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# Augmented Reality in Sports: Today and Tomorrow

**Zafer BOZYER**
Bartın University, Faculty of Economics and Administrative Sciences, Bartın, TURKEY
**Email:** zaferbozyer@bartin.edu.tr

## Abstract

The rapid change experienced in the field of Information Technologies makes the informatics more tangible in daily life. Today, it became possible to encounter with the informatics applications almost all the disciplines. As a matter of course, many informatics applications are put into the practice regarding the sports discipline. Because of the condition that the power of information processing has increased and the studies on wearable technologies in addition to the expert system design, augmented reality (AR) has become a topic which gains importance in the field of sports. There are many studies that are conducted with the aim of increasing the efficiency of physical activities done in many sports branches, ensuring a more fair management of competitions and providing the opportunity for spectators to watch the competitions in a more comfortable and efficient way. In this study; the information about the current augmented reality practices that are used in various sports branches has been given and the mobile and interactive augmented reality practices which are possible to be seen in future have been mentioned. In addition, there is an augmented reality practice which is designed with the aim of ensuring that the shoots of sports people who are interested in archery, are more stable and of ensuring that the trainings and exercises are more efficient by stating to the sports people whether he or she is in the right position for shoot which is called as T shape seen at the time of releasing the arrow.

**Keywords:** Augmented reality (AR), Sports informatics, AR applications, Augmented archery

# Sporda Arttırılmış Gerçeklik Uygulamaları: Bugünü ve Yarını


## Özet

Bilişim teknolojilerinde yaşanan hızlı değişim, bilişimi günlük hayatın içerisinde daha fazla hissedilir kılmaktadır. Günümüzde artık neredeyse her disiplinde bilişim uygulamalarına rastlamak mümkün hale gelmiştir. Doğal olarak spor disiplini ile de ilgili oldukça fazla bilişim uygulaması hayata geçirilmektedir. Uzman sistem tasarımı gibi konularla birlikte son yıllarda bilgi işlem gücünün artması ve giyilebilir teknolojiler üzerine yapılan çalışmalar nedeniyle spor alanında önem kazanan konulardan biriside arttırılmış gerçekliktir (Augmented Reality – "AR"). Birçok spor dalında yapılan fiziksel faaliyetlerinin verimliğinin artırılması, müsabakaların daha adil yönetilmesi ve müsabakaların seyirciler tarafından daha rahat takip edilebilmesi için çalışmalar yapılmıştır. Bu çalışmada ise; çeşitli spor branşlarında kullanılan mevcut arttırılmış gerçeklik uygulamaları hakkında bilgi verilmiş ve gelecekte karşımıza çıkması muhtemel olası mobil ve interaktif arttırılmış gerçeklik uygulamalarından bahsedilmiştir. Ayrıca çalışmada, okçuluk ile ilgilenen sporcular tarafından yapılan atışların daha tutarlı bir hale getirilmesi ve sporcunun oku bırakış esnasında vücudunun T formu olarak anılan doğru atış pozisyonunda olup olmadığının sporcuya bildirilerek eğitim ve antrenmanların daha verimli olmasını sağlamak üzere tasarlanan bir attırılmış gerçeklik uygulamasına yer verilmiştir.


**Anahtar Kelimeler:** Arttırılmış gerçeklik (AR), Spor bilişimi, AR uygulamaları, Arttırılmış okçuluk

## Introduction

Thanks to the rapid change which is experienced especially with 2000's in the field of informatics, technology has located into the center of our life. It is possible to access information without any time and place limits from everywhere thanks to technology. One of the points gathering importance to the developments gained in mobile technology and wearable technology is the augmented reality. Augmented reality is a new and under – development technology which makes it possible for us to see the beyond of what we see, hear the beyond of what we hear and to perceive the beyond of what we perceive by touching and what we smell. (Daponte, De Vito, Picariello, & Riccio, 2014). Being a derivative of virtual reality, AR develops the interaction with the real world and perception of its user (Azuma, 1997). While people interact in a computer environment with a copy of real world which is designed in computer environment in virtual reality practices; the virtual elements are submitted with the real world in augmented reality applications. Milgram and Kishino (1994) have positioned the augmented reality in a place in the middle of virtual reality and real world. (Figure 1). To sum up, augmented reality is submitting the information or message which is desired to be delivered to user with the help of various technologies in a way where the real world perceived via our senses by enriching with external images, sounds, data and information to the simultaneous user. Thanks to this way, the perception of a different, enriched and attractive world is created by redesigning the real world.

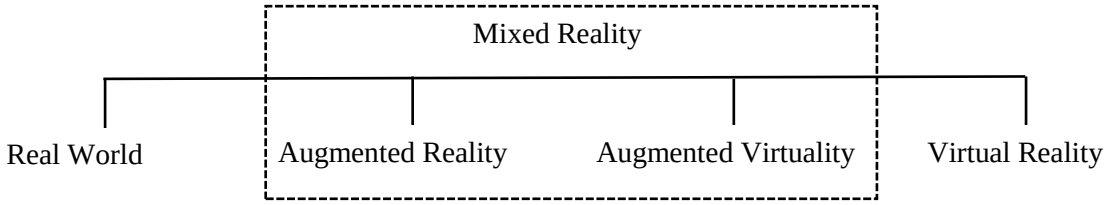


**Figure 1.** Milgram's reality–virtuality continuum (Milgram & Kishino, 1994)

It is possible to encounter with the augmented reality practices in almost all the areas where the eyesight is used especially in the fields such as education, defense, industry, medicine and tourism, etc. It is thought to be used in many fields of education especially because of the reasons that both the traditional education methods and ways not sufficient for the Z generation children who are the children of technology and augmented reality makes great contributions to education and it is also an attractive technology. (Somyürek, 2014) In the sports discipline where there are many visual elements; the augmented reality practices have the potential to provide great benefits for training of sports people. In some sports branches, the positive impacts of simultaneous information flow on conducted activities lead the experts to study on information technologies. In sports discipline, the opportunities ensured by the technology are assessed and the information technologies are benefitted in sports activities for increasing the performances of sports people (Li & Wang, 2012; Liebermann et al., 2002) and increasing the communication with the spectators who follow the sports activities in the place or through media (Boyle & Haynes, 2002). In recent years, a more emphasis is laid on applying the augmented reality in various sports branches, competition broadcast and implementation of sports education. The aim of this study is to create awareness on practicability of augmented reality technology in sports and on the opportunities created by augmented reality; to introduce the suggested or currently used applications; to define the design limits of to- be developed applications and software by taking the possible future development of augmented reality technology. In the first part of this study; general

information regarding the term of augmented reality and technologies is given. Then, the augmented reality practices made on sports discipline are transferred and the contributions of this technology into the sports activities, the management of competitions and the education of sports people have been discoursed. Afterwards, a practice which can be implemented via smart glasses in the branch of archery and which can ensure more pointed shoots by controlling the stance of sports people which is called as T shape in archery, before shoot, and controlling the position of used bow, is narrated. The aim of this practice is ensuring the personal – development of sports people up to a definite level without a trainer who narrate the mistakes that are made regarding the stance and technical points at the time of shoot by observing the sports people. In the last chapter of this study, the points regarding the possible changings which can be seen in sports discipline and in the augmented reality practices in sports training and the platforms for which the practices shall be developed are argued by taking the point to where the technology will achieve in next years. Thus, the framework of design platforms and the application – software borders for planned applications are drawn.

**Augmented Reality**

When the definitions given in the studies are taken into consideration; augmented reality can be summarized as the technologies developed for increasing the perceptions by transferring more information and data to people about real world which they perceive through their senses. Even though people concentrate on these fields in recent years; the idea to increase the perception by benefiting from the technology depends on earlier times. The patent obtained by Heilig in 1962 is one the first augmented reality ideas. Through the device which is called as Sensoroma, Heilig thought of performing the scenes shown in movies by delivering the vibrations and smell with the sounds and images given in films. The concept of augment reality has been included in the literature by Caudell & Mizell (1992). In their studies, they urged upon a glasses to be used in the manufacturing of plains in a more complex form which is made by inspiring from the protective glasses used by the employees working in factories, to increase the efficiency, performance and the quality of conducted works. In addition, within their studies, they have stated that it is more appropriate to virtualize and process images at required amounts by assuming that a more computer process force and thus more costs are required because of operating the virtual reality in computer environment after processing the real world as graphic at all. By noticing the importance of mobility in AR practices, the prototypes of especially head – mounted and wearable technology products are started to be developed and be suggested (Feiner, MacIntyre, Höllerer, & Webster, 1997; Mann, 1997). In this study, Mann (1997) has developed a mobile AR prototype (MAR) which transfers the real three dimensioned image of a university campus by compounding it with information on a transparent screen by using the global positioning system. However, this MAR is not compatible for utilization because of its 11 kilos of weight and high cost. In today's world, thanks to the developments ensured in the field of micro – electronic; it has become possible to integrate the micro – chips having high processing power with smaller devices (Carmigniani & Furht, 2011). The Mobile AR applications have become easy to develop thanks to cell phones, tablet PC's and moreover the smart watches and the GPS module which turns into a standard for glasses, the sensors for height, distance, etc. which can be integrated with AR. Eyesight is one of the most important sense of us without any doubt and it is possible to benefit from all the opportunities emerged by AR in every fields where there is eyesight. However, it has been stated that there are more AR applications developed in five main fields especially in smart phones as (i) sports, games and education (learning in

entertaining); (ii) cultural heritage and tourism, (iii) medicine, (iv) education and training, (v) marketing (Adhani & Rambli, 2012). In the future years, AR studies are will gain acceleration by submitting the smart glasses to end user and spreading its utilization.

## Method and Procedure

In the conducted study, various augmented reality applications that are found in literature and that are currently used in the field of sports have been collected and investigated under three main titles (training of sports people, management of competitions and presenting the competitions to the audience). By giving examples to the augmented reality applications used in each title; the aims of applications were mentioned. In addition, the information regarding the true form of T shape which has a fundamental role for making pointed shoots in the branch of archery have been gathered from the documents prepared by the Archery Federation. In line with this information; the video recordings of sports people during the bow shoot are taken from various angles; they have been processes via image processing methods and the stances to be analyzed have been determined. With the aim of ensuring the easy – processing of video images taken from various angles at the time when the sports person draws the bow; the bow and the arms of sports person have been indicated with different colors and the images have been processed in Java programming language.

## Augmented Reality Practices in Sports

When current practices are investigated; it is seen that the augmented reality applications in the field of sports concentrate on development of expert systems which will substitute or facilitate the training of sports people and help the trainers or on managing competitions in a more fair way and presenting the competitions to audiences in a more entertaining and attracting way. PingPongPlus, which aims analyzing the techniques of ping pong players and conducting a more interactive competition, is one of the applications developed regarding the training and analysis of sports people (Ishii, Wisneski, Orbanes, Chun, & Paradiso, 1999). In PingPongPlus, 8 microphones were installed under the table and the point to where the ball strikes was determined through the time in which the sound waves reach to each microphone. Then, collected data was transferred to the computer and the point to where the ball strikes on the table was reflected via a projector located on the table (Figure 2). By indicating each strike of ball on the table; information regarding the points to where the ball is sent at most and the tactics of players are seen simultaneously.

**Figure 2.** Marked table by PingPongPlus system

Another study which is similar to PingPongPlus aims to prevent monotony in climbing walls by ensuring more productivity from trainings conducted in climbing walls and making the climbing more entertaining with various duties (Kajastila & Hämäläinen, 2014). In the study, the area where the climbing wall is located was monitored and the collected images were processed; the next move of the sports people and the route information were reflected to wall again via projector by following the body motions of sports person. (Figure 3).

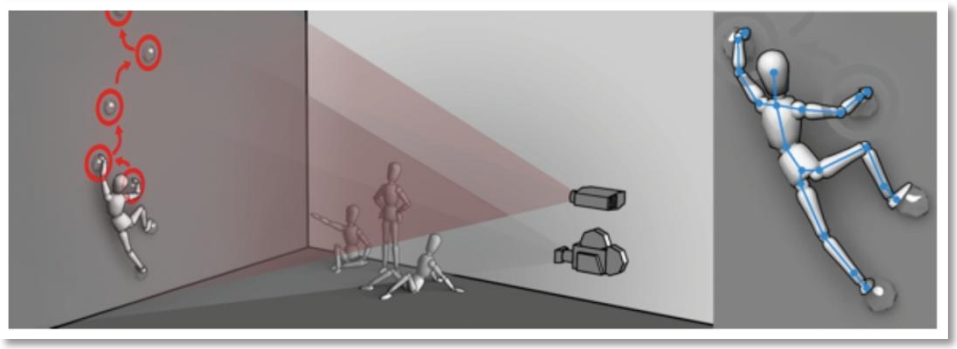

**Figure 3.** Augmented climbing wall system (Kajastila & Hämäläinen, 2014)

On the other hand, Yantaç (2011) has underlined in his study made as directed to increase the race performance of sailor that the sailor can show a better performance thanks to the glasses having the augmented reality technology to be used by the sports people using the sail and offered suggestions for interface design for to – be developed technology. Most of the advanced augmented reality applications in the field of sports are related to presenting the sports competitions to audiences. There are many applications made in this field and they are used currently. Eyeply system (Hurwitz & Jeffs, 2009) has been designed for offering

services to various aims via there layers as stadium layer, player layer and friend layer. In stadium layer, while the spectators scan various parts of stadium via mobile devices; they can see various parts as restaurants, cafes, loggias, exit doors and they are directly led to the seat where they sit. In the player layer; the previous statistics, performance tables and real time data regarding the players monitored via mobile device can be followed. In the friend layer, the options for socializations are offered. (Figure 4)

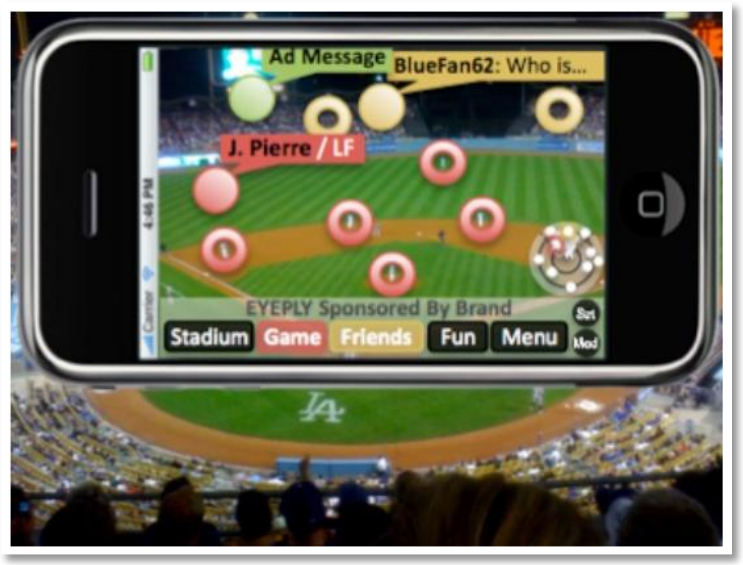


**Figure 4.** The user interface of Eyeply system

There are also many studies that are conducted for detecting and recognizing the players automatically and offering the statistical data to mentioned players automatically via an algorithm called as Adaboost (Mahmood, Ali, & Khattak, 2012). Various augmented reality applications have been developed by Sportvision that are used in sports branches such as baseball, American football, motor sports, sailing race, Olympics, etc. (Figure 5).


**Figure 5.** Sportvision applications in sports competitions ("Sportvision," n.d.)

However, except for presenting the competitions to spectators in a more entertaining and attractive way in sailing races thanks to the augmented technology; the data regarding the races are delivered to all the sports people (Honey & Mines, 2013). The Hawk-Eye innovation, on the other hand, develops applications for managing the competitions in a fairer way and for being utilized by trainers ("About Hawk-Eye", n.d.). Thanks to the system developed especially for tennis, the condition whether the ball is within the tennis court or not can be determined and the referees can have right decisions through this way (Figure 6). In addition, just like the system used in PingPongPlus system; the areas which are used by the players at most and their tactics can be followed. The applications developed for trainers by Hawk-Eye are based on following the ball via cameras, gathering quality videos and conducting the bio – mechanic analysis.


**Figure 6.** Hawk-Eye system in tennis (http://www.hawkeyeinnovations.co.uk/page/videos)

**Augmented Archery**

As stated before; the areas where the augmented reality can be applied are the trainings of sports people and the implementation of true practices. Archery can be developed just like the other sports branches by making practices. One of the most important factors for being successful in archery is to ensure the right stance in full draw by pulling the fingers under the chin at the time of drawing the bow in T shape during the shoot made to the target except for choosing the equipment which is well for the sports person ("FITA Coach's Manual", 2015). However, the condition whether the correct position is taken or not may not be understood by the sportsperson in all the times. Especially the ones, starting to archery as beginner, require an eye observing them to say whether they have the right stance or not during the shoot. Nevertheless, it may not be possible to have training with a trainer for all the times. Thus, it has been stipulated that an expert system which can observe the sportsperson and follow whether the stance is right or not and can deliver this to the sportsperson may be beneficial. The suggested system shall be constituted by cameras monitoring the sportsperson from three different angles and the information systems processing the information coming from cameras and delivering the processed information, in other words the condition whether the stance is right or wrong, to the sportsperson. (Figure 7) However, because of the reason that the smart glasses have not been released to the service commonly; the image of sportsperson seen during the shoot has been taken and the determination of right stance has been ensured. The images taken via cameras have been processed and on the condition that the sportsperson is in true position, the green virtual lines have been put on the image and on the condition that the sportsperson is in wrong position, then the red virtual lines have been put on the image. (Figure 8) In the study, the square stance which is generally preferred in archery and which can be applied easily by newly – started sports people has been argued. In line with FITA, in Olympic bows, the body is required to get the right form in each shoots fir ensuring that the (recurve) shoot is pointed and stable. FITA has stated that the draw arm during the draw

should be in the same direction with the bow when looked in profile; at the draw arm should be near to the body when looked from the top and there should be approximately 143 degree of angle between the bow arm and draw arm; there limbs should be vertical when looked from back side. ("FITA Coach's Manual", 2015).

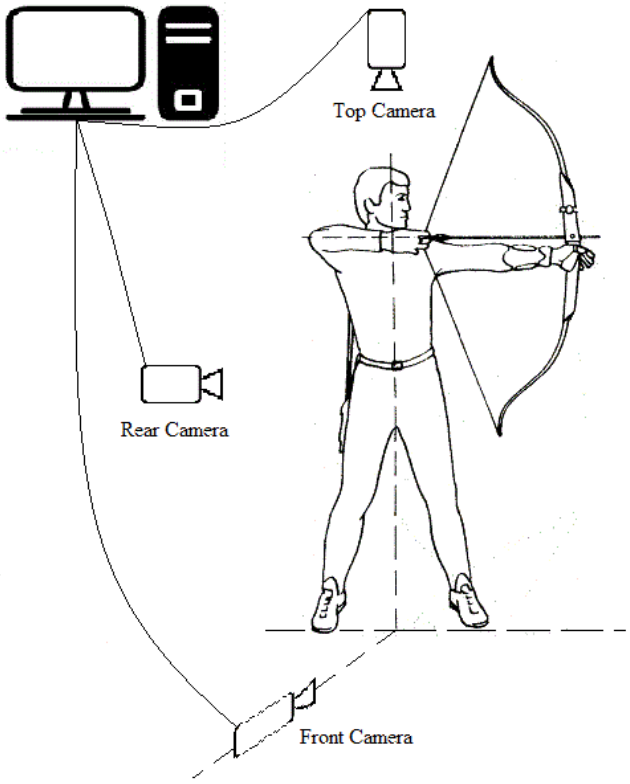


**Figure 7.** The proposed augmented archery system

In line with this information, on the condition that it is aimed to design an augmented reality application to serve as virtual trainer for sports people using Olympic bow; it is required to monitor the shooting sports person with at least three cameras. The images constantly taken from the cameras shall be processed simultaneously and the information regarding whether it is well for shooting or not shall be delivered to sports person. With wide – spread utilization of smart glasses; the application shall be adopted to the glasses and the information regarding the stance of sports person seen while looking at the target shall be delivered via smart glass to the sportsperson through a special interface to be designed. Thus, it shall be possible for the sportsperson to make practice on his / her own just like under the control of a trainer. In the study, it has been determined whether the stance of sportsperson is right or wrong in drawing the bow by processing the camera images via Java programming language. In the future, by offering the smart glasses to service, the application shall be transferred into mobile environment via Eclipse software and it shall gain a structure which can be used easily by sports people.

## Assessment and Result

It is possible to encounter with the augmented reality applications in very different fields thanks to the rapid technologic change seen within the last fifteen years. In the field of sports,

there are the augmented reality applications directed to the training of sports people and presenting the sports competitions in a way to attract the attention of spectators. However, it is a must for these applications to follow the development of technology and to endure update in line with the new technologic hardware. While a substantial part of current applications have been designed for Monitors (TV, etc.) and for platforms which can be grabbed such as smart phones, tablet PC; there is the concentration directed to wearable technology such as the smart glasses, lenses, etc. In near future, it is expected to start the designs of augmented reality applications for smart glasses and smart lenses. Because, on the condition that the augmented reality applications are transferred into mobile platforms; then they can be more productive and usable. Thus, as the technology develops; augmented reality will enter into all the areas and thus, it shall be required to mention about technology – supported sports and to produce more studies on sports informatics. It is not too far to ensure that a competition is watched from the eyes of a sports person; the personalized broadcasts are provided for each spectators and the artificial intelligence systems almost substituting the trainers are designed. In this study, current AR applications are collected and submitted with the aim of creating awareness on using the augmented reality in sports. In addition, an application has been suggested for archery and the transfer of application to mobile environment shall be ensured by wide spread usage of smart glasses.

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