

Full-Field Boundary Detection System

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1. Introduction

I chose to address the main issue that I think is not solved yet in modern football, which is deciding when the ball has fully crossed the boundary lines of the pitch. My reason is backed by the remarkable success that the goal-line technology (GLT) had [1], which expanded to every major football competition. Thanks to this technology, the rest of the errors that may occur on the football field are due to human error and end debates whether the ball is still on the pitch or not. This document introduces the application of computer vision which is designed to revolutionize close calls across the entire football pitch, not just the goal line.

Football, being the most popular sport in the world, influences the lives of billions and produces the most money out of any sport. Any wrong decision regarding whether a ball is still in play or not can influence the final outcome of a game and even tournament, which can have consequences on the financial side and emotional impact of fans. In today's world, where our lives are impacted by technology, it would be a pity if we didn't increase fairness in sports, by dropping controversies that may arise due to the limitations of the human eye. The naked eye often struggles to accurately perceive split-second events or millimeter-precise positions, especially in the heat of a fast-paced match, which can lead to unnecessary disputes and potentially alter the course of the entire match.

Such an example happened in the match between Real Madrid and Ajax in 2019, when in the 62nd minute Dušan Tadić scored a goal for the away side and helped eliminate the defending Champions League titleholder Real Madrid. The controversy came from the fact that the ball appeared to be out of bounds before one of Ajax's players saved it in the play and ultimately led to Tadić's goal. After a long video review using the VAR technology, the call was not overturned and the goal stood, thus the home team's chances were lost as they were 2 goals down with not much time left to play. The full-field boundary detection system addresses this problem by extending the current, in-use technology of goal-line technology, to the entire pitch, promising to

drop any controversy that may arise in the surrounding of the throw-ins, corner kicks and goal kicks.



Fig. 1: Ajax went on to score from this situation [2]

2. Tutorial

The goal-line technology showcased in the linked video serves as the basis for the proposed Full-Field-Boundary Detection System. This system expands the existing concept, from the goal line to the entire pitch, by employing a more extensive network of high-speed cameras and advanced algorithms. By doing so, it aims to maintain the same high degree of accuracy across all boundary lines.



Fig. 2: Breaking down Goal-Line Technology [3]

3. Challenges and potential solutions

The primary challenge for this computer vision application lies in its much larger space that it has to cover compared to the goal-line technology. While goal-line technology systems focus on a small area using 14 sophisticated cameras placed around the stadium at different positions pointing towards the two firm goal posts, seven focused on each [4], the Full-Field Boundary Detection System needs to keep the same degree of accuracy, but for the entire pitch. This expansion requires a much larger number of high-speed cameras that track the ball with high accuracy and use a more complex triangulation to calculate its precise position relative to all boundary lines, not just the goal line. This results in a considerably more technical challenge in terms of how the high-speed cameras should be placed around the stadium, using machine learning algorithms for efficient data processing and how the system is integrated.

Secondly, data must be processed in real time and the decision must be made on the spot, so is the goal line technology, where if the ball fully crosses the goalmouth, an encrypted signal is transmitted to the referee via a watch or an earpiece within half of a second, alerting them to a goal, in order to not disrupt the flow of the game. Also, the Full-Field Boundary Detection System must work seamlessly with other technologies that are already in use, such as VAR (Video Assistant Referee) and goal-line technology (GLT), ensuring that there are not any delays or confusions that may appear. The solution lies in developing an efficient data processing system with dedicated hardware acceleration that ensures smooth integration with current systems.

The environmental factors should also be taken into account, as the system must operate under different lighting and weather conditions and different stadium configurations. These problems can be addressed using adaptive imaging technologies and algorithms capable of adapting to various environmental conditions. But one of the main problems is on the financial side, as developing and installing such a broad system could become financially challenging for many football clubs. The expansion from goal-line technology to full-field coverage implies a substantial increase in the number of cameras, sensors, and processing units needed. To mitigate this, partnerships with technology providers and football associations should be explored to provide financial support for implementation, making it possible for the clubs to upgrade their infrastructure gradually.

4. Potential impact in our everyday life and future directions

Therefore, the fans can enjoy the football matches with an increased confidence in referees' decisions, leading to fewer controversies and a more satisfying experience. This technology, if it provides impressive results, can also be implemented in other sports, such as basketball, where such systems have not yet been implemented. Looking to the future, the integration of this system with augmented reality technology could provide real-time visualizations for viewers, both at home and in stadiums. Similar to the hawk-eye system used in tennis, spectators can see live animations showing how close the ball came to crossing the boundary lines, further enriching the viewing experience and bringing a new level of transparency and excitement.

5. References

- [1]: <https://inside.fifa.com/news/greater-use-of-goal-line-technology-2756397>
- [2]: <https://www.express.co.uk/sport/football/1096111/Real-Madrid-VAR-confusion-Ajax-goal-replay-Champions-League>
- [3]: <https://www.youtube.com/watch?v=m17ERc-kQhQ>
- [4]: <https://www.scienceabc.com/innovation/how-does-the-goal-line-technology-work.html>