Pervasive Computing in Sport

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INTRODUCTION

The term pervasive computing or, alternatively, ubiquitous computing describes the current evolution and propagation of information processing in human environment. The main idea behind this development involves the implementation of small, interconnected as well as integrated technologies, objects and activities in human's everyday life. Moreover, the concept specifies the modern way of Human-Computer Interaction (HCI) based on embedded systems, objects and activities. Accordingly, the increasingly powerful, sophisticated, networked and smaller developments of today's pervasive computing equipment lead to an invisibility and unawareness of their actual use ("calm technology").

As a consequence of the fast moving trend, this "technologization" is meanwhile fully present in various disciplines and fields of activities including sport and sport science, where ubiquitous technologies are meanwhile widely used for different purposes and in various contexts (Baca, 2008). In particular, the integration of pervasive methods and systems is nowadays seen as an essential part for the enhancement (in terms of improvement but also regarding prevention) of the coaching, training as well as competition processes – with modern equipment being applied for the acquisition, analysis and presentation of performance data without interfering the athletes. In this way, pervasive computing in sport has evolved to an upcoming research area of the interdisciplinary field of computer science in sport that has a high impact on the current development of sport (Link & Lames, 2009). In this article, a closer look is taken at the pervasive computing influence on sport and at the design of a variety of up-to-date sports frameworks for analysis, coaching, decision making, leisure, rehabilitation, and social networking scopes.

BACKGROUND

Going back in history, the idea of a pervasive computing world dates back to the late 1980s, beginning of 1990s, when the chief scientist of Xerox PARC, Mark Weiser, first introduced this term. Already at that time he believed in an environment with miniaturized technologies available at any time and any place (Weiser, 1991). Furthermore, he defined this trend as the "third wave in computing", following the period of the mainframes and personal computers. Due to the constant progresses in this area including the intelligent and networking behaviour of the miniaturized computer devices, the paradigm is also called "ambient intelligence", "things that thing", "The Internet of Things" or simply "everyware".

As a specialized area, the recently evolving research field of pervasive computing in sport is getting more and more important for the evolution of sport. Based on the technological advances during the past years and decades, up-to-date equipment is of great demand in the market of sports performance monitoring and feedback applications (Baca et al., 2009). The constant advancements, great facilities, feasibilities and diversity of pervasive methods as well as sophisticated information and communication technology developments enable effective ways for the design of various sports applications such as evaluating, assisting, enhancing, preventive, judging, entertaining or networking implementations. Consequently, pervasive computing has also become an important field of activity of applied sport science (Novatchkov et al., 2011).

MAIN FOCUS OF THE ARTICLE

The goal of the article is to point out the implication of pervasive computing for sport and sport science and to demonstrate some of the most important developments. The article gives an overview of typical implementations and fields of application regarding the use of ubiquitous computing equipment. The realization of recent developments such as a mobile coaching framework (Baca et al., 2010), aiming at the instant support of athletes and coaches during the training process, analysis systems based on positional data or computerized decision making tools will serve as typical examples in practice. Finally, the limitations and requirements as well as a couple of recommendations and future research perspectives are discussed.

Pervasive Computing Influence on Sport

The continuous progress in computer science and especially of pervasive computing has a huge influence on the progress of sport (Baca, 2006; Chi et al., 2005). In practice, the design and application of ubiquitous methods and systems play an increasingly important and beneficial role for a variety of sport-related factors. In particular, the constant advances in sensor but also information and communication technologies enable promising ways for the instant capturing, transmission, storage and further processing of significant parameters. In the first instance, the evolution of today's measuring equipment in terms of smaller designs and wireless facilities, enable more convenient opportunities for the acquisition of sport-specific data. Based on the possibilities of recording big quantities of data, also the analysis and interpretation of the information becomes a major research topic and goal (Chi, 2008). In this spirit, the increasing computing power as well as higher data and transfer rates of available communication technologies allow the design of powerful approaches for the prompt (if possible even real-time) transfer, handling, analysis and interpretation of the gathered data.

Sensor Systems, Mobile Devices, and Networking

Consequently, one of the main aspects regarding pervasive computing in sport is related to the steadily evolving sensor technology systems. Along with this progress, easier and more effective ways exist for establishing different kind of homogenous and heterogeneous sensor networks such as Body Sensor Networks (BSNs), Personal Area Networks (PANs) or Wireless Sensor Networks (WSNs). These possibilities are particularly important for the determination of significant characteristics such as relevant biomechanical or physiological parameters during various sport activities. Today, a variety of rather small and usually cable-free measuring elements are available that are most commonly attached to the sport equipment or even directly to the athlete's body.

One specific approach that was especially designed for sport applications is the so-called ANT+ technology, which is an extension of the ANT™ (2012) protocol. Based on its advantages such as simple network configuration, scalability, flexibility, reliability and low power consumption, the solution has meanwhile become a common standard and is increasingly integrated into different sensor equipment in sport. In fact, most of the commonly used devices such as heart rate monitors, bikepods, footpods and many other sensing elements are compatible with ANT+. Even more, the technology has also been embedded in some of the newest smartphones, thereby allowing an efficient supervision of the athletes' performances.

Moreover, up-to-date mobile devices such as handheld PCs get smaller but, at the same time, also more powerful. A major advantage is related to the improvement of the offered services including, for example, higher Internet transfer rates on the basis of the enhancement of the 3G (HSDPA, HSUPA, HSPA+) as well as the development and current establishment of the 4G LTE (Long Term Evolution) mobile communication technologies. Other relevant benefits of recent smartphones include their increasing storage capacities or also the integration of real-time sensing techniques such as Global Positioning System (GPS), being crucial for the detection of the position in various sports. In this way, mobile devices offer excellent possibilities for the measurement and acquisition, the local storage and immediate retransmission of sensor data.

As GPS is restricted to outdoor use only as well as to good weather conditions, other commonly applied sport approaches for position measuring purposes include the integration of radio-signal such as radio-wave based tracking systems (Leser et al., 2011). Radio-Frequency Identification (RFID) is another specific system that is,

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