# Work in Progress. SportSWARES, Towards an Intelligent Way of Physical Training

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**Abstract.** There is a developing interdisciplinary research field trying to provide advanced technological support to various sports activities. This support is focused mainly to professional elite athletes but is considering also about training in sports academies, gyms even about amateur athletes practicing at home. Advanced training can now be carried out using low-cost technology that can produce useful data for researchers and coaches. Sports data collected from athlete's skeletal tracking, movement analysis and physiological measurements may prove a valuable tool for motor and technical skills development. In addition, there is an increasing interest from coaches and sports academies to enrich sport activities by utilizing the use of serious exer-games and applications of augmented reality in order to provide a more intelligent, personalized and immersive training environment. In this paper a smart platform is proposed which collects athlete's bio-signals and data from visualization of skeletal movement, it analyses them and it provides affective and sport analytics feedback through application interfaces.

**Keywords:** Sport technology · Skeletal tracking · Motion analysis · Affective computing

## 1 Introduction

Sports and physical activities deal with the human body, its characteristics and its movements. In general sports contribute to a better quality of life, developing healthier human bodies and improving cognitive functions. Recent research is trying to integrate modern technology into sports. Computer technology may prove a valuable supportive tool for:

- Athletes of all ages to improve their technical skills.
- Improve amateur sports.
- Advanced coaching.
- Psychological support for athletes under pressure or amateurs as well.

Moreover, motion capture, computer vision and computer animation techniques have made a remarkable progress providing very realistic real - time human movement representations in augmented reality applications and exergames. After 2010, the


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tendency that emerged was exergames as a profitable market and an advanced training facility. Exergames or Active Video Games are innovative tools that have the potential to turn a traditional sedentary activity, such as playing video games, in physical exercise [1]. The skills that kids and adolescents acquire during playing exergames can be transferred to real world activities and benefit physical, social, and cognitive development.

However, in sports apart from the human motor skills development, emotion is another crucial factor of human health in general [2] and therefore has a significant impact on athlete's bodies, mental health, and behaviour. It is commonly accepted that, if an athlete experiences positive emotions during a sport activity, is more like to achieve a better performance. Thus, athlete's affective awareness may prove a very significant tool of effective training providing support to self-regulation as well as to coach's efficient interventions.

Furthermore, a very popular and advanced research area named Internet of Things (IoT) can apply many advanced technology techniques like human affective awareness, motion capture and skeletal tracking to various human activities making them smarter. Several applications of IoT are related to:

- smart home,
- e-health,
- smart transportation,
- wearable technology etc. [2].

The aim of this research proposal is the development of a technological platform which can be considered as a building block of interfaces to various applications providing psychological support and promoting the development of motor skills. Thus, this dynamic platform will deepen in athlete's (amateurs or professionals) affective response like anxiety, utilizing human body physiological reactions and provide a real-time affective feedback through a wearable wristband. Moreover, the proposed system will support physical activities by applying real-time vision techniques to biomechanical analysis of skeletal tracking and human posture recognition utilizing one or more depth cameras. Thus, this IoT platform aims to facilitate a smart gym – room. All data from affective feedback and biomechanical analysis collected and analysed by this platform, will be available through specific application interfaces to third party web or augmented reality applications and exergames supporting self – regulation and self - improvement.

The following section is dealing with an overview of the related research area. Then the research motivation is presented and another section is devoted to the design and system architecture. The final section is dealing with the future steps.

## 2 Related Work

A modern attitude of sports science and physical education examines sport activities through bio-technological interventions [3]. This view is related to:

- The development of training methods.

- The development of sports materials (e.g. sports shoes, training vests, basketball balls with integrated sensors).
- The collection of various information data on sports activities and their statistical processing providing intelligent and supportive feedback like sport analytics etc.
- The production and use of pharmaceutical products as food supplements.
- Facilitated ergonomic centers
- The development of fitness equipment
- Improvements on athlete's safety in certain sports [4].
- The reinforcement or the suspension of athlete's skills in cases where certain human functions are substituted by technological tools [5].

The rapid development of electronics and computer science makes it possible to use a wide range of technological solutions to support sporting activities. The cost of these solutions varies from very cheap to very expensive [6]. However, this variety may create an additional difficulty in choosing the right product for each particular occasion. Often the prospective customer is a coach or a gym trainer and the process of choosing the right product is complicated requiring some technological knowledge. There have been developed technological applications utilizing GPS, speedometers, gyroscopes and other sensors, mainly supporting the training of team sports [6–8]. In addition, several methods of movement analysis have been introduced, which process videos of various sporting activities in the area of team sports, like football or basketball matches [6, 9, 10]. Moreover, the visual processing is applied to the movement analysis of an athlete (isolated) in order to collect data related to the biomechanical analysis of h/her motions and technique [6, 11, 12]. Similar processing also applies to the collection of data relating to the performance of an athlete or a whole team during sporting activities. Therefore, in the aforementioned cases, technology has substituted the human observation which is prone to mistakes in many cases. These data are presented as raw material or analysed after statistical processing in real - time or offline for better information and awareness [6, 13]. Information derived from an external source in relation to an athlete and known as "augmented feedback" is considered to be particularly effective during the state of athlete's technique training [6, 14].

Modern sports science does not focus on physical exercise only; it examines ways to develop the psycho-mental skills of the athlete in order to achieve better results. According to scientific studies, psychological skills in sports can be developed under specific training, improving the performance of an athlete [15]. Besides, it is a common perception that the human psychological condition directly affects h/her physical function. Modern athletic psychology deals with the development of skills and techniques in order to achieve stress management, self-control, self-confidence and positive emotions. These techniques are not necessarily addressed only to high-level athletes [15], therefore, they could be applied to any athlete of any age. According to athletic psychology, the younger aged athletes can comprehend better the psychological techniques [15]. Furthermore, the persistent monitoring of athlete's physiological state is a crucial factor to identify periods of optimal training, to follow recovery status and to get emerged of any potential overtraining [16].

In Greece as far as it is commonly known, technological tools are rarely used on sport activities, examining a wide range of them from young athletes' academies to

professional sports. Moreover, it could be supported that during training period greater emphasis is given to physical exercise than on the development of mental skills. In most cases the coach through visual observation verifies if a physical exercise is performed well and correctly without any significant technological support since most of the time the financial resources of a sports club are very limited, and they cannot afford for advanced technological solutions. In addition, usually the coaches are stressed with athlete's psychological support but in many cases, they lack the necessary knowledge, the appropriate support for the task, or even the skills required. However, as technology is rapidly expanded and developing more cost-effective technological solutions are appearing as a challenge for an outdated condition to change.

## 3 Motivation

The specification of the most suitable and appropriate training program for every case, as stated in [17], is a very crucial factor for better performance. Furthermore, the authors are suggesting that personalized training programs adapted to specific athlete's needs are more probable to succeed. However, there are many difficulties in scheduling an appropriate personalized training program as it is a very hard process to perceive every trainee's psycho - physical condition, especially in team sports or sport academies. SportSWARES and its features may approve a significant tool to contribute to the specification of the most suitable training program, to monitor the training progress and to support self – regulation and assessment of training. The proposed system could be utilized as advanced equipment of a smart training room where the athlete can be trained using skill development applications interfaced to SportSWARES platform in conjunction with his/her bio-signal measurements (Fig. 1).

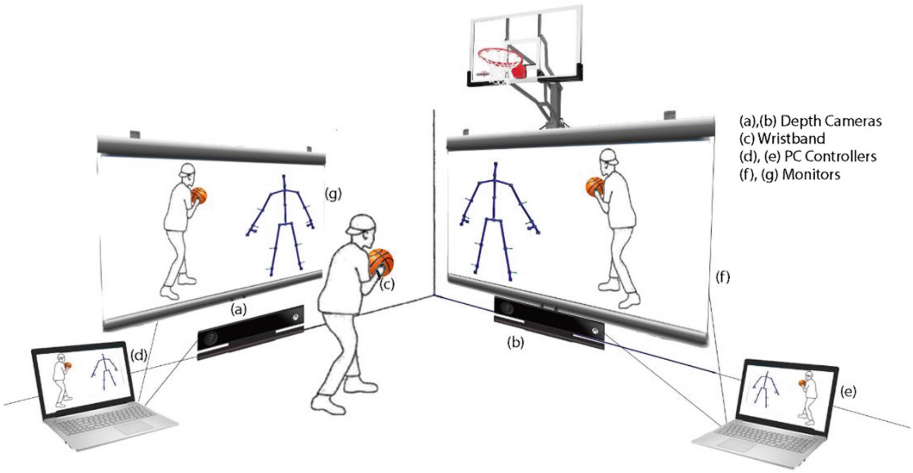


**Fig. 1.** Smart training room

## 4 System Design and Architecture

SportSWARES platform will rely on research works dealing with bio-signal processing and with skeletal tracking and motion capture such as the bio-feedback system [18] and the instructional mirroring application [19].

The bio-feedback system for anxiety awareness classifies human bio-signals applying a machine learning algorithm and displays real-time anxiety levels in interfaces executed in Windows or Android environments. This system utilizes three bio-signals, a) galvanic skin response (GSR), b) skin temperature (SKT) and c) heart rate (HR). Various cognitive and physiological functions of the human body can affect the aforementioned bio-signals. In particular, stressful situations may cause an increment of GSR and HR and a reduction of SKT.

Instructional mirroring uses the open source Vitruvius library [20], Microsoft Kinect for Windows SDK 2.0 and Microsoft Kinect sensor V2 (depth camera) in order to detect, analyse and support athlete's technique while executing free shot in basketball training. This research work was a first approach to construct a supportive tool functioning as a scaffold to athletes' practice. The core idea of this application is that many athletes use to stand in front of a mirror and practice on an exercise in order to calibrate themselves and improve their technique. Thus, the motivation of this work was to try to take advantage of this real life practice and extend it to a real time virtual mirror which will instruct and support the athlete with corrective signs.

SportSWARES will utilize the experience gathered from these aforementioned projects and extend the techniques used by them. This system will collect data from athlete's bio-signals and movements in real time in order to detect his/her psychological and physical condition. This system is consisting of the following subsystems:

- Skeletal tracking and motion detection subsystem utilizing depth cameras: This subsystem will be connected to one or more 3D depth cameras. The information received from every camera can be processed using Vitruvius library in order to apply user skeletal tracking.
- Bio- signal collection subsystem utilizing sensors of galvanic skin response (GSR) and heart rate (HR) in wearable form: This subsystem will implement a wireless connection to a device in the form of a wristband. This device will consist of an analog to digital converter (ADC) on a microcontroller board (e.g. Arduino board) connected to sensors collecting galvanic skin response (GSR) and heart rate (HR) bio-signals. Furthermore, this subsystem will collect the time intervals between successive heartbeats called "R-R intervals" in order to calculate heart rate variability (HRV) features.
- Bio - signal analysis and classification subsystem: This subsystem will process the received bio-signals applying filtering techniques, normalization and feature extraction. Then a machine learning algorithm will be applied using a pre-trained model in order to classify the bio-signal features into anxiety levels. Moreover, HRV metrics especially standard deviation of normal to normal intervals (SDNN) or root mean square of successive differences at rest (rMSSD) is significantly associated with physical capability of following a training schedule. Autonomic nervous system (ANS) function is significantly related to HRV and stress. Thus,

HRV is frequently used in the athletic world to identify periods of optimal training and to monitor recovery status and any potential overtraining [16].

- Visual and biomechanical analysis subsystem: This subsystem will utilize skeletal tracking and Vitruvius library in order to apply joint detection, joint angles and distance calculations and model user's movements.
- Open access application interface (API) providing affective feedback and biomechanical analytics to a variety of applications like augment reality applications, web applications with sport analytics and exergames: The application interface will provide real-time athlete's bio-feedback information like anxiety levels and physical capability as well as biomechanical metrics through the implementation of sockets and Web APIs. This subsystem will provide also a REST Web API applying many functions for storing and updating athlete's measurements in a database (Fig. 2).

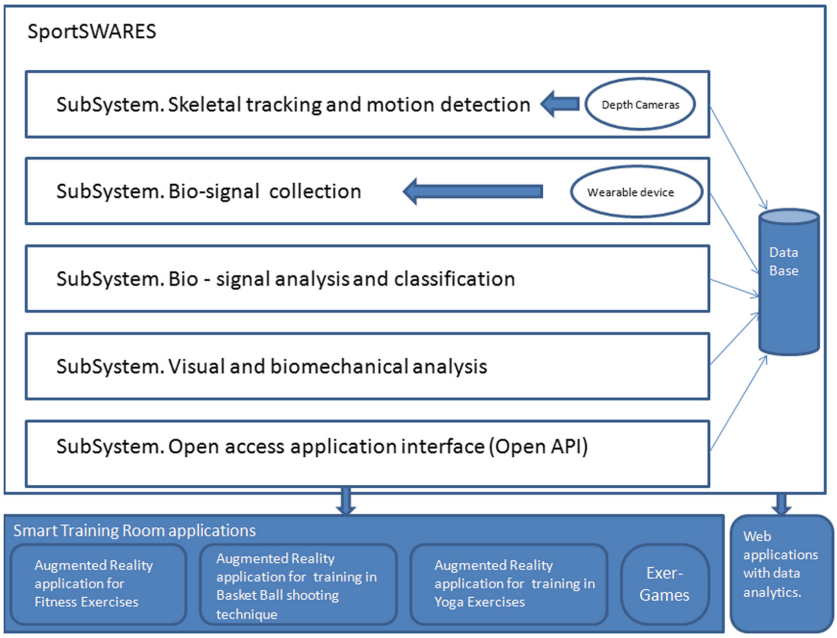


**Fig. 2.** SportsWARES architecture

## 5 Discussion and Future Steps

SportSWARES, up to the moment this article is being written, is at the stage of the development. This platform can form and facilitate a smart training room. In this room valuable information about athlete's psycho-physical condition and activity will be gathered and it will be provided through the open access API to augmented reality applications or exergames opening-up new prospects on common sport practice and training. Finally, SportSWARES long term evaluation in sports academies, fitness centers or even during house training, will present more safe results of its effectiveness.

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