Exploring New Potentials In Preventing Unhealthy Computer Habits

Tobias Sonne
Department of Computer Science
Aarhus University
Aabogade 34,
8200 Aarhus N, Denmark
tsonne@cs.au.dk

Kaj Grønbæk
Department of Computer Science
Aarhus University
Aabogade 34,
8200 Aarhus N, Denmark
kgronbak@cs.au.dk

CHI 2013 Extended Abstracts, April 27–May 2, 2013, Paris, France.
ACM 978-1-4503-1952-2/13/04.

Abstract
Each day millions of computer users experience pains due to unhealthy computer habits. Research in this field mainly focuses on encouraging users to take breaks and correct their posture. This paper shows that unhealthy computer habits calls for new sensing solutions. Based on a design process including experts in the field of computer-related injuries, The Habit-Aware Mouse prototype was developed. It provides high-accuracy sensing of whether a user's fingers are hovering above the mouse. This kind of hovering is known to cause pains in the forearm. The integration of transparent sensing in existing products enables medical researchers to gain new insights on unhealthy habits. The Habit-Aware Mouse is a diagnostic sensing tool to get detailed knowledge about the user's unhealthy computer habits. Sensing is the first step to enable feedback, preventing injuries from finger hovering.

Author Keywords
Carpal Tunnel Syndrome; Ergonomics; Repetitive Stress Injuries; Physical Computing; Human Computer Habits.

ACM Classification Keywords
J.3 [Computer Applications]: Life and medical sciences; H.5.2 [Information interfaces and presentation]: User Interfaces – Ergonomics, Haptic I/O, and Prototyping.

Introduction and Motivation

Today people spend an increasing amount of time in front of a computer [12], which unfortunately can lead to musculoskeletal disorders, repetitive stress injuries (RSI), carpal tunnel syndrome (CTS) and other computer-related injuries [13] [12]. Thus it has become more important than ever that computer users develop healthy computer habits.

So far most research has focused on getting people to take breaks from the computer [1] and to correct their posture [7] [3]. But there are other habits that are important when trying to prevent computer-related injuries. Research shows that up to 48% of computer users have a bad habit of lifting their index- or middle finger above the mouse, which can cause pain in the forearm [8]. Until now very little research has been made to prevent this habit that influences almost 50% of computer users. Thus the goals for this paper are 1) to show that there are potentials for new innovations and products to help people prevent unhealthy computer habits and computer-related injuries in general. 2) To create a prototype that can help medical researchers gather valuable data about this unhealthy habit and in turn give preventive feedback.

Related Work

In the following, state-of-the-art research and commercial products that help users prevent unhealthy computer habits will be presented.

Wearable sensing:

Wearable systems related to unhealthy computer habits include Wearable Therapist [5] and SMASH [6]. Both systems use shirts equipped with 3-axis accelerometers to measure the posture of the person wearing it. Both systems have the potential to monitor the posture of computer users, even though neither of them mentions this application area directly in their papers. A wearable system that primarily focuses on sensing and preventing unhealthy computer habits is Limber [9]. The Limber system monitors both posture and wrist angle (to prevent CTS) and uses a game-like feedback mechanism to motivate the user to stretch and take breaks while working in front of a computer. Limber is one of the few wearable systems, which focuses on preventing unhealthy computer habits. Unfortunately, the Limber system requires the user to wear a big torso-mounted enclosure, a hoodie, and a wrist-brace, which makes it uncomfortable for the user to use [9].

Camera-based sensing:

Many laptops today have a built-in webcam, which can be used to detect posture [7] and presence[14]. The system made by Jaimes et al. is able to detect the user’s posture when sitting in front of a computer and give real-time feedback [7]. The Kinect system by Microsoft is also able to detect posture and potentially prevent work related injuries [10] but due to the practical ranging limit of ~1.2m - 3.5m the current Kinect sensor is not optimal to use in a desktop environment. The next generation of Kinect cameras should be able to track users within 40cm and has an improved “Seated mode skeletal tracking” system [15] making it a potential system for monitoring the posture of computer users. A recent commercial product that incorporates posture detection into a LCD screen is the ErgoSensor monitor from Philips [14]. The ErgoSensor monitor keeps track and alerts the user of bad posture, time in front of the display, and distance to the display. Even though camera-based solutions offer transparent sensing, they focus only on posture and time in front of the computer.

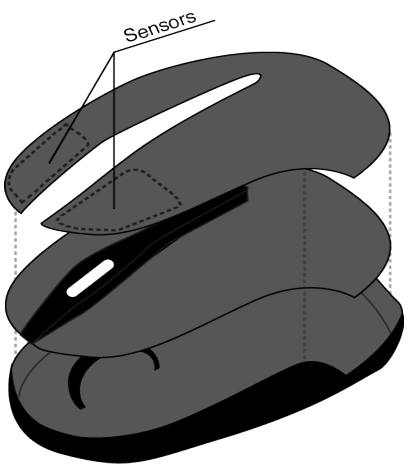

Figure 1. Exploded view of The Habit-Aware Mouse

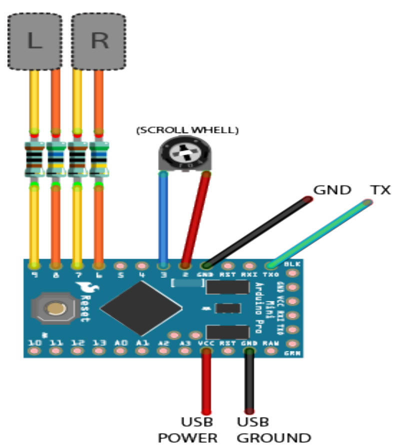

Figure 2. Simplified breadboard view of The Habit-Aware Mouse prototype

Implicit sensing

Today, many software solutions exist that remind computer users to take breaks when certain time periods have elapsed. Solutions like RSIGuard [16] and RSI-Shield [17] are popular commercial solutions that monitor the user's activity and uses "intelligence" to determine when to interrupt the user to minimize RSI. SuperBreak [11] investigated how different interaction types and activities influenced the users attitude towards RSI-breaks and found, that short activities (games, videos etc.) made more people take the break compared to a standard text and timer window.

The implicit sensing systems are transparent when sensing, but can be seen as annoying when repeatedly prompting the user to take a break. Incorporating activities as mentioned by [11], seems to make break-reminder systems less annoying. While systems of the type mentioned in this subsection can track the user's time in front of the computer, they do not monitor any other unhealthy habits.

Physical sensing:

Not much research has been done on how augmented physical devices can sense a potentially unhealthy routine or action. One of the only examples is the Sensitive Chair [2] that uses force sensors embedded in a normal office chair to sense the posture of the user.

In general most research and commercial systems focus on breaks from prolonged engagement in tasks and posture. Furthermore, only a small percentage of the solutions to help people avoid unhealthy computer habits and bad ergonomics are augmented physical objects, which could leave room for further exploration and new discoveries.

Empirical research

To gain a deeper understanding of ergonomics and unhealthy computer habits, interviews with a broad range of professionals were conducted. In the following an overview of the empirical process and the results are presented.

Empirical Methods

Interviews, observations, field studies etc. are often used in a design process to gain insights about the users' practice or needs. However, when it comes to unhealthy computer habits users may not be aware of their habits and it can be almost impossible to observe subtle hand or body positions and behaviors. Therefore, the empirical data gathering consisted of interviews and small workshop-like situations with a leading senior doctor who specializes in neurophysiology and an occupational therapist with over 30 years of experience within computer ergonomics.

Empirical Results

Based on the above-mentioned methods, several potential technology-based solutions to help prevent unhealthy computer habits were identified. Some of the potential solutions were very similar to the systems described earlier in the related work section. However, there were unsolved problem areas related to musculoskeletal disorders and other injuries that were discovered.

One of the major problems identified by the experts, was that many computer users have the unconscious and unhealthy habit of having one or more fingers hovering above the mouse for extended periods during their workday. Such an unconscious action puts a lot of

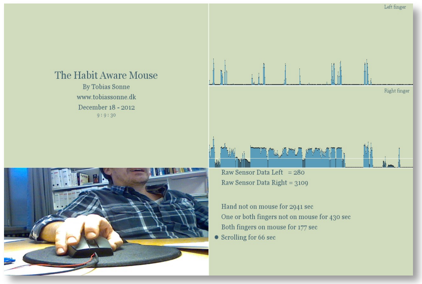

Figure 3. Screenshot from the video experiment.

Results from the video study	
Correct estimations	82%
Failed estimations	3%
Not able to verify estimation in video	15%

Table 1. Summarized results from the video studies validated with ground truth video.

Results from the video study (verifiable cases only)	
Correct estimations	96%
Failed estimations	4%

Table 2. The distribution between correct- and failed estimations of the verifiable cases.

stress on a small set of muscle fibers in the forearm that over time can cause severe pains.

One of the challenges for the experts today is that they don't have any precise statistics on how many, how often, and for how long people are doing this unhealthy habit - nor do they have any reliable way to find out. Therefore we developed The Habit-Aware Mouse that can sense these periods of hovering.

The Habit-Aware Mouse

This short section gives a brief technical overview of The Habit-Aware Mouse prototype.

The prototype consists of a normal cabled mouse with an Arduino Pro Mini [18] inside. The Arduino is powered from the USB power inside the mouse so no extra battery is needed. A layer of conductive ink from Bare Conductive [19] was painted underneath each mouse button, which forms two ultra thin capacitive sensors. When connected to the Arduino running the CapSense library [20] the two sensors are then able to measure the proximity to the user's fingers. To detect when the user is operating the scroll wheel, the Arduino is connected directly to the existing rotary encoder in the mouse as shown in Figure 2. In the current version of The Habit-Aware Mouse the raw sensor data is transmitted to a computer running Processing [21] where it is processed and visualized in various ways as explained in the next section.

Prototype Validation

This section investigates the accuracy of The Habit-Aware Mouse and presents the results of two user studies: A lab experiment and a video experiment.

Lab Study

To test the accuracy of The Habit-Aware Mouse a quantitative 7 minute lab experiment with 10 computer users was conducted. The participants were seated with their back to the author. All participants were told that the author would try to guess the position of their hand (on / off mouse) and their fingers (on / slightly above mouse). A software program had been developed that calculated the position of the user's hand and fingers from the sensor data from the Arduino in the mouse. The software program also randomly chose when to ask the participant for validation in a 5 – 20 sec. interval.

The result of the experiment showed that The Habit-Aware Mouse was able to estimate the correct hand and finger position in all test cases.

Video Study

To make sure we didn't get any false positives and to test The Habit-Aware Mouse in a more real world like setting, a video study with five participants was conducted. The participants were asked to use The Habit-Aware Mouse instead of their own mouse for a minimum of two hours while they were working on their own computer. The participants weren't told about the real purpose of the study to avoid influencing their normal work practices and habits. A webcam positioned at the participant's desk recorded the fingers' position, which afterwards was used as ground truth to validate and compare the sensor readings and estimations with what really happened as seen in Figure 3. Two participants used The Habit-Aware Mouse for seven hours, two used it for four to five hours and one participant used it for two hours.

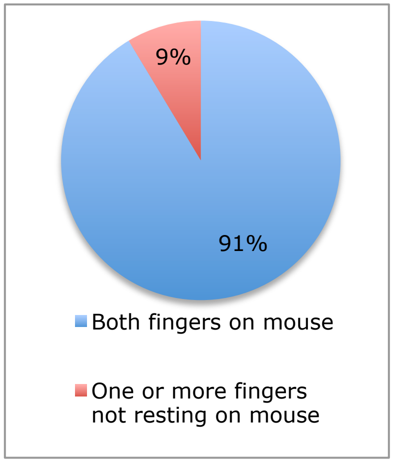

Chart 1. Summarized data from four participants with no prior pain in their hand, arms or shoulder.

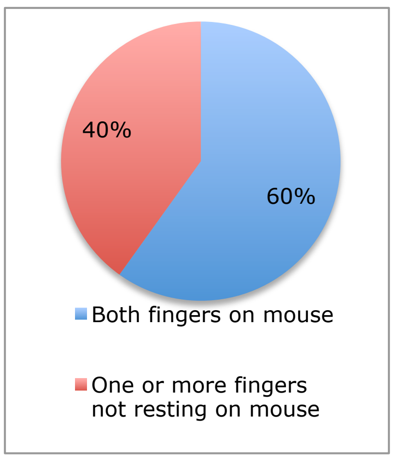

Chart 2. Data from participant A with existing pains in his forearm.

The result of the video experiment showed that out of the more than 2400 changes in finger positions, The Habit-Aware Mouse estimated the correct position in 82% of the cases (see table 1). Unfortunately, in 15% of the cases the video recording could not be used to validate the estimation, due to a blurred image or because the participants had moved the mouse to a position outside the view of the webcam.

One of the participants (A) said, in a follow up interview, that he on an almost daily basis has pains in his forearm and had visited an occupational therapist several times within the last year. Even though the aim for this paper only was to validate the technology, we could see that participant A in almost 40% of the time had one or both fingers lifted above the mouse compared to 8% for the four other participants who had no pains in their arms or shoulders. Due to the small number of participants no statistical conclusion can be drawn from these data, but the results are quite indicative and motivate further research.

Perspectives and Discussion

This paper has shown that there is a potential and a need for creating new sensor-based solutions to help people develop healthy computer habits and reduce the amount of computer-related injuries and pains.

The Habit-Aware Mouse has two potential uses. First, it can help medical researchers gather valuable and reliable data about people's computer habits that they can't otherwise observe. This new information can lead to new research and solutions focused on unhealthy computer habits and computer-related injuries. Second, occupational therapists and physiotherapists can use The Habit-Aware Mouse as a diagnostic tool when people complain about pains related to unhealthy computer habits. Patients complaining about pains could borrow The Habit-Aware Mouse and use it for a couple of weeks to monitor their habits and begin to correlate behaviors with symptoms. This could be similar to how doctors give patients a blood pressure monitor to gain insights into a patient's overall heart health when investigating a heart condition, identifying and ruling out health factors. The experts can then with a higher degree of certainty, based on data from The Habit-Aware Mouse, determine if a user has an unhealthy habit of hovering one or more fingers, and then in the best possible way try to help the patients avoid these situations in the future. This help may be provided through context-aware feedback based on the sensor.

The Habit-Aware Mouse, presented in this paper, is able to determine if the user is behaving in a way that can lead to computer-related injuries. But being able to monitor these unhealthy habits is only the first step to help people develop healthy computer habits. The next step for The Habits Aware Mouse is to give feedback to the user in context, so they can change their unhealthy behavior and avoid the pains in the first place. General research in persuasive computing has been conducted [4], but more research is needed to see if findings there can be directly transferred to unhealthy computer habits. Therefore, further research on feedback and behavioral change needs to be conducted before such effects can be determined.

Work-in-Progress: Health

CHI 2013: Changing Perspectives, Paris, France

References

[1] Bickmore, T., Mauer, D., Crespo, F., and Brown, T. Negotiating task interruptions with virtual agents for health behavior change. *In Proc. AAMAS 2008, Richland, SC, 1241-1244.*

[2] Daian, I., van Ruiten, A.M., Visser, A., and Zubic, S. Sensitive chair: a force sensing chair with multimodal real-time feedback via agent. *In Proc. ECCE 2007*, ACM 2007, 163–166.

[3] Demmans, C., Subramanian, S., and Titus, J. Posture monitoring and improvement for laptop use. *In CHI "07 extended abstracts on Human factors in computing systems*, ACM 2007, 2357-2362.

[4] Fogg, B.J. Persuasive technology: using computers to change what we think and do. *Ubiquity 2002*, December (2002).

[5] Harms, H., Amft, O., Tröster, G., Appert, M., Müller, R., and Meyer-Heim, A. Wearable therapist: sensing garments for supporting children improve posture. *In Proc. Ubicomp 2009,* ACM 2009, 85–88.

[6] Harms, H., Amft, O., Tröster, G., and Roggen, D. Smash: A distributed sensing and processing garment for the classification of upper body postures. *In Proc. BodyNets 2008*, 22.

[7] Jaimes, A. Sit straight (and tell me what I did today): a human posture alarm and activity summarization system. *In Proc. CARPE 2005, ACM, 23-34*

[8] Lee, D.L. Prevalence of Lifted Finger Behavior and Postures during Two-Button Computer Mouse Use. *In Proc. of the Human Factors and Ergonomics Society Annual Meeting 50*, 13 (2006), 1361–1365.

[9] Leung, K., Reilly, D., Hartman, K., Stein, S., and Westecott, E. Limber: DIY wearables for reducing risk of office injury. *In Proc. TEI 2012, ACM, 85-86*

[10] Martin, C.C., Burkert, D.C., Choi, K.R., et al. A real-time ergonomic monitoring system using the Microsoft Kinect. *Systems and Information Design Symposium (SIEDS), 2012 IEEE*, (2012), 50–55.

[11] Morris, D., Brush, A.J.B., and Meyers, B.R. SuperBreak: using interactivity to enhance ergonomic typing breaks. *In Proc. CHI 2008,* ACM (2008), 1817–1826.

[12] Wahlström, J. Ergonomics, musculoskeletal disorders and computer work. *Occupational medicine (Oxford, England) 55*, 3 (2005), 168–176.

[13] Woods, V. Musculoskeletal disorders and visual strain in intensive data processing workers. *Occupational medicine (Oxford, England) 55*, 2 (2005), 121–127.

[14] Philips Ergosense Monitor *http://ergosensormonitor.com*

[15] Microsoft Kinect *http://www.microsoft.com/en-us/kinectforwindows/develop/new.aspx*

[16] RSIGuard *http://www.rsiguard.com*

[17] RSI-Shield *http://www.eagerplanet.com/rsishield*

[18] Arduino Pro Mini *http://arduino.cc/en/Main/Hardware*

[19] Bare Conductive www.*bareconductive.com*

[20] CapSense Arduino Library *www.pjrc.com/teensy/td_libs_CapSense.html*

[21] Processing *www.processing.org*