Unobtrusively Measuring Stress and Workload of Knowledge Workers

S.J. Koldijk[1,3], M.A. Neerincx[2,3] and W. Kraaij[1,3]

[1] ICIS, Radboud University, Nijmegen. [2] Technical University, Delft. [3] TNO, The Netherlands.
{saskia.koldijk, mark.neerincx, wessel.kraaij}@tno.nl

Imagine a typical working day of a knowledge worker, i.e. someone who is predominantly concerned with interpreting and generating information. Bob gets into the office at 9, starts up his computer, takes a look at his mails and calendar and plans what things he has to do this day. Then he starts working on one of the important tasks that have to be completed this week. When an e-mail comes in, he quickly reads it. As it is not relevant to him, he continues his task. When a colleague drops by, Bob looks up and talks to him, which results in some more to-do's for the day. As they are quite urgent, Bob decides to do them right away. After completion he switches back to his previous task and continues his working day. At 5 'o clock Bob notices that he has not completed all planned tasks yet and he feels somewhat stressed. He starts wondering where the time went and whether he should work overtime again to finish up.

Bob and many other knowledge workers experience working days like this, with important tasks to complete, while interruptions cause task switches and unplanned things have to be handled. These people often experience stress building up, which in the worst case results in burn-out [1, 2]. To prevent this from happening, knowledge workers should become more aware of what makes them feel stressed and how they can handle or avoid that.

Our goal

In our research we want to investigate how well-being at work can be improved by means of computer tools. We particularly focus on the unobtrusive measurement of workload and stress in order to give knowledge workers feedback and support in their way of working, preventing burn-out in an early stage. In this extended abstract we describe how the context and user state of an individual knowledge worker will be captured, interpreted and used in a coaching tool aimed at changing behaviour, resulting in improved well-being at work.

Well-being at work

In order to design an effective coaching tool we need to know what is of influence on well-being at work. Based on a literature study we identified four categories of determinants of well-being at work: the work itself, the working conditions, private circumstances and personal factors [3]. First of all, the type of work has influence on the well-being of employees. It is important that the work is diverse and the workload is not too high and not too low. In addition, high autonomy and feedback on work performance are beneficial to well-being at work. By contrast, interruptions and responsibilities outside one's control reduce well-being.

Not only the work itself but also factors relating to work conditions play a role. Interpersonal relationships are important, causing a stable social environment for the employee, which can help him or her deal with challenging situations. In addition, factors like career opportunities, good payment or job security are also important determinants of well-being at work. Furthermore, physical work conditions and psychological comfort also play a role.

Besides work conditions, also the private circumstances of employees can have an influence on their well-being. Again, social support plays an important role, as it can act as a buffer against problems at work. In general, it is important that there is a good balance between work and life. Problems at home can have a negative effect on the well-being of employees.

The final important category that influences well-being comprises personal factors. Two people in the same situation can experience different well-being. Factors of influence are age, sex, education, social and intellectual skills. Moreover factors like expectations, emotional stability and sensitivity to suffer from stress are of influence on well-being.

In our research we want to develop a computer tool that can help people to better cope with the negative determinants of well-being. Preferably it should be possible to capture relevant factors by sensing interactions with a computer. Therefore, we focus on the factors of the work itself and the working conditions. We aim to automatically recognize the task and content users are involved in, as well as their social and physical context. Moreover, we intend to automatically infer the user state, in terms of cognitive load, valence and arousal in order to get an indication of the stress level experienced. These aspects can then be coached upon.

Regarding the other determinants, the category of personal factors should certainly also be kept in mind. Well-being is subjective, and so individual differences should be considered by personalizing the tool. Moreover, the private circumstances of the user are important to consider, as they may have a great influence on well-being. Nevertheless measuring these factors will only be possible by asking the employee.

Automatic recognition of context and user state

For providing effective support to knowledge workers it is crucial to understand their current situation. In our system we define four relevant forms of contexts (see Figure 1). With task context we mean the task the knowledge worker is currently working on (e.g. writing a report, making a presentation). Content context refers to the project or content the person is currently involved in. With social context we mean recent contacts with colleagues. Finally, physical context includes aspects as location, movement and posture.

We intend to capture these contexts automatically, without user effort. The inference of context will be formulated as a pattern recognition problem. From various sensors, specific features will be extracted which are provided to a classifier to assign a label. In a pilot study data from several knowledge workers will be collected during their working day and annotated with context labels. The annotated data will be used to train and test various pattern recognition approaches.

Important for automatic context recognition is that it requires little user effort. The sensors should preferably be unobtrusive, available in a normal office setting or otherwise relatively cheap. Moreover, for real-time support, the system should be able to quickly come from sensor data to context labels. It is important that the automatic recognition of context is reliable and robust, so that the users gain trust in the system. Finally, the privacy of the user has to be taken in mind when personal data is accessed.

Figure 1 depicts a first setup for linking different sensors to the described contexts and user states. A first selection of sensors has been made based on costs, availability, obtrusiveness and expected usefulness. The first set of sensors is located at the computer or mobile phone and is therefore readily available for most knowledge workers. Information from keyboard, mouse and applications can be used to infer what task the person is performing [4]. With information about the content that the user accessed, the content context can be determined. Analysing phone calls made and e-mail conversations can yield information about the social context of the user. Moreover, several sensors can be used to infer aspects of the user's physical context. GPS and accelerometers can be used to infer the position and level of activity of the user. With visual information from a camera or Kinect the body posture can be recognized and audio input can be used to recognize the level of noise in the environment.

Combining information from different contexts can give insights in the mental state of the users. The cognitive task load can be determined based on three dimensions: The duration of a task, the difficulty of the task and the amount of switching between tasks [5]. The information of the tasks performed and the contents worked on can thus give an

indication of the experienced workload, which is a first indication of the stress experienced during the day. Furthermore, the social context and physical context can influence the stress level experienced.

In addition, information from facial expressions or speech can be used for inferring the emotional state of the user, in terms of valence and arousal [6]. For determining valence, also asking the user can yield valuable information (e.g. do you like or dislike the work you are performing now). Besides computer sensors, wearable sensors to measure body signals can be used. The respiration of the user, his heart signal (ECG), skin response (SCR) and blood volume pulse (BVP) can be used to determine the level of arousal [7]. The recognized arousal and valence can then additionally be used to estimate the level of stress that the knowledge worker is experiencing. Our hypothesis is that a high workload in combination with high arousal and negative valence causes a negative feeling of stress.

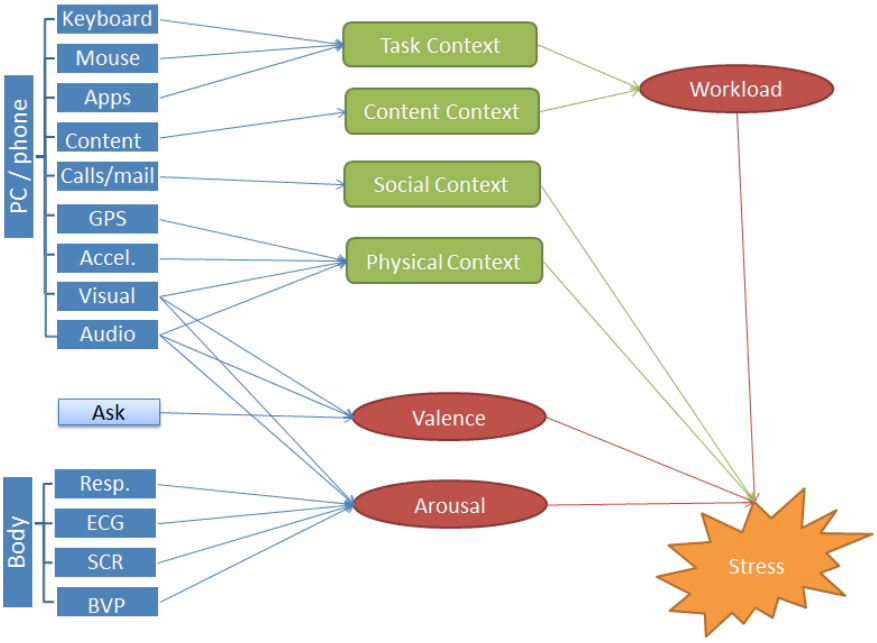

Figure 1. First setup for linking different sensors to the described contexts and user states.

Based upon these inferred contexts and user states, an e-coaching tool could support knowledge workers. For example, more awareness of performed activities could be created by providing an overview of active tasks and projects, as well as information about durations of tasks and the amount of task switching. Most informative is probably how the current behaviour relates to usual behaviour of the user. Slow or sudden changes or anomalies could be detected and users could be warned when, for example, the task load gets too high or the stress level is building up. By linking the workload and stress curves to the tasks performed, knowledge workers could gain insights into what has caused their feelings of stress. They could then learn to avoid stress by planning the week differently or taking more short breaks to relax.

Personalization

The general model described in the previous section will have to be adapted to the specific user, due to personal characteristics. The same task can for example have a lower or higher workload for a knowledge worker depending on his level of experience and expertise. Therefore a user model will be created for each user, which holds relevant information of personal factors, models of typical behaviour and how low level information links to the experienced well-being of this user. The tool should be person adaptive (applying personalization/ tailoring), as well as situation adaptive (taking the user's current context into account), to provide effective support and to gain trust of the user, so that the tool is used efficiently and over an extended period of time.

Discussion

Our contribution is focussed on providing knowledge workers efficient support. A state of the art study we performed revealed that although several applications with this aim exist on the market, applications which make use of sensors and smart interpretation of data to base support upon are rare. Typically the applications require much user effort and lack personalisation and adaptation to the user's context. In our research we want to overcome these problems by automatically inferring information about the context and state of the user. Unobtrusive and relatively cheap sensors will be used for estimating the workload and stress of knowledge workers. We will perform most research in real-world office settings and test our reasoning techniques on realistic data. In this way, our solution will be affordable and applicable for many knowledge workers, opposed to related work on workload and stress recognition, in which often rather obtrusive or expensive sensors are used and tested in controlled experiments. Finally, often the success of applications on the market is questionable, so we will perform a field study to evaluate the effect of our tool on well-being at work.

Research agenda

This work is part of the SWELL project[1], in which smart reasoning systems for well-being at work and at home will be developed. Important aspects of this project include the development of a stable and flexible framework for combining data from various sensors, and performing reasoning upon this data. Automatic inference of various context and user aspects will be enabled, as described here. Furthermore, possibilities to provide information support to knowledge workers by, for example delivering relevant information just in time, will be investigated. Policies for guaranteeing the privacy of the user will be developed. Finally, appropriate methods for achieving long lasting behavioural change and improved well-being will be applied and evaluated in field studies.

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[1] http://www.commit-nl.nl/projects/swell-smart-reasoning-systems-for-well-being-at-work-and-at-home