XRSpectator: Immersive, Augmented Sports Spectating

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Figure 1: Our XRSpectator prototype allowing immersive remote sports spectating with situated visualizations. Left: Screenshot of XRSpectator showing a game stats panel, triggered by looking at the timer. Right: When the user focuses on the 22-meters line, additional information appears explaining the lines on the field.

ABSTRACT

In-stadium sports spectating delivers a unique social experience in a variety of sports. However, in contrast to broadcast delivery, it lacks the provision of real-time information augmentation, like game statistics overlaid on screen. In an earlier iteration, we developed ARSpectator, a prototypical, mobile system which can be brought to the stadium to experience both, the live sport action and situated infographics spatially augmented into the scene. In some situations it is difficult or often impossible to go to the stadium though, for instance because of limited stadium access during pandemics or when wanting to conduct controlled user studies. We address this by turning our ARSpectator system into an indirect augmented reality experience deployed to an immersive, virtual reality head-mounted display: The live stadium experience is delivered by way of a surrounding 360 video recording while maintaining and extending the provision of interactive, situated infographics. With our XRSpectator demo prototype presented here, users can have an ARSpectator experience of a rugby game in our local stadium.

CCS CONCEPTS

• **Human-centered computing → Visual analytics**.

KEYWORDS

mixed reality, sports spectating, situated visualization

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1 INTRODUCTION

Our motivation to create a tool to facilitate sports spectating arises from the lack of commentary and game statistics provided to on-site sports spectators. We created an on-site AR experience in which spectators can get insight to a game via situated visualizations[2, 4]. Unfortunately, access to the stadium, can be limited or even impossible, eg. during the COVID-19 pandemic or when trying to conduct users studies in a controlled way. The concept of indirect AR [3] can be used to provide a similar experience to attending the live sports event. If combined with an immersive, virtual reality (VR) head-mounted display (HMD), we are effectively turning an AR stadium experience into an XR stadium experience, which we call XRSpectator. Users can see a recording of the game in the headset with situated visualizations augmented onto an in-stadium recorded 360 video. We implemented a center of field-of-view cursor interaction method where viewers can interact with certain elements they see by looking at them. Here, we present our XRSpectator system and discuss further uses cases and the potential this might bring to other application scenarios and contexts.

YouTube and other services allow to watch 360 videos on a mobile device, VR HMD or a web browser. There are also various VR experiences where the environment is completely virtual, such as the Anne Frank house VR experience [1]. XRSpectator is a hybrid of both, bringing interactive augmented visualizations spatially into a recorded 360 video, retaining context to the scene in the

[1]https://www.annefrank.org/en/about-us/what-we-do/publications/anne-frank-house-virtual-reality/

video. Hence, it is like an AR experience but in a remote setting, geographically separated from the actual location.

2 XRSPECTATOR

We designed XRSpectator initially with the use case of spectating the game of Rugby Union. However, the concept is applicable in many different scenarios and use cases. Here, we will describe how it works and a variety of use cases for XRSpectator. We also discuss some of the features that will help to improve on-site and off-site sports spectator experiences in the future.

2.1 Development

XRSpectator is derived from our mobile AR system ARSpectator which allows for real-time, spatial overlay of infographics on-site during actual gameplay. We extended this concept towards an indirect AR prototype where a 360 video is used to simulate a stadium environment in which a game is happening.This is now brought into a VR HMD, where the user interaction has to be altered and tailored to this new medium since there is no on-screen user interface. We use a center of field of view (FOV) cursor method to interact with the various visualizations. Users look at a particular point of interest and relevant information appears in-situ and on-demand.

In order to place augmented content in a spatially correct way, we utilize a 3D CAD model of the stadium to assist in anchoring visualizations. The model aids the process of locating canvases in which we can place visualizations coherent with the environment. The visualizations in the actual AR application take the position and viewing direction of the user in the stadium into consideration [1]. However, for XRSpectator, this is a fixed pre-calibrated seat as this is a simulated experience from a video.

2.2 Use-cases

Apart from our focus use case, supporting sports spectators, we identified additional use cases during our research, development, and evaluations. For instance, sports coaches, assistants, and trainers could utilize XRSpectator to replay past matches, view them from different perspectives, and getting relevant information like player performance data embedded into the actual scene. Players themselves, as well as referees, and other active stakeholders could use the same techniques to improve performance.

Apart from Rugby Union, XRSpectator could also be used in most sports in a stadium or arena-like environment, e.g. soccer and basketball. Both pre-recorded and live user experiences would be possible if bandwidth and processing infrastructure is available. This could also work in a concert environment where users would experience a recorded or live gig. Apart from the different viewpoints at the venue, real-time event-related information and artistic content could be overlaid in the same way as our sports statistics.

2.3 Potential in Sports Spectating

Here we discuss the potential benefits XRSpectator could provide over simply replaying a 360 video. By allowing interactivity with the visualizations, spectators can get on-demand information whenever they want to, rather than getting standard, potentially cluttering information. Our simulated, time-stamped visualizations can be shown automatically like game or team stats (Figure 1, Left), but

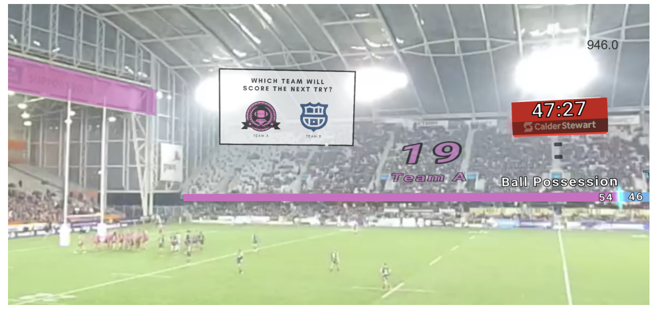

Figure 2: The prediction poll feature in which spectators can choose their pick where the results will be shown later.

also can be hidden when not needed. Spectators just need to look at the timer for game related states and the score of each team on the stands for team-based statistics appears, for instance.

Prediction polls (Figure 2) will engage spectators that are watching remotely together. E.g., simple prediction polls of who will score the next penalty goal would let spectators speculate, increasing the engagement towards the game and could also provide an indication of what the general crowd consensus is. Game assisting visual aids can also be integrated with the help of the stadium model such as looking at the lines on the field (Figure 1, Right) to get a general understanding of the terminology and role of each line.

3 CONCLUSION AND FUTURE WORK

In conclusion, we demonstrated an immersive remote sports spectating experience in which spectators can get a feeling of being seated in a stadium without physically being there. The introduction of game-related information facilitates a better understanding and allows for crowd engagement. However, one of the limitations is the fidelity of the 360 videos. In the future, high resolution multi-camera setups might be needed, requiring high bandwidth and computing infrastructure. There is also a lack of depth information as the 360 video is only two-dimensional, causing some visualizations to look out of place, potentially breaking the immersion. Future work will go into applying depth estimation techniques, improving the interaction methods, and better 360 video recordings.

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