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# Workshop on Wearables for Sports

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## Abstract

Wearables are becoming mainstream technology, however there is still room for improvement in the sports domain of this field. Monitoring performance and collecting large scale data are of high interest among athletes - amateurs and professionals alike. The current state-of-the art wearable solutions for sports analysis are able to provide individual statistics to the user, however they have shortcomings in certain aspects, such as isolating and visualizing important information for the user, beyond statistics. This workshop focuses on the application of wearable technology in sports. We will explore novel ideas and application scenarios of how sensors and actuators are capable of supporting athletes in monitoring and improving their performance. We will discuss the design space of the domain by bringing together experts from various communities and exchanging ideas from different perspectives on wearables for sports applications. Participants will collaboratively produce sports related prototype applications.

## Author Keywords

Workshop; Wearable Computing; Sensor Networks; Signal Processing; Data Mining

## ACM Classification Keywords

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

## Introduction

In the field of sports, a broad variety of commercial applications are popular, even though they have unknown accuracies and often, simply collect and display statistics. In addition, there are many ideas and visions of how to improve such applications by exploiting expert knowledge of the available sensors and data that could be of interest to athletes and coaches. Many current commercial solutions bombard the user with too much data and not enough precise, filtered, relevant information. Furthermore, a gap can be seen between research ideas, algorithms and prototypes and their counterpart in the commercial industry. This is often because there is a lack between answering a research question and creating a product. This workshop aims to provide a platform for researchers and practitioners to begin filling that gap, by discussing potential new sports applications of wearable technology and developing a selection of prototypes using the expert knowledge of the researchers.

Attending this Wearables for Sports Workshop enables participants to realize their ideas and at the same time familiarize themselves with new hardware. This workshop is also an opportunity for researchers to present their relevant work and form new collaborations. These aims are supported by giving an overview of existing applications, their advantages and problems, and exploring the work of the participants. To ease the implementation of the prototypes, a framework will be provided to enable immediate development of new ideas without having to address hardware or communication problems. This Wearables in Sports Workshop is an excellent platform to be creative in terms of producing new wearable based sports applications. Moreover, it aims at stimulating an intensive exchange of expertise and ideas.

## Expected Participation

We are looking for participants with a variety of backgrounds; including hardware development, wearables for sports applications, algorithm experts, designers, HCI (human computer interface) experts, as well as athletes and coaches. We aim to merge these expertise areas to enable idea generation and collaboration. We will select participants based on the relevance and quality of their work. Participation will be limited to 20 people to allow sufficient hardware and an efficient working environment. We encourage the applicants to submit their latest research results or a position paper (up to 4 pages) that fits the scope of this workshop.

## Objectives

The aim of the workshop is to enable participants to collaboratively design and implement their own solutions for wearable systems in the sports domain. The participants will be guided through the development of a mobile application which uses data from external IMMU sensors. With this hands-on workshop, researchers can learn how to create an individualized wearable system for their ongoing or future projects. For practitioners, the skillset that is conveyed in the workshop may become a valuable basis for product development and prototyping. Moreover, by bringing together participants with a variety of backgrounds and goals, the workshop provides a platform for interdisciplinary cooperation and networking.

## Agenda

The workshop is planned for two days, with about 20 participants. It will start with an introduction and overview by Prof. Dr. Bjoern Eskofier, which will include commercial and research examples (9:00-9:30). A deeper look into the subject of wearables in the context of sports will be provided by a keynote speaker (9:30-10:30). After a short break, participants will briefly present their submitted work in 5 minute

presentations (10:45-12:15). After lunch, the available hardware and its Android based framework will be introduced (13:15-14:15). This framework allows access to IMMU data via Bluetooth by a mobile phone. As part of this session a tutorial on Machine Learning and Signal Processing basics for wearables will be held. To this end an introduction to the Embedded Classification Software Toolbox (ECST) will be made. This will be followed by an ideation session to explore potential application scenarios (14:30-15:30).

The participants will divide themselves into groups based on mutual interests and the 'Hackathon' will begin (16:00). The following morning there will be a brief status update by the groups in order to identify problems and gain input from all of the workshop participants (9:00-9:30). The Hackathon will end late afternoon (16:00) and the groups will present their applications, followed by an open discussion and feedback session. The most innovative idea and the best implementation will receive an award.

#### *Hardware & Software*

We will use an Android-based framework and the ECST for basic signal processing. Regarding, hardware, we will provide mobile phones as well as several laptops with the above software, and its development environments, pre-installed. Additionally, we will send a list of used tools, software, and drivers to the participants a week before the workshop starts for those who wish to use their personal laptops. For the data acquisition, 20 TEK-Platforms (IMMUs) will be used, which include environmental sensors. The framework provided to the participants will stream data from the sensors to the phones reliably at 100 Hz with an example application to build on.

## **Outcome**

The interdisciplinary collaborations within the workshop allow creating visions for new wearables sports application ideas within an expert environment. Created solutions to the current limitations of wearable systems and applications can be continued in ongoing collaborations. Working on hands-on implementations of a wearable systems provides the potential to stimulate discussions about wearable systems for sports and health applications. In detail the intended outcomes are the combining of knowledge of participants from different fields related to wearables in sports applications, the creation of innovative ideas for applications in the sports domain and the visualization of the data acquired by wearables, identifying potential applications and challenges for future research, creating new collaborations among researchers and practitioners and enabling the possibility for joint publications based on the results of the workshop.

## **Acknowledgments**

We are grateful to Bosch Sensortec for their sponsorship of this workshop.

## **Organizer's Background**

**Christine F. Martindale** Computer scientist cross biomedical and mechatronics engineer. Research interests include robust algorithms for "in the wild" data.

**Markus Wirth** Research interests encompass human-computer interaction and ubiquitous computing with a focus on wearable computer systems and pervasive computing.

**Stefan Schneegeass** Research interests in ubiquitous computing (UbiComp) and human-computer interaction (HCI). His particular interests are in wearable computing and smart garments [5].

**Ben Groh** Research interests in data fusion and IMMU-based signal processing with the focus on orientation de-

termination for localization, biomechanical analysis and classification in sports [2].

**Peter Blank** Research interests include hardware development for sports and fitness applications as well as design and implementation of embedded sensor systems for processing of physiological and biomechanical signals [1].

**Dominik Schuldhaus** Research topics include the assessment of physical activity in sports and health, data mining for activity recognition challenges and Big Data analytics in activity recognition [6, 4].

**Thomas Kautz** Research interests include IMMU-based activity recognition and position tracking in sports as well as epilepsy monitoring using wearable sensors [3].

**Markus Zrenner** Research interests include machine learning, biomedical signal processing and the assessment of biomechanical parameters for sports related services.

**Bjoern M. Eskofier** Assistant Professor for Computer Science in Sports (endowed professorship of the adidas AG) and head of the Digital Sports Group at the Pattern Recognition Lab of the FAU. Prof. Dr. Eskofier has authored more than 100 peer reviewed articles and submitted 5 patent applications.

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