Designing Systems of Ubiquitous Sports Equipment

Matthias Kranz, Paul Holleis, Wolfgang Spiessl, Albrecht Schmidt
Research Group Embedded Interaction, University of Munich
Amalienstrasse 17
80333 Munich, Germany
{matthias, paul, wolfgang, albrecht}@hcilab.org

ABSTRACT

In this video, we report a user-centered, iterative design process for augmenting sports equipment with ubiquitous computing technology. The prime focus of the project is on user needs in this domain. In a multi-disciplinary effort we first investigated what short-comings current practices have and how novel technologies can help to improve the experience and value for users and instructors alike. In several design iterations, all deployed and used in a sports school, a fully working system for training and physiotherapy, comprising hard- and software components of ubiquitous computing technology has been developed. The system is deployed, in use and evaluated with a large user study. Currently sport scientists are evaluating its potentials and its benefits for training and rehabilitation in three further studies.

This paper accompanies a research video at UbiComp 2006 which demonstrates the various aspects of the system.

1. INTRODUCTION

Sports, personal fitness and healthcare are interesting domains for ubiquitous computing research. Over recent years interesting and useful systems have been deployed showing the benefit that can be achieved from using ubiquitous computing technologies in these fields [3, 6]. Especially small-scale embedded devices equipped with sensor input enabled a great number of new devices and applications. Simple and stand-alone sensor enhanced sports devices are already common in some areas; two prominent examples of mass sport products are ergometers and pulse and heart rate analyzers. In competitive sports and professional sports training facilities very complex technical systems are deployed, however these systems are very complex to operate and use and hence not suitable for wider deployment.

In this paper, we report on a successfully deployed novel system in the field of sports and healthcare called Therapy Top. The contribution of this work is on the design and evaluation process as well as on technological aspects.

2. THE THERAPY TOP

The Therapy Top is a spinning top nowadays used in sports studios and physiotherapy as well as in the home sector (see Fig. 2). It is used for a wide range of applications, starting from enhancing the equilibrium sense, improving muscle balance in the legs and ankles and maneuverability in the lower body parts.

With every new exercise, people have a hard time judging the correctness of their exercises. Of course, they are shown how to do it once or twice or can even watch a video supplied with the devices, e.g. when bought at a home shopping TV station, but usually left to themselves afterwards. In professional studios or sports schools, trainers are available, but there is a certain psychological barrier to inquire for assistance. On the project page at [8], there are short example videos of selected exercises available illustrating the difficulty of the exercises.

A system that is easy to understand, operable by the trainee or patient himself, that gives instant feedback on the respective exercise can greatly improve the learning and execution quality of the exercises. Sensors capture the respective input dimension and this data can then be used in a visualizing application. An additional aspect for physiotherapists is the availability of sensor data to monitor the patients success and convalescence. Also, limits like, e.g., the maximum tilt angle of the ankle can be monitored and insured by appropriate feedback in the application.

3. SYSTEM AND USER INTERFACE

The platform used for acquiring sensor data and transmitting them into the local subnet is the Particle Computer platform, discussed in [4, 5]. As sensor, a three-axis acceleration sensor (lis3l0sas4) is used. The Particle is powered by two mono batteries providing a runtime of about a month.

The data is collected by the sensors and streamed via radio frequency and made available to the local subnet in the form of UDP packets. The application software is implemented using Macromedia Flash. As Flash cannot directly handle UDP sockets, an intermediate Java application translates the UDP packages into TCP packets for the Flash application. The current setup runs on Linux and Windows, as Flash and Java are available on both systems.

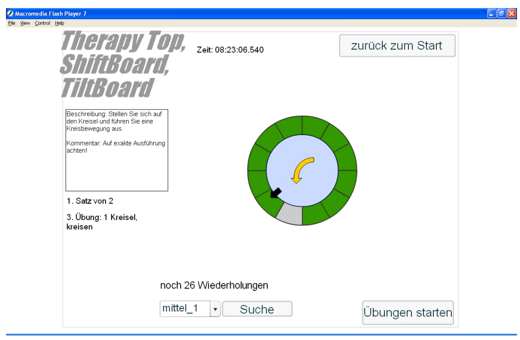
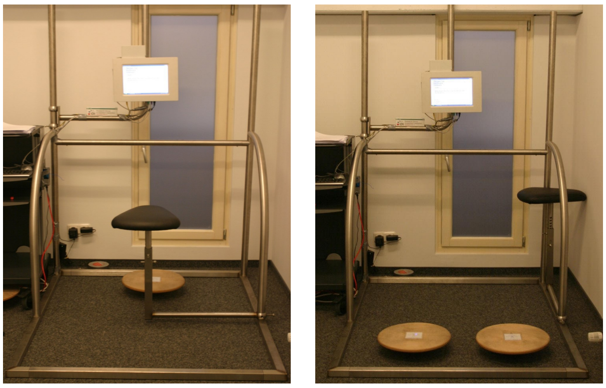


Figure 1: Final visualizations for circling exercises.

The Flash application (see Fig. 1) comes along with a graphical and simple-to-use editor allowing the physiotherapist or trainer to specify new exercises along with restrictions, e.g., that two Therapy Tops must be used and they are to rotate contrariwise.



(a) System setup for rehabilitation (b) System setup for normal training

Figure 2: (a) The chair can be swung in for patients recovering from an operation and who cannot stand on a therapy top. (b) All other users can exercise with one or two therapy tops within the steel frame. The round bars at the side provide safety in case of a stumbling or falling.

The exercises are stored as XML, as is the raw sensor data from the device. This enables the trainer or physiotherapist to later review the training sessions and discover potential problems, e.g., that the patient cannot reach a certain angle with his ankle. The developed system for rehabilitation and normal training is depicted in Fig. 2.

4. ADVANTAGES

The system allows the Therapy Top user to keep his head straight towards the user interface which provides him with sufficient feedback on his training quality. This also fosters a straight posture on the Therapy Top itself. The user no longer has to look down on his feet to judge his motions.

A mirror vis-a-vis of the user could be used for maintaining a meaningful posture on the Therapy Top. But mirrors in sports schools and fitness centers are rather occupied by people doing muscle build-up. Also, there is not an unlimited amount of wall space available.

Most important, the mirror cannot give enough feedback. Especially for rehabilitation, but also for normal training, the adherence to the tilt angles and speed defined by the trainer or physiotherapist cannot sufficiently determined by the user. Therefore a supportive sensor system is needed.

Audio feedback is inappropriate: as there are many people training in parallel, there already exists a certain background noise level which prevents audio to be understood when played at a reasonable level. Also, an additional audio noise is considered disturbing for other people doing their exercises. Also, another user doing his Therapy Top exercises next to the first user whould be distraced as well.

Also, by storing the raw sensor data, the system can be used by the trainer offline to judge training quality and suggest improvements in a much quicker time compared to a disturbing personal supervision of the user's training.

The system also prevents users from over-fulfilling their training plan (e.g. 'I can do that, I am aldready feeling much better') which can have negative impact, especially during rehabilitation where patience is needed.

5. RELATED WORK

Sensor support for competitive athletes is nowadays very common, for example in football or in skiing [9] or Taekwondo [2] and used for independent judgment of the athlete's performance. The technology used has to be accepted by all participants and should work in the background. Issues related social acceptance factors are important and have to be taken into account as early as possible in the design process, otherwise the system will always be problematic, as discussed for several deployed systems in [9]. However, it needs to be mentioned that in training for professional sports the acceptance for technology (even if not very usable) is high when it offers an competitive advantage. The benefits of a personal fitness and health monitoring device, the Personal Wellness Coach, has been discussed in [1]. The positive effects of electronically augmented sports equipment have been shown in the Thera-Network in [7].

6. ACKNOWLEDGMENTS

The work has been conducted in the context of the research project Embedded Interaction and was funded by the DFG ('Deutsche Forschungsgemeinschaft').

7. REFERENCES

[1] R. Asselin, G. Ortiz, J. Pui, A. Smailagic, and C. Kissling. Implementation and Evaluation of the Personal Wellness Coach. In *IWSAWC*, pages 429–535. IEEE Computer Society, June 2005.

[2] E. H. Chi. Introducing wearable force sensors in martial arts. *Pervasive Computing Magazine*, 04(3):47–53, July-September 2005.

[3] E. H. Chi, G. Borriello, G. Hunt, and N. Davies. Sports technologies. *IEEE Pervasive Computing, Special Issue On Mobile And Ubiquitous Systems*, 2005.

[4] C. Decker, A. Krohn, M. Beigl, and T. Zimmer. The particle computer system. In *IPSN Track on Sensor Platform, Tools and Design Methods for Networked Embedded Systems (SPOTS), Proceedings of the ACM/IEEE Fourth International Conference on Information Processing in Sensor Networks*, April 2005.

[5] H.-W. Gellersen, G. Kortuem, M. Beigl, and A. Schmidt. Physical Prototyping with Smart-Its. *IEEE Pervasive Computing Magazine*, 3(3):74–82, July–September 2004.

[6] J. A. Kientz, S. Boring, G. D. Abowd, and G. R. Hayes. Abaris: Evaluating automated capture applied to structured autism interventions. In *Ubicomp*, pages 323–339, 2005.

[7] J. C. Kimel. Thera-network: A wearable computing network to motivate exercise in patients undergoing physical therapy. In *ICDCS Workshops*, pages 491–495, 2005.

[8] M. Kranz. Research Group Embedded Interaction - Project Page UbiFitness. `http://www.hcilab.org/projects/ubifitness/`, visited January 2006, January 2006.

[9] F. Michahelles and B. Schiele. Sensing and Monitoring Professional Skiing Athletes: Lessons Learned from a Collaboration with Ski Trainer's. *Pervasive Computing Magazine*, 03, July-September 2005.