Physical WorkPace: a case study on exploiting context histories in personal healthcare domain

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ABSTRACT
In the Physical WorkPace project we research into how smart rooms will help the user to be more aware of their daily use of computers, and eventually contribute to the reduction or even prevention of physical discomfort and computer-addiction. In the paper we describe our current progress in this project on the design of an everyday object that collects context histories of user activities. We also present some preliminary results on inferring activities from context histories. We believe that our experimental approach towards the exploitation of context histories will motivate a lot of warm discussion in this area.

Keywords
Contexts, context histories, smart environments, pervasive computing, personal care

INTRODUCTION
As more and more work, education, entertainment are carried out in front of computers, people may become victims of Repetitive Stain Injury (also known as RSI, OOS and Carpal Tunnel Syndrome) caused by improper use of computer keyboards and mice. Software tools like WorkPace [1] can help the user to have more frequent breaks and exercise at work. Usually such tools are installed on the computers that the user has access to. Unfortunately those tools can not provide continuous and coherent break suggestions when the user uses computers at different locations, even though the computers are possibly interconnected.

We believe that *context histories*, which contain historical information on user and system activities in smart environments, have great potential for enhancing user experiences in smart rooms, especially on enhancing person healthcare experience. Anti-RSI software tools usually monitor only the duration and frequency of the use of keyboards and mice. With the profusion of sensors, smart rooms could provide more accurate information of the actual work rhythm of the user. Furthermore, existing anti-RSI software does not support cross-device profile exchanges. With the exchange of context histories of the user's work activities across physical boundaries, context histories can be synthesized at any place whenever needed and the joint context histories thus could provide continuous and coherent pictures of daily activities of the user and more sensible healthcare advices could be recommended based on this to the user.

PROJECT TOPICS
In view of ambient intelligence [2], smart rooms can perceive ongoing activities of the user, adapt system behaviors in ritual tasks, and anticipate the needs of the user and act accordingly. Taking this as the premise of our research, we investigate in the "Physical WorkPace" project on how smart environments could help the user to become more aware of their use of computers and regulate it, at work and at home.

In the Physical WorkPace project, we investigate on the follow research topics.

- Design of everyday objects that collect context histories of user activities.
- Algorithms for inferring activities from context history.
- Contextual feedback.
- Exchange and synthesis of context histories.

Exploiting context histories of the user will raise the discussion on privacy, trust, and other social and cultural issues. The results of the discussion may have impact on system design, especially on security and authentication mechanisms. In our project, however, we purposely focus ourselves on technological challenges, due to the experimental nature of our project.

Collecting Context Histories
In smart rooms, sensors are embedded into architecture, furniture and appliances in many ways. In our project, we will look into how sensors could be embedded into or become daily objects. In our point of view, tangibility of

everyday objects will contribute to the acceptance of sensors in their rooms by end users.

Inferring Activities

The data collected by sensors in smart rooms should be used to derive accurate information on user activities. In our projects we are looking for minimal solutions to presence detection of the user at his/her work space. Since we believe smartness will eventual be integrated into home and office environments, minimal resource requirements on sensors and computing power will make our system not only easy to install and maintain, but also affordable to use.

Contextual Feedback

In smart rooms, system behaviors may well be derived by the analysis of context histories, even without direct user interaction. Perceivable system status, thus, is not always the feedback to specific user action. Therefore, it is necessary for the user to understand why the system works in this/that way, or why the system recommends this/that. Anti-RSI software tools suggest breaks at work, based on short-term and long-run user activities. In our project, we will study the techniques, in addition to those used by anti-RSI software, that effectively provide context (history) related feedback.

Exchange and Synthesis of Context Histories

Context histories are gathered at different places and also at different times. To obtain integral and coherent knowledge of user activities, context histories should be exchanged and synthesized whenever needed. In our project, we will research into the synthesis of histories that record user activities at different circumstances (time and location).

In this paper we will present our design and prototyping work on a context history collecting device and some preliminary analysis of gathered data.

PROTOTYPING

At this stage, a device that can detect and collect user presence at work has been designed and prototyped, called *mPacer*. Major functionalities of mPacer are as follows.

- Detect and record user presence.
- Provide break suggestions.

mPacer first detects any movement within its range (about 100cm). It sends a distance reading to a nearby computer via serial communication. The computer records the reading, analyzes the ongoing activity, and sends proper feedback to mPacer. mPacer then displays the feedback.

Since our primary objective is to enhance the user's awareness of his/her daily use of computers, we divide a person's work time into two status: *at screen* and *off screen*, which stand for "using the computer" and "not using the computer" respectively.

In each working status, feedback was designed to indicate whether the user works with proper breaks, as illustrated in Figure 1. Initially, mPacer displays a neutral smiley, indicating no user activities around the computer. When the user starts to use his/her work, mPacer gives a sign signal, a big smile as shown in Figure 2. Similar approaches were used in other intelligent interfaces [3, 4]. When the user keeps on working without breaks, mPacer will give the user a warning signal by displaying a sadness smiley. When the user moves away from the computer, mPacer will display a resting smiley, telling the user to have a good rest and do some exercises. mPacer returns to its neural state when the resting time elapses. In our experiment we define the resting time to be one fifth of the duration of the last work period.

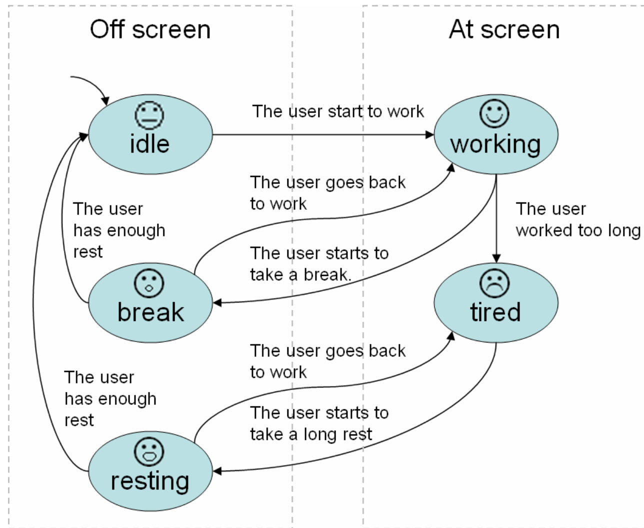

Figure 1 This state transition diagram illustrates the different status (feedback) and in-between transitions of mPacer.

Figure 2 mPacer can detect the presence of a user and provide emotional expressions at the different stages during work.

In our experiment, we use one microcontroller (PIC16F877) from Microchip, one long-distance measuring sensor (GP2Y0A02YK) from Sharp, and a matrix of LEDs for displaying. Together with additional accessory components, those components are integrated into a plastic case, 10cm x 10cm x 6cm (WxHxD). With better prototyping techniques, such devices could be made much smaller.

Currently our mPacer has an office-liked look-and-feel, as illustrated in Figure 2. The material, color and shape of mPacer were chosen to be as neutral as possible. For home environments, the look-and-feel of mPacer will certainly be adjusted accordingly to make it more personal and better suited for the home atmosphere.

INITIAL ANALYSIS

With our prototype device, we invited a colleague from our department for a case study. We put our prototyping mPacer on his desk and to the left of his computer. When the user sat on his chair with rollers, mPacer was in height between the chest and the belly of the user. We asked the user to work as usual and left our device there to run for 30 minutes. Figure 3 shows the sample data collected by mPacer. In the figure, the horizontal axis is the timeline and the vertical axis is the distance between the user and his computer. The closer to the computer the user is, the higher the reading appears to be.

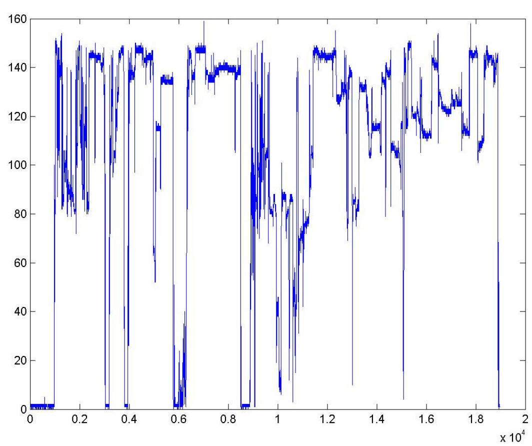

Figure 3 In one case study, user presence at his work was recorded by mPacer. mPacer sampled the distance between the user and his computer for 30 minutes at the frequency 10HZ.

Right after the test, we asked the user to recall his activities during the test. Little matching was found when we compared the activity description by the user with the reading history by mPacer. The main problem there was the activity description made by the user after the study was not detailed enough. To obtain a better idea about the user's activity, we showed the user the reading history by mPacer. All of sudden, the user recognized something and started to explain his activities in great detail!

Although we have doubts about whether the user would still be able to recall his activities in a longer user test, our initial case study does show that our simple and cheap solution to context collecting devices, namely mPacer, is indeed able to collect useful context histories.

Furthermore, we did find the need to create multiple streams of context histories and to synthesize them to obtain accurate information on user activities. Figure 4 shows what the mPacer observed in the first 10 minutes in the study. As can be seen in the figure, initially the readings are pretty low, indicating the user was away from his computer. Then after about 100 seconds, it seems that the user started to work in front of his computer. At this stage, there were a lot of fluctuations, probably showing that the user was cleaning up his desktop and arranging his keyboard and mouse. After about 250 seconds, the signal remains stable for 50 seconds. Without second stream of information, it is very difficult to infer the actual user activities between the 100th and the 250th seconds.

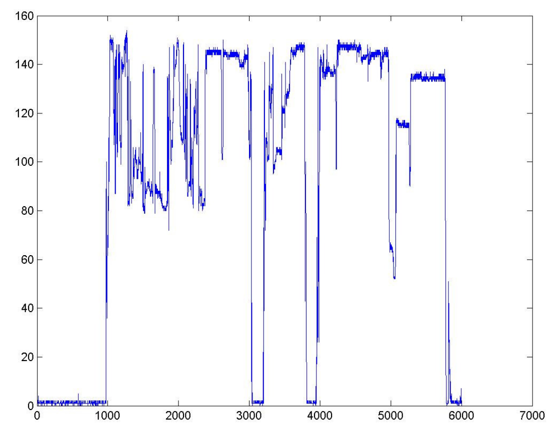

Figure 4 These are the 6000 samples of the first 10 minutes of the case study described in Figure 3.

Overall, the user was very enthusiastic about mPacer and its practical use. He likes the use of emotional expressions in break suggestion, and is in favor of mPacer's clock-liked look and feel. mPacer has been visited by many students and colleagues in our department in a less formal manners and their enthusiasm on mPacer has been recognized as well.

FUTURE WORK

In the rest of the Physical WorkPace project, the following issues will be addressed.

- We will design a software tool to synthesize activity information collected by mPacer and that done by the WorkPace software. Next we will carry out another case study, in which a video camera can be setup to record actual user activities. The synthesized context history will be checked against the taped information on the video. We expect to find a consistent matching between the two.

- At this moment inferring activities like being at work is mainly achieved by comparing the current reading with a reference reading. We aim to derive finer activity information via signal processing and pattern recognition.
- mPacer currently provides break suggestions when the user works longer than 10 minutes. Also the minimal duration of a rest is fixed at one fifth of the duration of the past work period. Learning algorithms will be implemented to make mPacer be able learn the favorite work rhythm that the user is used to.
- The current feedback system of mPacer may cause some confusion to the user. In our case study, the user told us his feeling that time passed by fast when he concentrated on his work. Sometimes he did not think that he had worked that long and had no need to take a break, though suggested by mPacer. Such phenomena have been attributed to "flow" in Csikszentmihalyi's study [5] and recently reevaluated in computer games [6]. We are going to investigate whether the provision of contextual feedforward and feedback in mPacer will help the user to escape from the flow mode.
- We will also look into technological solutions towards the exchange of context histories between devices across smart rooms. To enable data exchange, we will propose a markup language in XML for describing context histories. To make context histories available for applications in/across smart rooms, context histories management services will be designed and prototyped.

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Author Biography

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