BreakOut: Predicting and Breaking Sedentary Behaviour at Work

Maria José Ferreira

Madeira Interactive
Technologies Institute
Universidade da Madeira
Funchal, Portugal
maria_joserf@hotmail.com

Ana Caraban

Madeira Interactive
Technologies Institute
Universidade da Madeira
Funchal, Portugal
ana.caraban@gmail.com

Evangelos Karapanos

Madeira Interactive Technologies
Institute
Universidade da Madeira
Funchal, Portugal
e.karapanos@gmail.com

Abstract

We present *BreakOut*, a desktop system that infers an
individual's posture, stress levels, and engagement with
computer related tasks with the goal of recommending
a break of sedentary behaviour at appropriate times.
We present an Experience Sampling study that
attempted to evaluate *BreakOut's* ability to infer users'
posture and stress from a single webcamera as well as
their engagement from keyboard and mouse activity.
We conclude with the description of an ambient artistic
display as well as an intuitive gestural interaction
technique that enables the user to interact with
*BreakOut* with minimal cognitive resources.

Author Keywords

Sedentary Behaviour; Posture; Stress; Engagement;
Need for a Break; Break.

ACM Classification Keywords

H.5.2 [User Interfaces]: Evaluation/methodology, Input
devices and strategies (e.g., mouse, touchscreen).

Introduction

Research about the ill effects of sedentary behaviour is
increasingly known in the general population. Research
suggests that sitting for long periods of time,
independent of overall physical activity level, has a
negative impact on both short-term and long-term
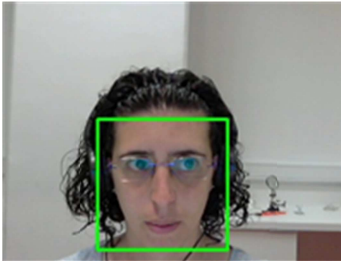
Figure 1 – Frontal face detection
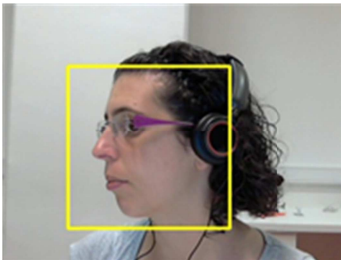
Figure 2 – Left profile face detection
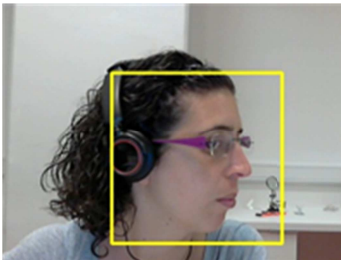
Figure 3 – Right profile face detection

health [11]. During working hours people tend to sit between 4.5 to 9 hours [11,2,12]. Some of the consequences associated are: eye strain, neck and shoulder pain [3], metabolic disruptions, obesity and premature mortality [13].

An increasing body of work suggests that breaking up sedentary periods with short periods of physical activity has a positive effect on health [11,5]. Motivated by these findings, researchers within Human-Computer Interaction have opted to devise technologies that persuade workers to take frequent breaks from sedentary behaviour. For instance, Jafarinaimi, et al. [6] designed Breakaway, a sculpture that sits at the user's desk and continues to slump over as the user remains sedentary, while it sits upright, appearing "healthy", when the user takes regular breaks. FitBit+ [11] leverages upon the commercial activity monitoring appliance FitBit to provide just-in-time recommendations when the system detects that user remains sedentary for prolonged periods of time.

Existing approaches are however agnostic to the user's physical, mental, emotional and social context. As a result they cannot infer when to recommend a break, and to suggest activities during the break, which results in increased intrusiveness and reduced effectiveness in behaviour change. In our line of work we attempt to develop sedentary behaviour change technologies that meet four principles:

a) They are aware of the user's mental and emotional state. For instance, users' engagement as well as availability for a break can be inferred from mouse and keyboard activity, while users' stress levels can be inferred from frequency and intensity of body

motion as tracked from a webcam or sensors placed in the chair of the user.

b) They track users' physical activity to deduce when it's the more appropriate time to suggest a break. For example, users' posture can be inferred from the viewing depth of the user from the screen.

c) They are aware of the users' social context. For instance, knowing which people are nearby and available for a break as well as the people and activities individuals engage with during different times of the day can increase the persuasive power of the system.

d) They provide concrete suggestions that evolve over time. For instance, rather than saying "you have been sitting for too long, take a break", the system could recommend the activity and the people nearby that are available. Crowdsourcing can be particularly effective here (i.e., taking advantage of co-workers knowledge of what activities may be more persuasive in taking a break from work).

In this paper we present *BreakOut*, a system that focuses on the first two principles. *BreakOut* is a desktop application that infers users' levels of sedentary behaviour, stress as well as engagement with computer related activities with the goal of recommending a break at appropriate times.

We present the design and implementation of *BreakOut* through one study. The study attempted to establish whether we can infer individuals' stress, posture and engagement with computer-related activities through a webcam. In the implementation we attempted to establish the effectiveness of different persuasive mechanisms in inducing behaviour change.
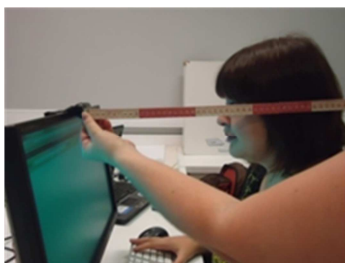
Figure 4 - Calibration made at 25cm from screen

0	1
25	3
37.5	4
50	5
62.5	4
75	3
87.5	2
100	1

Table 1 – Mapping of intervals in cm used to identify the distance to screen of the faces (left) to the correspondent 5 point scale of posture (right), ranging from weak posture to good posture

Inferring users' mental, emotional and physical state

Chen, et al. [3] describe a collaborative framework that uses a computer's web camera and cameras in the workplace environment to collect measurements such as the work breaks period, the distance between the worker and his monitor and measures of the worker's head motion. The extra cameras spread around the office environment provide information about her posture and the social interaction. In this study we try to achieve the same metrics using only a regular webcam. In order to infer users' mental (i.e., engagement with computer related activities), emotional (i.e., stress) and physical state (i.e., posture), we developed a desktop application that tracked two kinds of information. First, mouse and keyboard activity was continuously logged with the goal of inferring users' engagement with computer related activities. Second, pictures were taken every four seconds using a regular web camera with the goal of inferring users' stress and posture. We used the Open CV platform in order to track the user's face and estimate her distance from the screen as well as the frequency and intensity of her motion.

Ten university students (5 females and 5 males, mean age=24) participated in a 4-day field study. Throughout the study we performed Experience Sampling [1] with a regular frequency of twenty minutes in order to sample users' perceptions of their posture, stress, engagement with computer related activities, and need for a break. In each sample, users were asked to respond to the following four questions using 5-point scales: "How would you rate your current posture?" ranging from poor to excellent, "How would you rate your current stress level?" ranging from very low to very high, "To

what extent do you agree with the following statement?: I was really drawn into my computer–related task" ranging from strongly disagree to strongly agree, and "Rate the extend to witch you need a break at this moment." ranging from not at all to very much.

Inferring Posture
We attempted to infer users' posture through tracking their distance from the computer screen using a regular web camera. Research recommends a minimum distance from screen of 39.9cm [9], or 60 cm [14] and a maximum distance of 90cm [14]. Distance from screen was estimated from the size of the face detection square (with larger square signifying closer proximity of the user to the screen). We distinguished between frontal and left/right profile face detection (see Figure 1, Figure 2, Figure 3) and calibrated for each individual's desktop setting through taking 10 pictures for each of the following four distances: 25, 50, 75 and 100 cm (see Figure 4 as an example and Table 1 for the correspondent posture scale given to each interval).

The information was analysed following the paired process below: every thirty seconds, the application store the mean and median of the height from the square that detect a face, as well as their correspondent distance interval. Every twenty minutes all the previous collected occurrences were grouped with the same popup answer related with posture.

A positive correlation (r=0.42, p<0.01) was found between perceived-posture as reported by the participants and inferred posture as inferred from the web camera (i.e., the mean height of the face detection square).

Stress
We attempt to infer stress levels through tracking the practice of *fidgeting*, the act of moving about restlessly [10]. When individuals feel stressed, they are unable to control the situation, and in most of the times, they have limited conscience of their actions. We attempted to inquire into whether these fidgeting can be captured a regular webcam. Using the Open CV library we continuously logged the X and Y coordinates of the motion detected in the picture taken.

Overall, we found significant correlations between perceived stress and a number of metrics signifying frequency and intensity of motion. The strongest correlation (r=0.36, p<0.01) was detected for the Y coordinate that indicates were the movement was detected in the picture taken.

Engagement
Last, in order to infer appropriate times for recommending a break, the system should be aware about the user's engagement with computer-related activities. While we expected cases where the user is disengaged with computer-related activities, but still, not available to take a break, we assumed that this represented a minority of the population of opportunities for a break.

We hypothesized that users' engagement could be inferred from the frequency of keyboard strokes and mouse presses. Prior work shows that mouse tracking could offer a scalable way to infer user attention [8] and emotional states such as confidence and relaxation could be classified through keystroke dynamics [4]. In this work we intend to find out if simple mouse and keyboard metrics could predict the user engagement with their computer activities.

A negative correlation (r=-0.43, p<0.01) was found between perceived-engagement and the frequency of keyboard strokes and mouse presses.

Need of a break
Last, we wanted to understand which of the three measured variables, posture, stress and engagement are the best predictors of users' need for a break. Table 2 outlines the correlations, along with significance values, for each of the three questions. We found a strong correlation between users' need for a break and their perceived posture and stress. Perceived stress was the strongest predictor of users' need for a break. While we expected a negative correlation between perceived engagement and need for a break, this was not manifested in our data.

Correlations	Need Break Question
Posture Question	0,56**
Stress Question	0,73**
Engagement Question	-0,04
**. Correlation is significant at the 0.01 level (2-tailed).	

Table 2 - Correlation between all four popup questions

A multiple regressions with need for a break as the dependent variable and Posture and Stress as the independent variables revealed the formula:

Need_for_a_Break = 5.590 - 0.578P - 0.190S
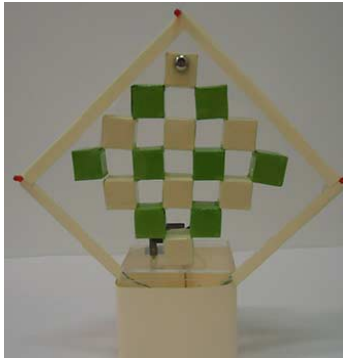
Figure 5 Ambient feedback prototype in a good posture representation

where Need for a Break is user's perceived need for a break as elicited through the self-reports, while **P** is the inferred posture by the system and **S** the inferred stress by the system.

Breaking sedentary behaviour

In our ongoing work we are exploring three different approaches to behavioural change: implicit, just-in-time and ambient feedback.

Implicit
User's behaviour is translated into four desktop wallpapers which reflect users' posture and levels of stress.


Figure 6 – Three wallpapers that represent levels of stress and one to recommend breaks. Dolphin image is for the beginning and a lower level of stress. Medium and higher levels are represented with turtle and cheetah + gazelle images respectively. Lion image is for break recommendation.

Just-in-time
The just-in time feedback employs prompting at the bottom right side of the user's screen at the moments when *BreakOut* estimates as appropriate based on the levels of posture and stress.

As we considered just-in-time recommendations too intrusive, we developed a gestural interaction prototype that enables individuals to interact with *BreakOut's* feedback using minimal cognitive resources (see Figure 7). The prototype uses capacitive sensing and distinguishes between three gestures: a tap reflects a

rejection of the recommendation, a swipe-down reflects users' agreement to accept a break recommendation and a swipe-up reflects a snooze for 5 minutes.
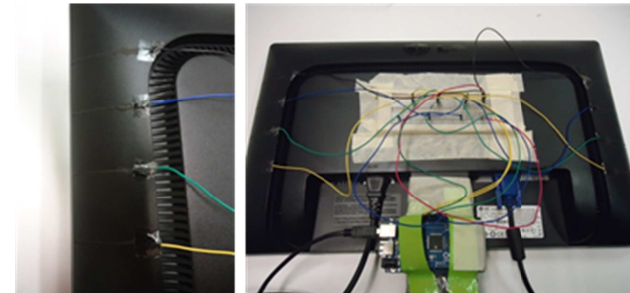
Figure 7 – Behind-screen prototype with gestures that allow intuitive interaction with *BreakOut's* Feedback.

Ambient feedback
The ambient feedback employs an origami construction (see Figure 5) sitting on the user's desk. The sculpture was implemented using the Arduino platform, a servo motor, acrylic material and LED lights. The behaviour of the sculpture reflects users' posture over time, with good posture being reflected in the symmetry of the origami construction, while a worsening posture breaks this symmetry.

Conclusion and Future Work

Nowadays ergonomic experts are developing strategies and references not just for workers but for employers too in order to reduce injuries in the workplace [3]. Self-conscience about ill habits in workers is important otherwise they will be reluctant to follow the guidelines provided to correct it [3].

In this paper, we presented *BreakOut*, a desktop system that infers an individual's posture, stress levels,

and engagement with computer related tasks with the goal of recommending a break of sedentary behaviour at appropriate times. The study revealed that *BreakOut* is able to infer users' posture and stress levels but not that of engagement with computer-related activities. In our future work we aim to conduct a field deployment of *BreakOut* to evaluate the effectiveness of the different feedback techniques described. We also aim to understand the users' interaction/ with the different systems and see if the system is able to engage over long periods of time [7].

References

1   Barrett, F., Barrett, DJ. An Introduction to Computerized Experience Sampling in Psychology. Social Science Computer Review Summer. 2001;19:175-185.

2   Brown, WJ, Miller YD, Miller R. Sitting time and work patterns as indicators of overweight and obesity in Australian adults. International Journal of obesity. 2003;27:1340-1346.

3   Chen CW, Määttä T, Wong KBY, Aghajan H. A Collaborative Framework for Ergonomic Feedback Using Smart Cameras. In: Distributed Smart Cameras; 2012; Hong Kong. p. 1-6.

4   Epp C, Lippold M, Mandryk. Identifying Emotional States using Keystroke Dynamics. In: Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems; 2011 May 7-12; Vancouver, BC, Canada. p. 715-724.

5   Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. European Heart Journal. 2011 March;32:590-597.

6   Jafarinaimi, N, Forlizzi, J., Hurst, A, Zimmerman J. Breakaway: An Ambient Display Designed to Change. In: ACM, editor. CHI '05 Extended Abstracts on Human Factors in Computing Systems; 2005 April; Portland, Oregon. p. 1945-1948.

7   Karapanos, E., Zimmerman, J., Forlizzi, J., Martens, JB. User experience over time. In: ACM, editor. CHI '09 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems; 2009 April; Boston, MA. p. 729-738.

8   Navalpakkam V, Churchill EF. Mouse Tracking: Measuring and Predicting Users' Experience of Web-based Content. In: CHI '12 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems; 2012 May 5-10; Austin, Texas. p. 2963-2972.

9   Openshaw, S, Allsteel;Taylor, E, Allsteel. Ergonomics and Design a Reference Guide. [Internet]. 2006 Available from: http://cms.allsteeloffice.com/SynergyDocuments/ErgonomicsAndDesignReferenceGuideWhitePaper.pdf.

10 Oxford University Press. Oxford Dictionaries. [Internet]. 2013 Available from: http://oxforddictionaries.com/definition/english/fidget.

11 Pina LR, Ramirez E, Griswold W. Fitbit+: A behavior-based intervention system to reduce sedentary behavior. In: Pervasive Computing Technologies for Healthcare; 2012; San Diego, CA. p. 175-178.

12 Proper KI, Cerin E, Brown WJ, Owen N. Sitting time and socio-economic differences in overweight and obesity. 2007;31:169-176.

13 SAGE Publications. Reducing Sedentary Behavior: A New Paradigm in Physical Activity Promotion. American Journal of Lifestyle Medicine. 2011 November;5-6:518-530.

14 WorkSafeNB. Office ergonomics - Guidelines for Preventing Musculoskeletal Injuries [Internet]. 2010 [cited 2013 June 11]. Available from: http://www.worksafenb.ca/docs/OFFICEEdist.pdf