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Mobile Motion Advisor – a feedback system for physical exercise in schools

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Abstract

The Mobile Motion Advisor (MMA) is a mobile feedback system designed to support high school students by giving them instructions during their physical exercises based on the integration of up-to-date sensor, data transmission and processing technologies to provide optimal training assistance. The aim is to give individually customized exercise instructions. We expect students to develop a positive attitude towards physical exercising when they do not experience frustration due to overstrain. This article gives an overview of the system architecture of the MMA framework and highlights some of the implementations.

Adolescents, fitness, ubiquitous computing, feedback systems

1. Introduction

Physical exercise at young age is a good disease prevention measure (e.g. obesity, diabetes) and has beneficial effects on an individual's adult life. Today's social surroundings do not create intrinsic motivation for doing sports in a child or a teenager. This coincides with the increase of civilisatory diseases connected with lack of physical exercise. Considering this, how can students be motivated to exert themselves to the physical strain experienced during exercising? High tech gadgets are very popular "toys" amongst the young. We propose that motivation can be obtained by using high tech in physical exercise and sports. The physical activity of adults as well as children has been decreasing recently [8,9]. Weiss [14] refers to a lack of motivation to do sports among the kids. This is an alarming fact considering that adolescents acquire athletic skills through physical experience which later may help to lower the risk of degenerative diseases [5]. In order to motivate people to more physical exercise [7] new ground is broken by the use of sensor, information and communication technologies [1]. Commercial computer games encourage users to physical activity with specially adapted concepts for their consoles [6]. The Nintendo Wii might be mentioned here as an example offering a user interface that allows the gamer to actuate the avatar by executing the same movements in front of the console. High popularity can be observed in relation to web-based training

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assistance applications (e.g. traineo.com). Users are provided with the possibility to select their favourite sports and to join virtual communities that match their athletic interests. Furthermore, they are able to document their training progress in a blog. High numbers of members and positive feedback seem to underline that these web portals have a motivating effect to do sports. In preventive and rehabilitative sports specially adapted sensor and wireless communication networks are in use. Therapy and feedback methods are provided by solutions like the "Therapy Top" [11]. The movements of the users training on specially designed balance boards are visualised in order to enable the evaluation and control of the performance. Different feedback systems are used in the field of leisure and competitive sports to improve the motion sequence or just to avoid overstrain [2,4]. For this kind of application the reactionless measuring of biomechanical and physiological characteristics as well as the immediate response of assorted parameters to the performing athlete are crucial. MarathonNET is a project that specialises on the monitoring of selected athletes (position, velocity and heart rate) and on the possibilities to personally keep records and analyse the recorded data with the help of an online service [12]. Specially adapted computer systems are used in cycling to evaluate and control performance more efficiently. At the TU Kaiserslautern a wireless sensor network was developed to optimise position changes within an inhomogeneous group of cyclists using their physiological data [10]. Ubiquitous solutions are also implemented for the fitness training environment, motivating users with the help of mobile applications that support them with training advices [13]. Figure 1 illustrates a feedback system that is based on miniaturised sensor, information and communication technologies and designed for use in competitive rowing [3]. Selected parameters (forces, accelerations, angles, etc.) are measured and transmitted to a server. The collected data is then plotted and analysed online by experts in order to identify distinctive features and give recommendations concerning rowing technique. Coaches are then able to give their instructions to the athletes. We propose that a system that integrates some of the mentioned concepts of activity feedback and interactive communication might have a beneficial effect on the motivation of young people to be more active by mingling the "intelligent" with the "cool". In this paper the main architecture of such a system and some of the technical details are being presented.

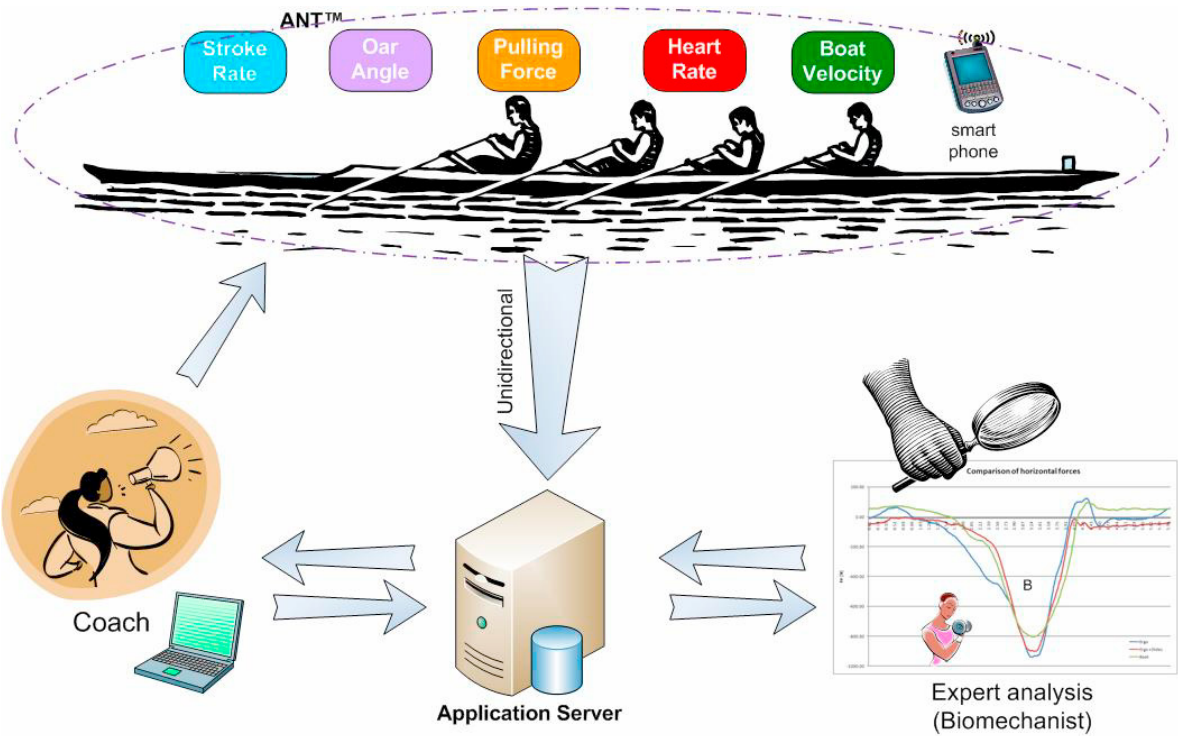

Fig. 1. Feedback system in rowing

2. System requirements and concept

The concept of the Mobile Motion Advisor (MMA) provides interactive communication technology to teachers and students and helps to adapt and evaluate certain performance parameters in respect to the individual performance level. Characteristic parameters of the performances of a whole class can be supervised continuously. In this way the teachers are able to coach a higher number of students individually and the students get feedback of the quality of their motion which helps to interpret the body's reactions to physical strain. The students' performances are recorded and so the bodily changes during a certain time are documented. Positive effects of physical exercise are highlighted. This might help to promote health conscious behaviour and to enhance the willingness to physical exercise. In particular, a sophisticated regulation of physiological stress can prevent students from demotivating experiences due to fatigue. For such purposes, sensors, either carried by the person or mounted onto the sports equipment, are used to measure different parameters like heart rate, velocity or reactive forces of an exercising person. These parameters are sent to a handheld PC via a wireless personal area network (WPAN). Then the measured data is transmitted to an application server using wireless communication technologies (UMTS, HSUPA). Based on this data exercising instructions are generated and sent back to the exercising person. The feedback is either automatically generated by a server application or individually provided by an expert. For the technical implementation of the MMA's different sensor and wireless technologies have to be adapted to the sports' movements. An online service provides the communication platform for the data transfer and gives feedback to the student that is accessible from any place in the world. The realisation of the MMA enables the evaluation of the application scenarios of ubiquitous technologies in sport and the acceptance of such applications in the day-to-day routines. Furthermore, the right timing and method of giving feedback in terms of performance enhancement must be tested.

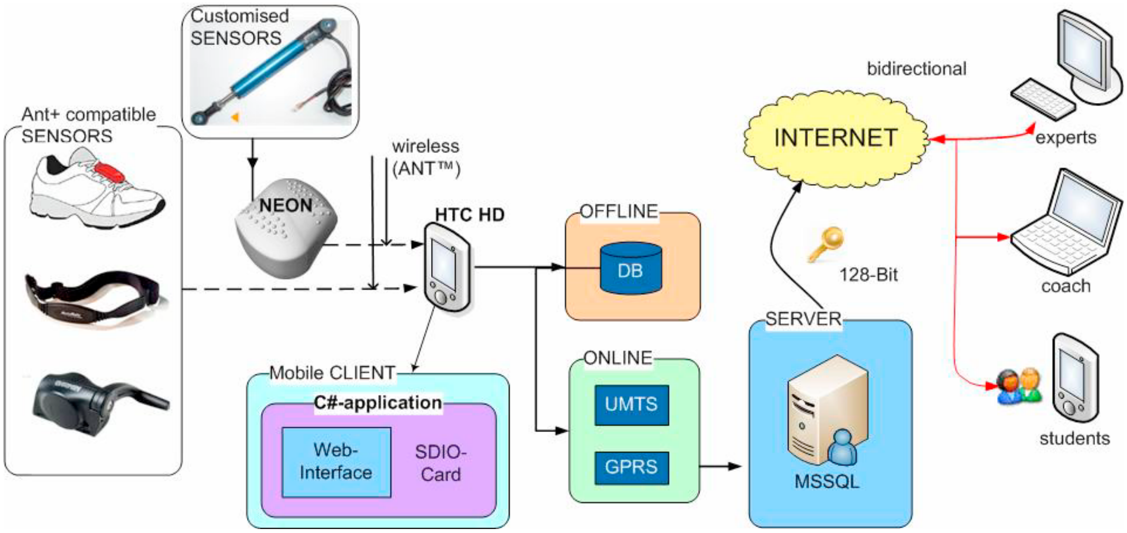

Fig. 2. The conceptual design of the MMA framework

3. Implementation

The system architecture comprises several components including the measuring units as well as the client applications that work separately as functional units. Fig. 2 describes the conceptual design of the framework. Several measurement units (sensors & μ-controller), a mobile client, a server component and several interfaces for experts, coaches and students using PCs or handheld PCs are shown. The hardware and software components of the system are configured as modules supporting different system setups. Preferably existing sensor applications like heart rate monitoring belts that communicate via the wireless protocol ANT™ (Dynastream Innovations, Alberta, Canada) transmit the recorded signals to the mobile client. High data rates and a versatile selection of sensors abet the development of sports specific applications. But also other sensors providing only an analogue or a digital output signal can be integrated using the NEON (Spantec GmbH, Linz, Austria). This device is a data acquisition platform communicating via the ANT^{TM} protocol allowing sensor data to be transmitted to the mobile client. To date there are no mobiles that have an onboard ANT^{TM}-Module. The communication between the sensor or the NEON respectively is realised using a SDIO Card (Micro SD ANT RF Card, Spectec Computer Co., Ltd., Taipeh, Taiwan) or an ANT^{TM}-to-USB converter. The mobile application is programmed in C#. Sensor data is transmitted via GPRS, UMTS or WLAN to a MSSQL server (Microsoft Corporation, Redmond, Washington, USA) where the data is stored and accessible to authorised persons all over the world. In case that the server is offline, the mobile buffers the data until connectivity is re-established.

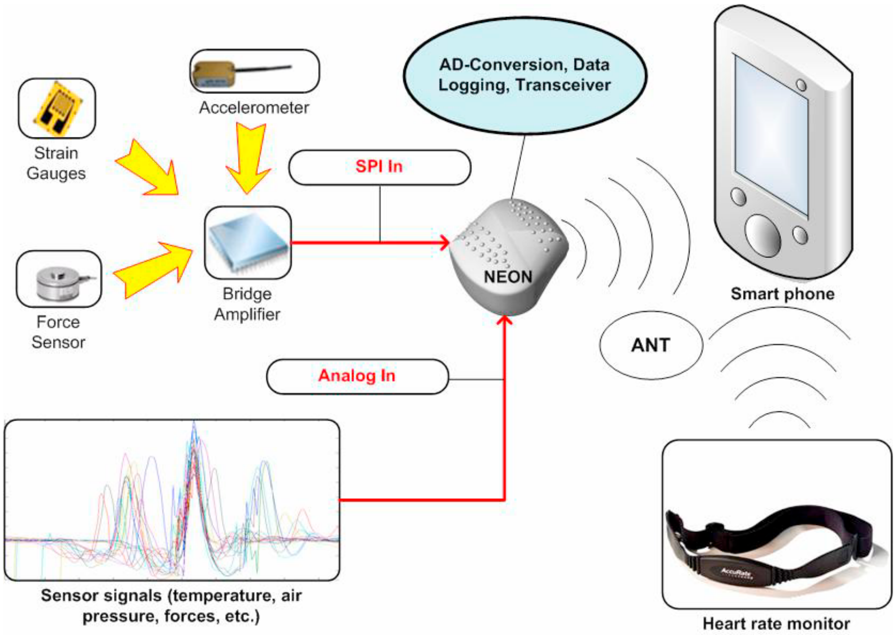

Fig. 3. Data acquisition components of the MMA

A block diagram of the data acquisition component of the system implementation is illustrated in Fig. 3. The main component is a µC with several interfaces to acquire sensor data connected to an ANT^{TM}-Module via UART which is implemented in the NEON. Additionally to the SPI-Bus and the analogue inputs used for sensors, bridge amplifiers amplify strain gauge or accelerometer signals. The ANT^{TM}-Module enables communication between the mobile client and the NEON's µC. Mobile client applications are implemented considering different sports specific parameters. Based on personal data like age, body weight and certain fitness parameters individual coaching during physical activity is facilitated. The accessibility and the actual costs of the sensor technology as well as the interoperability throughout different sports are basic considerations regarding physiological and biomechanical parameters. Cardiovascular parameters are definitely interesting in most of the sports and equally easy to implement. Application of accelerometers, dynamometers and other sensors might be interesting for the evaluation of the quality of a person's performance. Table 1 gives some examples for sports specific parameters in context to the different activities.

Table 1. Examples of sports specific parameters

activity	parameters
running	heart rate
	number of strides
	track length
	positioning (GPS)
mountain biking	heart rate
	pedal frequency
	gear
	altitude
	inclination
	velocity
endurance and strength training	heart rate
	weight
	repetitions
	duration
	joint angles

A particular solution of this system is the realisation of the communication between a heart rate monitor belt (HRM1, Garmin, , Country) and a smart phone (WM 6.5, HTC HD, HTC Company, Taoyuan, Taiwan). In order to transmit the heart rate values to the mobile client the DLL for communication with the micro SDIO-Card had to be modified. The application on the handheld was programmed in C#. The GUI of the mobile client provides basic functions for connecting and disconnecting the devices and of course information on their actual heart rate (Fig. 4).

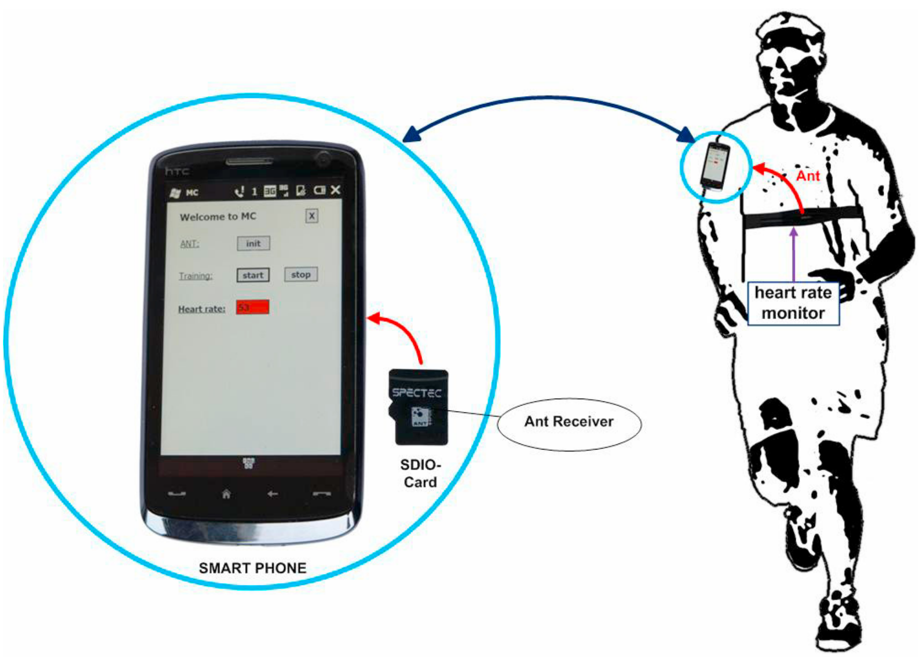

Fig. 4. Implementation of the heart rate monitoring on the handheld via SDIO-Card

4. Discussion and further work

There are only two interfaces to the hardware of modern mobile phones accessible to the engineer without ruining the device, the SD-Card slot and the USB-port. First tests with the ANT^{TM} compatible SDIO-card have shown that the transmission range is limited to about 1.5 meters which is quite restricting in terms of the number of different sensor applications. Taking into account that the SDIO-card is surrounded by metal parts within the mobile phone it is very much likely that these parts are disturbing the electromagnetic field of the ANT^{TM} transceiver. Arguably the implementation using the mobile's USB-port seems more reasonable because the transceiver can be placed outside the mobile, not being interfered by any metal structures. Still this application causes trouble due to the USB-standard used on handhelds. In general the mobile is used as a slave-client whereas the application requires the mobile to be the USB-host controller (master). Research has to be done if this status can be altered by programming or if the definition is a preset by hardware specifications which would make this solution a lot harder to realise.

The most ambitious aim of the project is likely to be the implementation of automatic feedback routines for giving training advice. Coaches are aware of the fact that coaching someone is not comparable to maintenance and adjusting work on a machine. After all there are numerous factors contributing to performance. The choice of the most significant factors for the quantification of human performance as well as the required sensor setups to provide measurability is crucial. Furthermore, to put these factors together and understand their interdependencies takes a lot of expertise. Yet unmentioned in this paper is the work that has to be done on the development of decision trees that are capable to classify the incoming data and return messages containing applicable training advice to the client. On top of that the way that the advice is presented to the user has to be considered carefully in order to have a motivating effect. Therefore the whole MMA system is evaluated in the practical field of physical education classes after the implementation has been tested for functionality. The evaluation is done as an empirical study using questionnaires for data collection. The evaluation is going to be a part of the class "*physical exercise and sports*". The test persons for the questionnaire must not be involved into the process of the development of the MMA in order to avoid the collection of biased opinions. Data regarding acceptance and usability of the system is going to be evaluated.

The results of this study may help to find the right approach for giving feedback to the average teenager. In addition it might show if the MMA is a good support for students in their physical education classes and if the MMA does help to improve the average fitness of the youth.

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