Thilo Paul-Stueve (Hrsg.): Mensch & Computer 2007 Workshopband. Weimar: Verlag der Bauhaus-Universität Weimar. 2007, S. 141

Innovative Experiments enable Wearable Applications' success

Ernesto Morales Kluge

BIBA, Bremen Institute of Industrial Technology and Applied Work Science at the University of Bremen

Abstract

Interaction and usability aspects of software systems are critical software quality measures. This paper highlights the necessity of research and development on specific user-centered and work process oriented topics in the innovative field of wearable computing. The different phases of the development process as well as experiments performed to implement the actual applications will be presented. This is done in order to implement an application to support aircraft maintenance tasks with wearable computers.

1 Introduction and Background

To support aircraft maintainers during their daily mobile work, wearable computing is deemed to be a promising technology[1]. Wearable computers can be unobtrusively worn on body to support a user during work. Unlike to stationary computing where users mainly concentrate on one task to be performed with the computer, wearable computing typically expects users to accomplish two different tasks. A primary task involves real world physical actions, while the secondary task is often dedicated to interaction with a wearable computer. These unique characteristics, however, call for new interaction concepts and user interfaces. The wearIT@work project[2] was arranged to investigate these issues with a user-centered approach. It is supposed to empower mobile workers with real wearable computing applications. Here, questions particularly arose with regards to the impact the real end users involved in the application development process will have on experiments conducted to investigate how wearable interfaces and applications have to be designed to meet end user re-

---

[1] Nicolai, T., Sindt, T., Kenn, H., Reimerders, J., Witt, H.: Wearable computing for aircraft maintenance: Simplifying the user interface. In: Proceedings of the 3rd International Forum on Applied Wearable Computing (IFAWC), Bremen, Germany (2006)

[2] WearIT@work: The wearit@work project: Empowering the mobile worker with wearable computing. IST Project (No. IP 004216-2004) (2004)

quirements. Meeting these requirements will have strong impacts whether wearable computing will enter industrial branches or not.

The main driver for our experiments were the missing information about how aircraft maintainers feel and behave when using specific wearable user interfaces that are usually controlled by novel interaction devices beyond those known from desktop systems. To examine these questions we started with interviews and workplace studies at an aircraft maintenance service facility to identify maintenance procedures suitable for a realistic experiment to evaluate different wearable input devices. Due to the involvement of domain experts in the experiment a set of real maintenance procedures was needed to motivate maintainers for participation. The main requirement of domain experts expressed during interviews regarding a wearable computer use was that is has to support and ease maintenance tasks and should be easy to operate.

The focus of this paper is to state that the simple provision of technology e.g. software-frameworks for Wearables, or any other hi-tech equipment may be enough for commercial leisure markets and their applications for mobile devices (e.g. cellular phones and their services). This does not hold for industrial branches and wearable systems. End-users differ from leisure markets, professionals, particularly mobile workers like aircraft maintainers, do judge systems from the efficiency and the added value of the system. As a consequence very specific research has to be performed; experiments with real end-users have to be conducted.

2 How to develop a wearable application

An approach will be presented which was proposed by (Morales Kluge & Witt 2007)[3] which makes use of a toolkit to develop a wearable application[4]. This approach considers the importance of the end-user in the research and development phase of a wearable application by involving him strongly in the requirements and evaluation phase. The author's insights coming out of the interviews with real end-users working in industrial environments suggest that acceptance of a wearable system (application) is mainly driven by the ability to solve end-user's problems in their daily work. This requires knowledge about the targeted field and very specific experiments that address end-users' problems. Two specific examples of experiments will be presented that are located thematically in the field of aircraft maintenance that are basically located at step 3 of the following approach.

[3] Morales Kluge, E., Witt, H.: Developing Applications for Wearable Computers: A Process driven Example. 4th International Forum on Applied Wearable Computing (IFAWC), Tel Aviv, Israel, March 12-13, 2007.

[4] Witt, H., Nicolai, T., Kenn, H.: Designing a wearable user interface for hands-free interaction in maintenance applications. In: PerCom'06: Proceedings of the 4th annual IEEE International Conference on Pervasive Computing and Communications, Pisa, Italy, IEEE Computer Society (2006)

2.1 The Approach

Through several workplace studies at the operators working environment the requirements for the envisioned application have to be elicited. The development process followed this approach:

1. Workplace study and User Requirements: This phase contains the elicitation of the users' needs and the understanding of the working environment and the existing problems in general and the ones addressing the wearable system.
2. Mock-Up: The Mock-Up is the first specific prototype that addresses the identified problems in form of an experiment set-up that allows creating quantitative and qualitative results.
3. Usability tests and interviews: Here, the mock-up from phase 2 is used to perform the experiments with the needed number of subjects (real end-users should be preferred).
4. User feedback and requirements: Measured metrics (e.g. performance measurements) and interview results (questionnaires) are the outcome of this phase.
5. Test and evaluation of the application: This is the last phase in one development iteration where the results of phase 5 are integrated into a demo application that has to be tested under real conditions.

2.2 Example 1: Usability Tests of Input-Methods

To examine usability questions for aircraft maintenance, interviews and workplace studies at an aircraft maintenance service facility were carried out to identify maintenance procedure steps suitable for an experiment that tests different input devices for wearable user interaction. The involvement of domain experts required a set of real procedures to motivate maintainers for participation in the experiment. The main requirement of operators was the support of complex maintenance tasks by wearable systems. A maintenance task dealing with a circuit breaker panel in an Airbus A300 was chosen for an experiment. The tests were performed in a real aircraft with 10 domain experts and at lab conditions with laymen (20 subjects) at the University of Bremen. The setup involved three different user groups and three different wearable input devices (pointing device, data glove, and speech-interaction). As a base case the traditional mouse (pointing device) input device was chosen; giving subjects confidence with a familiar device and to avoid fear. More innovative input devices are represented by a data glove (gesture interaction) and speech interaction. Users will then be given oral instructions to navigate through a multi-layered menu structure presented on a Head Mounted Display (HMD). By observing the user's performance in the navigation task and the accuracy of the navigation, i.e. the deviation from the optimal path, conclusions can be drawn on (1) what type of wearable input device is the most efficient (in terms of task performance) and appropriate for a particular user group and on (2) the differences between the type of subjects: Domain Expert vs. Layman.

2.3 Example 2: Calibration Experiment

Again this experiment starts with the first step of the proposed design approach which is the workplace study and the interview phase. It became clear that calibration of components/systems of aircrafts is very time consuming and could be done much faster with an appropriate wearable system. The challenge in this scenario is to find a suitable feedback method that does not interrupt the primary task of calibrating an aircraft system. The primary task of the experiment represents general calibration tasks. As an abstraction of those tasks, in a controlled laboratory environment, the adjustment of a four-leg table is used. To adjust the table to a predefined alignment on two axes, height adjustment screws mounted underneath each table leg are used. A single test session consists of one practice round where the subject gets to understand each feedback method (2 graphical, 1 textual), followed by one experimental round during which data is collected for analysis. In the end of the experiment subjects will be provided with questionnaires to record qualitative data used for later evaluation, e.g. to gain user acceptance measures. Additionally, ethnographic data and data based on a questionnaire from the social science consultant will be collected. The apparatus used in the experiment consists of a wearable computer (OQO), an HMD, and a special textile vest designed and tailored to unobtrusively carry all equipment as well as all needed cablings for the HMD without effecting the wearers freedom in movement. The hands of the user are free. The feedback provided to support calibration tasks is presented on a HMD. To measure the alignment of the calibration task abstraction object (table) an XSense MT9 motion sensor is used to acquire needed pitch and roll values. For the purpose of subject post-hoc motion analysis and to determine problem-solving strategies dependent on the feedback methods presented, a button is mounted to each leg of the table. Subjects have to press first the button mounted on the leg of the table to indicate their proceeding adjustment of the height adjustment screw of that particular leg. Button pressed events are logged in the central log file of each user.

3 Conclusion

This positionpaper wants to point out the necessity of specific experiments for exploring new concepts for HCI means in Wearable Computers particularly in industrial environments where users differ from what is known from (leisure) mobile device users. Real existing problems of work processes should be the basis of further research in order to create acceptance and in order to enter industrial branches.

Besides creating (technical) frameworks (services) and the basic infrastructure for wearable systems it is getting more and more important to focus on very specific demands of the industrial environments that come out of the work process and the End-User. Due to the nature of wearable computing, being seamlessly integrated in the personal environment of the user, wearables should also be integrated seamlessly in the work process which requires research on how to achieve this.