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The role of science and technology in sport

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Abstract

Wearable devices measuring some physical or physiological quantity of an individual have already become a part of daily life for many people. While such simple devices output mainly the statistical values of measured quantities or count events, demands in sport are more stringent. Quantities of interest must be measured in wider range, with greater precision, and with higher sampling frequency. We present a short introduction to motor learning in sport and its needs for technology back-up. We present properties and limitations of various sensors used for sport activity signal acquisition, means of communication, and properties and limitations of communication channels. We shed some light on the analysis of various aspects of sport activity signal and data processing. We present timing, spatial, and computational power constraints of processing. Attention is given also to the state of the art data processing techniques such as machine learning and data mining. In conclusion we present some technological trends and challenges in sport, such as Internet of Things, smart sport equipment, and real-time biofeedback systems and applications.

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Keywords: motor learning; sensors; sport activity signal acquisition; biofeedback system; sport data analysis; smart sport equipment

1. Introduction

Physical activity is becoming an increasingly important aspect of our lives. It is a necessary and a required ingredient of a healthy life and there is no doubt that it contributes to our wellbeing. While sport used to be a

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synonym for physical activity performed in a person's free time that might not be true anymore. We can roughly categorize the free time physical activity into recreational sport or recreation, amateur sport, and professional sport. Each of the three categories has a separate place in the society and includes people with different goals. But one thing is common to all of them; the need and the urge for the quantification of their physical activity [1].

Technology used in sport is developing very fast; recent day technology possesses properties and functionality only imagined a few years ago. For example, in the past the motion of gymnasts could only be analyzed in certain detail through video recordings, while at present gymnasts can wear a suit with motion sensors [2] that records their moves. Based on the athlete's kinematic model such systems can give a detailed analysis of their motion in three-dimensional space. Similar examples could be found for other sports.

In recent years a number of inexpensive toys and gadgets aimed for activity tracking have been introduced to the market. Gadgets, such as wrist bands, give statistical parameters and count events of a particular physical activity. For example, they count the number of steps made during the day, they can detect falls, they can monitor sleep quality, etc. Such gadgets usually acquire movements or physiological processes of the user with low frequency and low precision, what is at the end good enough for their intended use. At the other end of sport technology are complex and expensive systems that simultaneously gather and process large amounts of data. For example, a system for a real-time tracking of a football match and the analysis of training [3]. The majority of technology applications in sport lie somewhere between both abovementioned groups.

According to sports experts, feedback is the most important variable for learning, except the practice itself [4]. During the practice, the natural (inherent) feedback information is provided internally through human sense organs. Augmented feedback is provided by external source, traditionally by instructors and trainers. Modern technical equipment can help both the performer and the instructor by providing additional, parallel feedback information that is not obtainable by traditional observation methods. Motor learning is essential in the process of mastering of any of the physical activities; from walking to ballet. This observation is true for any group of sportsmen or sportswoman: recreational, amateur, or professional. Technology is already present or is making its way into all domains of sport. In this paper we focus primarily on the technologies important in feedback systems for the support of accelerated motor learning.

Many sports are performed using specialized equipment. The equipment can be as simple as a baseball bat, or it can be as complex as a Formula 1 car. For complex sport equipment the technology has always played a major role in getting the competitive advantage over the opponents. For example, technologically superior bob sledge can eventually win over the technologically inferior one, even if its team is not as good. The technology is now making its way also to the simple sport equipment. Manufacturers of sport equipment have already put to market several examples of *smart sport equipment*, such as smart tennis racket, smart basketball, smart running shoes, and others [5]. While simple sport equipment might not require complex technology, it might be difficult or even impossible to design because of its size and weight restrictions, its possible violent use (golf ball), or for any other reason.

The final goal of any sport training, being recreational, amateur or professional, is in gaining an advantage. While recreational sport the aim is primarily in gaining the advantage of being fit and healthy, in amateur and professional sport the aim is primarily in gaining the competitive advantage over their opponents. Our anticipation is that the majority of recreational sportsmen and sportswomen will be satisfied with activity tracking gadgets and smartphone applications. On the other hand the competitive athletes will try to exploit any possible improvement in training process, movement execution technique, and equipment that will offer them some competitive advantage. Augmented or enhanced motor learning can play a vital role in this endeavor. The use and help of technology for this purpose can be especially important for amateurs as they rarely have a personal coach.

Our vision is to design feedback systems and applications in sport that would be able to satisfy a wide range of possible uses for augmented motor learning and that would support the use of smart sport equipment. For example, a running application would be implemented on the smartphone. It would be able to give real time feedback to the user about some basic running parameters, such left and right leg period balance and similar. Users of this application would most probably be able to improve their running technique if given some advice by an expert (coach, instructor). Another viable example is a feedback system that would give real time information about athlete's performance to the coach only. The coach would then decide if immediate feedback to the athlete is necessary or not. Such system could be also used for later more detailed analysis and terminal feedback to the athlete and/or to the coach.