

Analysis of Video Assistant Referee (VAR) in football

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ANALYSIS OF VIDEO ASSISTANT REFEREE (VAR) IN FOOTBALL

by

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ABSTRACT

Technology has long been part of sports and recently football has also started to modernize, with the introduction of goal line technology and VAR, International Football Association Board (IFAB) and *Fédération Internationale de Football Association* (FIFA) finally opened the way for technology to help referees make in-game decisions.

This paper aims to analyze the impact of VAR in football, the analysis will include VAR's weaknesses, research regarding if it is the most appropriate technology to correct human error, football's fans perception of VAR and finally if AI could one day be introduced in order to help referees evaluate subjective in-game controversial situations.

For the purpose of this paper to be achieved, surveys regarding football fans' opinion on the VAR and openness to the introduction of new technologies in football will be performed and statistics and factual data regarding VAR will have to be obtained.

Finally, by adding new research concerning a very recent topic, new technologies and opportunities can be proposed in order to make football fairer and future studies regarding this subject will be able to expand on this topic.

KEYWORDS

Technology; Football; Video Assistant Referee.

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1. INTRODUCTION

In this chapter we will provide an overall review of the research topic, the background and the problem identification, the motivation for doing this research, its objectives and finally the relevance and importance of this study.

1.1. BACKGROUND AND PROBLEM IDENTIFICATION

Technology has long been used in sports, from the first photo finish images, in horse races, taken in the late 19th century to millimetric decisions made today in all kinds of different sports. Technology can be used to both improve the refereeing, the coaches' decisions and analysis, the players performances, game fairness in general and even the fans experience, it has made the sporting world a more accurate, fair, and enjoyable experience for everyone involved.

Football refereeing is a difficult task that implies analyzing difficult and fast in-game situations in a matter of seconds, these situations can involve several players and there is the possibility of having very limited visibility. (Lex et al., 2015).

The referees possible influence in the outcome of a game is monumental and major tournament results have been conditioned by controversial referee calls, as an example, in the 1966 World cup final between England and West-Germany at Wembley stadium in London, when the score was tied 2-2, English striker Geoff Hurst made a shot that hit the underside of the crossbar, bounced down on the ground and was cleared by the West German goalkeeper. The referee was uncertain if the ball had gone in and consulted the linesman who claimed it was a goal. The game ended 4-2 to England and this remains one of the most controversial World cup final decisions ever. In addition, it led to the creation of the expression "Wembley goal", which is used to denote a "Ghost" or "Phantom-goal" awarded (but not actually scored) in a similar fashion. (Tamir & Bar-eli, 2021)

As seen above, controversial referee decisions can severely affect the outcome of a game, therefore, recently, football finally started to modernize in order to improve the quality and fairness of the game, these changes, encompassing the use of new technologies were long overdue when compared with the digital transformation present in other sports and when taking a look at the rapid development of Internet of Things (IoT) and Artificial intelligence (AI).

However, due to the conservative nature of the IFAB, the body responsible for determining the laws of the game, and FIFA, they took longer than needed to be implemented and were subject to much debate. (Ryall, 2012).

Finally, in 2012, with the help of IoT, the goal-line technology was introduced and seemingly, technology started to be allowed to help make in-game football decisions. Afterwards, in 2018, Video Assistant Referee (VAR) was launched with the goal of correcting clear and obvious errors and serious missed incidents, it was the biggest revolution in professional football for more than a century.

VAR's design is similar to that of other sports, such as tennis, basketball and American football. The VAR watches the games from a video operation room (VOR) and automatically checks every

decision being made on the pitch related to the four established reviewable calls – goal or no goal, penalty or no penalty, direct red card, and in case of mistaken identity when the referee cautions or sends off the wrong player. (International Football Association Board, 2020).

1.2. MOTIVATION

Good refereeing decisions are critical for sports enjoyment and appreciation and the VAR introduction aimed at improving these decisions in football, yet this introduction has been nothing short of controversial. Despite being effective in factual decisions such as offside, subjective decisions such as red cards or penalties remain an issue and are subject to much debate.

In spite of the introduction of VAR in major competitions, human error remains a big part of the game and VAR added to these controversies since human judgement is still necessary. It has been shown that VAR has had a negative impact on the sentiment of English Premier League spectators that post on social media (Kolbinger & Knopp, 2020), and it is likely that the same thing happens in other competitions that adopted the VAR. In the same sense, football managers tend to question or disagree with VAR decisions when they go against their club, and VAR has become a major talking point in post-match discussions. However, VAR did indeed shift the focus of discussion from the on-field referees to the video room and achieved the goal of protecting referees from making mistakes that everyone can see immediately (Chen & Davidson, 2021), in this context, some technology aided changes could still be made to make the beautiful game fairer.

IoT adoption is rapidly growing in all kinds of different areas and is forecasted to keep growing for the foreseeable future, it is already used in sports training and health monitoring in the form of motion sensors and wearable sensors, for example. It grants training staff the ability to capture their players data at anytime from anywhere, medical sensing devices are also becoming more and more portable allowing players to wear them during training sessions for supervision. (Zhan, 2021). This rapid growth and improvements can potentially lead to new ways of monitoring sports games and aid referees in making more accurate decisions.

In similar fashion, artificial intelligence is also experiencing a fast growth and could one day be used in live sports events.

The recent adoptions of technology in football and the future possibilities are the biggest motivations for the development of this study considering that the fairer the game, the more alluring the game is for fans and players alike.

With this research we aim to analyze the impact of VAR and give an overview on future possibilities.

1.3. OBJECTIVES

The goal of the paper is to find out how VAR has impacted football and to propose ways in which it could potentially be improved. In order to achieve this goal, the following intermediate objectives were defined:

- Identify VAR shortcomings;
- Analyze fans' perception on the impact of VAR;
- Analyze general football fans satisfaction with VAR;
- Study football fans openness to the introduction of AI based VAR improvements by exploring the possibility of using AI to aid in-game decisions.

1.4. STUDY RELEVANCE AND IMPORTANCE

Sports are an essential part of every human's life, they help people remain fit, healthy and in good physical shape. Sporting events have been present in society for thousands of years, from the first written records of the ancient Greek Olympic games in 776 B.C. to the Tokyo Olympics in 2021, sports have entertained the masses and have become a staple in society.

Therefore, if one is in the business of understanding how society works, they have to take sports seriously, *"It is impossible to fully understand contemporary society and culture without acknowledging the place of sport."* We live in a world where sports are an international phenomenon, politicians and world leaders want to be associated with sports personalities, it contributes to the economy and boosts tourism, while also having a large transformative power in some of the poorest areas around the globe. (Grant Jarvie & James Thornton, 2012).

Football is without a doubt the world's biggest sport, it has an extraordinary reach in different countries and cultures and is unequalled in terms of value to media and sponsors, a survey of 18 major markets has shown that the sport garners great interest in more than 40% of the population, far ahead of any other sport. (Nielsen Sports, 2018).

This study aims at allowing people to better understand how the VAR has impacted the beautiful game, to identify where improvements could be made and what technologies can potentially be used to improve the game and help referees in their decisions in the future.

The possibility of utilizing AI in in-game decisions could potentially eradicate dissent regarding referee decisions and could make games completely fair, making players, coaches and fans focus on their own performance instead of the referee's and improving the experience for everyone involved.

2. METHODOLOGY

To achieve the goal of identifying how VAR has impacted football and to propose ways in which it could potentially be improved, the methodological pathway will be divided in three different phases: the exploration phase; analytical phase and conclusive phase. Each phase will be divided in various specific steps as identified in figure 1 and will help us reach the proposed specific goals.

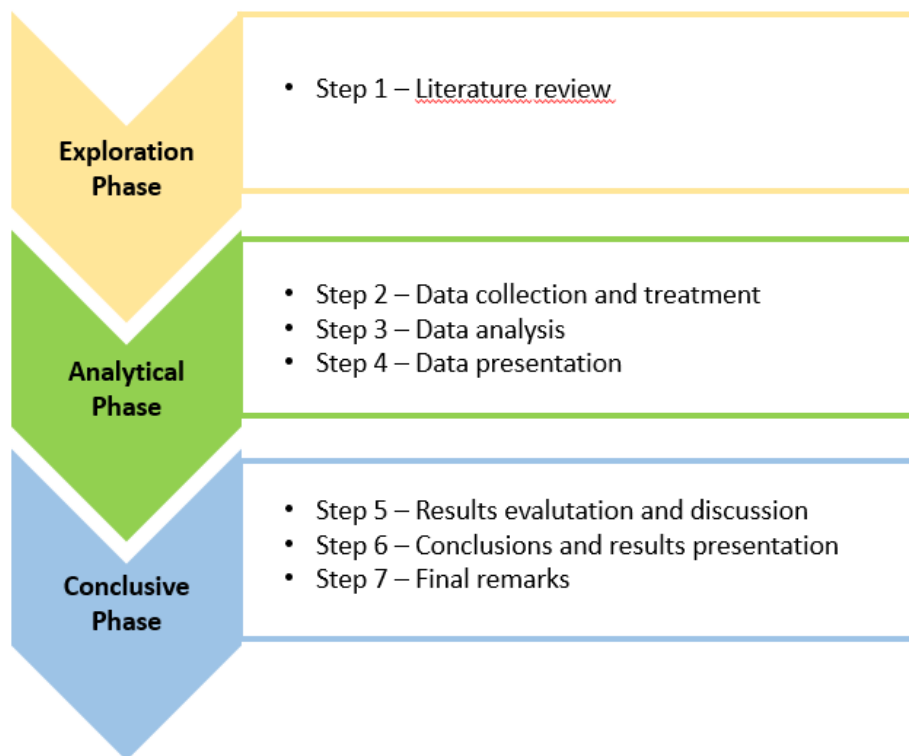


Figure 1 - Methodology pathway proposal

In the exploration phase, the literature review will be performed in order to obtain an overview of the research already performed regarding technology in football and VAR specifically, along with the biggest problems and issues identified. Additionally, research and analysis regarding the use of AI to replace human decisions will be performed. During this step, works that may contribute to this study will also be identified and, by the end of this phase, some of the initial predicted methodology might need to be redefined.

In the analytical phase, data will be collected, organized, analyzed, and presented in a schematic approach. The data to be collected will be mainly through surveys regarding:

- Football fans satisfaction with VAR
- Football fans openness to new technologies in football, such as AI.

The literature review and collected data will make it possible to analyze and discuss the proposed objectives of the paper, as well as how receptive the average football fan is to new technologies. This analysis will possibly allow the proposal of new technologies to help referees make in-game decisions.

In the conclusive phase the proposed framework will be discussed and will be evaluated in order to identify VAR shortcomings, the perception of fans on the impact of VAR and if football fans in general are happy with it. Additionally, we will analyze if football fans are open to the introduction of AI based alternatives to the VAR.

In the end, we will identify the contribution of this work and recommend future studies that could develop it.

3. LITERATURE REVIEW

3.1. FOOTBALL

3.1.1. Concepts and Rules

The sport of federation football was first organized in England, when different schools met to determine a standard set of rules. Before this meeting, football was played in many different versions and rules, depending on which region it was played at. Rule differences led to confusion when teams from different parts of the country, or even in the same city, played with each other. The rules meeting in Cambridge bound all to a standard set of rules that formed the foundation for the Laws of the Game, which are still in use today.

The IFAB was founded in 1886, at first it was purely an ethical overseer to the games rules but after joining FIFA in 1913, it became the authority that dictates the rules of the game (Kent et al., 2013).

“Football is the greatest sport on earth. It is played on every continent, in every country and at many different levels. The fact that the Laws of the Game are the same for all football throughout the world, from the FIFA World Cup™ through to a game between young children in a remote village, is a considerable strength which must continue to be harnessed for the good of football everywhere” (IFAB, 2021).

The Laws of the Game are clearly and systematically addressed in IFAB’s Laws of the Game, every year a new version is published, with the changes that are being implemented and rectifying old rules, everything from the smallest details to widely known rules are extensively explained. There are 17 different Laws.

In football, there are two teams (usually made up of 11 individual players) who work amongst themselves to score and prevent opposition goals (Beal, Changder, et al., 2020). In the Laws of the Game it is highlighted that a football match has two equal halves of 45 minutes, with an interval at half-time that usually lasts for 15 minutes. At the end of each half the referee may opt to grant an allowance for time lost during the game, due to injuries, time wasting or VAR checks and reviews for example. The objective of a match is scoring more goals than the opposite team, a goal occurs when the whole of the ball passes over the goal line, between the goalposts and under the crossbar.

Likewise, other major rules such as the offside rule, how fouls and misconduct are addressed, free kicks, the penalty kick, throw-ins, goal kicks and corner kicks are conveyed in great detail.

3.1.2. Tactics and Performance

Many tactical decisions are involved when it comes to winning a game, including but not limited to, assigning positions to players, the team's composition, and the reactions to in-game events. Such decisions have to be made against significant degrees of uncertainty, and often in a very dynamic setting (Beal, Chalkiadakis, et al., 2020).

Tactical decisions are usually just made through subjective opinions based on the manager's experience and "gut feeling", and are a popular subject of discussion in football media (Beal, Changder, et al., 2020).

These decisions can have a significant impact on the overall result of the game and can help boost the chance of a team winning, even if a team does not have the best players. It is worth noting that in a standard league (such as the Bundesliga or La Liga) a win is worth 3 points, a draw 1 point and a loss no points. As a result, some teams prefer to use more conservative tactics in order to improve their chances of drawing a game they are unlikely to win (Beal, Chalkiadakis, et al., 2020).

Managers and coaches plan tactically for forthcoming matches down to the last detail, often relying on subjective assessments from their own and opposing teams/players (Papataxiarhis et al., 2009).

In the Spanish La Liga, German Bundesliga, and English Premier League, the most successful teams scored an average of two goals each game, compared to lower-ranked clubs that scored an average of one goal per game (Mara et al., 2012).

Score-box possession occurs when the attacking team enters the score-box with a high degree of control over the ball or when the attacking team is awarded a set play as a result. A high degree of ball control entails having enough space and time to complete the appropriate action on the ball.

Studies have investigated the effect of playing tactics on achieving score-box and scoring goals. Counterattacks were found to be the most effective tactic compared with positional elaborate attacks, specifically when playing against an imbalanced defence. Thus, the evaluation of opponent interactions is crucial to evaluate differences in the probability of producing a score-box possession between different offensive playing tactics (Tenga et al., 2010).

Direct attacks and counterattacks were three times more effective than elaborate attacks in obtaining a score-box possession in the Spanish first division, according to studies. Team possession originating from the middle zones and playing against less than 6 defenders resulted in more success than those started in defensive zones with a balanced defence. Additionally, when teams were drawing or winning, the probability of reaching the box decreases by 43 and 53%, respectively, compared with teams that were losing (Lago-Ballesteros et al., 2012).

3.1.3. Fairness

The importance of referees in the sport of football and how they might influence its future development is becoming more widely recognized. (Wicker & Frick, 2016).

The role of the referee is a very complex one and their performances are under severe constant scrutiny since everyone expects their decisions to be flawless and undisputable. They are most often than not, the target of criticism and other forms of social pressure by players, coaches, the media or the general public (Johansen, 2015).

Part of these complaints are exacerbated by the passion with which football is played and watched, but there is in fact a degree to which a referee's judgement can be biased and it is important to study this subject, in order to better deal with the problem and improve performance overall (Dohmen & Sauermann, 2016).

Referees do in fact favour the home team by allowing for more stoppage time when it is behind at the end of regular time, this bias in stoppage time decisions stems from the incentive to satisfy the home crowd in the stadium or put differently from the referee's quest for social approval. This ends up granting the team the opportunity to turn the score. It is apparent that referees adapt their decisions to changing objectives of the home crowd, by shortening the remaining stoppage time once the home team scores during stoppage time.

These findings suggest that social payoffs influence the referee's decision who seeks social approval and tries to avoid social sanctioning by the crowd (Garicano et al., 2001).

Studies have also shown that expert judgements on the correctness of referee decisions found that goals awarded to the home team were significantly less likely awarded correctly. Additionally, the traveling team receives less disputable goals, and there is significant evidence suggesting the home team receives more illegitimate goals than the visiting team.

In the same context, a larger fraction of awarded penalty kicks is either wrongly awarded or disputable when the home team is one goal behind, and home teams are significantly more likely to be awarded a penalty kick in situations that are rated as disputable by experts (T. J. Dohmen, 2008).

Additionally, yellow and red cards are awarded more frequently to the visiting team and there is a clear home team favouritism when it comes to booking players (Buraimo et al., 2012).

Crowd size also decreases the probability of a home team player being awarded with a yellow card. In Italy during the 2006-2007 season spectators were banned for several games due to hooligan violence, during this time it was made clear that the referees favour the home team by punishing their players less and those of the visiting team more strongly when the game has attendance, in turn, when a game had no attendance the referee bias was less prevalent (Pettersson-Lidbom & Priks, 2010).

When it comes to how the players themselves perceive fairness, it is important to note that the way in which a referee communicates their decision can severely impact an athlete's psychological state. If a referee has a greater awareness of how their communication can influence a player's performance and behaviour, conflicts between both parties can be prevented (Mellick et al., 2011).

3.1.4. Challenges and Opportunities

European football has grown into a global market with billions in income over the last few decades (Dimitropoulos et al., 2016). The same may be said about European football clubs (Gammelsæter, 2010).

Professional football in Europe has seen a significant shift in recent years, with more professionalization and commercialization present (Galariotis et al., 2018). Football clubs are acquiring new (digital) marketing opportunities and foreign markets as global knowledge of football as "the world's most popular sport" grows. (Goossens et al., 2012).

Professional football has begun to reconsider its institutional and organizational environment as a result of this new race for money, which is characterized by new revenue sources. Clubs face changing environmental conditions as a result of UEFA's Financial Fair Play (FFP) legislation, tighter licensing requirements, and the rising diversity of ownership types. In addition, clubs must increasingly focus on strengthening their economic foundation (Rohde & Breuer, 2017).

Technology is becoming more and more prevalent in sports, however, there are some barriers. One of the biggest limitations for the implementation of technology in sports is the elevated costs associated with some technologies, Hawk-Eye patented system's installation for example, was estimated to cost between £100,000 and £125,000 per stadium, so it is still only used in top tier football leagues right now (Bal & Dureja, 2012).

The rise of AI and IoT technologies represent an enormous opportunity for the development of several different areas of football, including fairness (Deloitte, 2018).

3.2. TECHNOLOGIES IN SPORTS

3.2.1. IoT based technologies

Sports Technology is constantly expanding and developing, as we see more science and technology participation in sports than we have ever seen before. The best sporting performances nowadays are typically found in the intricacies that may be detected and predicted with the aid of any technology or instrument that can make a difference. Sports are included in the Big Data era since vast amounts of data are progressively being collected that can be analysed, resulting in competitive advantages that can be used in real-time during a competition or during practice, preparation, or recruitment (Pires & Santos, 2018),

Therefore, we can assert that in today's sports, Internet of Things (IoT) plays a role in player development, player safety, and fan engagement. Coaches, players, and fans can use data collected from different devices to modify game strategy, analyse potential injuries, and personalise their experience.

IoT provides sports organizations with limitless options to improve their efficiency and offers, as well as provides a personalized, one-of-a-kind experience for spectators (Deloitte, 2018).

Recent technical advancements have substantially improved the possibility of collecting data from IoT devices in an efficient and cost-effective manner, this has been designated as a key research subject in the field of sports analytics (Cokins & Schrader, 2017).

Several professional sports organizations, as well as huge university athletic programs, have made significant expenditures in a variety of systems that give large amounts of data about sport performance capacities. The use of these large amounts of data, including data obtained by IoT devices, can also help sports coaches or trainers identify athletes who are at a higher risk of injury and try to mitigate this risk, by resting a player for example (Wilkerson et al., 2018).

Regarding the topic of IoT it is important to mention the rise of wearable tech. Due to their capacity to classify posture, movement, energy consumption, and balance management, differential capacitors are the most commonly used in sports, these can be seen when a player takes off their shirts for instance. Team physicians and trainers now have a multimodal platform to evaluate the energy cost and specificity of movement patterns over the duration of a game or practice, thanks to the integration of GPS, accelerometer, and heart rate technology into one sensor. Inertial measuring units, which are kept in a smaller casing and worn in a small purpose-built pocket in the back of a jersey or strapped to an athlete, are currently included in most commercially available integrated technology (IT) devices employing this platform (Li et al., 2016).

Additionally, IoT provided several improvements to fan engagement, sports venues are becoming smart venues in at least four ways: fan interaction, parking management, infrastructure, and public safety. Fans are demanding more data, and technology is responding by improving the fan experience by allowing for more customisation.

Smart stadiums enable fans to connect to the game they love in new and exciting ways, with seat upgrades, concession line updates, and interactive touch-screen information kiosks.

Smart venue technology can handle transportation congestion and parking concerns that are an issue for many guests as sporting events and entertainment draw more followers (Penrose, 2022).

3.2.2. Image recognition

The most known and used technology for assisting in refereeing across all sports is the Hawk-Eye Officiating System, it was developed by engineers at Roke Manor Research Limited of Romsey, Hampshire in the UK, in 2001, it was first used in cricket, and it was the first and only ball-tracking system to pass the International Tennis Federation rigorous testing. It is precise, dependable, and useful (Cui et al., 2017).

Hawk-Eye and other innovations like it are used for the betterment of sports. It was groundbreaking in sports television when it was first used in cricket and was then adopted by numerous sports such as tennis and snooker. Hawk-Eye initially tracked the route of a ball in three dimensions on an imaginary cricket pitch by capturing and processing images from a number of cameras, it has since been applied to several other sports.

Hawk-Eye is an example of a cutting-edge technology that is used in a variety of sports. Hawk-Eye has revolutionized the athletic world with its unique blend of invention, experience, and precision. The primary concept is to keep track of the ball's trajectory during the game. This information is then analysed to create lifelike visualizations of the ball's route (Bal & Dureja, 2012).

Hawk-Eye is one of two FIFA's approved goal-line technology (GLT) systems. Hawk-Eye keeps track of the ball and alerts the referee if it crosses the goal line and into the goal. The system's goal is to eliminate errors in determining whether or not a goal was scored. Prior to the 2012 modification to the Laws of the Game that made GLT a permanent feature of the game, the Hawk-Eye system was one of the systems trialed by the sport's governors, and it has since been utilized in numerous events.

GLT is optional, and due to Hawk-Eye's and its competitors' exorbitant costs, systems are only used in high-level events.

It is also important to mention that, with the rapid growth of video analysis technology in the market for public security, commercial, and military applications, among other applications, research and development of intelligent video analysis systems has increased in recent years, and a large number of intelligent video analysis products have begun to emerge in the market. These technologies can moreover widely be used in sports (Yunwei & Shiwei, 2019).

When utilized in sports, video-replay technology has been heavily criticized for disrupting the flow and rhythm of the game by pausing and starting the game to check the footage of a disputed time. This has been observed in several sports such as football, cricket, and ice hockey. However, in both wrestling and rugby officials' failure to check match footage at important points has sparked uproar and led to legal challenges in the past (Nafziger, 2004).

3.2.3. The Role of AI

Since Lady Ada Lovelace's foresightful concepts for the analytical engine predicted the future of AI in the 1840s, artificial intelligence has come a long way (Boden, 2016).

AI and quantum computing offer new ways to use computers more efficiently, allowing athletes and competitors to be better understood through the application of concepts and models. In domains as disparate as biomechanics, kinesiology, and the physiology branch of adaptive processes, the use of AI-based approaches in sports has been discussed (Novatchkov & Baca, 2013).

Artificial neural networks (ANNs), which are at the heart of AI applications and have gotten a lot of attention as a result of deep learning's success, are appealing to the sports world as a way to model learning (Perl, 2001). Parallel distributed processing (PDP) may learn patterns and relationships while identifying partial patterns and accepting unstructured evidence through restricted satisfaction (Boden, 2016).

Given the constant struggle with massive volumes of data, dynamism, and complicated input–output relationships, ANNs are particularly well suited for sports applications. ANN has a wide range of applications in sports, from detecting talents and analysing game strategy to forecasting injuries and training loads, as well as overall performance (McCullagh & Whitfort, 2013).

It is important to mention that AI can also aid in increasing fairness in sports and in helping referees making better decisions thanks to the continuous development of ball tracking technologies and limb-tracking technology, or skeletal-tracking technology as some refer to it (Xu et al., 2021).

3.3. VIDEOS ASSISTANCE REFEREE (VAR)

3.3.1. Overview

In association football, the video assistant referee (VAR) is a tool developed by the Royal Dutch Football Association (KNVB) to assist on-field referees in correctly judging potentially game-changing decisions by reviewing video evidence from multiple angles immediately after situations have occurred (KNVB, n.d.).

The VAR, supported by a replay operator, checks all video feeds and replays of match changing moments, according to the protocol. The VAR suggests that the referee review/change the first decision if a check finds that the referee or assistant referee committed a clear and evident error. A factual decision, like an offside incident before a goal, might be altered solely based on VAR information. A VAR-only review is what it's called. The main referee can study the footage directly on a monitor near the pitch before making a final decision for subjective decisions like red cards (on-field review) (Spitz et al., 2021).

In situations requiring temporal (precise time) and spatial (where is the ball, where is the player?) accuracy, the use of technology can help increase the precision of decision making (Carboch et al., 2016).

VAR was unanimously accepted by the International Football Association Board (IFAB) on March 3, 2018 after a successful testing session (International Football Association Board, 2018).

The English Premier League (EPL) implemented VAR into the league ahead of the 2019/20 season, with the intention of only using it to correct clear and obvious errors such as missed incidents, penalty decisions, incidents that may warrant a red card, and incidents where a player's identity has been mistaken. VAR was used in all 380 games played in the 19/20 EPL season in its debut season, resulting in 109 goals being impacted by the use of VAR (Johnson, 2020).

During the 2016-17 and 2017-2018 seasons, researchers examined the impact of the VAR system on 1,024 matches from the Italian (Serie A) and German (Bundesliga) professional leagues. Key findings in the study conducted have revealed that once the VAR system was deployed, playing time increased in both the first half and the entire match, but variables like offside, fouls, and yellow cards declined (Carlos et al., 2019).

Similarly, the playing length of both the first and second halves, as well as the entire match, increased significantly after the implementation of VAR in the Chinese Super League. It was also discovered that there had been a considerable reduction in the number of offsides and fouls (Han et al., 2020).

Furthermore, after the introduction of VAR, the ratio of home penalties to away penalties fell substantially in each league, implying that a penalty issued by the referee to a home side was more likely to be overturned by VAR than a penalty awarded to an away team (Petty, 2018).

3.3.2. Tools and platforms

The IFAB's 132nd Annual General Meeting adopted the Implementation Assistance and Approval Programme (IAAP) on March 3, 2018. Every competition that intends to deploy VARs must follow the five-step process (as its use is regulated by the Laws of the Game).

Every step of the IAAP must be followed by all "new" competition organizers, i.e. those who have not yet deployed VARs in their competitions. This includes having the technology evaluated and certified by FIFA. No further review or approval by FIFA is necessary for tournament organizers who already utilize VARs in competitive matches, as long as the system has been tested at all venues where VAR use is intended. At stadiums where VARs have never been employed by the competition organizer, however, technical tests are essential.

The following list, in alphabetical order, details the VAR system integrators (VSIs) that have successfully completed the IAAP procedure and are thus authorized to supply VAR technical services: Broadcasting Televisio Ltda, ChyronHego ApS, ColosseoEAS, Evertz Microsystems Ltd., EVS Broadcast Equipment, Goal Sport (Daite), Hawk-Eye Innovations, Medialuso & Mediapro, OZ Sports, SBG Sports Software, Simplylive, Slomo.TV, Sporthub, Vieww GmbH, TGI Worldwide.

Following the accreditation of VAR systems under the new global quality standard, using a FIFA-certified system will be required beginning in July 2022. FIFA will begin validating compliance with this condition as part of the IAAP as of this date for competitions that have not yet implemented VARs (FIFA, 2021).

3.3.3. Challenges and Opportunities

According to studies, the recently implemented Video Assistant Referee has had a negative impact on the emotions of English Premier League fans who post on social media. Thus, VAR has a significant detrimental impact on the spectator experience, which must be considered by football's regulatory organizations (Kolbinger & Knopp, 2020b).

It is necessary to assess how this negative influence can be mitigated. Two options are usually suggested. First and foremost, football bodies should strive for maximum transparency in the use of VAR. It has been emphasized how critical it is for fans to have accurate information regarding the replay review decision-making process. To achieve this level of transparency, the leagues might stream the dialogue between the referee and the video assistant (like in field hockey) or equip officials with appropriate technology to broadcast information about the review process in the stadium (as in the NFL) (Stoney & Fletcher, 2021).

Another method to improve the spectator experience with the VAR is to implement a challenge system, in which the opposing parties are responsible for starting the review process by appealing the on-field decision. The IFAB immediately decided to introduce a new system in football, in which the video assistant is responsible for initiating reviews by double-checking every conceivable event. This not only resulted in a nontransparent system, but it also put the entire burden on the shoulders of the referees. Other sports, such as tennis and baseball, have challenge systems, which relieve some of the strain on referees by requiring participants or coaches to (immediately) identify the scenes that should be examined.

Considering athletes or teams usually only have a limited number of such challenges, the method for using them has become a hot research topic, which could indicate how challenge systems improve viewer experience (Kolbinger & Knopp, 2020b).

Changes that could be made to the current VAR system, the increase of AI and IoT use in sports all constitute enormous opportunities when it comes to making the VAR a better system for fairness.

4. CURRENT FOOTBALL FANS VAR PERCEPTION

As defined in the Methodology section, in the analysis phase, after concluding the literature review, a survey was carried out with two main objectives, to evaluate the satisfaction of football fans with VAR, if they perceive it as a transparent tool for fairness, and if they are open to the introduction of new technologies in football for fairness, specifically AI based technologies to aid in the decision making process.

The survey was conducted through quantitative research, based on a structured survey in Google Forms. To ensure the quality of the collected data some of the following characteristics were considered as described below in the first section: the respondent's age, location and if they consider themselves football fans and are familiar with VAR.

The survey has four sections. The first section aims to characterize the interviewed person and assess their familiarity with the VAR based on:

- The respondent's age;
- Respondent's geographical location;
- Respondent's interest in football and if they are familiar with the VAR.

The second section aims to assess how fans perceive the impact of the VAR in football based on:

- The amount of games that are impacted by the VAR;
- Their opinion on the transparency of the VAR;
- The contribution of the VAR for the reduction of bias in football.

The third section aim at assessing how VAR has impacted the fan experience during football games:

- Their opinion on VAR stops and if they negatively affect the experience of watching a game;
- Their opinion on whether VAR decisions should be broadcasted live in stadiums or not;
- Their opinion on whether VAR stops should have a maximum duration or not.

The fourth section intends to assess how open football fans are to the introduction of new technologies for fairness in football based on:

- The general openness to new technologies for fairness in football;
- The openness for AI based technologies to be introduced in football.

The survey was delivered to football fans through the use of several social media websites and messaging applications, the goal is to obtain the maximum amount of data to proceed with an in-depth analysis and answer the questions proposed for this study. After collecting the data, two main questions will be posed:

- 1) What is the perception football fans have regarding the VAR?
- 2) How open are football fans to the introduction of new technologies for fairness in football?

The survey was written, distributed, and the information was gathered in English (Annex). A university pier was necessary to examine and recommend adjustments to the questionnaire, offering the survey resolution average time, in order to ensure the survey's clarity.

4.1. SURVEY QUESTIONS

Table 1 – Survey Questions

Main questions	Sub-questions
First Section	
Respondant Characterization	How old are you?
	Where are you located?
	Are you interested in football? If yes, are you familiar with the VAR?
Second Section	
What is your perception of VAR in football?	How many games do you think are affected by VAR? (Percentages)
	Do you think the VAR is a transparent tool?
	Do you think the VAR has successfully reduced referee bias in football?
	Do you trust the VAR?
	Do you think the VAR has helped improve the decisions of on-field referees?
	Do you think the VAR shifted the focus of post-match discussion from on-field referees to the video room?
	Do you tend to agree with the decisions made by the VAR?
Third Section	
Fan Experience	VAR stops negatively affect the experience of watching a game.
	VAR decisions should be broadcasted live in stadiums.
	VAR stops should have a maximum duration.
Fourth Section	
How open are you to the introduction of new technologies for fairness in football?	Were you in favour of the introduction of the goal line technology and VAR in football?
	How open are you to the introduction of new technologies for fairness in football?
	Would you be in favour of the introduction of AI technologies in football to help referees make decisions?

4.2. DATA COLLECTION PROCEDURE

The collection of data took place from the 22nd of July to the 16th of August 2022 through a survey conducted using Qualtrics. The web-based survey tool Qualtrics makes conducting surveys, evaluations, and other data collection tasks easier, this data can then be analyzed using graphs and different tools offered by the platform.

During this period, the survey was shared through several social media platforms such as LinkedIn, a business and employment-oriented platform, WhatsApp, an instant messaging application and finally Facebook, an online social media and social networking service.

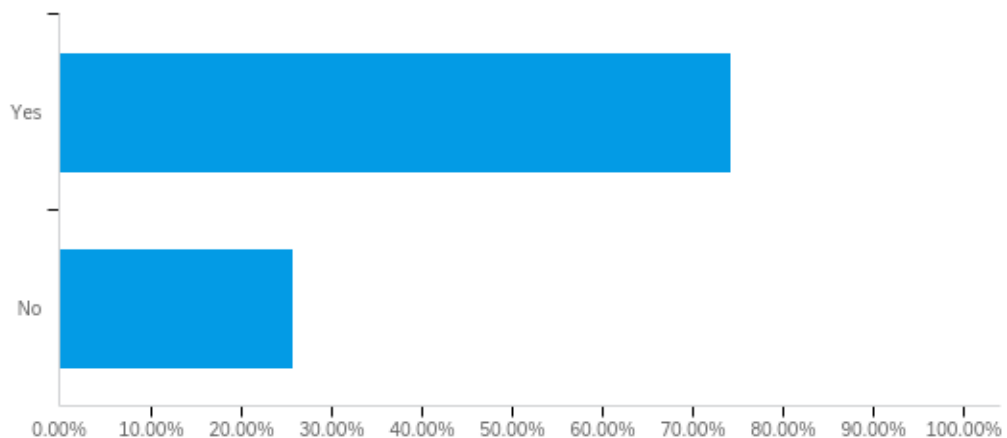
It was possible to collect 175 answers, the data from these answers was examined using Qualtrics, SPSS and SPSS Modeler.

5. RESULTS PRESENTATION AND DISCUSSION

5.1. RESPONDENT CHARACTERIZATION

In the beginning of the survey, we asked the respondents about their interest in football and if they are familiar with the VAR, in order to only proceed with interested and coincidentally more informed respondents. The responses regarding their interest in football can be seen in Chart 1 where approximately 74% of respondents said yes and 26% said no.

Chart 1 – Respondent's interest in football



When it comes to familiarity with the VAR (Chart 2), approximately 88% of respondents said they are familiar and 12% said they are not. The respondents that are familiar with the VAR were asked to continue the survey.

Chart 2 – Respondent's familiarity with the VAR

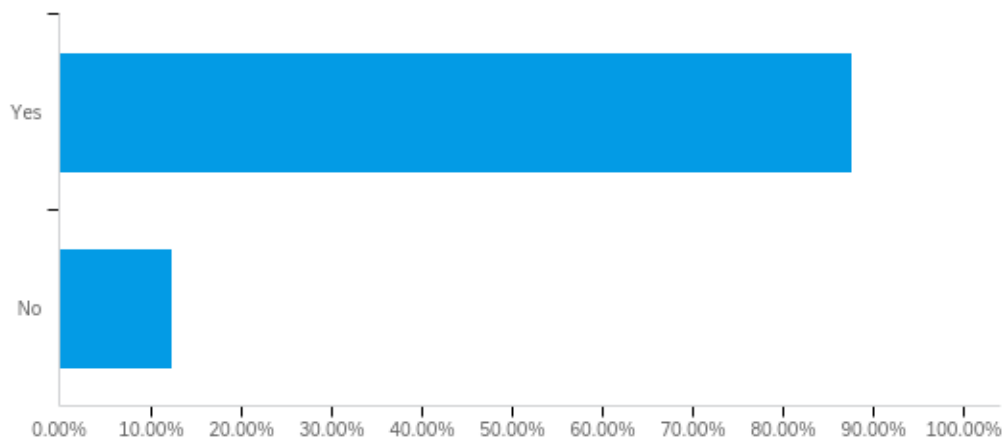
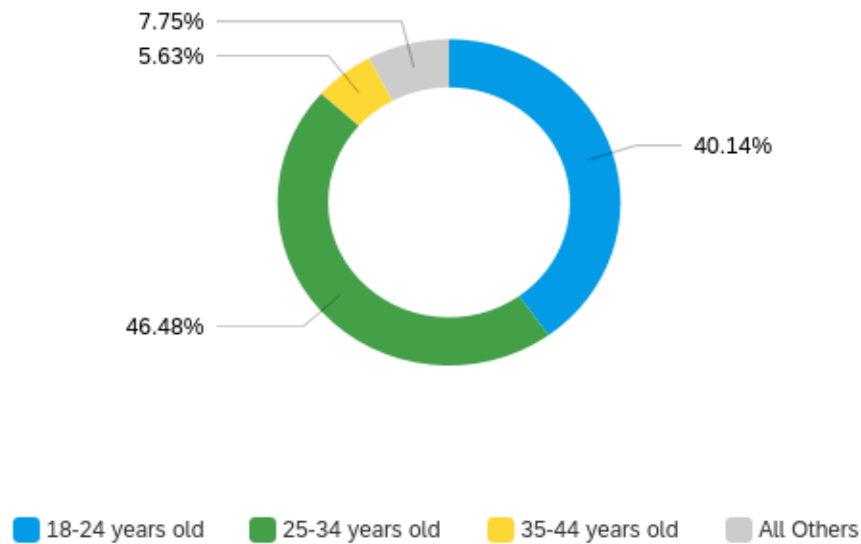


Chart 3 presents the age demographic of the survey respondents. The highest number of responses came from people aged between 25 and 34 years old (46.48%) followed by 18 and 24 years old (40.14%).

Chart 3 – Age groups



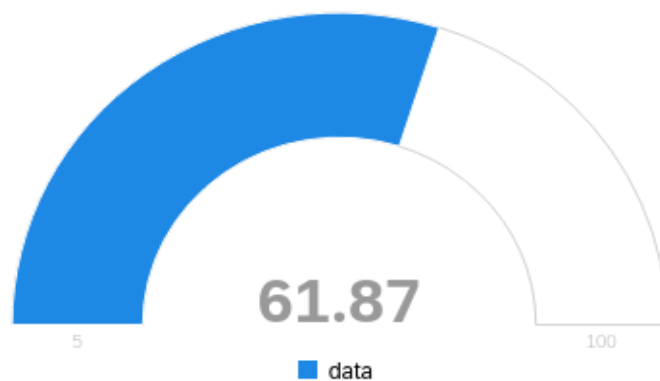
Most respondents are based in Portugal (84.51%) however, there were also responses from Hong Kong, Malta, Turkey, Germany, Spain, the UK, Austria, Belgium, Denmark, France, Italy, Romania and the USA.

5.2. DESCRIPTIVE ANALYSIS

5.2.1. Perception of VAR in football

The questions regarding the perception of the VAR start with a question on how many games the respondents think are affected by the VAR in terms of percentage (Chart 4), the average answer was 61.87% and the minimum and maximum responses were 5% and 100% respectively.

Chart 4 – Percentage of games affected by the VAR



In Chart 5, 6, 7 and 8 we presented the respondents with several statements regarding the VAR, their perception and opinions on it, and asked them to respond if they strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree or strongly agree.

As we can see in Chart 5, most people somewhat agree that “the VAR is a transparent tool” (46.9%) followed by somewhat disagree (24.14%), strongly agree (14.48%) and neither agree nor disagree (11.03%). This was the most divisive statement presented in this chart.

In the next question (in green) we stated that “the VAR has successfully reduced referee bias in football”, a large majority of respondents somewhat agrees with this statement (55.56%) and 19.44% responded that they strongly agree.

When it comes to trusting the VAR, most respondents somewhat agree that it can be trusted (50%), while both 18.75% strongly agreed and neither agreed nor disagreed that they trust it.

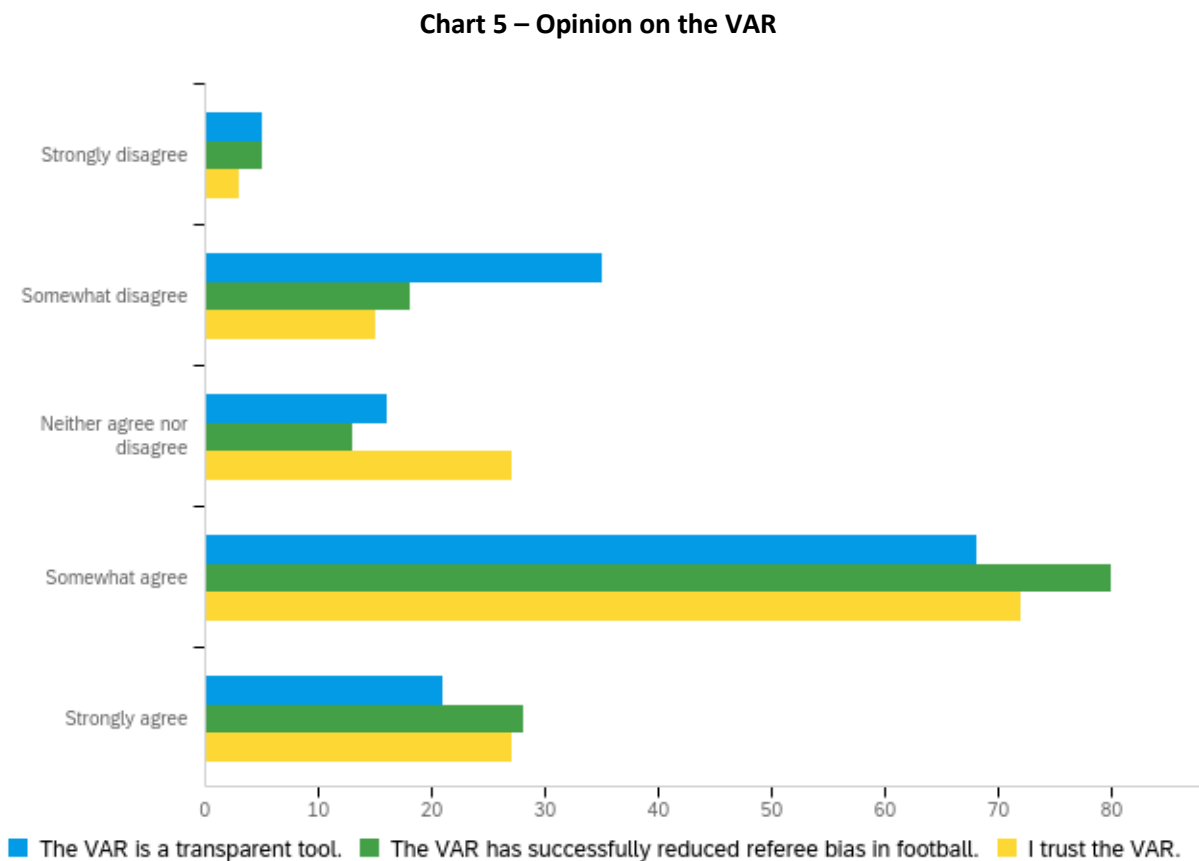


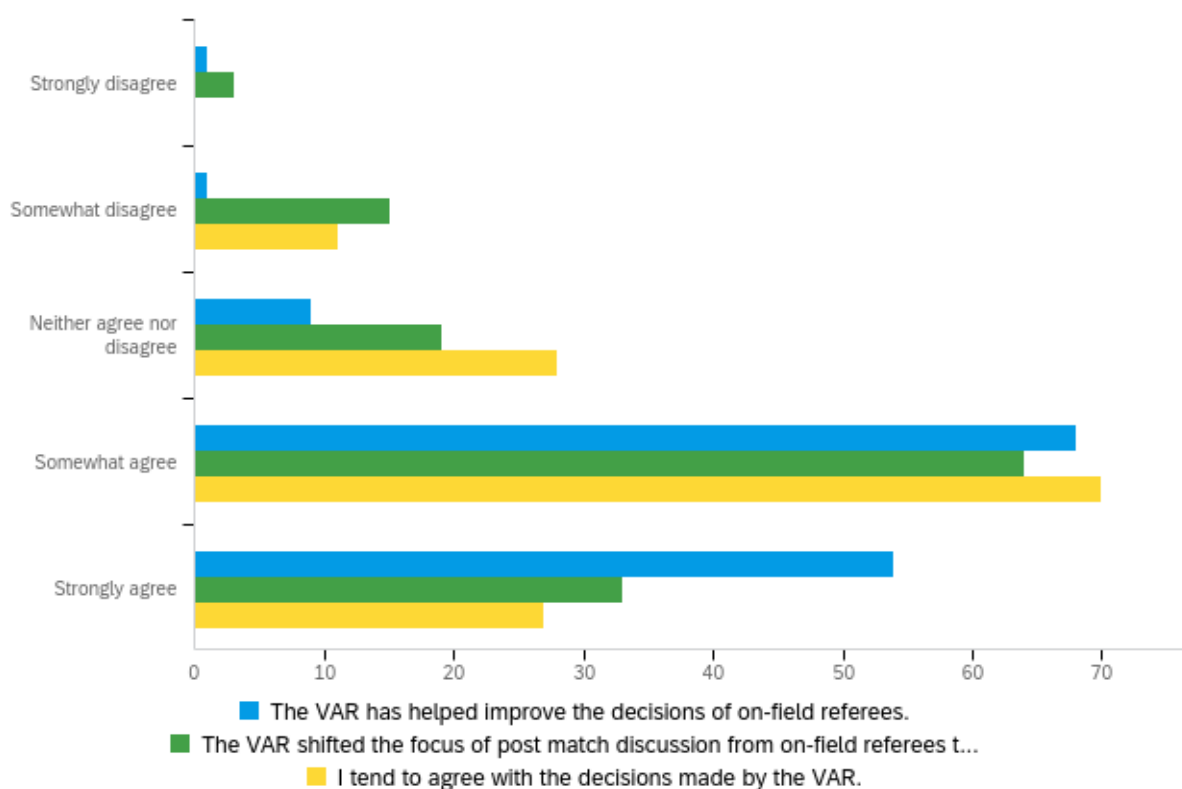
Chart 6 keeps expanding on this topic and on how the respondents think the VAR has changed football.

First, we stated that “the VAR has helped improve the decisions of on-field referees”, a vast majority answered positively with approximately 51% of respondents saying that they somewhat agree and 41% saying that they strongly agree.

Afterwards, we confronted them with whether “the VAR has shifted the focus of post-match discussion from on-field referees to the video room” or not, the answers here were more divided, with the majority stating that they somewhat agree (47.76%) followed by strongly agree and neither agree nor disagree (24.63% and 14.18%, respectively).

The last statement of this section asks the respondents if they “tend to agree with the decisions made by the VAR”. 51.47% said that they somewhat agree, followed by 20.59% that neither agree nor disagree and 19.85% that strongly agree.

Chart 6 – Opinion on the VAR

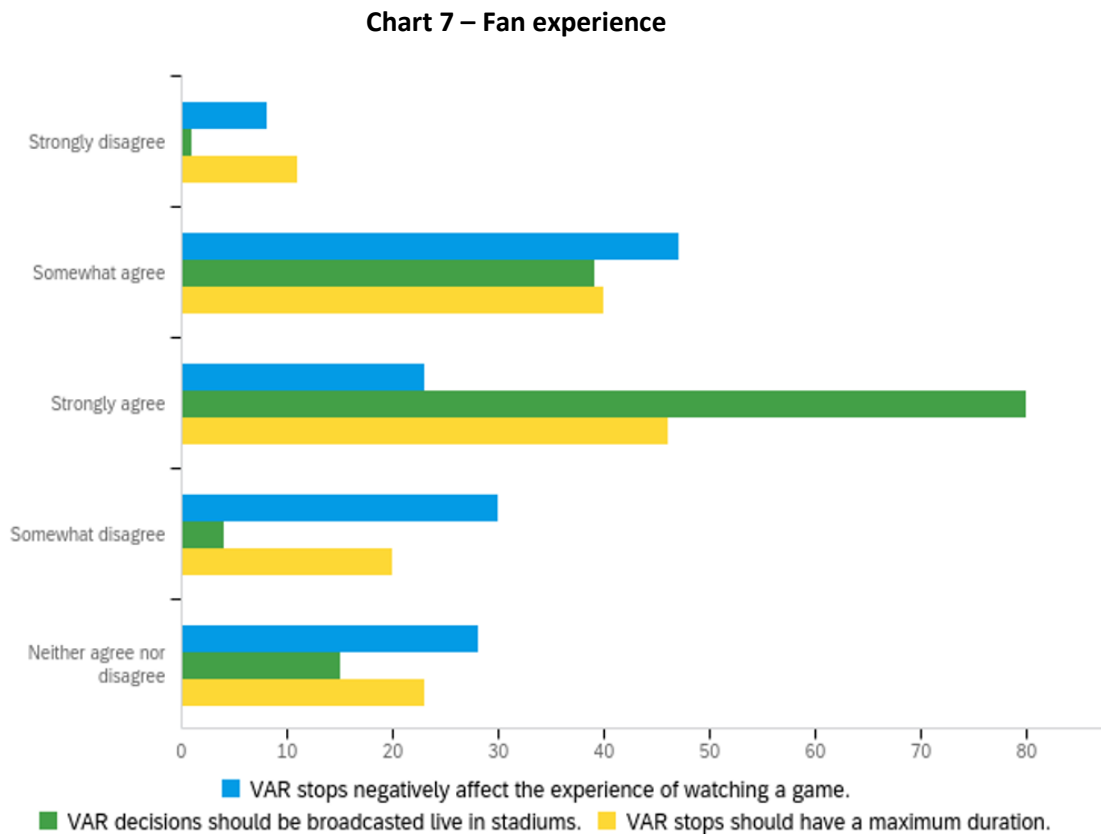


5.2.2. Fan experience in football

Chart 7 presents the respondents with statements regarding how the VAR has impacted the experience of fans. The answers regarding whether “VAR stops negatively affect the experience of watching a football game” are very scattered but there are more people that somewhat agree 34.56%, followed by somewhat disagree 22.06%.

In the next sentence we mentioned a very controversial and discussed topic, whether “VAR decisions should be broadcasted live in stadiums” or not, 57.55% of respondents strongly agreed with this statement and 28.06% somewhat agree.

When it comes to if “VAR stops should have a maximum duration” or not, 32.86% of respondents strongly agree and 28.57% somewhat agreed.



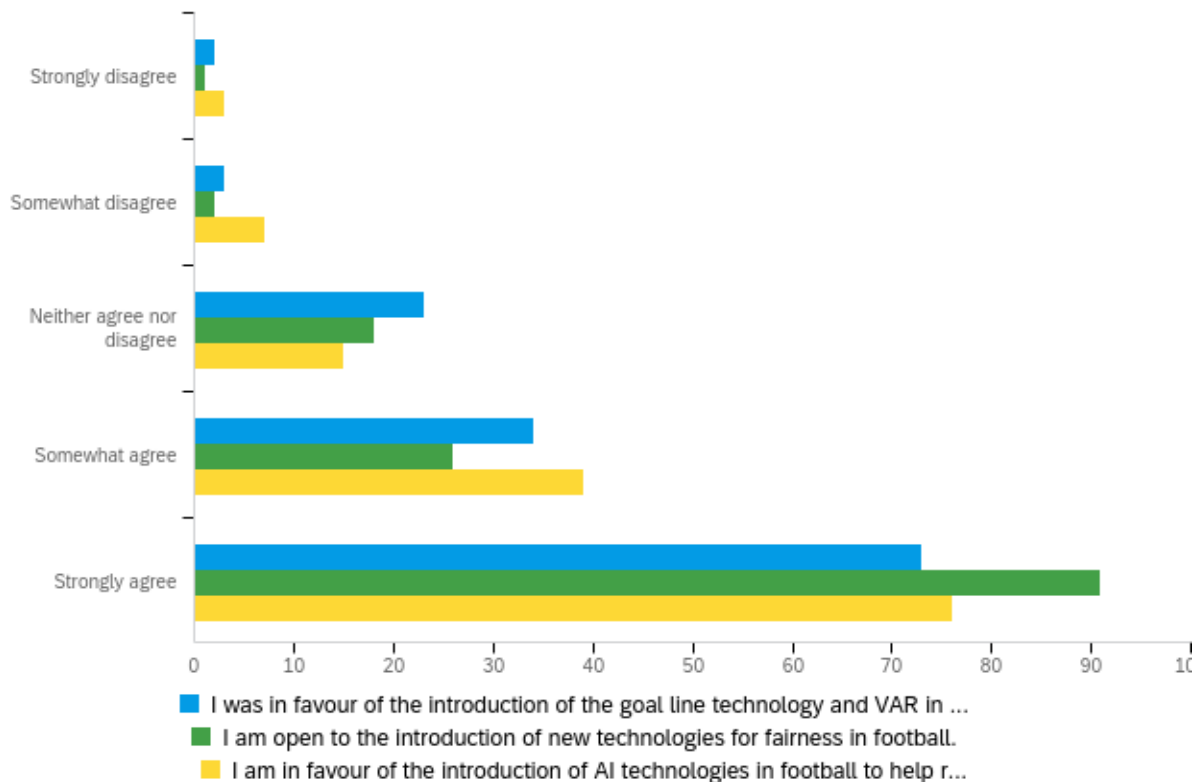
5.2.3. Openness to the introduction of new technologies for fairness in football

Regarding fans openness to new technologies, and as we can see in Chart 8, most fans were in “favour of the introduction of goal line technology and the VAR in football”, with about 54% of respondents saying that they strongly agree, 25.19% that they somewhat agree and less than 4% answered that they strongly disagreed or somewhat disagreed.

In the next statement “I am open to the introduction of new technologies for fairness in football”, here the results were even more overwhelmingly positive with 65.94% of people saying that they strongly agree and 18.84% saying that they somewhat agree.

To conclude we asked if they would be “in favour on the introduction of AI based technologies to help referees making decisions”, 54.29% said that they strongly agree and 27.86% said that they somewhat agree.

Chart 8 – Openness to new technologies



5.3. CORRELATIONAL ANALYSIS

Named after the English psychologist Charles Spearman, Spearman's rank correlation coefficient is a nonparametric method for evaluating rank correlation (statistical dependence between the rankings of two variables). It evaluates how well a monotonic function can characterize the relationship between two variables (Artusi et al., 2002)

This coefficient is normally represented by the Greek letter ρ , and it only assumes values between -1 and 1.

$\rho = 1$: means there is a perfect positive correlation between the two variables.

$\rho = -1$: means there is a perfect negative correlation between the two variables (if one increases, the other will always decrease).

$\rho = 0$: means that the two variables are not linearly dependent on each other. However, there may be a non-linear dependency. Thus, the result $\rho = 0$ must be investigated by other means.

A Spearman correlation analysis was conducted in SPSS comparing the answers from “The VAR is a transparent tool” and eleven other variables regarding the perception of VAR use. Cohen's standard was used to evaluate the strength of the relationships, where correlation coefficients between 0.10 and 0.29 represent a small association, correlation coefficients between 0.30 and 0.49 represent a moderate association, and correlation coefficients above 0.50 indicate a large association or relationship (Cohen, 1998).

5.3.1. The VAR is a transparent tool - Perception and Impact

Table 2 reflects the positive correlation of the variable X with variables U, V, W, Y, Z. In this table we can observe several relevant correlations to the study.

There is a significant positive correlation between variables X and U with a value of 0.464 and variables X and W with a value of 0.341, indicating a moderate association, this suggests that when the belief that VAR is a transparent tool increases, the belief that the VAR has successfully reduced referee bias in football and that the VAR has helped improve the decisions of on-field referees also increases.

Regarding variables X and V and X and Z, the correlations with the value of 0.707 and 0.532, respectively, imply that there is a large association between both. This denotes that, when the belief that the VAR is a transparent tool increases the trust in the VAR also tends to increase and the same can be said regarding the agreeability with the decisions made by the VAR.

On the other hand, the belief that the VAR is a transparent tool is not related with the variable Y, "The VAR shifted the focus of post-match discussion from on-field referees to the video room."

Table 2 – The VAR is a transparent tool - Perception and Impact

		Variable U	Variable V	Variable W	Variable Y	Variable Z
Spearman's correlation coefficient results		The VAR has successfully reduced referee bias in football.	I trust the VAR.	The VAR has helped improve the decisions of on-field referees.	The VAR shifted the focus of post-match discussion from on-field referees to the video room.	I tend to agree with the decisions made by the VAR.
Variable X	The VAR is a transparent tool.	0.464	0.707	0.341	0.004	0.532

5.3.2. The VAR is a transparent tool - Fan experience

In table 3 we can discern that there is no correlation between variable X, “The VAR is a transparent tool” with variables W, Y and Z, “VAR stops negatively affect the experience of watching a game”, “VAR decisions should be broadcasted live in stadiums”, “VAR stops should have a maximum duration”.

Table 3 – The VAR is a transparent tool – Fan experience

		Variable W	Variable Y	Variable Z
Spearman's correlation coefficient results		VAR stops negatively affect the experience of watching a game.	VAR decisions should be broadcasted live in stadiums.	VAR stops should have a maximum duration.
Variable X	The VAR is a transparent tool.	0.069	-0.013	0.075

5.3.3. The VAR is a transparent tool - Openness to the introduction of new technologies in football

As seen in Table 4 significant positive correlation was observed between variable X, “The VAR is a Transparent tool” and variables W, Y and Z, “I was in favour of the introduction of the goal line technology and VAR in football”, “I am open to the introduction of new technologies for fairness in football”, “I am in favour of the introduction of AI technologies in football to help referees make decisions”.

However, it is important to note that these 3 correlations have a small association according to Cohen’s standard.

Table 4 – The VAR is a transparent tool – Openness to new technologies

		Variable W	Variable Y	Variable Z
Spearman's correlation coefficient results		I was in favour of the introduction of the goal line technology and VAR in football.	I am open to the introduction of new technologies for fairness in football.	I am in favour of the introduction of AI technologies in football to help referees make decisions.
Variable X	The VAR is a transparent tool.	0.14	0.173	0.134

5.4. ASSOCIATION RULES ANALYSIS

The analysis of association rules was carried out using IBM's SPSS Modeler. For this analysis, the a priori algorithm was used targeting the belief that the VAR is a transparent tool.

For the analysis, the following variables were defined as consequent and antecedents:

- Consequent: "The VAR is a transparent tool".
- Antecedents:
 1. "The VAR has successfully reduced referee bias in football"
 2. "I trust the VAR";
 3. "The VAR has helped improve the decisions of on-field referees";
 4. "The VAR shifted the focus of post-match discussion from on-field referees to the video room";
 5. "I tend to agree with the decisions made by the VAR."

Table 5 – The VAR is a transparent tool – A priori algorithm

Consequent	Antecedent	Support	Confidence
The VAR is a transparent tool.	The VAR has successfully reduced referee bias in football.	16.384	100%
	I trust the VAR.		
	The VAR has helped improve the decisions of on-field referees.		
	The VAR shifted the focus of post-match discussion from on-field referees to the video room.		
	I tend to agree with the decisions made by the VAR.		

In the analysis carried out in Table 5 we can see that there is 16.384% of support relationships for 100% of confidence, meaning that we can not conclude that the belief that the VAR is a transparent tool occurs together with "The VAR has successfully reduced referee bias in football", "I trust the VAR", "The VAR has helped improve the decisions of on-field referees", "The VAR shifted the focus of post-match discussion from on-field referees to the video room", "I tend to agree with the decisions made by the VAR".

5.5. DISCUSSION

Based on the analyses that were carried out in points 5.2, 5.3 and 5.4 it is possible to conclude that the average football fan was in favour of the introduction of the VAR and is moderately happy with it. There seems to be a general openness to the introduction of new technologies for fairness.

In order to meet the objectives that were set in point 1.3, we conducted a descriptive analysis, a correlational analysis and an association rules analysis.

After conducting these analyses, we can take several conclusions regarding the impact of the VAR and its perception by football fans. Regarding the perception of fans and the impact they think VAR has had on the game, we can gather that:

- The general fan is not aware on the amount of games that the VAR impacts;
- Fans believe that the VAR has improved fairness in football in general, they believe that the VAR has reduced referee bias, that it improved the decisions of on field referees and that it successfully shifted the focus of post-match discussion to the video room;
- Fans tend to trust the VAR and agree with its decisions but not fully;
- VAR stops somewhat negatively affect the experience of watching a game;
- Fans attending games in stadiums believe that VAR decisions should be broadcasted live in stadiums;
- The vast majority of fans were in favour of the introduction of the goal line technology and the VAR;
- Most fans are open to the introduction of AI technologies in football to help improve fairness;
- There is still some apprehension regarding the use of AI in football for fairness since there are more fans in favour of the introduction of new technologies than fans in favour of the introduction of AI based technologies.
- When the belief that VAR is a transparent tool increases, the belief that the VAR has successfully reduced referee bias in football and that the VAR has helped improve the decisions of on-field referees also increases, the same can be said for the trust in the VAR and fans agreeability with the decisions made by the VAR.

6. CONCLUSIONS

This chapter aims to summarize the work that was carried out, present its limitations and future work.

6.1. SYNTHESIS OF THE DEVELOPED WORK

The main goal of this thesis was to identify the shortcoming of the VAR, to access how football fans perceive the impact of the VAR, to analyse fans general satisfaction with VAR and their openness to the introduction of new technologies for fairness and AI based technologies specifically.

In order to meet the abovementioned objectives, a literature review was carried out which is composed of the following subtopics: Football, Technology in Sports and VAR (points 3.1, 3.2 and 3.3, respectively), with this literature review we were able to discern the research already previously made, including research regarding technologies that are used in other sports, this was a great instrument since there are sports that have adopted technologies for fairness decades before football.

After the literature review was carried out, a questionnaire was prepared targeting football fans in order to access their perception on the impact of the VAR, their opinion on the VAR and their openness to new technologies for fairness in football.

Following the collection of responses, a descriptive, correlation and association rules analysis was carried out and we were able to make some conclusions based on these analyses.

6.2. LIMITATIONS

Seeing that most of the survey respondents are Portuguese and between the age of 18 and 34 years old, we cannot assess whether people from other countries or ages have the same perceptions regarding the VAR. It should also be noted that the sample size used only contains 175 respondents.

6.3. FUTURE WORK

Regarding future work, I recommend performing a worldwide study regarding fans perceptions of the VAR and their openness to new technologies. Additionally, the openness to the use of different AI based technologies that are being tested or already in use for fairness in other sports could be studied for football.

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ANNEX

This survey should take less than 1 minute.

Dear participant,

The present study is being carried out within the scope of the dissertation for the completion of the Master's in Information Management at NOVA IMS University.

In this survey, we will invite you to share your perception regarding the Video Assistant Referee (**VAR**) and your openness for the adoption of new technologies for fairness in football. Bear in mind that, answering any of the following questions does not involve risk, nor is there a right or wrong answer.

Please remember that your participation in this survey is entirely voluntary, so you may choose not to participate, and you can give up at any time, your responses will remain anonymous, and will only be used for academic purposes. Participating in this survey will help me finish my master's thesis. Thank you very much!

Informed Consent Form

I declare that I am 18 or older and agree to participate in this research. I declare that I was informed that my participation in this study was voluntary and that I was free to leave at any time without penalty, and all data is confidential. It is understood that I will evaluate responses and that this study has no serious risks.

By clicking "I agree", I declare that I am at least 18 years old.

I agree

I disagree



Are you interested in football?

Yes

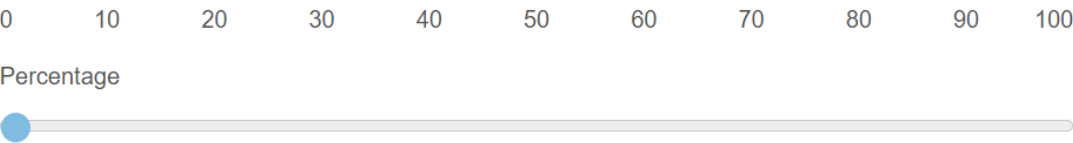
No

Are you familiar with the VAR?

Yes

No

How many games do you think are affected by the VAR? (In %)



Please rate the following statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The VAR is a transparent tool.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The VAR has successfully reduced referee bias in football.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I trust the VAR.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please rate the following statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The VAR has helped improve the decisions of on-field referees.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The VAR shifted the focus of post match discussion from on-field referees to the video room.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I tend to agree with the decisions made by the VAR.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please rate the following statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
VAR stops negatively affect the experience of watching a game.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
VAR decisions should be broadcasted live in stadiums.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
VAR stops should have a maximum duration.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please rate the following statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I was in favour of the introduction of the goal line technology and VAR in football.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am open to the introduction of new technologies for fairness in football.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am in favour of the introduction of AI technologies in football to help referees make decisions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How old are you?

18-24 years old

25-34 years old

35-44 years old

45-54 years old

55-64 years old

65+ years old

Where are you located? (Country)

