A participative system for tactics analysis in sport training based on immersive virtual reality

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A Participative System for Tactics Analysis in Sport Training based on Immersive Virtual Reality

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Abstract

The use of new technologies is becoming a common practice in many competitive sports, from soccer to football, basketball, golf, tennis, swimming, etc. In particular, Virtual Reality (VR) is increasingly being used to cope with a number of aspects that are essential in athletes' preparation. Within the above context, this paper presents a platform that allows coaches to interactively create and modify game tactics, which can be then visualized simultaneously by multiple players wearing VR headsets into an immersive 3D environment.

Index Terms: Immersive Virtual Reality—Multi-user interface—game tactics analysis—training system;

1 Introduction

In the last decade, competitive sports like basketball, soccer and football, to name a few, have been characterized by the progressive introduction of new technologies aimed to support different aspects of the sport activity. This trend solicited an increasing interest by the research community, and more and more solutions have been presented to improve the efficiency and effectiveness of traditional (less technological) approaches [1, 8, 10]. In particular, Virtual Reality (VR), which is the main focus of this paper, seems to represent a promising technology capable to bring significant changes to the way a number of sport-related tasks are carried out [7]. Examples of the use of VR in sport range from tools designed to boost the players' performance [1], e.g., by improving action-reaction skills [3], to applications for psychological training helping players to mentally prepare for an important sport event [9], to solutions meant to let users experience the feeling of extreme sports [2], etc.

Another promising field in which VR is becoming a well-established practice is the analysis and planning of game tactics [4]. In the training sessions devoted to tactic analysis, players need to memorize, for instance, the movement they have to make in a particular situation that can occur during the game, the action they have to perform, etc. Traditionally, these training sessions involve the use of physical books that contain illustrations of the players' movements and actions drawn on paper or tactics boards by coaches [10]. These representations are generally rather abstract. Hence, without many hours of on-field training, players (especially the youngest ones) could find it difficult to mentally recreate the exact situation in which a given tactic should be applied [10]. VR could be a powerful technology to cope with this limitation, because it allows players to easily immerse in a virtual experience mimicking the real one [7].

Based on the above considerations, the aim of this paper is to propose a system for coaches and players named "VR Playbook", which allow them to create, visualize and study tactics that exceeds the use of 2D instruments such as tactics boards or diagrams on paper, in order to bring the players into an immersive environment where they can learn movements and actions in a (hopefully) more effective and engaging way. To this aim, features available in commercial software tools for the creation and editing of sport tactics are empowered with 3D visualizations based on immersive VR. Moreover, spatio-temporal data (3D spatial coordinates in time) of the players and of sport equipment (e.g., the ball) gathered during previous matches (through some tracking methods) can be loaded in the system to permit their visualization and analysis from different viewpoints. Recorded actions can also be altered and players' behavior revised, e.g., to correct mistakes made during the game.

Generally, the creation and analysis of tactics require the involvement of multiple users [4]. Hence, a network architecture was designed for the system, in which multiple users (coaches and players) could simultaneously connect to in order to join the same training session. At present, players' live performance is not considered. Hence devices capable to gather also users' interactions through hand controllers or other equipment, like the Oculus Rift, the HTC Vive or the new Windows Mixed Reality-based headsets, were not necessary. Rather, any device that support Google Carboard applications can be used, thus allowing for the participation of a larger number of users.

Though the devised methodology could be applied to a number of sports, so far, a prototype implementation has been developed for basketball. Advice on sport-related aspects has been provided by Francesco Raho, the technical manager of the Auxilium CUS basketball Torino's youth sector, Italy. A testing phase is currently being designed, aimed to investigate, from different perspectives, users' experience with the prototype. Based on results obtained, the analysis will hopefully move to consider the efficacy of the devised approach on a possibly revised implementation.

2 Background

In a competitive sport like basketball, several tools and applications are already present in the market to allow coaches analyze previous matches and show new tactics and behaviors to the players in order to defend and attack as best as possible against the opponents' strategy in the next game.

Examples of such tools are Dartfish[1] and LongoMatch[2], two software applications that enable video editing and labeling of game footage present in a shared database or captured in real time and allow coaches to easily discuss the results of the video analysis with the entire team. The main objective of the above tools is the generation of match reports that can be helpful to study the tactics previously adopted by the opposing team or to analyze the behavior of single players in previous games.

Another category of tools is represented by FastDraw[3] and Basketball Playbook Home[4]. These software applications allow coaches to easily draw and manage basketball plays and drills. Although every action, possibly belonging to previous games, can be created

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[1]Dartfish: `http://www.dartfish.com/`
[2]LongoMatch: `https://longomatch.com/en/`
[3]Fast Draw: `https://goo.gl/WsUSyC`
[4]Basketball Playbook Home: `https://goo.gl/wGtgWN`

by using this kind of tools, the visualization is just in two dimensions. Moreover, only Basketball Playbook Home automatically creates animations of the player's movements between frames. Generally, the outcome is a collection of static diagrams. Other products developed by companies like STRIVR[5] and Beyond Sports[6] overcome the intrinsic limitation of 2D visualizations by offering training tools leveraging immersive 360° videos [12] and VR, respectively, for different sports like football, soccer and basketball.

In the literature, many works demonstrated the effectiveness of VR for training purposes [6, 11].

For what it concerns, in particular, the design and evaluation of tactics using VR, it is worth mentioning the work in [5]. Here, a training software based on immersive VR named SIDEKIQ was developed to improve the ability of football athletes. A minimalistic interface allows coaches to create football game plays that can be visualized either on a desktop screen or using an immersive display (headset or CAVE). A user study was conducted by involving 17 football players in a 3-day evaluation. Results demonstrated the effectiveness of VR for training. SIDEKIQ was developed for one-on-one training sessions. No collaboration is allowed among the coach and the various players during the training session.

Differently than in above work, in [4] a strategy analysis tool for soccer is presented. The tool allows multiple users to jointly analyze a game from different viewpoints into a virtual space representing the pitch. Users are able to manipulate virtual objects using a tabletop interface and visualize a simple representation of the game on a wall-mounted display with virtual objects that move according to timeline information specified by the user or loaded from file. Even though realistic animations of players' movements were missing, the results of a user study carried out by the authors demonstrated that the use of the above system could facilitate the understanding of tactical errors, since users are made aware of their spatial position in the pitch. Promising results that were obtained in this work suggest to further investigate immersive technologies as interfaces for tactics visualization, with the aim to improve the users' spatial awareness. Notwithstanding, the introduction of animations and the use of realistic graphics (in [4], players' body was represented by a conic shape, players' head by a sphere, etc.) could make these systems more engaging and effective for learning purposes.

For instance, a tactics simulation software for basketball was presented in [13], where accurate 3D models of the venue and of the players were used. Moreover, high-quality animations (pass, dribbling, shooting, breakthrough, defense, etc.) were created with professional animation tools to show players' movements. The limit of this work is the lack of a tool for the creation of tactics and the modification of existing games, since actions could only be chosen from a predefined list.

Moving from the above considerations, a participative system based on wearable VR has been developed, which combines a tool for the creation and editing of tactics and a methodology for game visualization and analysis leveraging an immersive virtual environment. The system integrates realistic 3D models and animations, which were created using the Neuron Axis motion capture suit.

3 The VR Playbook System

This section describes the proposed VR system by providing details of the two core components of the overall architecture (Fig. 1), namely the *coach application* and the *player application*. Both applications have been implemented using the Unity3D real time rendering engine, since it supports building for different platforms.

3.1 Coach application

This component lets the coach create and edit tactics through an intuitive interface that has been designed for being displayed on tablet devices (Fig. 2). Interaction is based on touch gestures, which allow the coach to easily activate the various functionalities of the application. Functionalities are managed by the modules discussed in the following.

[5] STRIVR: https://strivr.com/sports/

[6] Beyond Sport: https://www.beyondsports.nl/

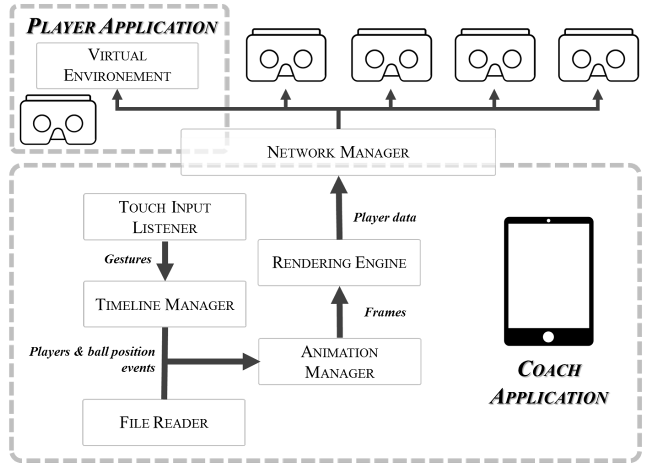

Figure 1: Architecture of the proposed system.

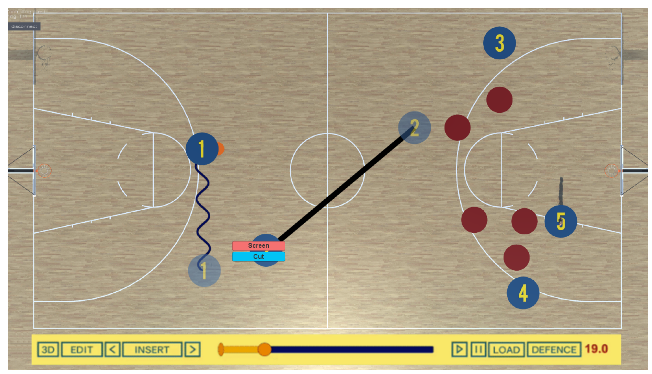

Figure 2: Graphics interface of the coach application.

3.1.1 Touch input listener

This module detects user's touches and recognizes common gestures performed on the display. In particular, press and release gestures are identified and used to specify a behavior for each virtual player (represented by a blue/red numbered icon in Fig. 5). The TouchScript[7] library that was used to deal with touch input supports also multi-touch gestures and provides mechanisms for gathering information about gestures' execution, like the beginning or end of a gesture. Thus, for instance, when the beginning of a press gesture is recognized on a player's icon, a method activates the drawing of the lines describing player' behavior according the official FIBA symbols (asking the user to choose among available alternatives).

3.1.2 Timeline manager

This module converts user's gestures performed on the tablet screen into basketball events (e.g., a player movement, a ball passing, a defense position, etc.). Events are recorded in a data structure based on *frames*, which constitutes the timeline of either the whole game or of a single play. Each frame records information concerning the 2D position and orientation of the players, the 3D position of the

[7] Touch Script: `https://goo.gl/i6gAFd`

ball, and the occurrence of given basketball events at a given instant in time.

As anticipated, in order to define a movement for a specific player, the coach should first perform a press gesture on its icon, then drag it to the desired position and finally release it. At the end of the release gesture, the user can select the movement type by choosing, at present, between "cut" (movement performed with a shot in order to beat the defender and receive the ball) and "screen" (attack movement without the ball, performed with the purpose of creating an advantage for a teammate) if the player is not the owner of the ball; otherwise, a movement with the ball is automatically added to the timeline (as for player 1 in Fig. 2). The ball owner can be defined by simply dragging and releasing the icon representing the ball (the small orange dot) near a player. If ball owner changes between two different frames, a ball passing event is automatically detected and represented through a dotted line that links the two players involved in the game play. The start position of the movement is shown with a transparent icon (see player 1 and player 2 in Fig. 2). The multi-touch features allow the coach to move more than one player at the same time.

The "*Insert*" button in the lower part of the interface allows the coach to insert a keyframe in the timeline. Frames between two keyframes are calculated by the system through interpolation. Navigation (backward and forward) in the timeline is accomplished via "<" and ">" buttons or the slider. The orange ellipse(s) over the slider indicates the presence of a keyframe defined by the coach for a given instant in time. The current frame is displayed in bottom-right corner. The "*Defence*" button lets the coach enable/disable the visualization of the opposing team (the red players).

3.1.3 File reader

As said, the devised system allows the coach to work with tactics created in previous sessions as well as with data collected from previous games using some tracking methods. The former functionality lets the coach adjust a single tactic; the latter functionality lets the coach analyze with the team computer-generated game animations in order to highlight correct movements, but also to possibly correct wrong ones (through direct editing). In both cases, it is assumed that data are stored in a file (containing spatio-temporal information and events), and a mechanism is needed to read it and create a structure comparable to the structure that would be normally generated by manual editing operations. File reading is activated by pressing the "*Load*" button, whereas the tactic is automatically saved when the coach starts the animation playback with the "*Play*" button.

3.1.4 Animation manager

This module manages the 2D and 3D visualization of the game/game play. The pressure of the "*Play*" button creates the path that the players and the ball will follow by interpolating the position data defined in the keyframes. Once the animation has been created, it is played not only on the tablet device managed by the coach, but also on players' devices connected to the live session. The "*Pause*" button suspends the visualization on all the devices.

Depending on the events specified by the coach for a given frame, different animations are activated during the playback to show, for instance, a throw, a dribbling, or a defense play. This module, which has been implemented using the Unity Animator component, is able to blend animations (e.g., the walk and run animations are mixed depending on the velocity of the player) and to manage the transition between different animations when specific situations occur in the game (e.g., a transition from dribbling to ball passing).

The "*3D*" button switches from the 2D to 3D visualization, where the icons representing players are replaced by 3D human models.

When the coach presses the "*Edit*" button, the edit mode is activated, in which modifications to the current tactic can be applied.

Figure 3: Player application: Main menu.

In this mode, the animations displayed on the players' devices connected to the live session are automatically paused.

3.1.5 Network manager

Network communications were implemented using the Photon Unity3D Networking Framework SDK[8], in order to allow multiple client devices to receive and visualize data to be shown into the VR environment through a wearable headset (worn by each player). The coach application represents the server side of the network architecture, to which up to 100 clients can theoretically connect at the same time. This module, which is present both in the coach and in the player application, is also responsible for network configuration. Lastly, it is in charge for the synchronization of the virtual objects, so that an animation played on the server is visualized at the same pace on all the connected devices.

3.2 Player application

This application is developed for devices that support Google Cardboard. Its main goal is to provide an intuitive interface to let players visualize whole games or game plays into an immersive VR environment. Once the player has connected his or her device to the live session, the interface in Fig. 3 is shown. By using his or her gaze, the player can choose the number of the (virtual) player to impersonate. This way, he or she will see the action from a fist-person perspective, as shown in Fig. 4.

When the edit mode is activated, a top-view visualization is adopted (Fig. 5), which is expected to limit motion sickness issues when the coach drags the player's representation during the editing. This visualization lets players see the tactics while they are being created by, at the same time, providing them with a wide view of the field where the position of teammates and opponents can be better identified.

4 Usage Scenario

A typical example of use of the proposed system can be summarized in the following steps.

1. The coach uses his or her tablet device to prepare a training session, by either defining several keyframes which specify the behavior of given players during one or more game plays, or by loading a file with previously recorded data.

2. He or she activates the edit mode to modify players' behavior at some instants of time.

[8]PUN: https://www.photonengine.com/en/PUN

Figure 4: Player application: First-person visualization.

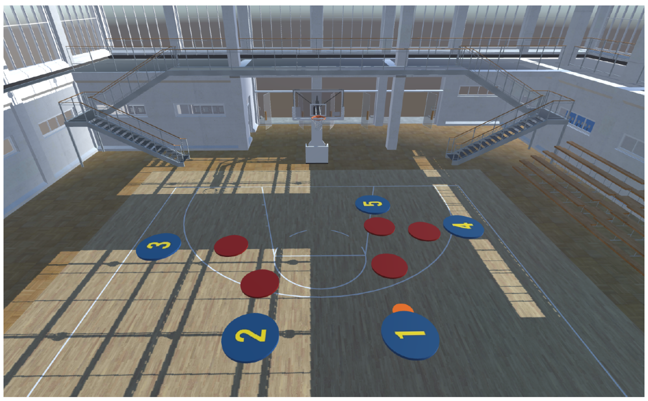

Figure 5: Player application: Visualization from top-view.

3. Multiple players connect to the live session through their VR headsets to visualize the tactics creation.

4. The coach exits the edit mode and starts the playback of the animation.

5. Players and coach visualize together the game/game play and the movements to be analyzed or learned.

6. Steps from 2 to 5 can be iterated to improve the tactics based on coach-players interaction.

A video showing the coach application (on top) and the players' interface (at the bottom) during a live session is available for download[9]. In the video, different players' movements (walking, running, etc.), as well as a ball passing and a throw animation are shown.

5 Conclusions and Future Work

In this paper, a participative VR training platform for the creation and analysis of basketball tactics is presented. The proposed system combines the features of the most common applications for tactics editing (though not all the features have been implemented in their full depth) with a tool that allows multiple users to visualize in real time the movements to be learned into an immersive VR environment.

Future work will be devoted to validate the effectiveness of the proposed system through a user study with coaches and players of the Auxilium CUS basketball Torino's youth sector, Italy. In particular, the methodology that is expected to be pursued will envisage the progressive introduction of the VR-based system in the training sessions, with the aim to collect a preliminary feedback on acceptance and usability. Aspects to be considered in the evaluation will include the users' feeling after a prolonged use of the prototype (e.g., in terms of motion sickness), the impact of the selected visualization methods on spatial awareness, the perceived importance of quality graphics and animations, etc. Afterwards, experiments aimed to evaluate the effectiveness of the devised approach on training efficacy will be planned.

From the point of view of the tool itself, new animations will be added to further enhance the realism of the simulation and completeness of the tool. Moreover, though at present collaboration among coach and players is based on oral communication, in the future the possibility to introduce dedicated interfaces directly within the VR-based system will be verified. Lastly, the applicability of the proposed methodology to other sports will be possibly investigated.

[9]video: `https://goo.gl/Rj6796`

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