Mover – Activity Monitor and Fall Detector for Android

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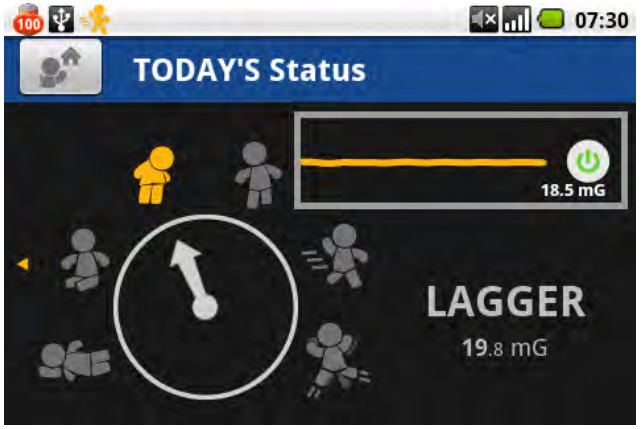

figure 1. Today's status screen of the user compared with the Mover community.

Abstract
Mover is an exciting application that allows you to track your activity level and helps you become more active. Mover includes also an experimental fall detection system.

Keywords
Activity Monitor, Smartphone, Fall Detector, Motion Sensors

ACM Classification Keywords
H5.2. Graphical user interfaces (GUI).

General Terms

Design, Experimentation.

Introduction

The lack of physical movement is one of present day concerns. Population is more and more exhibiting health problems partially caused by their lack of movement. Among these issues we find the risk of cardiovascular diseases and obesity.

One way to solve the problem would be to go to a gym on a regular basis, however, people do not always find the time and motivation to do it and even if they do, there is rarely a systematic advice from a personal trainer. Nonetheless, a few minutes of walking or other similar activities can significantly improve people's daily routines. Mover offers the permanent availability of a personal trainer on your phone, an object that you carry every day, everywhere.

Falling unconscious is another problem, which is difficult to solve, especially for older adults. In order to detect falls, there is the need to continuously monitor the movement of the user. Once a fall is detected people who can help, should be warned, since there is often the possibility the user is completely alone. Mover tackles this problem bringing fall detection and communication together.

Activity Monitor

As James Harrington referred, "Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, (…) you can't control it". Activity is usually something that is not really measurable. Although it reflects in the body, one cannot objectively compare the activity of one day with another. Mover categorizes activity and turns it into something the user can see and compare.

In order to measure your activity level, Mover reads data from the phone's accelerometer and sums it out throughout the day. People's average level of activity is then translated into a type of mover: Sleeper, Sitter, Lagger, Walker, Mover or Hyper.

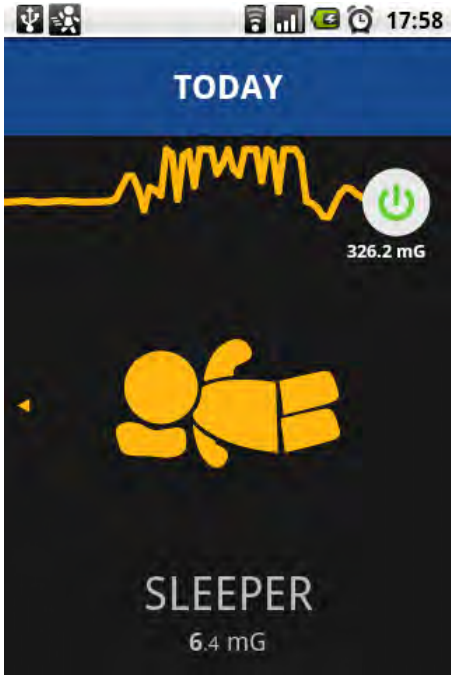

figure 2. Screen showing instant movement at the top and average movement at the bottom. Today you are a Sleeper.

The type of mover a person is depends on the movement of others in the community. For instance, if

Mover tells the user “you are a Hyper”, this means that the user is on the top 16% of the community. If it tells the user “you are a Sleeper”, then the user is on the bottom 16% (see figure. 2).

Mover will also make the user aware if she/he is moving less or more than usual, hinting when to exercise more.

Currently hints are very simple as they just compare the user movement average with her/his previous movement. In the future these hints will give much more detailed information, such as the number of kilometers the user has to walk to be on the next status level.

Fall Detector

Falls are dangerous, prevalent and costly. The frequency of falling is considerably higher among elderly. Nearly one third of the people aged over 65 falls every year [1]. Approximately 3% of all fallers lie for more than 20 minutes without external support. Reliable fall detection and notification is essential in independent living facilities and in ambulatory systems for elders or patients.

Mover can detect user falls and send alerts to user’s emergency contacts. The objective is to improve the medical outcome which is largely dependent upon the response and rescue time. It is possible to configure two contacts that will be alerted of this fall event either through SMS or email. Before calling for help, Mover will play a sound to make sure you are unconscious.

Carrying a mobile phone implies the user choice of its place. This in turn increases the difficulty of fall detection. The sensor location on the body relatively to the point of impact modifies the pattern of the recorded acceleration signal [3]. Besides position variability, some chaotic environments like a loose pocket might increase the turbulence of the mobile phone sensor. Another problem is the lack of a fixed referential for simpler approaches such as tilt analysis. Under static conditions a three axis accelerometer can be used to find the direction of the gravity vector, which can be used to find the tilt angle of a person relative to the gravity vector. Unfortunately, human movements are far from being static and even small motions can cause high accelerometer readings. For this reason, they are only really good for gross measurements like the analysis of intense acceleration magnitudes due to fall impacts.

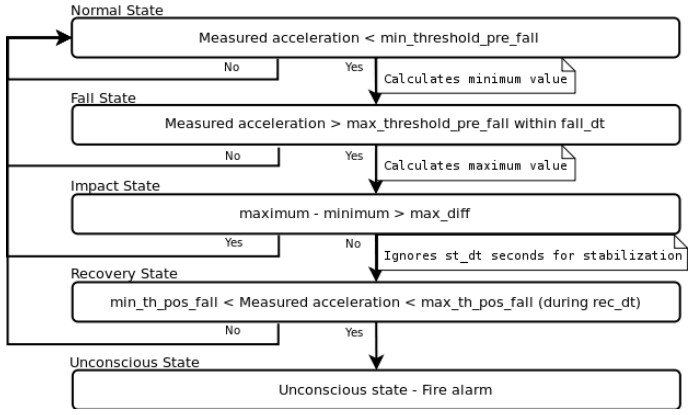

figure 3. Fall detection algorithm [4].

The fall detection algorithm was designed as a state machine as illustrated in figure 3. The behavior model is composed by five finite states: normal, fall, impact, recovery and unconscious states. Transitions between states are done by inspecting the acceleration values and by analyzing its symbolic sequences. The threshold values used in the fall-detection algorithm resulted from the analysis of a set of 120 recorded simulated falls and non-fall activities on a lab environment and are presented in table 1.

Threshold	Value	Unit
min_threshold_pre_fall	8.00	m/s^2
max_threshold_pre_fall	13.42	m/s^2
max_diff	12.00	m/s^2
fall_dt	2000	ms
st_dt	7500	ms
min_th_pos_fall	9.35	m/s^2
max_th_pos_fall	10.45	m/s^2
rec_dt	5000	ms

table 1. Threshold values and units of the different parameters for the fall-detection algorithm [4].

The algorithm was tested on 5 different phone models: HTC G1, Samsung i7500, HTC Desire, HTC Desire HD and the Google Nexus One. We found out that the acceleration polling frequency can vary from approximately 20 to 40 ms on the HTC models and it is never a fixed interval. On the Samsung model we were unable to reduce the accelerometer polling frequency below an average of 250 ms. Furthermore, we observed that the reference acceleration value while the phone was resting would vary significantly depending on the phone orientation (horizontal versus vertical); we observed the reference acceleration value to vary between approximately 9.4 and 10.1 ms^{-2}.

The algorithm was tested in a laboratory environment performing falls onto a crash mat and normal activities in order to evaluate its performance, following the protocol in [2]. At the beginning of the trial, a mobile phone running the algorithm was placed in the pocket of each subject at the thigh position. The subjects were 10 young (<30 years) healthy males. The mean ± standard deviation age, height and mass of the subjects were 26,2 ± 3,04 years, 1,776 ± 0,052m, and 78,3 ± 5,3kg respectively.

Each activity was performed 3 times for each subject obtaining an amount of 600 activity tests. Results have shown that falls can be distinguished from normal activities with a sensitivity of 92.67% and a specificity of 72.67%. We observed that the processing power of current phones is more than sufficient to process the accelerometer data in real-time. Consumptions of 2%, 2% and 1% battery life per hour were observed respectively in Google Nexus One, HTC Desire and Nexus S.

Future Work

An inactivity monitor is in the roadmap so that it is possible to detect health problems with isolated older adults.

By gathering information on a large number of users, it will be possible to characterize human movement. Depending on the gender, age, etc., persons move differently, and this study may introduce more information on the subject.

Mover (still) cannot distinguish between walking from, for instance, going on a train. Of course it will not record the whole movement of the train, just the

trepidation and acceleration that you feel inside the train. You can always stop the tracking. Nonetheless a more sensible mover interpreter will be created in the future.

Example citations

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