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Monitoring Heartbeat per Day to Motivate Increasing Physical Activity

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Abstract Physical activity is one of the most basic human functions and essential for physical and mental health and has major beneficial effect on chronic diseases such as heart disease, stroke, etc. Awareness of this condition has been one of the focuses for researching over recent years. One common way for making this awareness is monitoring the number of steps taken by a person and comparing it with the minimum amount of steps s/he needs. In this paper we suggest that instead of this, heartbeat can be monitored to aware physical activity.

Keywords physical activity, pedometer, step, heartbeat rate, health, ECG

1 Introduction

Physical activity is one of the most basic human functions and is fundamental to preserve and improve physical and mental health. The usage of many technical aids which are designed to make life easier directly impact the amount of physical activity we do. Most common examples are transport and movement. The availability of cars, elevators, escalators, and public transport systems make many people walk less during a day. Hence counting steps and making the user aware of this has been a focus of researches over recent years [1][2][3][4][5].

However there are many more technical advances that reduce the physical activity such as robot vacuum cleaners (from iRobot or Samsung) or dishwashers. Tasks such as sweeping or washing dishes are accounted as physical activity and as those tasks are automated, the overall physical activity of people is reduced. This trend is ongoing and relates to technical advances as well as standard of living.

To monitor the overall activity of a person, our suggestion is considering the number of heartbeats instead of steps. This number relates to activity and in-activity of a person and takes into account all different forms of "exercises".

In this paper we explore the potential of monitoring the heartbeat over a period of time to motivate people become more physically active. In section 2 we provide some background information on the importance of physical activity. In section 3 the concept of monitoring the heartbeat rate as means for activity detection and motivation is assessed. In section 4 some initial experiments are described. We conclude the paper with a discussion of the potential benefits and drawbacks of this approach.

2 Background on the Importance of Activity

According to the World Health Organization (WHO) in 2002 two thirds of the adult population (aged 15 years and over) in the European Union (EU) did not reach recommended levels of activity [1]. Across the WHO European Region as a whole, one in five people takes little or no physical activity, with higher levels of inactivity in the eastern part of the Region. Physical inactivity is estimated to cause 600 000 deaths per year in the Region (5–10% of total mortality, depending on countries) and leads to a loss of 5.3 million years of healthy life due to premature mortality and disability per year [2]. As explained in [3] physical activity has major beneficial effect on chronic diseases such as heart disease, stroke, overweight and obesity, type 2 diabetes, colon cancer. The benefits are not just limited to preventing or limiting the progression of diseases but on the other hand include the improving of physical fitness, muscular strength, and life quality.

Also Rooney *et al*. [4] mentioned that physical inactivity is a health concern in the United States and nearly 70% of the population are getting an inadequate amount of exercise.

These studies imply that increasing physical activity is important for the individual as well as the society. Increasing the awareness of a person's daily activity, based on the number of steps they take, is one option that has been explored in different project. Overall the concept is related to persuasive technologies [9] and the assumptions is that individuals have made the decision to increase their activity and that the technology motivates and supports awareness, hence such a system is helping the users to achieve their goals. If the users have not made the basic decision to

increase their awareness such technologies can be regarded a manipulative and are ethically questionable.

There are examples of projects in which different kind of sensors such as pedometer, accelerometer, ECG (electrocardiogram) combined with ubiquitous computing technologies are explored for achieving this goal.

Maitland *et al.* [5] designed the SHAKRA prototype that helps to motivate adults who do not currently achieve the minimum of the recommended daily activity level and who can benefit from a raised awareness of their current levels of activity by detecting patterns in signal strength fluctuation and changes in the visibility of the GSM (Global System for Mobile communication) cells to find out either the user is still sitting, walking, or driving.

Another way to increase awareness is using a pedometer. Basically a pedometer is a device that counts the number of strides taken by the wearer by responding to the impact of the wearer's steps. Rooney *et al.* [4] did a survey by using pedometers with 400 women and found out that wearing a pedometer is a non-invasive way for women to increase awareness of daily activity and lead to increase daily activity. C Tudor-Locke *et al* [6] also used pedometers to examine physical activity (steps/day) as continuous variables using correlation analysis to quantify the relation between steps/day and body mass index (BMI) or percentage body fat.

We can find many other research projects that monitor movement/transportation based on steps/day. However other physical activities besides that are interested to measure such as normal daily activity. Here we suggest that using the number of heartbeats instead of steps per day/activity is well suited.

3 Monitoring heart beat to motivate physical activity

There are several sensors for monitoring heartbeat rate and ECG commercially available, which can be connected to other devices via Bluetooth: for example the Pulse Oximeter and ECG from Alivetec [6]. At the moment these seem cumbersome to attach and wear, however several companies have shown prototypes and products where heart rate sensors are incorporated in clothing articles. Important examples are sensors integrated into T-shirts [7] or into sport bras [8]. As most users have mobile phones which can be connected to such sensors via short range radio frequency RF (e.g. Bluetooth) and provided processing power and network connectivity, such systems are already technically feasible. Current technological developments suggest that in the future the monitoring of ECG during normal daily activities will be possible (or even common) without causing any interference in ongoing activities.

Increasing the number of steps is often restricted by external conditions of the workplace or personal commitments. In contrast we assume that doing activities which include more physical activities in such a way that metabolism and heartbeat are increased, are possible in a wider range of tasks. Moving folders from one self to another can be done in ways which are more physically demanding. This should be reflected when monitoring activity. Calculating the amount of energy spent based on counting steps can be really hard for some activities. For instance the amount of energy used to climb upstairs is higher than downstairs and so walking upstairs is considered as more physical activities. Also climbing steps faster or running a distance instead of walking, results in a significantly different amount of energy spent. As the number of steps either are the same in both condition or only have slight variation, monitoring these activities based on counting steps cannot be useful to identify the differences. Similarly there is same condition for walking with or without a load. So in these situations heartbeat gives a better estimation than counting steps.
We expect that monitoring the heartbeat offers good means to motivate someone increases his/her activity level. Especially for people who cannot find enough time for walking, running, or have difficulties with these exercises to reach the number of steps they should take, this can provide an alternative motivation. In some cases we also expect that increasing the amount of heartbeats requires less change in a life style than increasing the steps.

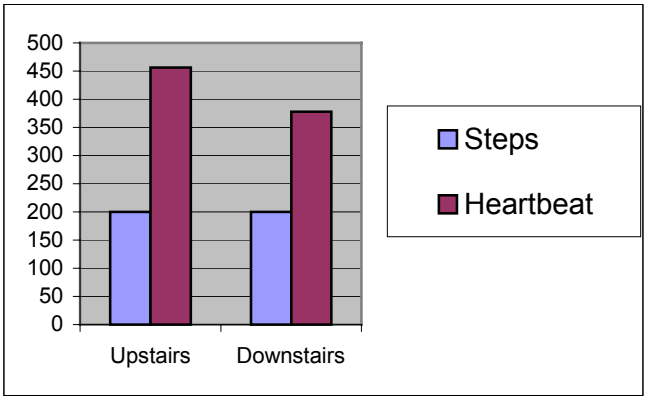
4 Implementation and Experiments

To monitor the heartbeat rate we used the Alive Pulse Oximeter sensor from Alivetec which reads oxygen saturation and heartbeat rate data from a sensor, and transmits the data via Bluetooth. The sensor can be attached to the finger, hand, or foot. To compare heartbeat with the number of step per each activity we also used a normal pedometer. A java application was developed and run on a mobile phone which reads the HR data from the sensor via Bluetooth connection and saves it to a file. Additionally the application asks the user after a constant time period to enter the number of steps s/he took via the mobile phone's keypad by reading from the pedometer's display. All data is recorded on the mobile phone and later are used for analysis.

Fig. 1 User with heartbeat sensor on the finger, the step counter on the belt and the mobile phone.

For collecting data we chose three activities which might happen more often during a day: walking upstairs and downstairs, walking and running same distance, and walking with and without a load. We asked the users to connect the Pulse Oximeter sensors to their finger as well as carrying the pedometer.
Figure 1 shows the result of the first activity. In this case the user climbed 10 floors up and down. As it was expected before the amount of heartbeat while walking upstairs is more than walking downstairs which shows that the person is more active during walking upstairs, meanwhile the number of steps taken in both situations is constant. The average of heartbeat while walking downstairs was 93 beats/min and while walking upstairs 114 beats/min.

Fig. 2 Comparing heartbeat rate and steps while walking steps up and down. The read bar show that the user needed the same number of steps (200). When walking upstairs the number of heartbeats (blue box) was much higher than downstairs. Upstairs and downstairs took about the same time.

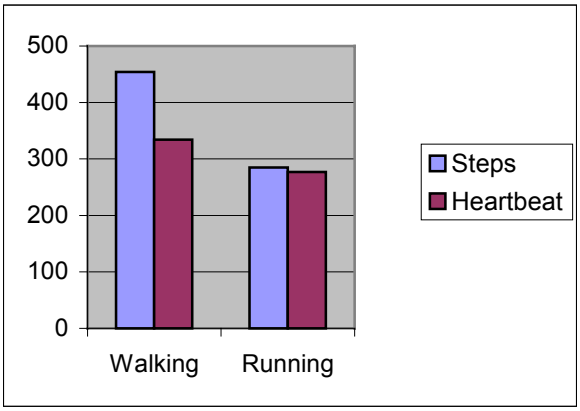


For the second experiment we specified a path (200 meters) and asked the user to walk and run meanwhile the data was recorded. As it is shown in figure 2 the number of beatings during running is less than walking and the average heartbeat rate for walking was 84 beats/min and for running 132 beats/min. The reason is that the duration of running is near half of walking. By considering the same amount of time for both situations, it is obvious that the number of heartbeat during walking is less than running wherefrom can be concluded that running has more physical activity than walking.

Also for the third activity which was walking with and without a load we got the same result. As it was predictable, the heartbeat was more during walking with a load. But again we had nearly the same amount of steps in both cases.

When looking at the overall number of heartbeats it has to be taken into account that the overall time required to do a task varies. This can be seen in the case of running vs. walking.

Fig. 3 Comparing heartbeats rate and steps while walking and running same distance. The number of steps (red) is much bigger when walking compared to running. The number of heartbeats (blue) is also bigger as the time needed for walking is longer.



5 Discussion and Conclusion

As explained in section 2 physical activity is one of the fundamental aspects of health. As many daily tasks were automated by using new technologies like robot vacuum cleaners, decreasing the amount of physical activity is a big concern and having awareness and motivation based on this condition becomes an important area in research.

We explained that monitoring different parameters such as the GSM cell pattern explained in [5] or steps can be useful to detect the status and activity of a person. But as it was shown in section 4, in some situations monitoring the number of steps using for example a pedometer is, though it offers a low-cost monitoring opportunity, obviously not suitable to derive accurate data (e.g. walking stairs up and down needing the same amount of steps results in a significantly different number of heartbeats). Thus the idea we suggested in this paper was that instead of monitoring the steps, it would be more suitable to monitor the heartbeats as a factor for creating awareness about a user's activity.

We think that monitoring the overall number of heart beats per day (in 24 hours) could provide users with a good metric for estimating their overall activiry during this day. It is obvious that 24 hour monitoring would require a very unobtrusive sensor, e.g. an implant (which is currently not available for wellness use). Such sensor, if they come in the future in mainstream use, could be used for the described scenario.

With current technology (e.g. clip-on/stick on sensors) the approach is useful to monitor and compare activity in a certain time. An example could be to monitor how many heartbeats did one have

during 4pm and 8pm very day. Increasing this number could be done with different types of activiry. If one wants to compare time slots that are different in length still the average heartbeat rate can be used.

Monitoring the overall number of heartbeats or the average heartbeat rate carries little information about the activity of a person. However there is a risk of mis-use of the data and loss of privacy when having the heartbeat rate reated to the time. E.g. it is likely that one can estimate from that data when someone gets up or goes to bed or other activities.

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