: GPS, accelerometer and microphone.
- ML Library (C) plus device specific components (Java) handle communication, storage and the UI.
- Classification pipeline does the inference of the user behavior, through continuously sampling the sensors and feature extraction.
- Data stored in SQLite files and pushed to the cloud whenever WiFi and line-power is available.

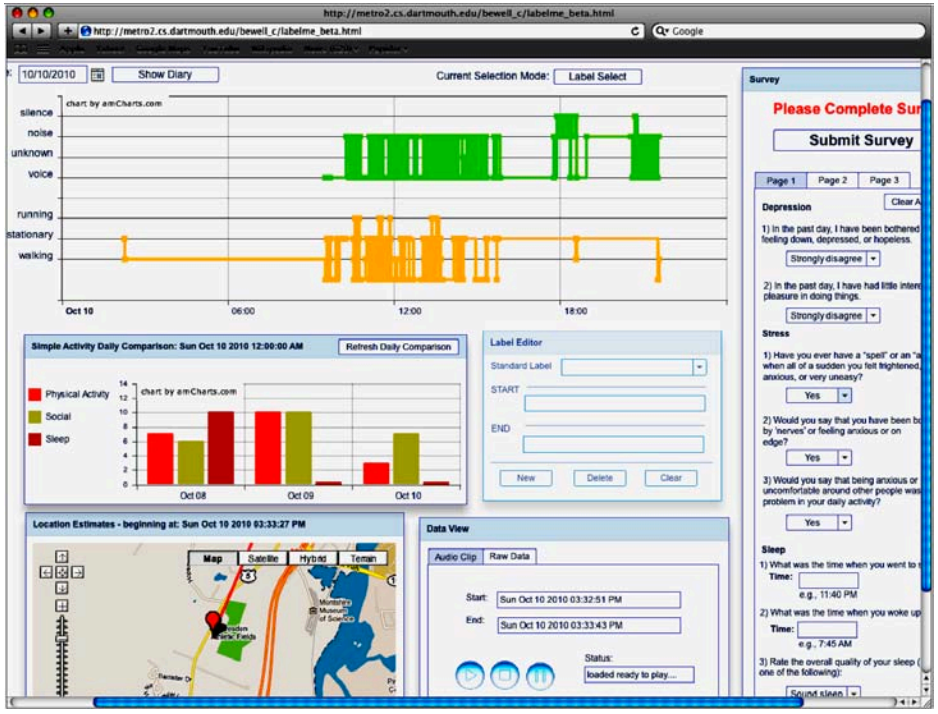


Mobile Ambient Wellbeing Display

- Ambient Display on phone's lock-screen and wallpaper.
- Clown Fish: Physical activity, the more physical activity, the faster moves the fish.
- Turtle: Sleep, if the user lacks of sleep, the turtle sleeps for him.
- School of Fish: Social Interaction, more fishes represent more social interactions.

Desktop BeWell Portal

- User can view the behavior in a diary-like manner, as well as see all the data the app gathered (and edit it). E.g. listen to the sound data, browse the GPS locations.
- User can fill out standard medical surveys that monitor depression, sleep and wellbeing (additional data source).



Evaluation - Benchmark

- The BeWell app consumes resources for the (ambient) GUI, the acceleration and audio classification of about 31% of the CPU.

- This drains the battery (extended 3200 mAh) so it needs to be recharged (“quickly”) during the day and in the evening.
- Comparison with the Phone’s MP3 player (16%), but with enabled visualizations.

Evaluation - Privacy

- Necessary since for detecting social interacting the microphone records ambient conversations.
- Enough information must be available to detect a conversation, but not the content of the conversation (i.e. the spoken words).
- A cleaning process is performed in the cloud on the servers. Every second is segmented into 12 chunks and every 3rd chunk is zeroed out.

Evaluation – Behavioral Inference Accuracy

- Experiment with 5 people and manually recorded ground truth.
- Sleep duration error is about +/- 1.5h what is regarded by medical studies to be accurate enough.
- Social interaction recognition difficult, because different kinds of ambient conversations (watching TV, somebody else talks). Error is about 14%.
- Overall physical activity error is about 22%.

Future Work

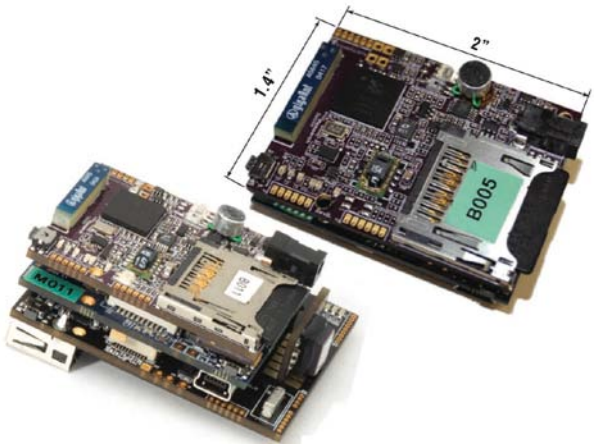
- Further increase the accuracy of sensing the sleep duration, social interaction and physical activities (include muscle-strengthening).
- Add even more dimensions, e.g. nutrition and sleep quality.
- Get a more accurate measurement for physical activity or include parameters for MET (age, weight, sex, fitness…)
- Perform an experiment with more people over a longer period.

Reviews

- Overall Rating – average: 2.1 (accept) / median: 2 (accept)
- New Insights? – average: 3.7 (agree) / median: 4 (agree)
- Originality – average: 3.7 (agree) / median: 4 (agree)
- Presentation – average: 4.2 (good) / median: 4 (good)
- Related Work – average: 3.0 (good) / median: 3 (good)
- Contributions – average: 3.9 (strongly) / median: 4 (strongly)

Mobile Sensing Platform – An Embedded Activity Recognition System

- Small wearable device designed for activity recognition.
- Linux, 416MHz CPU, 2GB Flash, Bluetooth, ZB, USB, IR, 115g, 20h
- Different kind of sensors: Mic, IR & visible light detector, accelerometer, barometer, temperature, humidity, 3D compass, 3D magnetometer, 3D gyro.



Evolution of a platform

- Shows the evolution steps in developing the platform.
- v1 communicated via Bluetooth since it had no local storage, but the connection was interrupted very often.
- v2 included local storage to solve this problem, better cpu and a bigger battery.
- Communicates to a mobile phone via Bluetooth to use its display for feedback to the user, as well via a ambient display.

Questions?