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Augmented Reality and Virtual Reality: Advances in Sports

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Abstract:

Sports in general has been approached in a more digital way in the 21st century with the Internet and Computers. In this direction, the introduction of Augmented Reality (AR) and Virtual Reality (VR) has given a new outlook to many fields, especially in the field of sports. Players, coaches, sports analysts, fans and teams could benefit from the AR and VR technologies, which has proven to be economical in terms of time and finances. In this review, a short description of the how the AR and VR are utilized in the various sports, are outlined. Further, in short, it is established that integrating AR and VR along with Artificial Intelligence and Machine learning can help the user get deeper insight to the information.

Keywords —**Sports, Augmented Reality, Virtual Reality, Internet**

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I. INTRODUCTION

Analysis in Sports has risen in the 21st century and the metrics used have become complex, making the knowledge of the sport paramount to arrive at valuable results. The goal is to help players improve performance, reduce injuries and also sports businesses to increase fan following and win major tournaments [1-4]. The role of the user (analyst) is prominent in the success and efficacy of the tool; hence pertinent information should be delivered to the user as part of their training. The incorporation of modern technologies like Augmented Reality (AR) and Virtual Reality (VR) can be useful in handling the huge data and improving the performance. The primary feature of AR and VR that makes it attractive is that it lets the user to be at a remote location without compromising on the actual feel of its usage; the user can simulate an actual playing scenario at his comfort before competing in the actual environment where the stakes are high and mistakes can be expensive. Sport businesses are investing heavily on AR-VR, which can be fruitful in the longer run, not just in

cutting down the operational costs but also in terms of convenience, safety and welfare of its users [4-8]. Therefore, the stimulation through AR and VR is gaining gradual prominence nowadays.

II. SIMULATION THROUGH VIRTUAL REALITY IN SPORTS

A. The definition of Virtual Reality

VR, replaces vision and reality which can take the person to a completely new place. The new environment is generated using the computer in its entirety. The various applications of VR are represented in Fig.1. VR can be used for simulation where the user is set in a place under these special conditions (opponent player positions, stadium positions, particular game scenarios, surrounding acoustic and visual effects). The reality part that is provided is virtual as suggested by the title [9].

B. VR for Performance and Sports Analysis

Sports analysis has become an essential solution to many teams and players, as the competition and stakes increase. With greater fan following, bigger monetary prizes and social media popularity, analysis is the key to increase a team's or player's

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worth. Several Artificial Intelligence (AI) or Machine learning (ML) solutions have been used for this purpose.
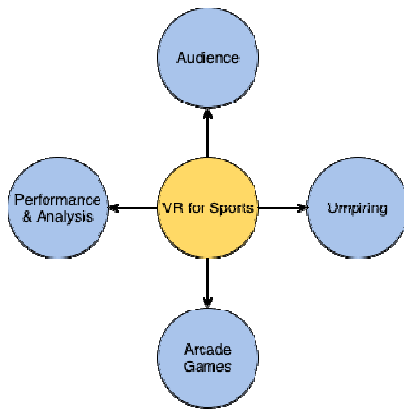

Fig. 1 Applications of VR

Integrating AR and VR solutions can help analysts deal with more data which later can prove to be more beneficial. VR can significantly help a player or a team to improve performance as a realistic match scenario such as a particular position of the opponent or a team formation can be virtually created and analysed to play against. This can help the team understand the dynamics of the game and strategize the game plan accordingly. The visualization could be made more realistic now as the computer generates this match environment at the comfort of the house. A coach can use this to devise tactics and through simulation predict the opponent's shots or moves which is popularly in the sports arena as predictive analytics. A player is now well prepared to handle that situation who can now access and anticipate and make moves; this type of analysis is termed as prescriptive analytics. In terms of outdoor sports such as football, a particular playing condition such as rain can be simulated in which conditions the ball would slip more, which can make the players prepared for a match that is going to be played in the rain. In the case of tennis, the ball pitches faster on grass (lawn) than other courts, where simulations can help the player prepare, beforehand to handle the "quicker" shots from the opponents. Many players and teams are using VR in their training regimen across different sports to get that 'edge' in the competition [10-12].

Additionally, there are some constraints in certain sports, for which the solutions can be implemented through VR.

C. VR for Sports Umpiring

Many sports such as tennis and badminton have adopted the hawk-eye system. This is a real-time computer-generated animation on the events of the match, that can help an umpire decide if a particular shot that has been played fell in or out. This is a beneficial tool to ensure fairness in the match that would otherwise be prone to human errors. The same could be applied to football where the ball has a sensor embedded to it that shows its position real-time on a computer screen and the empire could then decide if the ball has crossed the goal line and the team should be awarded a goal or not. VR helps match officials in major tournaments across different sports and leagues to ensure that the rules of the competitions are not breached, and no team is given an unfair opportunity during play [14].

D. VR for Audience

VR has the potential to bring the audience one step closer to reality. A fan can watch a game at eye-level view. The immersion of the user to the stadium through the VR can make the user experience the effects stronger than just watching it on television. In the Rio 2016 Olympics, audience could experience action through a VR headset. These can also help teams organize stadium tours and re-live key moments from the game. Team owners are investing on VR solutions to increase fan following by engaging fans in interactive activities. In a situation like Covid-19, where a massive pandemic either closed down so many events or matches were played with no in-stadium spectators, which meant a huge loss to team owners. However, with the help of VR, the entire match can be streamed almost close to reality to give the audience a feel like they were seated in a stadium with all the suitable and special effects, through the usage of VR [15].

E. VR for Arcade Games

There are some sports that cannot be played in all conditions (temperature, location and other environmental factors), these sports could be played

using VR. A sport like ice-hockey could be simulated in a VR zone where the user living in a tropical region can play. The other widely used application in major clubs and resorts would be a miniature golf course, where the entire golf course could be laid out in a 3-dimensional space that the user could stand in and play. The most common application of VR in arcade game centers is car racing [13]. On a general, the user is provided with a joystick, steering wheel and other input devices to emulate a clutch, brake and gas pedal. The screen could be 2-D or 3-D that displays the racing circuit where the user gets a realistic feeling of the race. Other dimensions of space could be added to allow the user experience special effects such as dust, moisture and vibrations arising from the racetracks and the engines. These VR applications are for recreational purposes and give the users an opportunity to get an almost close to reality experience of the actual environments.

III.   ADDED FUNCTIONALITY THROUGH AUGMENTED REALITY IN SPORTS

F. The definition of Augmented reality

According to According to Azuma [1997], "AR must have the following three characteristics: combines real and virtual screening, must be interactive in real time, and must be registered in 3D" [16]. AR adds (augments) to the reality wherein it builds upon the current scene and provides the users with digitally generated content on top of the camera content. The various applications of AR are represented in Fig.2. AR can be used to improvise on the existing environment (for example, stadium) by overlaying a layer of digital content that allows the user to perform extra functions (move objects, change theme, and add visual effects) on the scene, thus enriching the existing features. The reality part that is provided is augmented with extra content as suggested by the title.

G. AR for Sports Analysis

Enriching the application by adding AR functionality makes the application more powerful. The augmented features can make VR more intuitive for a first-timer or simplify the tasks for an

advanced user. AR is also widely used for analysis. Many sports overlay the camera's content with digital markers and metrics to denote a particular value from play.
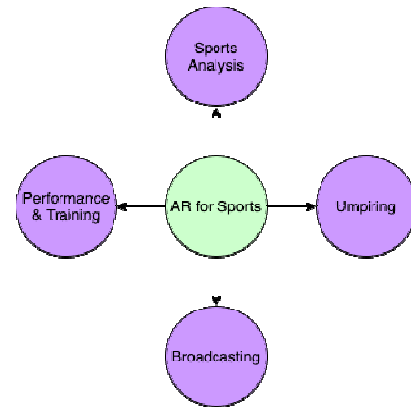

Fig. 2 Applications of AR

As seen in cricket, a batsman's range of shots are displayed with markers indicating the ball's trajectory along with colours indicating a type of shot or the runs scored. In football, the formation of the players and their movement can be trailed with markers which can later be used as feedback to improve their strategies. These extra statistics could be used by a sports analysts in a team that can be used to make strategies against their opponents. In general, adding these extra metrics could prove to be more visually helpful as the basic understanding obtained through AR-VR improves the sporting events [17]. More data and more metrics means more technical data which implicates better performance outcomes and results.

H. AR for Performance and Training

Including AR during training sessions can enhance a player's workout. As seen in sports like golf where a small subtle change to the technique can have a big impact on the performance. By integrating AR, a players could improve their swing and action that can help them maximize their performance. Subtle details such as angle, distance and point of contact could prove to contribute a massive amount to the outcome wherein these

intricate details could be better identified by AR software tools. Using AR could also guide the player with the right technique that can reduce the chances of an injury. Squatting and bench-pressing heavy weights with the wrong posture can cause instant injuries or chronic injuries if done for a prolonged period of time. AR could assist the player during training process to make sure they maintain the correct stance that can help avoid the risk of long-term injuries. AR can also be used for sports therapy or sports massage where the AR tool could identify the trigger points of release on the muscles to relieve spasms of an athlete [18].

I. AR for Umpiring

In a sport like cricket where some situations like a leg-before-wicket (LBW) is very subjective, VR can be used to improve them. The umpire can view the footage that can show the ball's trajectory with the help of markers (that are augmented) towards the wicket. This can also help in football, where identifying an 'Off-Side' could be done by projecting 2 lines. In swimming, blips can be digitally overlaid the swimmers to see their progress and confirm they are touching the sidewalls during every lap. The TV referee can re-validate the on-field referee's calls to ensure a fair-play. By digitally placing these graphic elements, an umpire could get a very accurate insight on a particular action that can ensure an unbiased game. AR and VR together, are now used in major sporting competitions across the globe where it makes the lives of the umpires or referees easier [20].

J. AR for Broadcasting

Broadcasting channels try to increase their reach and want more people to view their channel or medium. Advertisers also want to showcase their commercials on these popular channels. Many sporting channels use AR for overlaying the advertisement posters on top of the playing field or stadium. The sporting action would continue, and the broadcasting network could keep changing the advertising content at different intervals. Another application is to overlay graphics to denote a player who is a local favourite, or text that explain rules of

the sport or just the score-sheet of the game. This extra content could engage the fans more as they can understand the sport better and follow their star player. Displaying extra statistics apart from the scores could also promote the sport as fans notice the fine-tuned details of the way the game progresses [19].

K. Common Methods used in AR

In order to enable and use AR effectively, the target device should understand the nature of the surroundings before laying out the digital content. Several conventional methods are used to achieve this such as plane detection, image tracking, and object detection. The concept of plane detection is very conventional in the AR domain where the devices uses computer vision algorithms to determine a plane surface caught on camera. The plane surface can be a football field, a tennis court or a gym floor. A similar detection method to plane detection, is image tracking where the device uses the camera to find and track a particular image. Graphics like lines on the court or particular markers can be used as references by the AR application. Another important application close to image traction would be image detection where the image could contain a QR code that identifies a sporting item stored in a database housed in the cloud. The most graphic or compute intensive method is object detection. For example, a metric indicating a player's current running pace can follow the player as he is running on the field where the player is the object to be tracked here.

IV.   THE INTERNET AND THE FUTURE OF AR AND VR IN SPORTS

Mobiles are the greatest example of ubiquitous computing and the growth of cloud infrastructure have proven to feed the boom of internet usage. Wearables like smart watches, heart-rate monitors or fitness trackers can be devices that can form the important parts in the IoT universe. These so-called things can be integrated to the digital ecosystem to make its role in sports more prominent, which may improve the performance or even general awareness. These wearables can give more

information that is recorded or tracked on the target (player), which could give greater insight for analysis. The integration of IoT can mean that the AR and VR applications could be merged to make the runtimes more powerful which results in better user engagement and experience [21]. The next step after AR and VR is XR which combines both the real and virtual world elements.

V. CONCLUSIONS

The advantages of using AR and VR has proven its worthiness in niche markets, many bigger companies are trying to incorporate it in their different modes of operation. The processing power of mobile devices has continued to increase over the years – this has a direct impact on the performance of AR and VR applications. IoT and Cloud Computing have also established itself in the market which fuel most of today's large scale applications used by many billion dollar corporations, these are other important tools that enable the efficient usage of AR and VR applications.

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