Current Development of a Server-Based Mobile Coaching System

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Abstract

The emergence and the continuous improvement of mobile devices and sensor technologies have awakened interest in the application of such hardware for various professional and amateur sports. Mobile coaching, for instance, is an upcoming approach focusing on the use of present-day handheld PCs, innovative sensors and intelligent feedback methods for the purpose of assisting sportsmen, coaches and other specialists in their training and coaching programs. This paper presents our current development of a server-based mobile coaching application, appealing and adaptable to the requirements of elite as well as hobby athletes coming from different sports.

KEY WORDS: MOBILE COMPUTING, SENSOR TECHNOLOGIES, FEEDBACK, COACHING

Introduction

The constant progress of today's information and communication technologies results in their widespread usage in various research fields. Novel sensor techniques as well as mobile devices are advancing steadily, making their integration also attractive for practical implementations in sport scientific disciplines. Mobile coaching, being driven by recent technological development, is one example for such an area of application (Link & Lames, 2009). Thereby, the main focus is set on the support and enhancement of the athlete's training by the use of wireless sensors and modern handhelds, but also remote feedback methods (Baca & Kornfeind 2009; Novatchkov et al., 2009).

Starting with a short introduction into the background aspects and goals of our research, the current development of a mobile coaching system including first prototypical implementations are presented thereafter. The paper ends with a discussion and final conclusions.

Motivation and Objectives

Nowadays due to the extremely high competition in professional sport, immediate feedback tools are of great relevance. In (Baca, 2008) the author underlines the competitive advantage provided by such systems by stating that at the end small "fractions of a percentage point decide on success or failure". But also amateur sportsmen often explore

their limits and are therefore more and more interested in a prompt knowledge about their achievements.

Feedback Systems

Computer-science based feedback systems on sport performance are primarily designed to assist sportsmen and monitor their training for the purpose of achieving better results (Baca, 2003) but also avoidance of overstrain. Typically this involves a data flow chain consisting of various phases. In a first instance, several parameters of the users (for example heart rate values etc.) are measured. Thereupon the information is collected in order to process it in the next step and finally present it appropriately.

It is thereby essential to determine at which point and in what way feedback should be given. Several investigations prove that a rather rapid return contributes to a significant improvement of the results (Lames, 2004; Mueller et al., 2000). Additionally, a user-friendly design plays a crucial role for the acceptance of such feedback systems. Common presentation tools are often based on the use of graphical visualizations like for instance charts. Another convenient possibility is for instance the notification by audio feedback.

Sensors and Mobile Devices - Modern Information and Communication Technologies and their Influence on Current Feedback Approaches

One important determinant in the development of today's feedback systems is certainly the continuous progress in up-to-date technologies such as sensors and mobile devices. In particular, due to the extensive and powerful functionalities as well as their miniaturization, such (rather high-tech) hardware equipment is more and more applicable for the design of wearable feedback solutions.

Present-day sensors are not only becoming smaller and lighter but also are practically cable-free. This wireless characteristic enables a convenient integration facility and easier usage during the data acquisition phase. At the same time interference with the athlete can be reduced considerably. Furthermore, recent sensor technologies have the advantage of low power consumption, allowing their use during long-lasting trainings.

In addition, modern mobile devices provide their users with many functionalities that were rather unrealistic some time ago but are standard features nowadays. The support of different communication tools, such as internet-related technologies but also various sensor protocols, on handheld PCs enable a wide range of applications. For instance, such devices can be now used for the reception, storage and further transmission of sensor data. Even more, their networking abilities and their small design make them applicable at almost any place, in particular at the place of performance.

Research Aims

Our main research goal is to establish a mobile coaching system that is capable of integrating the above mentioned information and communication technologies and makes use of their advantages for the purpose of providing intelligent “live-online-feedbacks”.

This requires a framework that includes prompt and suitable sensor data acquisition solutions as well as feedback methodologies for the detection of relevant information during training.

One challenge is thereby to find efficient methods for the collection and transfer of huge amount of data as it occurs during different sport activities and motion sequences. The

intention is to design effective services for the convergence of mobile devices and sensor networks in terms of feature extraction, data reduction and information retrieval (Fitzek & Rein, 2007). Another complex task is to implement and adapt intelligent algorithms based on the integration of specific training as well as potential data into knowledge-based and expert systems for the automatic generation of feedback (Mester & Perl, 2000).

The generalization of the concept is also a crucial point. Here it should be noticed that one beneficial factor is the development of a system that is suitable to the needs of professional and amateur athletes coming from various sport sectors. The main focus, though, is set on popular sports like running, cycling and fitness. Consequently, a basic idea is to integrate common handheld PCs with standardized protocols that are used by the majority of the population.

Methods

During their trainings, sportsmen are equipped with a mobile device and wireless sensors in order to carry out biomechanical, physiological and/or other sport specific measurements. At the same time, coaches, biomechanists, sport medicine specialists and other experts should have access to the data from remote locations and return feedback in real time.

Architecture

Figure 1 shows the overall architecture of the mobile coaching system, designed on the basis of a typical client-server model.

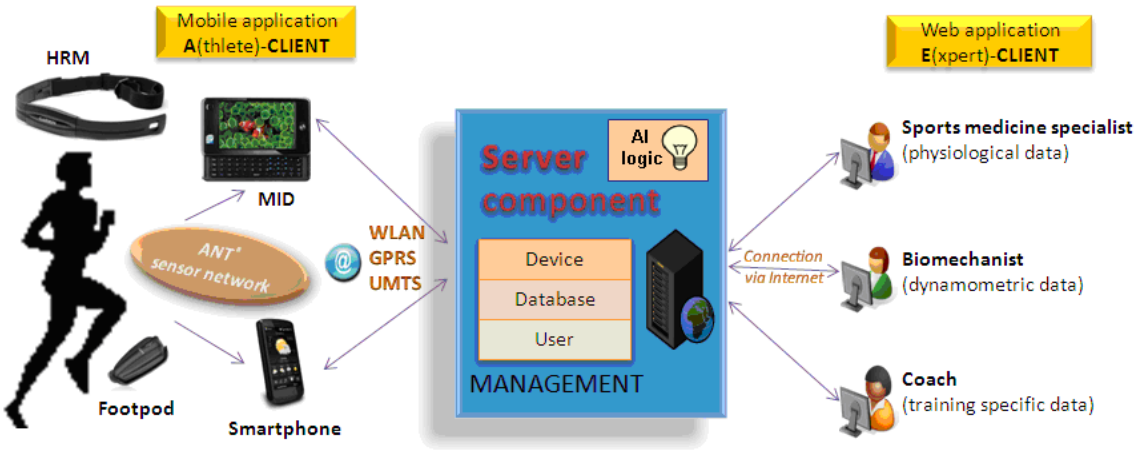

Figure 1. Architecture of the mobile coaching system.

The data acquisition is implemented by the so-called A(Athlete)-client with the aid of wireless sensors (e.g. heart rate monitor (HRM), footpod etc.) and a mobile device (e.g. Mobile Internet Device (MID), smartphone etc.). The implemented mobile application stores the measured information temporarily on the device and immediately forwards it via data-transfer protocols (e.g. via WLAN or UMTS) to a server. As shown, the concept is based on a centralized host machine that is mainly responsible for the management of the registered devices and users as well as the administration of the parameter values. Therefore a sophisticated database management tool for the storage and maintenance of the big amount of information flow is of high importance. The host includes also web applications, representing the so-called E(Expert)-clients. Based on the stored

athlete's training units but also effective algorithms, their main purpose is to provide experts with remote data access, analysis and feedback routines.

Results

Our current implementation is capable of integrating wireless sensors based on the ANT® protocol, which is meanwhile well-established for practical applications in the field of sport. The A-client includes a smartphone (HTC® Touch 2, Windows® Mobile 6.5) and a microSD card (Spectec® ANT™ (http://www.thisisant.com) RF Card) for the reception of the measured signals.

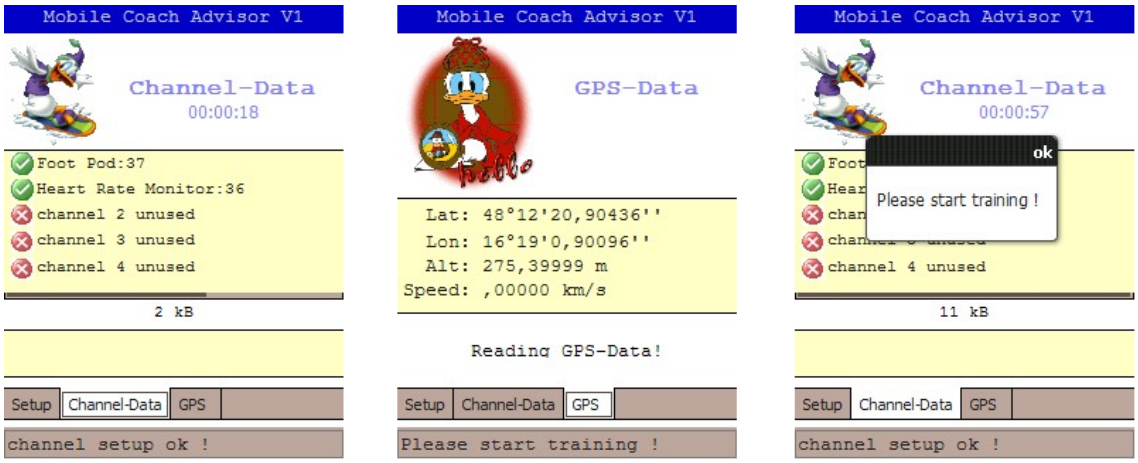

Figure 2. GUI of the mobile A-client application.

Currently the mobile programs are implemented in C# using Microsoft's® .NET Framework. As shown in the GUI design of the A-client in figure 2, the application is listening on different channels for incoming signals from surrounding sensors. In addition, the current GPS location of the athlete is identified as well. The gathered information is collected, thereupon saved temporarily and - in case the mobile device is connected to the Internet – immediately sent to the host component. The data is transferred and stored in the SQL database via timed client pushes.

The web development is based on the Apache™ HTTP Server and for the database implementation the MySQL® Server is installed and configured. Figure 3 illustrates an exemplary implementation of the E-client application. The program displays the recently processed sensor data like the strides, distance and speed or current pulse rate based on the measured signals from the footpod and heart rate monitor.

In addition, the development offers a tool for visualizing the progress of the measured parameters (for example the heart rate values) in real time. In this way, experts are able to analyze the athlete's performance throughout the entire training. Moreover, a further feature allows them to return personal feedback messages from remote locations. Such notifications are sent via the server back to the mobile device using pull technology mechanisms and displayed there as an alert notice including a beep and vibration signal.

Figure 3. E-client of the framework.

Further Work and Outlook

Currently we are working on the generic approach and optimization of the system. This involves, on the one hand, the establishment and automatic integration of sensor networks as well as their convergence with mobile devices by developing efficient services. The implementation of platform independent mobile applications is another important improvement factor that would contribute to the portability of the framework. In order to accomplish this goal, the intention is to integrate the ANT equipment into individually designed USB adapters, which would then allow a multi-platform development on various handheld PCs.

Further work concentrates on the realization of a suitable database structure for the management of registered users, devices and the measured parameter values. One essential feature is to provide access for trainers and other specialists to the athletes' performances from the past as well as their achievement potentials in order to allow the comparative analysis of the current exercises and return specific recommendations or instructions in real time. A possible solution is to classify and optimize the workout process by modeling the interdependency of the training potentials and impacts of the sportsmen. Such meta-models and time series analyses can be then used for the purpose of implementing intelligent routines for the notification via automatically generated feedback messages.

Extensive software testing phases and a final evaluation of the framework are required in order to verify and review the acceptance as well as the usability of the mobile training system.

Discussion

As can be inferred from the presented framework, assisting methods aiming at the improvement of the athletes' sport performances but also avoidance of overstrain are advancing constantly in the last couple of years. The high importance and practicability of such systems are illustrated by the conceptual idea of the approach and highlighted by its novelty of combining feasible mobilizing possibilities with server-based feedback methods based on the integration of modern information and communication technologies.

The miniaturized design of recent wireless sensors allows a very efficient and less interfering way of measuring different kinds of biomechanical, physiological or other important values. In addition, today's mobile devices have the benefits that they are small and handy to use and can also connect to the Internet as well as various sensor networks at almost any place and time.

Such high tech equipment brings therefore great advantages for sportsmen and coaches who can access and analyze relevant training results just after completing the workout or even concurrently without leaving the place of performance. The integration of such online methods for the analysis of real time data including automatically generated notifications based on intelligent algorithms is therefore a crucial point of the framework and definitely the major innovation of the approach.

Available systems like the Nokia® Sportstracker (http://sportstracker.nokia.com) are capable of recording the athlete's training, thereby allowing users to follow their performances via the Internet. The implementation, though, processes only GPS and heart rate information and doesn't offer any feedback routines either. Similarly, Athlosoft's® (http://www.athlosoft.com) commercial realization evaluates basic sensor data locally on the mobile device but doesn't integrate remote experts into the solution. Consequently, to our knowledge there is no approach available that is capable of combining mobile data acquisition methods with centralized analysis routines in the way the presented system does.

Conclusion

This paper presents the current development of a server-based mobile coaching system. Thereby, the high potentials of modern information and communication technologies in supporting sportsmen and coaches in their workout process are clearly visible. On the one hand, the application of small-sized wireless sensors and mobile devices provide handy methods for the measurement, collection and transfer of sport-specific parameters. On the other hand, the additional integration of a server component into the development involves efficient assisting opportunities for experts by allowing them to analyze the athletes' performances and return remote feedback messages during the training.

Overall, it can be concluded that the presented mobile coaching system builds a very future-oriented basis for sportsmen and coaches in means of assistance and support. Nonetheless, the progress of sustainably effective solutions depends also on further investigations as well as implementations and particularly on the integration of up-to-date information and communication technologies.

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