Recall your Actions! Using Wearable Activity Recognition to Augment the Human Mind

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Abstract
In this position paper we will focus on wearable activity recognitions tools in regard to their function of detecting human activities and thus enabling the user to recall everyday experience in a new way. The capabilities of activity recognition to detect, store and present activities to the person who has performed it can not only help to recall the activities but also encourage the user to remember experiences related to the activities. In order to demonstrate this, we present two projects (cases) in which wearable activity recognition is used to support the users' recall capabilities. In the next step, we present a narrative theory of action and mind, which focuses on how humans retrospectively interpret and structure personal experience in their minds, their so called autobiographical memory. Finally, we present some further concepts and distinctions about what it means to memorize and recall personal data.

Author Keywords
Wearable Activity Recognition, Interdisciplinary Approach, Design Issues

Introduction
Wearable activity recognition is about detecting human activities (mostly activities related to physical movements) using sensors placed near or on the body. The technical

research belongs mainly to the field of computer science, especially in the ubiquitous computing community. Here it is about using simple, miniature sensors for example motion and posture sensors (accelerometers) which can be worn like a wrist-watch. Smartphones as a multi-sensor-platform are equipped with similar sensors. The paradigm of 'everytime and anywhere' is one of the key characteristics of this technology. Using wearable activity recognition for self-tracking or life-logging is already common in the field of sport life-style products such as Nike Fuelband, Fitbit or Jawbone UP. There also exist research projects where, for example, sleeping behavior is logged [2] or leisure activities detected [1].

People have a growing interest in tracking or logging their everyday lives, for example in the lifestyle-oriented field of quantified self. A scientific investigation of self-tracking and life-logging with ubiquitous computing devices can be originally found in the work of Li et al., whose uses the term "personal informatics" for it [4]. Other research projects have studied how and why people use ubiquitous computing devices for tracking their personal data [3] [5]. The possibility to retrospectively observe the own activity can be understood as recalling life-experience for the purpose of documentation and often for the further goal of changing behavior.

First Systematization

As a first systematization of how to understand the wearable activity recognition as a technology for augmented mind support, we chose the concept of a cybernetic loop (Figure 1). In this scheme the recall process is modeled as a reflection on computer-mediated personal activity data. In the systematization the different entities of this process are shown. Starting with a person's everyday experience, which is mostly determined by the daily activities, the automatic detection of the system (recording and interpretation), the visualization for the user and finally the reflection on the memorized data, which is again influencing the everyday experience, are the steps of the process.

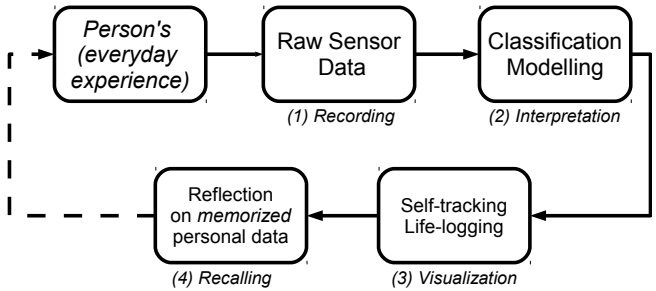


Figure 1: A cybernetic loop: A person's everyday life is logged or tracked, which makes it possible for her to recall on these events or data retrospectively. This can again influence the everyday behavior and the self-perception.

It can be assumed that this technology is providing a new perspective on own actions. But this perspective is mediated by the machine learning algorithms being used, including the chosen models and classifications, and the way in which the activities are visualized for the user. So the technology enables the possibility to retrospectively observe (recall) everyday experience.

Recalling is in itself an activity which brings something into consciousness, which is somewhere stored in mind, but is not present at that moment. In our position paper we argue that the activity of recalling with augmented mind technology should be analyzed with a wider approach. To fulfill this we will discuss a social science

narrative model of action and mind. Before that, two of our research projects, in which wearable activity recognition is used as an augmented mind technology, are presented.

Case Studies

The case studies are about detection of smoking behavior and the recognition of working steps in a laboratory. For the discussion of the case studies we use a cybernetic loop scheme, which was presented above.

Case study A (Table 1) is about using wearable activity recognition for recalling smoking events, with the future goal of increasing the awareness on smoking behavior [7]. Therefore, a wrist-worn motion-sensor is used to detect the smoking activity. The results can then be recalled by the user, concerning the time of the day, duration of smoking activity and the amount of cigarettes. Further goals of such computer-supported recalling is to interpret the data concerning triggers reasoning the activity, e.g. time, location or social events. This can help to raise the recalling capacity of smoking behavior and thereby increase the awareness on smoking behavior.

Case study B (Table 2) is about a recognition system supporting scientists, who work in a biological laboratory. In this project, possibilities for detecting single working steps in different experimental settings in a biological laboratory and possibilities to visualize the data for the scientists were explored. The system can in this way help to recall different working steps and how they were done. In laboratories where it is forbidden to bring sheets and pencils, because of the danger of contamination, the challenges of memorizing are overcome with this technology.

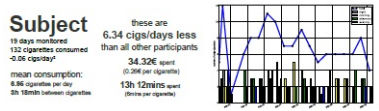
Phases	**Example**
Recording (1)	A person's arm motions and postures are recorded from a wrist-worn sensor 
Interpretation (2)	Frequently repeated movements of the arm when bringing the cigarette to the mouth are interpreted as a smoking activity
Visualization (3)	A visualization showing when a person was smoking over the day (combinable with information about the costs of cigarettes) 
Recall (4)	Using this information for increasing the awareness of a user's smoking behaviour

Table 1: Case Study A: Detecting Smoking Behavior

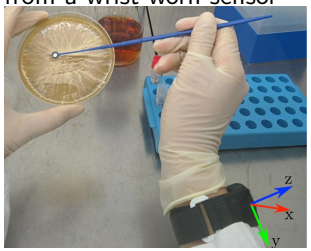
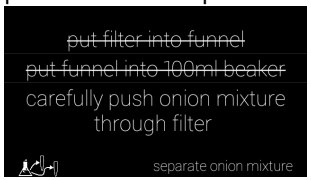
Phases	Example
Recording (1)	A persons arm motions and postures are recorded from a wrist-worn sensor 
Interpretation (2)	Frequently repeated movements of the arm when e.g. stirring or position of the arm when e.g. pipetting or poring
Visualization (3)	A visualization showing a protocol of the experiment 
Recall (4)	Storing the results automatically as well as recalling and comparing the different executions of the experiment

Table 2: Case Study B: Lab Support

A Narrative Concept of Action and Mind

Outgoing from these case studies we will extend our analysis by bringing in a new concept that we call narrative theory of action and mind. Storing personal data and enabling access retrospectively has an autobiographical or rather a narrative aspect, that we will take more into account.

We consider actions as part of our everyday experience. Actions are 'objects' that live on and are reinterpreted by, for instance, talking with others about them. Humans have the habit to retrospectively sort their actions [8]. Interpretations of everyday activities can change over time and by recalling them in different situations. This can result in changes of order and structure of memorization. There is a distinction between 'ad-hoc' actions and their reasons and the retrospective interpretation and order of these actions. According to Suchman, most actions, such as those routinely performed, are in the moment of performance not as purposeful and planned as they seem in retrospective interpretation [8]. This retrospective observation and evaluation of everyday experience is important for a person's self-perception. "Persons are constituted by narratives: autobiographical stories in which past, present, and future events have a meaning that is determined by all the other elements in the story" [6].

The usage of technologies which support memorizing and recalling, e.g. activity recognition tools, are mostly about retrospectively observing everyday experience and therefore can adequately be described with the narrative concept. The way the narratives are produced (e.g. automatic interpretation of activity) and presented, for example in a temporal sequence as well as qualitative or quantitative evaluation, predetermines how the user reflects on it and what can be recalled.

Further Concepts and Distinctions

We have discussed why wearable activity recognition is an augmenting human mind technology. On basis of two concrete projects, we have shown, how memorizing and

recalling can take place. Another goal of this position paper is to expand this discussion by including social science based concepts on human mind and distinctions for understanding them. Beside the narrative theory shown above, we will give some further suggestions on what should be taken into account when discussing ubiquitous augmented mind technologies. The current research especially investigates, how and why persons use existing ubiquitous technology to store or memorize personal data and their further purposes for doing that, e.g. using it for self-reflection and behavior change. This is an important discussion, especially when the phenomena is new. We argue for a wider approach by thinking about what it means to recall something on a conceptual level and how systems should be designed to support this.

(1) Support Memorizing vs. Recalling

Augmented mind support can on the one hand reduce the need to memorize things by storing personal experience and on the other hand encourage the possibilities of recalling things, which are stored in mind, but not present. For example, self-tracking or life-logging tools can record, interpret and store activity or other personal data. On demand the data can be visualized to bring it into mind and then used for further reflection. For example, the technology detects and stores the activity of a person (e.g. such as done routinely) over the whole day additionally with information on time and place. So the user does not have to memorize this information, because he has the possibility to recall on it simply by requesting it from the system.

The other approach focuses on encouraging the activity of recalling instead of reducing the need of memorizing by simply storing personal data. The human memory works with references, classifications and context information. So it can also be an augmented mind technology, when such systems refer to the activity of recalling. Therefore, the technology can provide context information or associations with the purpose of triggering the memory, to bring a specific information into the conscious mind. For example ubiquitous devices like the "Narrative Clip" (www.getnarrative.com) promise the user never to forget any moment of her life by taking a photo every so many seconds. These photos could be the context information, which helps to encourage someone to recall specific information, which happened in this context. A person is then guided by the technology to remember again.

(2) Trigger Recalling vs. Increasing Recalling Capacity

Focusing on the second aspect, a further distinction can be made. The recalling can be, like shown above, supported by triggering experiences stored in the mind, but another possibility could be to use technology for supporting recalling capacity in general or at least the capacity to recall specific personal data. In case A (detecting smoking behavior with a wearable activity recognition tool) the technology is providing a retrospective self-observation of smoking behavior by the user. Using this tool over some time can then raise the awareness on the smoking in general. So an augmented mind device should be designed in such a way that it focuses on supporting the 'natural' recalling capability.

This raises the question, if augmented mind technology should be more about unburdening the user because she has to memorize less or about supporting or animating the available 'natural' abilities.

(3) Privacy vs. Security

Recording everyday experience with ubiquitous technologies, for example wearable activity recognition,

results in a big amount of personal data. Using them for recalling or self-reflection is on the first view unproblematic regarding privacy concerns, but at the same time having this data stored on a device opens the door for unauthorized access. Then it becomes a privacy problem, but even more a security problem. However, we think it is reasonable here not to simplify privacy exclusively as an security issue. For example people can voluntarily share their raw data, without knowing how it will be interpreted in the future is a specific privacy problem regarding this technology.

(4) Reflection on Computer-Mediated Mind Support
The starting point of this idea is the question, how personal data is acquired and stored, especially by tools which automatically memorize everyday experience and which role the automation plays for persons recalling this data. Recalling can be seen as a reflection on memorized or stored data. This raises the question how user can trust the memorized data provided by the technology. We suggest there should be the possibility to evaluate the external mind support by including meta-data, which can be information about the algorithms and classification methods. Knowing the interpretation algorithms, can enable the user to put himself in relation to the data presented to him. For example, Rooksby at al. conclude from an empirical study that many persons "interweave various activity trackers, sometimes with ostensibly the same functionality" [5]. Out of this finding it is possible to reason that people probably have the need of a parallel instance to verify what the supporting technology is providing. We think this should be investigated more deeply.

Conclusion
We can conclude that an augmented mind technology can be designed to provide different ways of support, because it can address different "functions" of the mind. We provided a richer terminology of what mind, memorizing and recalling can mean, for example, the narrative dimension of mind and action. This makes the understanding of how humans memorize more complex, by including aspects of recollecting the memory and changing interpretations over time. A system design which fulfills this, should include also the possibility to reflect on the interpretation mechanism and how the data is stored with the possibility to change these.

References

[1] Berlin, E., and Laerhoven, K. V. Detecting leisure activities with dense motif discovery. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*, 250–259.

[2] Borazio, M., and Laerhoven, K. V. Combining wearable and environmental sensing into an unobtrusive tool for long-term sleep studies. In *Proceedings of the 2nd ACM SIGHIT International Health Informatics Symposium*, 71–80.

[3] Choe, E. K., Lee, N. B., Lee, B., Pratt, W., and Kientz, J. A. Understanding quantified-selfers' practices in collecting and exploring personal data. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1143–1152.

[4] Li, I., Dey, A. K., and Forlizzi, J. Understanding my data, myself: supporting self-reflection with ubicomp technologies. In *Proceedings of the 13th international conference on Ubiquitous computing*, 405–414.

[5] Rooksby, J., Rost, M., Morrison, A., and Chalmers, M. C. Personal tracking as lived informatics. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1163–1172.

[6] Schechtman, M. *The Constitution of Selves*. Cornell University Press, 1996.

[7] Scholl, P. M., Kkyildiz, N., and Laerhoven, K. V. When do you light a fire?: capturing tobacco use with situated, wearable sensors. In *Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing*, 1295–1304.

[8] Suchman, L. A. *Plans and situated actions: the problem of human-machine communication*. Cambridge Univ. Press, Cambridge Mass., 1987.