

Hybrid XRSpectator: A Hybrid Tabletop XR Sports Spectating Experience

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Figure 1: Our Hybrid XRSpectator prototype enables an immersive and remote sports spectating with situated visualizations. Left: Screenshot of XRSpectator showing the table top experience. Right: After switching to indirect AR.

ABSTRACT

In this demonstration, we present Hybrid XRSpectator — a hybrid combination of Augmented Reality (AR) and Indirect AR for an immersive home-based sports spectating experience. Sports fans who cannot be physically present at a live game can use the application to engage with game information via a Tabletop Stadium AR at home, then seamlessly transition into an indirect AR mode where they are surrounded by a 360-degree video recording of the stadium experience, complete with integrated information and replays. This hybrid combination of AR and Indirect AR gives users a better understanding of the game while increasing engagement and immersion.

1 INTRODUCTION

Our initial motivation for developing an AR sports spectating experience stemmed from the lack of commentary and game insights during live matches. To address this lack, in earlier work we developed ARSpectator [8], which overlays situated visualizations onto the playing field [2], followed by the development of XRSpectator [1], introducing a VR module that immerses spectators in 360° video recordings of stadium games in a VR headset.

Within our research, we discovered the need for supporting remote spectators in their ability to interactively explore game-relevant statistics. Earlier work on table-top-based AR soccer experiences further inspired our work [4] by providing immersive replays of a soccer game on a table computed from broadcast camera input.

These inspirations motivated us to develop a Hybrid XRSpectator interface (Figure 1), where we combine the benefits of AR and Indirect AR [7], bringing an augmented tabletop experience that allows to transition into an interactive 360° video recording that simulates an on-site AR experience. This provides game insights from an aerial vantage point before adopting a spectator’s perspective in the stadium. Currently we mainly support a handheld mobile

mixed reality (MR) experience, but experimented with MR headsets that could be used in the near future.

As AR sports spectating experiences emerge in academia [8] and industry¹, immersive home-based solutions remain scarce. While there are AR apps that enrich televised content with supplementary insights through AR-TV [3], it differs from our research, where we distinctively enhance spatial comprehension via a virtual stadium model before transitioning into an immersive, stadium-like experience through indirect AR.

2 HYBRID XRSPECTATOR

Although Hybrid XRSpectator was designed for Rugby Union, the concept is applicable to almost every type of sports. Here, we describe the overall system, use cases and future potentials.

2.1 System Overview

The Hybrid XRSpectator system is built on the original ARSpectator system [8] and comprises three primary components: *Content Sources*, *User Localization*, and *Client Device*. The *Content Sources* stores game-related data and summaries, whereas the *User Localization* component, employs different localization methods including marker-based localization and line-based localization [5]. The *Client Device* then utilizes this data to populate the virtual field with relevant content (Figure 1, left) such as the visualization of locations of game events (e.g. fouls, tackles) or player annotations or heatmaps. Currently, the system stores stadium models and multimedia assets, such as 360-degree videos, on the device. However, we are exploring avenues for live-streaming these assets as needed in the future, which would be an ideal approach.

Hybrid XRSpectator is built using Unity3D and supports multiple modalities. For content alignment, we employ a 3D CAD model of the stadium as an anchor for visualizations in the tabletop AR experience and the 360° video experience. The AR experience is extended by a transitional interface that puts the user into an indirect AR view when they move to preset physical locations within the tabletop 3D model. This approach is inspired by transitional interfaces that were previously used for capturing 3D data [6] using an AR interface. The trigger points for the transitions are setup using the 3D CAD model, using views that we deemed are would be beneficial for the user, such as from the center of the stands. The

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¹<https://www.fifa.com/fifaplus/en/articles/fan-experience-fifa-world-cup-qatar-2022>

resulting 360° video will also match the trigger points for a seamless viewing experience.

2.2 Demonstration

From the user's perspective, the experience commences with the tabletop AR rendering of the stadium, where users can engage with game data visualizations². The user initializes the AR view by capturing a full view of the stadium layout that functions as a marker-template for initializing the tracking. Once the stadium layout has been found and placed on the tabletop, on-device tracking is started and game-related visualizations [2] are displayed (Figure 2). By physically maneuvering the device to certain positions within the tabletop stadium, the user transitions then into an indirect AR view, immersing themselves in a 360-degree video recording of the stadium. This approach blends the advantages of AR and indirect AR to deliver an enriched, immersive experience to the user, combining an overview with spatial understanding in the miniature mode, followed by a first-person perspective in the 360° video mode. The user can switch back to the AR view using the user interface.

3 USE-CASES

There are two primary use cases for Hybrid XRSpectator: (1) Remote Match Engagement and (2) Lab-based Development for On-site AR Sports Spectating. Apart from that, we also describe some future potentials of XRSpectator.

3.1 Remote Post-Match Engagement

This use case facilitates remote viewers in engaging with the game statistics through an immersive experience. Users initially interact with a tabletop miniature stadium, where key statistics and highlights are displayed on the field to provide spatial understanding. Subsequently, Hybrid XRSpectator transitions them into an immersive first-person view inside the stadium through indirect AR, letting them relive selected game events. It is important to note that Hybrid XRSpectator is intended for engaging with highlights to reduce hand fatigue as it is a handheld mobile experience. For the demonstration, participants would be able to see a summary of a game and then transition into a recording of a practice session in the stadium, with some visualizations on field.

3.2 Development for On-site AR Sports Spectating

This use case supports the development and content creation for on-site spectators seeking in-depth game insights. Using the localization module, XRSpectator calculates the spectator's position within the stadium and overlays relevant data and visualizations into their surroundings. For development and demonstration purposes, we simulate an on-site experience using printed views depicting different virtual stadium viewpoints. Participants can then interact with these perspectives via the provided mobile phone, as the localization module computes their simulated position and orientation within the stadium. The augmented content is dynamically adjusted based on this information, showcasing the system's potential during a live spectating experience.

3.3 Future Potentials

Beyond these use cases, there is potential for extending Hybrid XRSpectator to a broader audience, including sports coaches, assistants, and athletes. With the capability to review past matches from varying perspectives and coupled with insightful data, it can be an invaluable tool for performance analysis and strategic discussions. Moreover, the system's applications can extend beyond sports to encompass other events such as concerts or exhibitions, where immersive and informative experiences are sought after.



Figure 2: Demonstration the Tabletop XRSpectator prototype. A user explores the tabletop prototype.

4 CONCLUSION AND FUTURE WORK

By seamlessly integrating Augmented Reality (AR) and Indirect AR, Hybrid XRSpectator fosters an immersive and informative experience for remote sports spectators. The ability to engage with game summaries through a virtual tabletop stadium and transition into first-person viewpoints in the stadium via indirect AR enriches the match engagement for remote viewers. Hybrid XRSpectator's modular design is also versatile and extensible to different venues. While the current demonstration is for mobile devices, the advancements in VR headset technology suggests promising avenues for future development. In the future, Hybrid XRSpectator could extend beyond sports, potentially into different sectors such as entertainment and commercial events. Our demonstration is just a preview of what there is to come in the avenue of sports spectating.

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²Video Demonstration: https://youtu.be/N3THcf1XN_w