

**GVR: An intuitive tool for the visualization and easy interpretation of advanced exploration methods for the analysis of soccer matches**

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**Abstract.** Raw tracking data from soccer matches is available to professional teams by specialized soccer analysis providers. However, most of this data is not fully exploited by teams because of the lack of tools to provide an interactive and intuitive visualization of the tracked positions. In this work, we are presenting virtual replay (GVR). This innovative tool allows the user to visualize tracking data by using 3D models of the players and the field from any arbitrary point of view in the virtual space, including from the perspective of the players' eyes. Additionally, GVR incorporates interactive tools that allows the user to quickly identify the players, make annotations on the field, move players to arbitrary positions and measure distances between selected players. Moreover, GVR allows the integration of advanced data exploration methods and visualizations such as pitch control models.

**Keywords:** Soccer tracking data · match analysis tools · soccer match visualization · 3D replay · intuitive visualization.

## **1 Introduction**

Current soccer performance data can be divided into two categories: i) statistics on individual players or teams (i.e., team ball possessions, successful passes, number of shots on target, total distance traveled, maximum velocity, number of sprints, etc.), and (ii) detailed

spatiotemporal information of the players and the ball during the match (i.e., raw tracking data).

The first type of data is normally provided to the team's coaching staff and his sports intelligence team in printed or digital reports containing plots, charts, and tables, which are useful to identify individual and collective skills of teams and players. On the other hand, raw tracking data is given as files containing the coordinates of each player and the ball on the field at regular time intervals. Normally, the tracking data is converted to a 2D top-view representation on which the players are depicted as tokens of different colors that move along an image that represents the soccer field (e.g., Fig. 1(a)). Tracking data can also be used to compute other high-order analysis such as those based on Voronoi tessellation (e.g., [2,4]) and other advanced pitch control models (e.g., [5,1]). Unfortunately, it isn't easy for the coaching staff to understand, explore, and exploit these models, so soccer clubs have to rely on data scientists who are capable of implementing these models and interpret the data. Similarly, while top-view videos can be useful to coaches to evaluate team tactics of previous matches, it would be game-changing if visualization of the tracking data could employ human models and perspective views that could bring a more natural and intuitive feeling of the data recollected from the game, and therefore, be easier to interact with the data collected (e.g., make annotations or visualize hypothetical variations of the field positions of one or more players), as well as to interact and understand the more advanced models (such as pitch control, xT, among others).

In this work, we present virtual replay (GVR). This cutting-edge tool allows the user (e.g., the coaching staff) to visualize the on-the-ball action and tracking data through 3D models of the players and field from any arbitrary point of view in the virtual space (including POV from the perspective of the eyes of the players). Additionally, GVR incorporates tools that allows the user to identify the players quickly, make annotations on the field, move players interactively, and dynamically measure the distance between selected players. GVR also allows the incorporation of more advanced visualizations such as pitch control models.

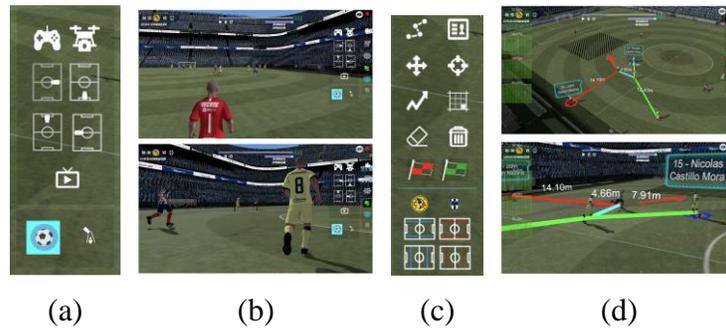


**Fig.1.** Example of (a) a common visualization of tracking data in soccer, and (b) the user interface of the proposed tool: GVR.

## 2 Methods

We employed a game engine to develop the proposed tool. In this environment, we created a “player” type game-object which consists of a 3D model of a soccer player and a two-dimensional array that contains the raw tracking data (positions  $x_p(t)$  and  $y_p(t)$  on the field) corresponding to each player from the match. Each player object incorporates a script that controls the 3D model’s position depending on the point in time  $t$  of the tracking data. For a more natural visualization of the play, each player object has a second script that controls the animation of the 3D model (i.e., movements such as walking, trotting, running, tackles, foot shots, headers, throw-ins, etc.) depending on the actions of the real-life players during the corresponding instants in the game.

Similarly, a “ball” type game object is generated. In this case, the ball tracking data is complemented with the following four possible states: (i) the ball is with a player, (ii) the ball is leaving a position by ground, (iii) the ball is leaving a position by air, and (iv) the ball is at an arbitrary position in the field. The ball object incorporates a script that determines the three dimensional position of the ball  $[x_b(t), y_b(t), z_b(t)]$  for any given moment  $t$ . With the appropriate set of states of the ball, it is possible to recreate ground and air passes, ball bounces and shots on goal.



**Fig.2.** Depiction of (a) the camera position menu, (b) examples of two arbitrary views of the same instant of a play portrayed from different perspectives, (c) the annotation tools menu, and (d) two perspectives of the same play with annotations on the field and players.

For a given soccer match, we instantiate a ball and the number of players on the field in the raw tracking data. The positions of the player and ball objects are modified depending on a defined time instant  $t$  that is set by a time progress-bar element and a script that increments its position at regular intervals (corresponding to the sampling rate of the tracking data) similar to regular video media controllers (Fig. 1(b)).

GVR incorporates a set of tools that allows users to easily manipulate the camera of the 3D replay (Fig. 2(a)) and set it at any position of the virtual field (Fig. 2(d)). One of these arbitrary positions is from the perspective of the eyes of any player on the field, which allows the user to “see what the player was able to see at any specific time during the game” (Fig. 2(b)). A set of annotation tools (Fig. 2(c)) provides the user the possibility to identify the players in the field quickly, make annotations, move players interactively, and dynamically measure the distance between selected players (Fig. 2(d)). In addition to the 3D recreation of the game, we add the option of watching synchronized videos of the play that can consist of panoramic or TV videos (Fig. 3).

The proposed tool is capable of incorporating more advanced tracking data analysis tools such as pitch control models. For example, we employed the pitch control code provided by Laurie Shaw, which is

available at [3] to project the results of the model into the virtual field, synchronized and influenced by the movement of the players (Fig. 4(a)). Additionally, when the user moves a player using the GVR tool, we added an automatic execution of a python script that re-computes the pitch control to evaluate the impact of the player's new hypothetical position, and project it on the field (Fig. 3).

It is important to note that currently existing and future discoveries can be easily integrated into GVR, which can help bridge the gap between scientific discoveries and non-scientific users.



**Fig.3.** Example of a panoramic video at the same instant of the 3D GVR replay.



**Fig.4.** Example of pitch control of the same play at the same moment (a) with the players on their original positions, and (b) with player 13 moved to a different position.

### 3 Results

We selected a play from a soccer match and showed the panoramic video of that play to Alfonso Sosa (who holds the all-time record for promoted teams. As a Head Coach, he has promoted 3 different clubs into Mexican First Division and has been Head Coach of several First Division clubs). We asked him to find an alternative action to what actually happened that could have added value to the play. The conclusion was that all players seemed to have acted correctly. Next, we presented him with a 2D representation of the same play. His answer remained the same. Finally, we showed him the same play using GVR, where we activated the pitch control tool, and asked the expert coach to analyze the play using the annotation tools. This time, he concluded that there was one player who had a better alternative and could have and acted differently (video at <https://youtu.be/7463DD547Jw>). This demonstrates the value of having a user-friendly and comprehensive analysis tool that does not require the user to have any previous training. The user can see immediate results which are easy to visualize and put into context.

Additionally, GVR has been used by professional coaches such as Gustavo Matosas (as Head Coach he has won three 1<sup>st</sup> division league titles, 1 with Danubio (Uruguay) and 2 with Leon (México), and one International Concacaf title with America (Mexico)), Raúl Gutiérrez, (World Cup Champion U17, Head Coach of the Mexican National team, among other championships) Paco Jémez (former Head Coach of Rayo Vallecano, Las Palmas (Spain) and Cruz Azul (Mexico)) and Jose Manuel “Chepo” de la Torre (Former Head Coach of the Mexican National Team (Champion at 2011 Concacaf tournament,) and has won three 1<sup>st</sup> division league titles in Mexico, 1 with Chivas (México), 2 with Toluca (México)), and others, in US live National TV during the 2018 World Cup to explain the most relevant plays (Fig. 5(a), video at <https://youtu.be/5Hayy3xdgVM>).

The results were positive- given that users without prior training were able to interact with the tools which helped them to easily explain and portray their analysis and thoughts in real-time broadcast (LIVE).

We achieved to replicate the plays in 2 minutes maximum after the play occurred, allowing us to include plays that happened in the last

seconds of the first half within time for clients to use during the half-time show.

Additionally, the tool was modified to be able to work with augmented reality technologies that enable to project a “hologram” of the field. This allowed users to replay the best plays in a unique and interactive form during the half-time broadcasts of the World Cup 2018 (Fig. 5(b), video at <https://youtu.be/zzpoRKDqblA>).



**Fig.5.** Examples of applications of GVR during World Cup 2018 (Univision, USA). (a) An example of media talent using GVR to analyze a play during a live broadcast, and (b) an example of a hologram of a play on the TV set presented during a live broadcast.

## 4 Discussion

First division coaching staff are often retired professional soccer players who learnt “old school” how to make decisions based on knowledge, experience and intuition.

Up until today, in order to learn from past games, players and coaching staff had to rely on basically three options: a subjective interpretation of the reality (e.g., knowledge, experience, memory and intuition), statistics and data (which sometimes are not exactly user friendly, therefore hard to understand) or video recordings of the game. In this work, we present the fourth option. GVR helps the user to learn from past games in a very user-friendly and intuitive way: they can learn from the data and information obtained with the most advanced methods

such as xT, pitch control, VAEP, etc... by experiencing the sense of “traveling to the past” (Example on <https://youtu.be/buDC93U4fLo>). GVR replicates the data and all of the plays that happened during the game in a “virtual world,” which helps the players and coaches “re-live” the play’s experienced and understand the full reality while having a more contextualized picture of the events. Users can even experience the game by using virtual or augmented reality headsets, such as Oculus, HTC-Vive, Hololens, etc.

There have been great advances in the research of soccer analysis methods such as xT, pitch control, VAEP, etc. that allow the users to understand the strengths and opportunities a team/player has available, and that it can benefit the soccer clubs if the coaching staff can use them. However, as mentioned above, most of the people who integrate the coaching staff do not come from a scientific/data analysis background. In order for these advances to have a significant impact in today’s soccer, all teams must have easy access and understanding of how they could use these advances to their advantage. Unfortunately, there are many soccer clubs around the globe with little or no economic resources to create/maintain a science department they can rely on, therefore there is a big gap between scientific discoveries and final users worldwide. The proposed tool is designed to allow non-scientific users, including players and coaching staff, to use the most advanced scientific discoveries to reach the most efficient conclusions based on hard-fact evidence.

Examples of the possible uses of the proposed GVR tool are:

- Professional players and coaches can “travel back in time” to the situation of a specific play and analyze whether other options were available. Then, by integrating value measuring tools (e.g., pitch control, expected goal, expected threat, VAEP, etc.) GVR can provide users with easy-to-understand and immediate feedback.
  - o An example of this could be analyzing a play where a player loses the ball because a bad decision (not bad execution)- where he may have thought he was forced into an action- to possibly realizing that he had an alternate choice of action, by using the analysis tools.
- Users can employ GVR to understand the rivals’ movements, explore their strengths and weaknesses, and exploit them.

- By using VR headsets such as Oculus or HTC-vive, youth players can immerse themselves in the eyes of professional players, and learn how they should be moving, as well as mentally prepare to experience what it would be to play in fan-packed stadiums.

## 5 Conclusion

GVR can help speed up non-scientific users' process to understand and use tracking data on a day-to-day basis, in their decision-making process, and in their evolution to integrate all of the scientific discoveries into their training.

Most of the findings made by the non-scientific users in this work could be something that can be calculated and found automatically by a computer. Computers have the ability to analyze more extensive and more complex data; however, there will always be the need for tools that can be used by non-scientific users without previous training to interact and understand the most advanced scientific tools and discoveries.

GVR code is available for research purposes upon request.

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