Tutorial on Wearable Computing in Sports

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Abstract
Wearable sports technology such as fitness trackers, smart watches or heart rate sensors has become ubiquitous in our everyday lives. This technology enables even recreational athletes to keep track of their workouts in a comprehensive manner. Besides the general assumption that this technology improves motivation to exercise more often, it also enables the athlete to get a better understanding of her current fitness level. However, current technology is mainly focussed on (quantifiable) performance indicators such as mileage, pace, cadence, watts, heart rate, etc.

In this tutorial we aim to introduce wearable sports technologies that provide real-time support to athletes while exercising. Topics of interest range from engineering problems to research methods as they apply in the context of mobile and ubiquitous sports technologies.

Author Keywords
Wearable Devices; Wearables; Sports Tracking; Real-time Feedback; Motor Skills; Motor Learning; In-situ Feedback; Real-time Assistance

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Tutorial Topic and Relevance to the Community

Nowadays, sports and activity trackers are ubiquitous and widely used by professional and non-professional athletes to record and analyze their workouts. In Mobile HCI and UbiComp, wearable technology has been explored in the context of sports. Ahtinen et al. [1] studied outdoor sports tracking in general. A large body of research investigates running (see Jensen and Muller [5] for an overview). Climbing has recently been an active exploration field for tracking [7, 9] and interaction [6, 8].

However, the currently used measurements are mostly quantitative, i.e. assistance and feedback is only provided on performance (for example distance, elevation, or pace) but not on technique (e.g. running technique [5]). For recreational athletes, it is often difficult to interpret such numbers while displayed on a small screen (e.g. bike computer, running watch). Numerous factors influence adequate information representation and are not taken into account by current sports technologies [12].

An effective analysis of the technique can only be provided by professionals or expert coaches using slow motion video analysis. Since most athletes have no clue about biomechanics and no access to a professional coach, this might lead to adaptation of wrong techniques and for example in running, a wrong technique might cause a high incidence of repetitive stress injuries, including stress fractures and knee problems [10, 13]. Only few approaches exists that aim to assist the athlete to improve their running technique in real-time (e.g. [3, 2, 11, 14]). Just recently, we propose the FootStriker [4], a wearable running assistant for motor learning of the correct running stride using EMS.

To overcome these problems, it is necessary to go beyond feedback that addresses just the quantitative aspects of the exercise and focus on meaningful feedback that gives insights into the qualitative aspects of the exercise. Designing such interactive assistance systems bares a lot of challenges. The system has to sense the user's movements, interpret them, and provide feedback in such a way that the athlete is able to easily adapt to the changes the system suggests. To achieve this, a deliberate choice of both sensors and actuators has to be made. Furthermore, all of the components have to be assembled into a small form factor robust enough to be wearable during a sporting exercise. Finally, the system has to be evaluated in appropriate user studies to proof the effectiveness of its application.

The purpose of this tutorial is to introduce participants to wearable computing in sports and the special challenges that arise in the design of wearable sports technologies. Topics of interest range from engineering problems to research methods as they apply in the context of ubiquitous sports technologies.

Tutorial

Requested length and physical requirements
The tutorial will be a two hour session. A seminar room equipped with projector and movable tables and chairs is needed. No other special needs are required.

The intended audience(s)
The target community is practitioners and academics who are interested in the intersection of mobile computing and sports.

We expect attendees to have an interest in sports and we expect a great deal of variation in attendees' experience level with both research in mobile HCI and in sports itself. Some attendees will have little experience in sports, while other participants will have significant experience in one or more kinds of sports. Similarly, some attendees may have done significant research, design or development in wear-

able computing while other attendees may have no such experience.

Topics
We will first give a broad overview of wearable sports technologies and then focus on a few distinct approaches that enable athletes to improve their technique. The tutorial includes a hands-on session.

The following topics will be mainly addressed:

- Activity and sports tracking
- Real-time tracking
- Feedback methods
- Mobile coaches
- Study design

The tutorial will address the following learning goals:

- Understanding the technical challenges: How to design wearable sports technologies (e.g. miniaturization, unobtrusiveness, robustness)?
- Understanding wearable data: How to get in touch with the data (logging, recording, interpretation)?
- Understanding feedback channels: How to give appropriate feedback to the user?
- Understanding research methods for ubiquitous sports technologies: How to measure effectiveness of sports technology and how to design user studies?

Activities that attendees will engage in
There will be presentations to introduce the topic and hands-on exercises. During the presentations in the first hour of the tutorial, the participants will receive an overview of ubiquitous and wearable sports technologies. This includes the special challenges that arise when prototyping devices which should be used in a sporting environment. Furthermore, best practices for designing user studies will be addressed.

During the second hour the participants will get the chance to build, program, and test their own running wearables in small groups: a smart insole that can detect whether the user runs mid- or forefoot or strikes with her heel first and can provide corresponding feedback to the wearer. This process will be in style of a step-by-step tutorial.

Overview of the materials provided to the participants
The participants will be provided with an extended summary of the presentations. To recreate the built prototypes in the hands-on session, we further provide a bill of material and sample code.

Organizers' Backgrounds

Florian Daiber
Florian Daiber is a post-doctoral researcher at the German Research Center for Artificial Intelligence (DFKI) in Saarbrücken, Germany. His main research is in the field of human-computer interaction, 3D user interfaces and wearable computing with a strong interest in wearable sports technologies. Florian is co-organizing the UbiComp Workshops on Ubiquitous Computing in the Mountains (UbiMount) and the CHI 2017 Special Interest Group on Interactive Computing in Outdoor Recreation.

Felix Kosmalla
Felix Kosmalla is a doctoral student at the German Research Center for Artificial Intelligence (DFKI) in Saarbrücken, Germany. His primary interests lie in human-computer interaction in sports, including on- and off-body sensing, and assistive systems to support learning and collaboration. Felix is co-organizing the UbiComp Workshops on Ubiquitous Computing in the Mountains (UbiMount).

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