A Typology of Wearable Activity Recognition and Interaction

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ABSTRACT
In this paper, we will provide a typology of sensor-based activity recognition and interaction, which we call wearable activity recognition. The typology will focus on a conceptual level regarding the relation between persons and computing systems. Two paradigms, first the activity based seamless and obtrusive interaction and second activity-tracking for reflection, are seen as predominant. The conceptual approach will lead to the key term of this technology research, which is currently underexposed in a wider and conceptual understanding: human action/activity. Modeling human action as a topic for human-computer interaction (HCI) in general exists since its beginning. We will apply two classic theories which are influential in the HCI research to the application of wearable activity recognition. It is both a survey and a critical reflection on these concepts. As a further goal of our approach, we argue for the relevance and the benefits this typology can have. Beside practical consequences, a typology of the human-computer relation and the discussion of the key term activity can be a medium for exchange which other disciplines. Especially when applications become more serious, for example in health care, a typology including a wider mutual understanding can be useful for cooperations with non-technical practitioners e.g. doctors or psychologists.

Author Keywords
Wearables; Activity Recognition; Interaction Design; Ubiquitous Computing; HCI Theory; Seamless Interaction; Self-Reflection

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION
Activity recognition research is changing from mainly feasibility oriented projects to more serious applications ("next step" [17]). These applications can be part of medicine, sport science, psychology, psychiatric, elder and child care as well education and learning. By this, requirements in robustness, effectiveness and reliability, but also knowledge about socio-cultural interdependencies become more important. On a level of lifestyle products, the everyday pervasion of wearable devices for activity recognition already develops fast. Quantified self is here a widely discussed topic which mainly focuses on activity tracking, for example personal fitness motivation or sleep behavior tracking. In these lifestyle and consumer applications, the demands on the performance, do not have to have high standards. This changes with serious applications and its requirements. Exchanges about these requirements can be done, based on a wider perspective and insights in the relation between user and the wearable devices, which the typology of wearable activity recognition can provide.

The typology structures this field and in this way strengthens wearable activity recognition as a partly interdependent and important topic. In the typology we are not following the logic of material technology, for example sensors and algorithms (such a survey is done by [14]), rather on the logic of the relation persons have to the technology in typical applications. Of course wearable activity recognition and interaction is about micro-electro-mechanical sensors (accelerometers, gyroscope, light sensor) and our examples are based on this technologies. What is interesting for our approach, are the consequences these sensors have for the relation between user and technology. This is beside others the closeness of this relation, as the devices have a long-term endurance and are small of size and thus allow for an unobtrusive device usage (everyday and anytime).

The typology that we present here is especially based on the distinction between the paradigm of a seamless or unobtrusive interaction and the activity-based self-tracking and self-reflection. The relations which are highlighted here have been partly discussed in different settings in ubiquitous, context-aware and pervasive computing. We will also relate to that. These paradigmatic relations will be extended by a discussion of the key term human activity, which is in its wider understanding quite underexposed in the research. Two classic HCI concepts, first situated action and second activity theory are used to refine the paradigm structure.

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This paper has three main sections: First, the paradigms of human-computer relation; second, the refining of this based on an understanding of human activity/action; and third, the benefits and consequences of these thoughts for the design practice. The third are the benefits of the typology as (1) a medium for exchange across disciplines and with non-technical practitioners, (2) as a medium for creating new ideas for technical design (practical consequences) and (3) as a medium for a normative discussion which all together can strengthen wearable activity recognition as a partly independent research field.

TWO PARADIGMS

We will discuss two human-computer relations as paradigmatic for the usage of wearable activity recognition systems.

In the first paradigm, the detection of human activity is an implicit part of the interaction between user and the wearable device. We can conclude this under the paradigm of seamless or unobtrusive interaction. Activity is part of the context, the system is aware of (activity-sensitive) and is adapting, to make the interaction unobtrusive for the user.

The second paradigm can be named as activity-based self-tracking and self-reflection. The detected activity is visualized for the user to be able to reflect on it. We can subsume here quantified self applications, self-monitoring, personal informatics, self-regulation as well as health behavior change or concepts of storing memories based on activity.

The paradigms do not include all possible usages of wearable activity recognition technologies. The criteria we orient our paradigms on is these of design principles. That means that the paradigms are based on desirable human-technology relations in ubiquitous and pervasive computing technologies. There are various publications which orient their design on one of the two paradigms, what we will also show in the next section. What is not the goal of this structure is to involve every possible application. For example surveillance applications are not included because we do not see it as a desirable principle (there are maybe exceptions in elder care applications, for instance fall detection or activity pattern detection).

The two paradigms have similarities to the distinction of an implicit and explicit interaction, Albrecht Schmidt had introduced [23], but they are not the same. It is indeed true that the first paradigm is very similar to the idea of an implicit interaction. The detected human behavior could be seen, following this concept, as an implicit input in the interaction process. Rather Schmidt's understanding of an explicit interaction is different to what we mean in the self-reflection paradigm. An explicit interaction would be, regarding the activity recognition technology, for example a wearable controller (e.g. based on an accelerometer) for playing video games. This is another type of activity recognition technology, we did not include in the paradigms structure because it does not count for us as paradigm following the criteria of an "interesting" design principle in ubiquitous computing research. What we mean with the self-reflection paradigm is that not the interaction is explicit rather it is the purpose to make everyday behavior explicit by tracking and visualizing it for the user. We will explain this more precise in the next section.

Seamless Interaction

Following this paradigm, the detection of activity is seen as implicit input in the interaction process. Figure 1 shows a systematic relation between the user and the technical device. Persons are in interaction with for example a mobile device (e.g., smart-phone or smart-watch). The activity recognition system provides a parallel relation or connection to the user, beside the "normal" interaction. When the user performs for example the activity "running" or "jogging", the wearable device can automatically adapt the font size on the display (example of Albrecht Schmidt [24]). This adaption to the specifics of what a person is doing can make the interaction more unobtrusive and intuitive. What makes it unobtrusive is that the effort of adapting is shifted from the user to the device. Not the user has to learn new aspects of usage in new situations or contexts (e.g., adapting font size manually), rather the system is doing this automatically. This paradigm is similar to the concept of activity-aware computing (introduced here [28]). The terms seamless and unobtrusive can be found in various publications. For example Kanz et al. provides a "seamless and unobtrusive interaction with everyday objects". Persons interact with a kitchen setting, outdoor activities and entertainment setting [11], or a medical staff activity recognition system to support a nurse-doctor collaboration [20].

This application field is strongly related to the research of context-aware computing. It is motivated by the idea of having computing systems which adapt to the specifics of a certain situation [24]. The most common definition of context is: "context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves" [1]. Information which can characterize a situation are, following this definition, seen as most relevant are location, identity, time and activity. Following this, activity is one aspect of context which makes the interaction unobtrusive, so to say an activity-sensitive interaction system.

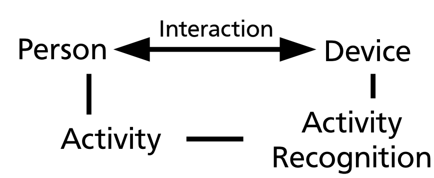


Figure 1: Wearable activity recognition as part of an activity-sensitive device for seamless and unobtrusive interaction.

Self-Tracking and Self-Reflection

In this paradigm wearable activity recognition is used for the purpose of providing persons with a new perspective on their own activities. In various publications, self-reflection or similar terms of self-monitoring, self-tracking or self-observation, have been used as a goal of activity recognition

[2] [10] [12] [7]. The idea is that computer-based interpretations of activity is retrospectively visualized for the user and encourages reflection. As we can see in the schematic Figure 2, we can explain this relation following the logic of a loop. Thus, persons have a mediated perspective on their actions, which results in an influence on their further actions and decisions to act. Central here are concepts of reasoning about own action (e.g. finding triggers for certain actions), getting aware of certain actions, memorizing actions, and events or changing and regulating the execution of action.

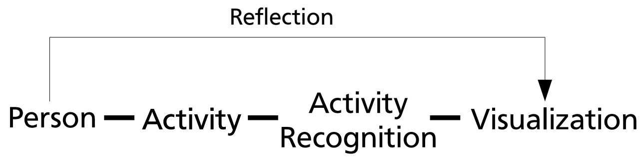


Figure 2: Wearable activity recognition for supporting self-reflection or activity related behavior regulation and memorizing.

Activity recognition for tracking and reflection is already common as a lifestyle product, like fitness wrist devices and apps for smart-phones and smart-watches. Step counting, jogging and specific gym exercises are for example detectable.

Under the umbrella term of quantified self or personal informatics, some mostly empirical research for structuring this application field is being done [15] [22] [6]. These works focus on activity recognition especially with wearable devices and ask through interviews and observation what and why people are interested in using quantifying self devices and techniques. Systematic concepts regarding the praxis of self-reflection and regulation are not focused upon.

The purpose of this paper is to structure wearable activity recognition following the paradigms described above and include an analysis of activity as a key term. This will be done in the next two chapters.

The Paradigms Regarding Two Cases

To illustrate the paradigms, we present two of our research projects in this field. Both projects are based on activity recognition with a wrist-worn accelerometer. The first is a project for smoking detection and visualization of smoking behavior and related information [25]. The second focuses on procedure detection in a microbiology laboratory [26].

Latter involves an interaction with a head-mounted device in a biological laboratory setting while a wrist-worn device, which can be seen on the left side of Table 1, is used to detected working steps, e.g. pipetting, stirring or mixing fluids. The knowledge about the activity helps to support the interaction with the head-mounted device while executing the experiments. Together it is the activity-sensitive interaction system. The focus of this technology could also be set differently. When the documentation and the reflection of working steps are the key aspects of usage (without the head-mounted device), it would belong to the self-reflection paradigm.

In the smoking detection project, the users had the possibility to monitor their smoking behavior during two weeks. The smoking behavior was visualized to the user in combination with information with overall time spent and approximately money spent for the cigarettes. This should motivate users to reflect on their smoking behavior.

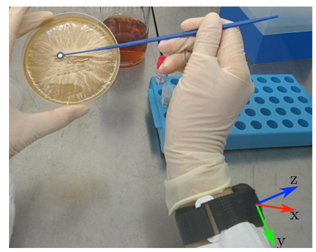
Bio-laboratory Seamless Interaction Support	**Smoking Behavior Reflection**
	
A laboratory assistant system for a seamless interaction with a head-mounted device. The activity recognition data is used to support the interaction.	The smoking behavior is detected by a wrist-worn motion sensor for smoking behavior monitoring and reflection

Table 1: The paradigms regarding two cases.

UNDERSTANDING HUMAN ACTIVITY

Activity as the key term of this technology is mostly underexposed on a conceptual level. Human activity as a conceptual topic is nothing new for the HCI and ubiquitous computing communities: Most famous are the early works of Lucy Suchman [27] about planned and situated actions and concepts of activity theory by Nardi [18] and Kuutti [13]. The purpose of this chapter is to adapt these concepts to the wearable activity recognition paradigms and to include a critical reflection.

Situated Actions

In Lucy Suchman's monograph plans and situated actions, she is arguing against a model of action in computer science, a model which is exclusively focusing on planned actions [27]. Rather, she is arguing that human actions mostly emerge "spontaneously" in strong relation to the situation. She calls these actions situated actions which, according to her, constitutes everyday behavior. This concept, originally based on sociology and anthropology theory, was very influential in HCI and Ubiquitous Computing over the past years [21].

The "user model" of planned action, which she is criticizing, is a concept of cognitive science and brought in to computer science by Donald Norman [19]. It was used to model the user to predict his behavior in interaction with the computer system. Following that, acting starts with an explicit plan of how to act (intention), which causes the actual execution. This is followed by steps of evaluation of the execution and the adjustment of further actions.

Suchman rather focuses on situated actions, which means action as a moment-by-moment adaptation to the circumstances. ”The term [situated action] underscores the view that every course of action depends in an essential way upon its material and social circumstances” [27]. There are often general goals and decision how to start but no detailed plans for reaching it. Her famous example describes a canoeist who is steering down a series of rapids above a fall. He has the concrete purpose to come down the fall without turning over, and he maybe also decides on a starting position (where to enter the fall). But while going down, the canoeist is spontaneously adapting to currents and rocks along the way. This is a very specialized example but it also takes effect in situations of everyday life. This means that people are not planning every action in an explicit sense, but rather reacting with versed sub-movements and routines. As an example, when confronted with a new device, persons are normally not planning every step in advance, but rather work in a modus of trial and error. This is highly situational and often leads, and this is Suchman’s observation, to unintended and unexpected usage. This is the twist on modeling action in interaction especially for everyday technologies.

The research on situated action had a two-fold influence on research: First, it motivated the designer to use less formal models of human action, meaning for example that users cannot always be predicted as acting rational. Second, it lead to new methods on how to do usability studies in HCI research. This is related to the ethnological method in sociology, in which the investigation of everyday social settings should not be over-interpreted by researchers with concepts, theories, personal norms and experiences. It is rather important to have an observation method with less semantic preassumptions. This had lead to new perspectives and concepts for user modeling.

Examples include newer developments which can be found under the term of ”wild studies” arguing for this. This approach criticizes the so-called laboratory settings for interaction design and on the contrary suggests a design practice in the wild, that means in the everyday circumstances of usage: ”New technologies were being designed, prototyped and implemented in situ” [21]. Into the wild leads to less artificial settings of everyday behavior and so opens the space for unexpected things happening.

The last aspect is especially interesting for learning based activity recognition. The question is here how to make the training of the activity learning algorithms the most authentic, and the evaluation of the algorithms most realistic. Especially the observation of the ground truth data can influence the way people behave and thus makes the training data less realistic. An example for this is the project about the detection of smoking behavior, as introduced earlier [25]: A laboratory setting would have involved participants to visit the researcher’s office, get the sensor and are asked to show the movements they normally do while smoking. But what was done in the project was to build a special lighter, which logs every usage. Having this, the ground truth is likely to suffer (compared to when someone would be standing next to the user making notes) but the experiment can be taken in everyday circumstances and thus provides much more realistic data.

Activity Theory

Activity theory has been common in HCI and ubiquitous computing research for a long time. Kuutti [13] and Nardi [18] have developed a highly cited framework based on activity theory. The central concept of activity theory is a hierarchical model of activity and action. This model is already used in activity recognition research, but activity theory provides a richer understanding on human action, not only the hierarchical model that we will focus on. First we summarize the hierarchical model.

The hierarchical model contains three levels. This differentiation is based on the consciousness that persons have about their behavior. The bottom level encompasses less conscious behaviour, operations, which are mostly routines or sub-automatic gestures. For example, when opening a window by turning the lever, persons are not explicitly conscious about how they move their hand, they normally just know how to do this. An ”action”, which is the name of the second level, consists normally of a chain of operations. Regarding our example ”opening the window” is the action which can include ”going there”, ”turning the lever” and ”pulling it until the window is open”. But it can even make sense to summarize actions under a higher semantic level called ”activity”, the third level. This identifies a set of actions under a higher purpose or goal which motivates the particular actions. Following our example, the motivation can be ”airing the room”, which could include besides opening the window also opening the front door to have a draught. With respect to the HCI design, this concept was for example used for structuring technology mediated cooperative work in e.g. programming projects, when different people work together on a higher purpose (activity) by doing their specialized actions [13].

In wearable activity recognition, this hierarchical model was used as a basis for a hidden markov model by for example by [5] [29]. The core idea is that certain low-level activities (operations) belong to a high-level activity (action or activity) and for that probabilities can be stated. These ontologies were helpful to structure certain application fields but were not using, in our view, the central strengths of this theory. Which is that ”activity theory does not consider activities as given or static entities, but dynamic ones: activities are always changing and developing ” [13]. That means the classification of certain human behavior in the hierarchical structure is nothing static or fixed. What is an operation, an action, or an activity can change. For example, operations can fail and thus become more conscious, which means that it receives the characteristics of an action. Regarding our example of opening a window, when the window-mechanisms are different in another country, the steps for opening it might no longer work. Then this ”becomes” an action, because the focus is changing and the behavior is getting more conscious for the person. The dynamic character thus means that describing actions depends on the point of view and the interest people have in the interpretation.

Mutual Reflection and Relation to the Paradigms

We will discuss both concepts in a mutual reflection as well as relate them to the paradigms. Our method for the typology of wearable activity recognition is to structure possible human-computer relations and discuss action, as a central term, regarding these types of relation. We argue that activity recognition research can profit from further thoughts on this. We will conclude both frameworks with respect to the technology of activity recognition. The two paradigms should be the base for further thinking about key terms and concepts. Key terms here are action and reflection; In Table 2 we have concluded some concepts and ideas of how activity can be seen and modelled regarding the two paradigms.

The distinctions in both theories can be seen as the following: First, the difference between situated and planned actions, and second, the difference between operation and actions/activities. Everyday behavior is characterized by iteration, named as habits or routines. These habits are determined by more or less explicit goals and mostly unconscious subactions, which can also be seen as operations or situated actions. For example smoking, as an everyday habit, is in certain situations not caused by a concrete purpose, for instance ”now I want to smoke because I feel the need to relax and smoking helps me to do this” as well as an explicit plan for the performance: Lighting the cigarette, moving the cigarette to the mouth and so on. Rather it is mostly embedded in everyday situations for example the habit of smoking when waiting for the tram in the morning.

With respect to the sphere of the paradigms, we can refer to this distinction differently. The purpose of the self-tracking and self-reflection applications is to track everyday habits and routines. The goal is to make them present to the user and bring them in relation to information about the situation. By doing this, the awareness regarding certain behaviors increases, and the routines are getting more conscious next time, which gives them a status of an action/activity. Thus we can talk about a transition which could be called ”making explicit” which means making the underlying plans and relations to situations present and the behaviors become manageable. For example, the user wants to know what triggers certain activity (e.g. smoking) or what are corresponding factors of the behavior which could help to be more aware of this behavior next time. In the smoking detection project, additional information about time of the day, how much time spent for smoking, as well the approximately money spent for cigarettes are visualized.

The purpose of seamless interaction design has the opposite direction. The idea is to embed the usage (interaction) in the procedures of everyday habits and routines. The design is successful when the interaction with the technology is part of the everyday routines, based on less conscious operations. Being less conscious about the interaction and not requiring continues reflection makes the interaction unobtrusive. For example the goal of the activity-sensitive head mounted display is to become part of the everyday laboratory practice.

BENEFITS AND CONSEQUENCES OF THE TYPOLOGY

In this last section, we will discuss the benefits and consequences of our typology. The typology provides a profound discussion in how people relate to the technology of wearable activity recognition. This is realized by orienting on a paradigmatic distinction, but also by discussing human action as a key term.

We collect the benefits under the terminology of a medium. The following three benefits are chosen based on the general idea of how theory can influence practice. Theories or conceptual frameworks can make general claims, for our typology about the relation between persons and technology. The benefit is that not everything have to be thought out once again for every applications and technical realization. Even more it is possible to transfer ideas or solutions for certain challenges between different areas. That means certain technical systems and applications have their specific challenges but also more general questions which can be discussed on a conceptual level. For example, ethical aspects concern all forms of a certain type of human-technology relation.

We suggest the following three benefits, but this is should not be seen as mandatory, so there is the possibility to extended the list:

1. The typology as a medium for exchange between disciplines, and with non-technical experts, especially in common research in more complex systems and in more serious applications.

2. The typology as medium for creating new ideas in the design of wearable activity recognition systems.

3. The typology as a medium for a normative discussion, especially with respect to privacy and control.

The typology can be a base to strengthen activity recognition and interaction with wearable sensors as a partly independent research field, including its own challenges and solutions.

Medium for Exchange

In the science and technology studies (STS) exists a method called ”vision assessment” [8] [16]. It is an analysis of technological innovations by investigating how strong certain visions in research fields are. Do the persons understand the same thing under central and key terms and how does this influence their actual research and design? Regarding this, it highlights the benefits a strong shared understanding can have. Having a mutual base on the types of human-technology relation on a conceptual level inside the technical research can help to discuss challenges of different kind. For example, the concepts of action can exchange inside the research.

For more complex and ”serious” projects, for example expertise from doctors, psychologists or sociologists, is required. Thereby a conceptual understanding, like it is grounded in the typology, can be helpful. Mutual informing about strategies and methods as well the discussion of concerns can be done based on the concepts of the typology. For instance, psychologists have their definitions (concepts) of action and

Paradigms	Key Function	Interaction	Reflection
Seamless Interaction	Intention oriented: Supports users in reaching their goals/intentions.	An implicit interaction which works parallel to the explicit interaction is provided, what makes an intuitive and unobtrusive usage possible.	The ideal is a not reflective behavior while interaction to make the interaction as unobtrusive as possible.
Self-tracking, Self-reflection	Reason oriented: Supports the reflection on actions with the further purpose of changing.	Interaction is based on the reflection and the influences on intention and performance of future actions.	Retrospective reflection (evaluation) of the own behavior is a key element.

Table 2: Different levels of structuring and districting the two paradigms on the human-technology relation in wearable activity recognition systems.

reflection. It can help to have an shared understanding inside the disciplinary research to compare it with these of other disciplines. The typology is, following this, useful for getting insights in the interdependencies of users and computing systems including the individual and social aspects, ethical concerns as well as trust and usability aspects.

There are different approaches focusing on the exchange character for both practical reasons and critical concerns. One is called critical design, in which Bardzell et al. argue for an ”intellectual infrastructure” so that methods, concepts and theories can be developed based on a mutual understanding and an ongoing discussion [3].

Medium for Creating New Ideas

To show the possibility of creating new ideas, we list a set of concepts and ideas which focus on the self-tracking and self-reflection paradigm. With creating new ideas, we mean new ideas for implementation and concepts for design which are based on the typology.

We have shown two concepts in which human activity is seen as not a static entity, meaning that the execution, the intention, but also description and evaluation of actions can change. There is a difference between an activity recognition of natural phenomena (e.g., volcano activity or animal activity) and human behavior. Humans adapt their behavior by interpreting their activity provided through the technology or in interaction with a seamless interaction device.

Based on that, we suggest an interactive and cooperative concept for wearable activity recognition devices for self-reflection. The idea is that users and the detection system work together in interpreting the activities of a person. Most existing systems are just providing the results of the detection by showing: you have done a certain activity from this to that point in time. Moreover, the naming or labelling of the activities is determined beforehand by the designer, i.e. before runtime. The interpreting or the labelling of an activity can be of different semantic quality, as we have shown in both theoretical concepts. Referring to our examples, the activity of a fast movement of the legs over time can be named as just that ”fast movement of the legs” or alternatively as ”running” or as ”jogging”. The latter has the most semantic quality, because jogging includes also the assumption of the reason for the activity running, which is doing sports. An absolutely different intention for running could be ”catching a train”, when it is detected in a train-station.

The idea for a cooperation refers to giving the possibility to reflect not only on the results, but also on the emergence, including its labelling. The detection system, depending on the chosen algorithms, consists of different steps which could be mirrored for the user. These levels also include basic information with less semantic quality which could be used by the persons. Intervening in the labelling based on the knowledge of the function of the system could be an additional possibility to make it even more interactive.

We will illustrate this idea by briefly introducing a project in progress: A study on visualization techniques for reflection on activity data provided by an accelerometer wrist-worn detection system. The recognition system we use is based on a dense motif discovery (for a detailed explanation see [4]). The raw accelerometer data is searched for characteristic sub-movements (gesture-patterns or motifs) of a certain activity. When the density of these motifs is significantly high, the system is predicting that the activity has taken place in this period. Our idea is it to make these inter-steps of the recognition system visible for the user. An example for a visualization of these levels of the system is Figure 3, which shows from top to bottom, raw data, motifs and prediction.

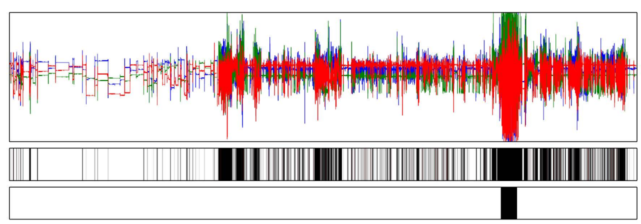


Figure 3: The three visualization levels: raw data in a 24 h period (top), identified characteristic patterns for badminton (middle), prediction of the system (bottom).

Using this extended visualization, we assume (1) that the interpretive skills of the users can be utilized to find the right interpretation, (2) leading to a better reflection, and (3) that the motivation of using such system can increase.

The latter refers to articulated problems of quantified self technologies in long-term usage. We argue that achievements and scores only have a short-term motivation. When the user has found out that moving his arm while sitting increases his device's step count, he might not be motivated by the score anymore. What he is really interested in, is to increase his fitness and that is when he is seriously animated and challenged to reflect his behavior, however.

Therefore, what we liked to stress here, is that mediated self-reflection is an interactive design challenge rather than a pure detection challenge. For this, the emergence of the detection prediction is useful information. Considerations should include if and how this information could be visualized for the user.

Medium for a Normative Discussion

Control and Privacy are two of the main normative concerns regarding wearable activity recognition technologies. Starting with the first, control can be understood as control your data and the perspective you have on the world and on yourself. It is a topic of transparency and of reflectiveness on system insights. It also concerns aspects of trust, including trust in the results, and the support the technology is providing. For both paradigms, the issue of control, meaning which information about the system (how it works, which information it is receiving about the user) should be made transparent, can be answered differently.

In applications for seamless and obtrusive interaction, too much information about the internal functions can disturb the interaction procedure. What is suggested for this, is to provide an additional channel in which the user can have insights when needed. This can also prevent misunderstandings about goals and the need for support. Here a concept of parallel communication is suggested [9]. In the applications for mediated self-reflection the opposite can be said: Providing insights on the mechanisms of the system can help to reflect on the behavior even more. We have suggested several ideas on this in the previous section.

Regarding the privacy aspect, the raw data and its potential for further interpretations tends to not be much considered. The sensed raw data are cryptic and that is why they are normally not shown to the users. Normally the data is used for a certain application for example fitness. But the raw data has also its potentials for other activity-interpretations. Design-projects which focus on how to strengthen privacy purposes should also include the potential aspect of the raw data. This could include, beside security issues, also increasing the awareness of the user for the potentials of the raw data.

CONCLUSION

In this paper, we have presented a typology of sensor-based (wearable) activity recognition regarding the relation persons have to the computing device. This typology goes above the technological considerations, it rather is based on an understanding of human action. Its benefits for computing design lie in its medial role for exchange inside the discipline and most of all with other disciplines. New ideas how to design the interactive relation, which might be more than a high detection rate, is a second benefit. Finally, normative concerns, which will be discussed even more in the future, can be focused on more precisely. A firm conceptual background can thus strengthen wearable activity recognition as a partly independent discipline.

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