Augmented Reality for Supporting Accessible Sports Spectating and Training

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Abstract

Sports events are widely enjoyed. However, following the game's flow and recognizing key moments can pose challenges for attendees with varying accessibility needs. In this work, we explore using Augmented Reality (AR) to enhance accessibility and inclusivity at sports events and training sessions by providing real-time visual and contextual support to make sports experiences more engaging and comprehensible to those with vision and hearing impairments. Beyond addressing sports spectating, we also discuss how AR can achieve broader inclusivity by enabling dynamic, adaptable, and personalized visual support for sports training.

Keywords

Augmented Reality, Sports Spectating, Sports Training, Accessibility

1. Introduction

Sports events offer entertainment and exciting experiences, but fully engaging with the action can present challenges for many attendees, particularly those with accessibility needs. Individuals with hearing impairments may miss important auditory cues, such as commentary, crowd reactions, or sound effects, that help interpret the flow of the game. Similarly, those with visual impairments or difficulty following fast-paced action may struggle to perceive key moments, such as player movements, goals, or fouls. Beyond these specific impairments, a variety of attendees, whether due to temporary conditions, situational factors, or differing abilities, may benefit from enhanced support to better understand and enjoy the event.

In this work, we explore how Augmented Reality (AR) can enhance the accessibility and inclusivity of sports events and sports activities by providing real-time, contextual visual support. The AR system overlays key information directly onto the attendee's view, highlighting significant game actions, explaining important events, and offering visual cues to guide understanding of the game's progression. Our goal is to investigate how AR can bridge the gap between the fast-paced on-field action and the diverse sensory experiences of attendees, ultimately supporting a more inclusive, engaging, and accessible environment for a diverse cohort. With this work, we also want to inspire further research in this important area, as sport has become a cultural cornerstone and point of identification in many cultures.

2. Related Work

Augmented Reality (AR) has been explored as a tool to support various domains, including navigation, education, and entertainment. There is also a lot of potential to support individuals with different

The Third Workshop on Building an Inclusive and Accessible Metaverse for All, CHI, Yokohama, Japan, 2025
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accessibility needs. Particularly, AR can provide contextual and interactive information that is adaptive to users' specific needs. For instance, Zhao et al. developed a wayfinding guidance for smartglasses with visual and audio support and found that blind as well as sighted people make fewer mistakes when being presented with visual feedback [1]. Fox et al. explored how AR can be used to enhance obstacle visibility for low-vision users [2]. Zhao et al. also developed an approach to support low-vision users in stair-walking tasks [3]. Langlotz et al. introduced ChromaGlasses, computational glasses designed to compensate for colour vision deficiency [4, 5]. These glasses utilize optical see-through head-mounted displays to analyze the environment and adjust the visual output to enhance colour differentiation for users with colour vision deficiency. They demonstrated how this approach can be utilised to support people when playing computer games but mainly focused on real-world objects that are hard to distinguish. Later, they also showed in a different work how they could effectively guide the human gaze using real-world saliency modulation [6]. More recently, the XR Access[7] initiative focuses on making emerging technologies like AR and Virtual Reality (VR) accessible to people with impairments.

Similarly, in the context of sports, AR has been applied to enhance spectator experiences by overlaying real-time statistics and interactive game analyses [8]. However, there is limited research on how AR can be used to support individuals with accessibility needs during sports events and sports activities. For instance, Gong et al. explored previously how VR can be used to support the training of seated volleyball players, as there are only limited training possibilities available [9]. In our work, we aim to further address this gap by exploring how AR can support accessibility principles in sports spectating and training, providing real-time, contextual visual support to create a more inclusive and engaging environment for all attendees.

3. Design and Implementation

Figure 1: The AR overlay provides textual annotations describing a game event: "Penalty due to HIG offside in ruck". In addition, game statistics such as scoring information and game time are displayed in the user's field of view.

In our previous work, we developed an AR system that overlays real-time, context-aware information about sports events, focusing on delivering visual overlays for key game actions, player movements, and significant events like goals or penalties [8, 10]. Our initial implementation involved an on-site stadium AR prototype designed to be used on-site via mobile devices or AR headsets. Users view the action on the field through the camera live stream or an optical see-through setup, receiving additional game-related information augmented into their field of view.

Given the stadium environment, registration and tracking methods are crucial for testing, debugging, and deployment. The system integrates tracking components with different options, and requires thorough on-site testing as only the actual stadium environment can provide the necessary conditions.

Using AR for digital overlays in large-scale environments like stadiums presents challenges, particularly in placing content accurately relative to the user. In our system, we use a network-based approach to estimate the initial position and orientation of the user and then track the device locally using on-device Visual Inertial Odometry (VIO) [11].

The AR system consists of a mobile AR client and a content server. The client, available as both an iOS and Android app, uses a combination of localization and tracking to align content with the spectator's view. The content server is connected to tracking cameras and game data sources, and it delivers content based on a spatial reference model of the stadium. With this prototype, we are exploring the concept of using AR to create an accessible on-site sports spectator experience for everyone.

The AR features include:

Highlighted Player Actions and Key Moments: Key actions (e.g., scoring, passing) are emphasized through clear visual cues, such as colored outlines, directional arrows, and interactive annotations, to ensure that all users, including those with visual impairment, can quickly identify important events. Highlighting player actions also has the potential to be beneficial in training situations where a coach can use this to explain tactics and use them for planning. Having visual support from the AR application has the potential to support players with different abilities.

Real-Time Game Event Explanations: The system provides real-time text-based descriptions of the game and game situations (e.g., "Team A: Goal Scored", "Player P: Foul Committed"), and brief contextual information (Figure 1). This gives an additional explanation of game events for all users and also has the potential to provide additional support for hearing-impaired spectators to follow the game just as easily as those with full hearing.

Score and Event Visual Updates: With the AR overlays, we can provide continuous visual updates of scores and key statistics, offering all users consistent situational awareness and context throughout the game.

Visual Representation for Crowd Emotions and Fan Reactions One of the defining aspects of live sports is the collective energy of the crowd, often conveyed through loud cheers and chants. For spectators who are hearing-impaired, hard of hearing, or sensitive to auditory stimuli, these cues can be inaccessible or overwhelming. With our collaborative AR system, we translate crowd emotions into visual emoticons and ambient overlays—such as animated emoticons (Figure 2, but also other visual representations such as colour pulses or graphical indicators—reflecting fan reactions in real-time. These visual cues offer an inclusive alternative to auditory crowd noise, ensuring all users can engage with the social atmosphere.

4. Methodology

To assess the potential effectiveness of the AR system, we plan to conduct an in-the-wild user study involving participants with diverse accessibility needs, including individuals with hearing impairments and low vision. The study will be co-designed in collaboration with members of these communities to ensure that the evaluation reflects their priorities and experiences. During the study, participants will attend a live sports event while using the AR prototype on a mobile device. We aim to measure the following:

User and Fan Engagement: We plan to assess whether the AR system increases participants' ability to follow and understand the game, particularly during key moments. Engagement metrics, such as fan engagement and how often users interact with the AR features, will be measured [12].

User Satisfaction: After using the AR prototype, participants will complete questionnaires evaluating their satisfaction with the AR system's ability to enhance accessibility, focusing on how well it addresses their specific needs.

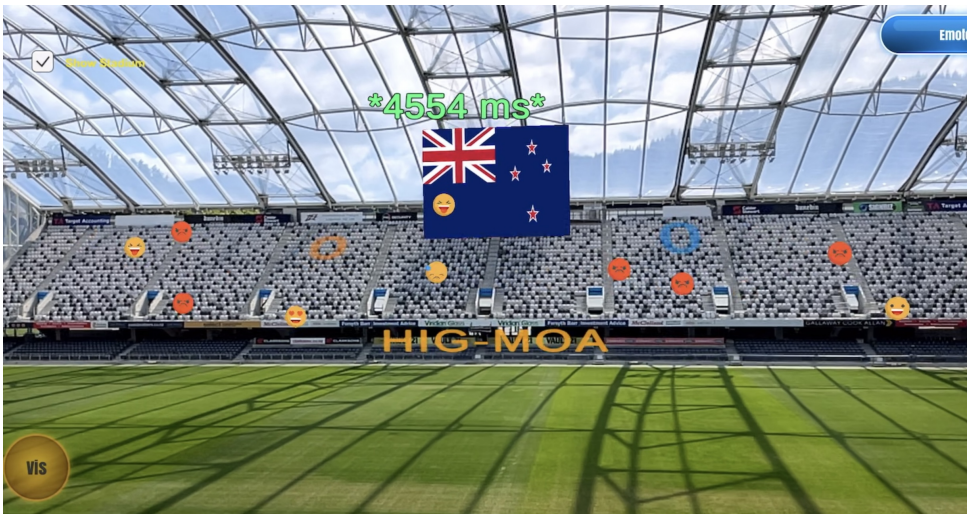

Figure 2: Visual Representation of the Crowd Emotions using spatially aligned emoticons.

Usability: Usability will be measured by how easily participants are able to navigate the AR system, access game information, and use features like text-based explanations or visual enhancements.

Perceived Accessibility Impact: We will ask participants to rate the system's perceived impact on their ability to fully experience the event, comparing their experience with and without the AR system.

5. Hypotheses

Based on the system's design and preliminary feedback from users, we anticipate that the AR system will significantly improve accessibility for spectators with different levels of accessibility needs. Expected outcomes include:

Positive Impact on Overall Satisfaction: We hypothesize that the majority of participants will express high satisfaction with the system. The AR overlays are expected to add an immersive dimension to the event, helping users stay engaged even when traditional audio or visual cues are insufficient.

Improved Understanding for Hearing-Impaired Users: We anticipate that participants with hearing impairments will find the real-time text-based explanations of game events helpful in following the action. Combining visual cues and textual descriptions is expected to ensure they do not miss critical plays, such as goals or penalties.

Enhanced Engagement for Visually Impaired Users: We expect low-vision users to benefit from features like highlighted player actions and key moments. These features are likely to make them feel more connected to the game.

6. Discussion and Future Work

We anticipate that the findings from our study will demonstrate the potential to improve accessibility in sports events for individuals with sensory sensitivities, hearing impairments and visual impairments. We hope that our findings and our development will make sports events more inclusive for spectators with varying levels of accessibility needs. Nonetheless, we recognize certain challenges that will likely emerge. For example, we expect some users may find the text-based explanations too fast to read during rapid game events. Here, we believe that an approach that adjusts to the users' needs could be beneficial for further improvements.

Additionally, while the system's potential ability to enhance visual clarity for individuals with low vision appears promising, further studies will be required to evaluate how best to support users with more severe visual impairments, such as those who rely on screen readers or audio descriptions. These

areas will form the focus of future iterations and testing phases.

Stopping one-size-fits-all systems and incorporating multi-modal feedback seems to be a future direction for these challenges. For instance, hearing-impaired users may rely on text captions and haptic alerts, while vision-impaired users may benefit from spoken descriptions and audio cues. Moreover, by supporting diverse input methods—such as voice commands, gesture controls, and touch interactions—the system empowers users to choose the mode that best fits their abilities.

While we focus on sports spectating in our planned study, another use case is using AR in sports training, with further studies needed to explore the potential for this.

7. Conclusion

This paper discusses the potential of AR to enhance accessibility at sports events, particularly for individuals with hearing impairments and visual impairments. By providing real-time, context-aware visual support and text-based explanations, the AR system has the potential to support the engagement and understanding of the game for attendees who might otherwise struggle to follow the action. With this paper, we hope to start the discussion within the research community on how AR can support users with special needs in sports events and how to make sports events inclusive and interactive for all attendees.

Acknowledgments

Parts of this work were supported by an MBIE Endeavour Smart Ideas grant. We thank Animation Research Ltd, Forsyth Barr Stadium, the Highlanders, Otago Rugby (ORFU), and OptaPerform for their support.

Declaration on Generative AI

While preparing this work, the authors used Grammarly for spell-checking but manually reviewed the changes and take responsibility of the publication's content.

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