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Artificial Intelligence in Football: Coaching and Decision Support

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Master Thesis

presented as partial requirement for obtaining the Master Degree in Information Management

NOVA Information Management School

Instituto Superior de Estatística e Gestão de Informação

Universidade Nova de Lisboa

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Artificial Intelligence in Football: Coaching and Decision Support Systems

by

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Master Thesis presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence.

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

[Lisboa, 15 July 2024]

ABSTRACT

The advent of artificial intelligence (AI) in football coaching marks a significant paradigm shifts in the way the sport is approached, understood, and played. This thesis explores the multifaceted impact of AI-driven technologies on football coaching, focusing on performance enhancement, strategic decision-making, injury prevention, and player development. Drawing upon a comprehensive literature review, this study examines the evolution of AI applications in football, from basic performance metrics to sophisticated predictive analytics and computer vision systems. Research findings highlight the transformative potential of AI in revolutionizing player analysis, tactical insights, talent scouting, and recruitment strategies. Utilizing the Technology Acceptance Model (TAM) as a theoretical framework, the thesis investigates the factors influencing the adoption of AI-driven technologies among football coaches and practitioners. Through in-depth interviews, participants' perceptions of the usefulness, ease of use, awareness, price value, facilitating conditions, and ethical considerations surrounding AI technologies in football coaching are analysed. The research findings shed light on the attitudes, beliefs, and experiences of football analysts towards AI-driven coaching tools, offering valuable insights into the adoption process and identifying key drivers and barriers to technology acceptance. Practical implications for coaches, technology developers, and sports organizations are discussed, aiming to facilitate the successful integration of AI in football coaching practices. Overall, this thesis contributes to advancing our understanding of the role of AI in football coaching, paving the way for future research and innovation in leveraging technology to optimize player performance, strategy formulation, and overall player and team success.

KEYWORDS

Artificial Intelligence; Football; Advanced Analytics; Data; Computer Vision; Coaching; Decision; Performance.

Sustainable Development Goals (SDG):

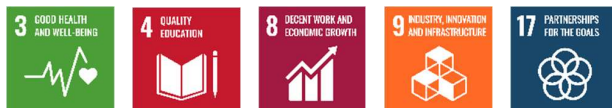


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LIST OF ABBREVIATIONS AND ACRONYMS

Acronym AI - Artificial Intelligence

Acronym VR - Virtual Reality

Acronym AR - Augmented Reality

Acronym AHP - Analytical Hierarchy Process

Acronym TOPSIS - Technique for Order Preference by Similarity to Ideal Solution

Acronym ECO - Efficient Convolution Operators (ECO)

Acronym TAM - Technology Acceptance Model

Acronym PU - Perceived Usefulness

Acronym PEOU - Perceived Ease of Use

Acronym BI - Behavioural Intention to Use

Acronym AU - Actual Use

Acronym xG – Expected Goals

1. INTRODUCTION

Football, one of the most popular and widely followed games in the world, has always been formed by human intuition, experience, and expertise. The sport's progress, from muddy grounds to beautiful, technology-enhanced arenas, has been a tribute to the never-ending pursuit for perfection. In this fluid environment, the introduction of Artificial Intelligence has emerged as a revolutionary force, transforming not only the way football is played and coached, but also the fundamental nature of decision-making on the pitch.

The combination of AI with football exemplifies a larger trend in the modern world, in which advanced technologies are penetrating many aspects of human life. AI has found a home in football coaching and decision support systems, ushering in a new era of possibilities. Coaches are now empowered with sophisticated algorithms that analyse player performance, develop tactics, and provide insights that go beyond the scope of traditional coaching approaches. AI-powered decision support systems are changing the course of games by providing real-time tactical recommendations and forecasting game-changing moments. This fusion of technology and tradition has created an environment in which the distinctions between human intuition and computational precision are becoming increasingly muddled.

The central idea of this thesis is to investigate the multidimensional impact of AI in football coaching and decision support systems. It is an effort to deconstruct and comprehend how artificial intelligence technologies are revolutionizing coaching strategies, player development, and match tactics. It aims to present a detailed examination of AI's current engagement in football, as well as the promise it contains.

While AI's presence in football is apparent, there is still an intriguing and scientifically backed study gap about the intricacies of its impact. The existing level of knowledge emphasizes the necessity for a systematic investigation of AI's impact on sports. How do AI algorithms improve coaching methods? How do they affect player performance and development? What tactical advancements will they bring to the game? The answers to these questions are at the heart of this study.

This thesis strives to be a beneficial resource for football teams, coaches, and stakeholders, in addition to shining light on AI's current and potential effect on football. It seeks to be a guiding compass for the footballing world by providing insights on the appropriate integration of AI to obtain a competitive edge while addressing potential barriers and ethical problems.

In the following pages, we'll look at the world of football, where history meets technology, and the pursuit of excellence is fuelled by data and analytics. The lines between the coach's wisdom and the machine's precision, but the purpose remains the same: to enhance the game, inspire spectators, and discover football's untapped potential.

2. LITERATURE REVIEW

2.1. BACKGROUND

The use of performance data in football has evolved significantly, transitioning from basic metrics to sophisticated analyses involving artificial intelligence (AI) and machine learning. This section reviews the literature on the historical context, advancements, and current applications of performance data, highlighting the integration of AI in modern football analytics.

2.2 Importance and Evolution of Performance Data

The evolution of performance data in football started from simple metrics like goals scored, passes completed, and distance run. These metrics provided basic insights into player and team performances.

However, over time, football's performance data has developed, with machine learning playing a crucial role. Bauer & Anzer (2021) research on counter pressing in professional football using data-driven methods exemplifies this development towards advanced analytical techniques. Similarly, (Linke et al., 2020) assessed the validity of TRACAB's optical video tracking systems, highlighting the integration of cutting-edge technology in performance analysis.

Furthermore, Nergård Rongved et al. (2021) explored automated event detection in soccer, indicating the growing reliance on multifaceted data analysis. These studies collectively show the transition from basic metrics to a more comprehensive and technology-driven approach in understanding football's individual and team performance.

Furthermore, according to Plakias et al. (2023) AI and machine learning not only analyse performance data but also identify distinct playing styles of soccer players. This adds a layer of sophistication to performance data analysis, moving beyond basic metrics to understanding the unique contributions and styles of each player.

2.2.1 Predictive Analytics in Performance Data

The sophistication of artificial intelligence in predictive analytics has significantly changed the landscape of performance data in football. In this study "Individual ball possession in soccer", Link & Hoernig (2017), show the application of artificial intelligence in predicting player performance trends. Similarly, Lago & Martín (2007) research on "Determinants of possession of the ball in soccer" provides insights into team dynamics under various game scenarios. These studies exemplify how AI-driven predictive analytics can provide coaches with various robust tools for them to make strategies based and prepare them for future games and seasons.

2.2.2 Real-Time Data and Dynamic Decision-Making

Real-time performance data analysis has revolutionized decision-making processes during live football matches. The study "In-play forecasting in football using event and positional data" explores the capacity of AI systems to process and interpret live data, offering instant strategic insights. This advancement facilitates immediate tactical adjustments, crucial for responding to the fluid dynamics of the game.

2.3 AI and Advanced Analytics

2.3.1 Deep Data Analysis and Player Performance

The deep data analysis capabilities of AI have transformed player performance evaluation. According to X. Wei et al. (2013), AI's capacity to analyse extensive datasets, provide a different understanding of player efficiency and adaptability. Such comprehensive analytics helps in making informed decisions regarding player selection and training, underlining the importance of artificial intelligence in the modern evaluation of player performance.

2.3.2 Tactical Insights and Strategy Formulation

AI's influence in developing tactical insights and strategies is enormous, as evidenced by Gudmundsson & Wolle (2010). This study highlights how AI algorithms can dissect historical and real-time game data to uncover opponent tendencies and formulate better tactical approaches. AI's analytical capabilities have become essential tools for modern football strategists.

2.3.3 Integrating AI with Traditional Coaching

The integration of AI with traditional coaching methods represents a significant evolution in football analytics. The DFL Deutsche Fußball Liga's (2020) publication "How is the official match data collected?". By combining AI-driven insights with the experience and intuition of coaching staff, they can achieve a more holistic and effective approach to strategy formulation and player development. This unity between technology and traditional coaching guides the future of the sport to different football strategies and training methodologies.

These topics underscore the big impact of artificial intelligence and advanced analytics in reshaping the understanding, planning, and execution of football strategies, emphasizing the importance of data-driven decision-making in the modern era of the sport.

2.4 Decision Support Systems

The introduction of AI decision assistance tools has changed the role of coaches on the sidelines. Jauhari et al. (2019) provide a decision support system for calculating the ideal positions for football players during a match, which can considerably assist coaches in making educated judgements based on player data in their job.

The model built by Chai & Xu (2009) that uses data mining techniques to discover trends in football matches is a remarkable example of AI integration in player performance research. This decision support model assists coaches in developing successful strategies for countering opponent tactics, hence improving strategic decision-making in real-time circumstances.

The use of such algorithms in player performance analysis constitutes a paradigm change in the practical use of artificial intelligence. Coaches that use these systems receive access to a variety of data that extends beyond typical measurements. Systems such as those presented by Sierksma (2006) provide a sophisticated support for football coaching and scouting, allowing a more objective and sensible management of player performance and resource allocation.

The selection algorithm created by Karamazov et al. (2021) for finding the optimal position of football players stands out in the landscape of AI applications in football coaching. It makes use of the Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methodologies to help in the strategic selection of players for various roles.

Safabun et al. (2020) unique AI assistant for player assessment in football shows the attempt to harness AI for decision assistance in the field of football tactics. This method supports coaching staff in generating data-driven judgements that go beyond typical tactical evaluations by combining machine learning algorithms and football knowledge.

2.5 Computer Vision in Player Analysis

The implementation of computer vision, particularly enhanced by deep learning techniques, in football player analysis is a technological breakthrough in sport. This section explores how computer vision is revolutionizing player analysis.

2.5.1 Advanced Player Tracking Analysis

Computer vision systems have changed player monitoring and analysis by utilizing advanced algorithms. These devices allow for the precise tracking of players' motions, providing insights into placement, spacing, and movement patterns. Thinh et al. (2019) describe a method for monitoring numerous football players in video streams using Efficient Convolution Operators (ECO), which allows for high-precision tracking of player movements.

This level of depth includes comprehension of player relationships, roles in specific plays, and success in various tactical configurations. This type of research is critical for understanding complex team plans and player contributions.

2.5.2 Tactical Pattern Recognition

In football, one significant application of computer vision is the recognition of tactical patterns.

Jurca & Giosan (2022) describe a pipeline for football analysis using computer vision and machine learning methods, which analyses game footage to identify and classify various tactical patterns used by teams, providing coaches with deeper insights into their opponent's tactical strategies, which is valuable for tactical planning and adjustments during games.

2.5.3 Performance Metrics Enhancement

Computer vision adds a visual analysis layer to performance metrics, making them more comprehensive. Sun et al. (2022) discusses an intelligent optimization algorithm of 3D tracking technology in football player movement analysis, enhancing traditional performance metrics like heat maps and pass completion under pressure through visual analysis.

2.5.4 Real-Time Decision Support

The real-time capabilities of computer vision systems introduce new possibilities to in-game decision support. These systems provide immediate feedback on player alignments, spacing issues, or exploitable gaps in the opponent's defence, thereby aiding coaches and players in making quick tactical decisions and improving the team's adaptability during matches.

Tsai et al. (2007) introduced Scout, a game speed analysis and tracking system employing computer vision to track moving objects, providing real-time feedback on player alignments and spacing issues during matches.

2.5.5 Injury Prevention and Biomechanical Analysis

An emerging area in which computer vision is making a significant impact in injury prevention and biomechanical analysis. Leo et al. (2010) present a multi-camera system for detecting ball-player interactions during soccer matches, which helps in biomechanical analysis and in injury prevention by analysing players' movements and postures.

2.6 AI in Injury Prevention and Player Health

The use of AI in sports medicine for injury prevention and player health is a growing area of research, with several studies demonstrating its effectiveness.

2.6.1 Injury Risk Assessment

AI's application in advanced injury risk assessment is significant in sports. Machine learning algorithms analyse data such as players' historical injury records, gameplay intensity, and physiological metrics. A study titled "An Overview of Machine Learning Applications in Sports Injury Prediction" published in Cureus in 2023 explores these aspects. It discusses how AI techniques like K-Nearest Neighbour, decision trees, random forests, and neural networks are applied in sports injury prediction, offering valuable insights for injury risk assessment (Amendolara et al., 2023).

2.6.2 Real-Time Biomechanical Feedback

Integrating AI with biomechanical analysis provides real-time feedback on players' movements. The article "Sports Medicine and Artificial Intelligence: A Primer" from PubMed discusses the use of AI in sports medicine. It outlines how AI can analyse performance data and biomechanical factors to help detect inefficient or harmful movement patterns, playing a crucial role in developing personalized injury prevention programs (Ramkumar et al., 2022).

2.6.3 Recovery and Rehabilitation Optimization

AI also plays an essential role in optimizing the recovery and rehabilitation process for athletes. The systematic review "Current Approaches to the Use of Artificial Intelligence for Injury Risk Assessment and Performance Prediction in Team Sports" from Sports Medicine - Open discusses the use of various AI techniques for injury risk assessment and performance prediction. This study emphasizes the potential of AI and machine learning in enhancing injury mitigation and rehabilitation protocols (Claudino et al., 2019).

2.7 Innovation in AI-Driven Training

2.7.1 Athletic Programs

AI's role in developing customized athletic programs is a significant advancement in sports training. Using AI algorithms, these programs analyse a comprehensive array of athlete data, including physical attributes, performance metrics, and psychological profiles. As outlined in "Enhancing Individual Sports Training through Artificial Intelligence: A Comprehensive Review" by Bodemer (2023), AI models are adept at evaluating an athlete's unique strengths, weaknesses, and training responses. This analysis enables the creation of specialized training plans tailored to each athlete's specific needs, optimizing their development and performance. These plans can focus on various aspects such as endurance, speed, agility, and technical skills, ensuring each athlete reaches their full potential.

2.7.2 Enhanced Performance Analysis

AI significantly improves performance analysis during training. Advanced AI-driven analytics tools can track and evaluate every aspect of an athlete's performance in real-time. In the study "Exploring the Application of Artificial Intelligence in Sports Training: A Case Study Approach", S. Wei et al. (2021), it's shown how AI systems monitor and analyse training session data to provide immediate feedback on execution, technique, and tactical understanding. This immediate feedback is crucial for athletes and coaches, allowing for swift adjustments and focused training, leading to rapid improvement and skill development.

2.7.3 Integration of AI, VR and AR in Training

The fusion of AI with Virtual Reality (VR) and Augmented Reality (AR) is revolutionizing training experiences. As highlighted in "Exploring the Application of Artificial Intelligence in Sports Training: A Case Study Approach" (S. Wei et al., 2021) these technologies create simulated real-game environments for a highly interactive training experience. AI-enhanced VR and AR replicate game scenarios, enabling athletes to practice and hone their skills in a controlled yet realistic setting. This method advances not only technical and tactical training but also aids in mental preparation and decision-making skills.

2.8 AI in Talent Scouting and Recruitment in Football

2.8.1 AI-Driven Talent Identification

Artificial neural networks are revolutionizing football talent identification. Traditional methods, often based on subjective evaluation, are being enhanced by AI's data-driven insights. Barron et al. (2018) in their PLOS ONE article, "Artificial neural networks and player

recruitment in professional soccer," demonstrate the power of artificial neural networks in predicting the career trajectories of professional footballers through performance data analysis. This methodological shift provides a more objective foundation for assessing potential transfer targets and supplements the traditional scouting methods.

2.8.2 Optimizing Recruitment Strategies

The integration of AI and technology in sports teams, particularly in terms of recruitment strategies, is significant. As discussed in "Golf and GameForge: Innovative Analytics for Recommender Systems" by Kreitzer et al. (2022), the use of advanced analytics and machine learning models in team sports, including football, enables more informed decision-making. These systems, incorporating AI, help in analysing player performances and dynamics, ensuring that new recruits are a tactical and cultural fit for the team. Such technological advancements are vital in identifying and selecting the best student-athletes, crucial for maintaining the power of sports programs and enhancing the recruitment process.

2.8.3 Market Value Assessment and Negotiations

The application of AI in market value assessment and negotiations in football, though not directly studied, is implied by the general use of data mining and technology in sports. Gomes et al. (2016) in his work on predicting football results through data mining, indirectly suggest the potential of AI in evaluating players' market values and aiding negotiation strategies. The reliance on data-driven methods for performance analysis points toward the growing importance of AI in financial aspects of player transfers.

2.8.4 Long-Term Player Development and Career Planning

Lawlor et al. (2021) in their research on player scouting and recruitment in English men's professional football emphasize the critical role of AI in both immediate performance assessment and long-term career planning. Performance Identification, focusing on short-term goals like winning games, is as important as the long-term development of athletes. This dual focus, supported by AI and data-driven methods, is essential for future talent pipeline planning and maintaining team balance over time.

2.9 Challenges and Ethical Considerations in AI for Football Coaching

2.9.1 Challenges

Data Privacy Concerns:

In football coaching, where AI systems rely on player performance data, ensuring data privacy is crucial. Vlahovich et al. (2017) discuss the ethics of genetic testing and research in sport, relevant to data privacy in AI for football coaching as it addresses the implications for athlete health and well-being. This is particularly pertinent when considering data collected from wearables and fitness tests.

Furthermore, Constantin & Barbu (2013) highlights the role of ethics in the activity of coaches, which can be extended to the management of player data, emphasizing the need for clear guidelines on data responsibility.

Algorithm Bias and Fairness:

It is important to maintain data accuracy to prevent biases in AI systems and the need for transparent and ethical AI practices in sports.

Taddeo & Floridi (2018) discuss the ethical framework required to harness AI potential while maintaining control, which is relevant for addressing biases in AI algorithms and ensuring fairness in football coaching.

Educational Gaps Among Coaching Staff:

The rapid shift towards a data-driven culture in sports organizations requires a deeper understanding of AI and machine learning tools by coaching staff. This change necessitates comprehensive knowledge among all stakeholders involved, including coaches, to effectively utilize AI in sports.

Eastabrook & Collins (2022) delve into the ethical considerations and challenges in adventure sports coaching research, which is applicable to understanding the educational gaps among coaching staff in football regarding AI and machine learning tools.

2.9.2 Ethical Considerations

Fairness and Transparency:

Ensuring fairness and transparency in AI decision-making is crucial. The GDPR, as discussed by the Sports Tech Research Network, highlights the need for transparency in the processing of personal data and compliance with principles like data minimization and accuracy. This is particularly important to prevent any bias in decisions regarding a player's performance and abilities.

Hardman et al. (2011) explore the ethics of sports coaching, providing insights relevant to ensuring fairness and transparency in AI decision-making in football coaching.

Accountability and Responsibility:

With AI increasingly influencing decisions in football coaching, questions of accountability arise. (Brown & Cogan, 2006). provide insights into ethical dilemmas in sport psychology settings, applicable to AI in football coaching. Their work emphasizes the importance of accountability and responsible use of AI, including issues like confidentiality and professional competence.

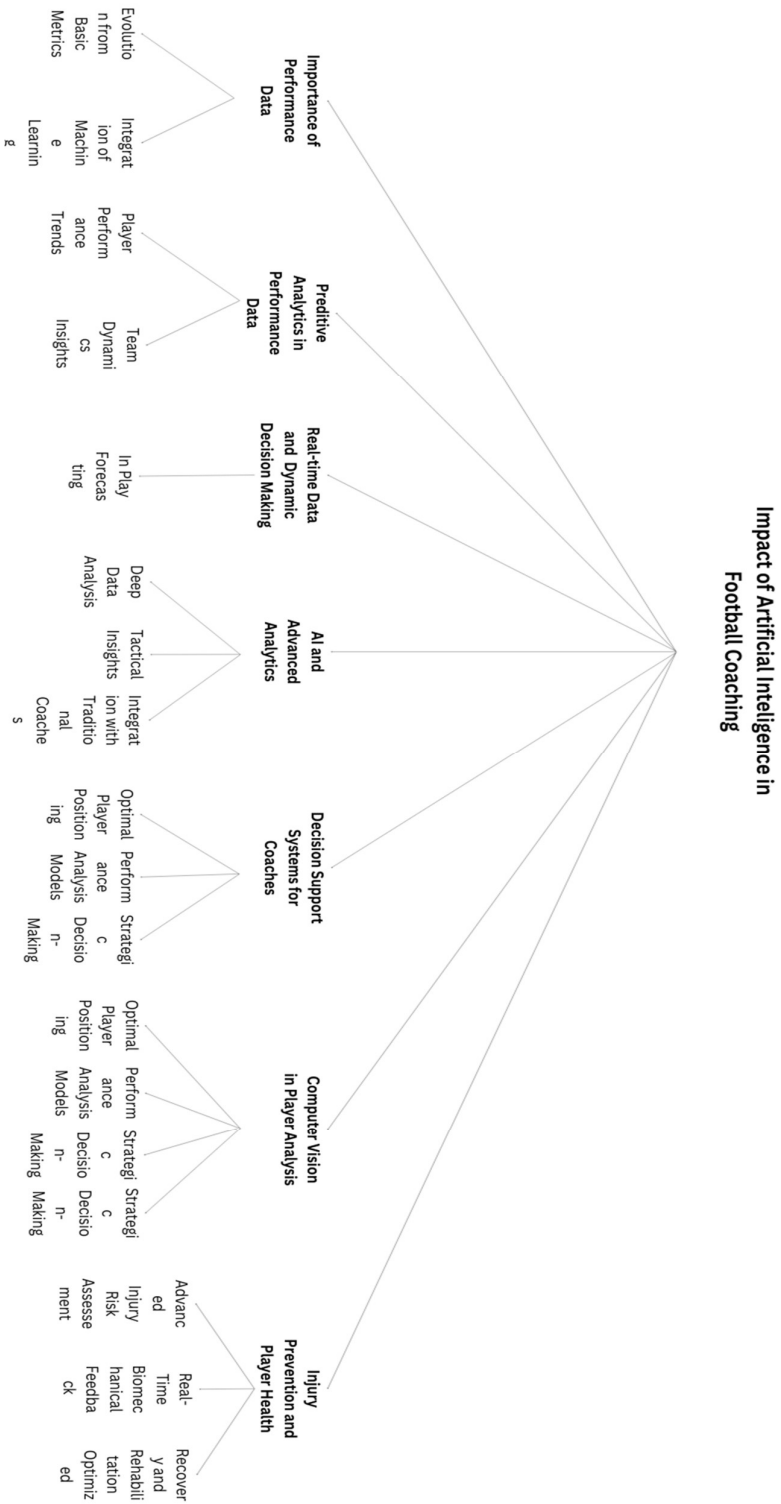


Figure 1. Impact of Artificial Intelligence

Technology	Description	Applications in Football Coaching
Wearable Technology	Devices with smart sensors worn by athletes.	Real-time performance tracking, health monitoring, fatigue assessment.
Augmented Reality (AR)	Technology that overlays digital information onto the physical world.	Enhanced strategy visualization, immersive training, tactical planning.
Artificial Intelligence (AI)	Algorithms and systems that mimic human intelligence to perform tasks.	Player performance analysis, predictive analytics, decision support.
Machine Learning	A subset of AI focused on the ability of machines to learn and adapt from experience.	Identifying playing patterns, performance trend analysis.
Computer Vision	AI technology that enables computers to interpret and process visual data from the real world.	Advanced player tracking, tactical pattern recognition, injury prevention.
Data Analytics	The process of analyzing raw data to find trends and answer questions.	Player and team performance analysis, scouting, strategy development.
Biomechanical Analysis	Study of the structure, function and motion of the mechanical aspects of biological systems.	Injury prevention, player movement efficiency, rehabilitation programs.
GPS Tracking	Using Global Positioning System technology for tracking and monitoring.	Monitoring player movements, physical demands assessment, training load analysis.

Table 1. Technology Used

3 METHODOLOGY

TAM Model

In the ever-changing football scene, the integration of Artificial Intelligence (AI) and sophisticated analytics has emerged as a critical component in developing current coaching techniques. As sports grow more data-driven, it is critical to understand the elements that impact football coaches' adoption and usage of new technology. This study investigates this issue using the Technology Acceptance Model (TAM) as its theoretical framework. Fred Davis developed TAM in the 1980s, and it provides a solid foundation for evaluating how perceptions of usability and utility impact the adoption of new technology.

This section describes TAM's use in the context of AI in football coaching, including model constructs and other aspects influencing technological acceptance. This study will use structured interviews with experienced football analysts to identify the extent of AI integration in coaching techniques, as well as the numerous elements that support or impede its implementation. The technique provided below is intended to assure a thorough knowledge of AI technology adoption trends among football coaches, hence offering insights that may impact future technological deployments in sports settings.

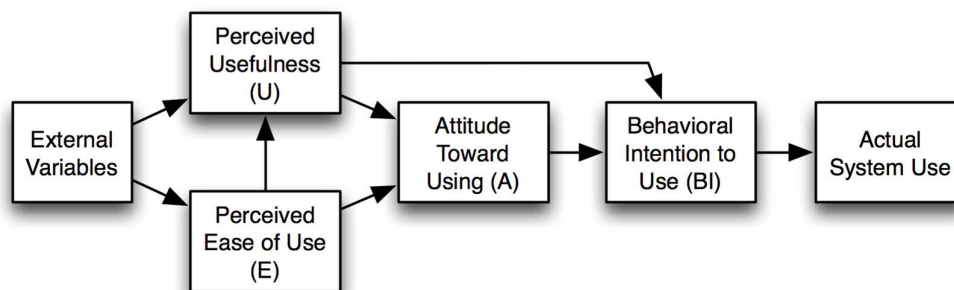


Figure 2. TAM Model

1. **Perceived Usefulness (PU):** This metric measures how much a user believes a technology will improve their performance or make their work simpler. In my interviews, I will inquire about participants' perspectives of how AI-powered technologies in football coaching improve areas such as player performance analysis, strategic decision-making, injury prevention, and talent scouting.

2. **Perceived Ease of Use (PEOU):** Ease of use is another important component in technology adoption. Participants will be asked to judge how easy it is to learn and use AI-powered technologies in football coaching. This covers user interface design, system complexity, and technological intuitiveness.
3. **Behavioural Intention to Use (BI):** Behavioural intention refers to the user's desire or intention to accept and use a technology. During the interviews, i will assess participants' willingness to employ AI-driven coaching tools based on their perceived usefulness and convenience of use. Understanding their behavioural objectives might help predict the likelihood of technology uptake in real-world coaching scenarios.
4. **Actual Use (AU):** This metric indicates how much consumers utilize the technology nowadays. While behavioural intention is a good predictor of actual usage, there may be differences between users' intentions and actual behaviour. I will examine TAM's validity in forecasting technology adoption behaviour by collecting data on participants' previous and present use of AI-driven coaching solutions.

In addition to the TAM metrics, my interviews will also explore other factors that may influence technology acceptance, such as:

- **Awareness:** Participants' level of awareness and familiarity with AI-driven technologies in football coaching.
- **Price Value:** Perceptions of the cost-effectiveness and value proposition of AI-driven coaching tools.
- **Facilitating Conditions:** External factors that may facilitate or hinder the adoption of technology, such as organizational support, infrastructure, and training resources.

By examining these factors through the lens of the TAM model, your research aims to provide valuable insights into the factors influencing the acceptance and adoption of AI-driven technologies in football coaching.

Interview Questions:

To get deeper into this theme, a series of structured interviews were conducted with analysts and Data Scientists from various football clubs.

The primary aim of these interviews is to uncover the multifaceted impact of AI and advanced analytics across different club environments and to understand how these tools are reshaping the tactical and strategic aspects of football coaching. By exploring the experiences and insights of key club analysts, this research seeks to highlight both the benefits and the challenges associated with the deployment of data-driven technologies in football.

Question Number	Interview Questions
Q1	How familiar are you with the application of AI and emerging technologies in football coaching?
Q2	In your opinion, how do AI and advanced analytics enhance the effectiveness of football coaching?
Q3	Describe any specific improvements in team performance or decision-making attributed to these technologies.
Q4	How easy is it to integrate and use these AI technologies?
Q5	What challenges, if any, have you faced while using these technologies?
Q6	How do you utilize predictive analytics and real-time data during training and matches?
Q7	How has AI contributed to injury prevention and player health management in your team?
Q8	Considering the cost of these technologies, do you find them to be a valuable investment?

Table 2. Interview Question

Participant Number	Group	Degree	Speciality
1	Analyst	Master	Football
2	Analyst	Master	Football
3	Data Scientist	Master	Football
4	Analyst	Master	Football
5	Analyst	Master	Football

Table 3. Participants

4 EMPIRICAL STUDY

Interviews

This detailed summary reflects the insights and opinions shared by the analysts regarding the impact of AI and advanced analytics on modern football coaching and my interpretation of it, highlighting both the benefits and the challenges of integrating these technologies into the sport.

1. Familiarity with AI and Emerging Technologies in Football Coaching:

Analyst (1C): "Since 2014, there has been a noticeable shift from basic statistics to advanced analytics like expected goals (xG) and threat levels." This evolution marks a significant development in the analytical landscape of football, transitioning from rudimentary metrics that only scratched the surface of statistical analysis to sophisticated models that offer a deep dive into the intricacies of game dynamics and player performance. This shift enables teams to assess not just the outcome of actions but their quality and potential impact, leading to a refined strategy and better-informed decision-making processes. Real-time analysis tools now allow coaches and analysts to adjust tactics on the fly, greatly enhancing the team's adaptability during matches.

Analyst (2B): "The sector has progressively embraced more sophisticated tracking data." This observation highlights a broader industry trend toward the integration of AI into sports analytics, moving beyond manual data collection to embrace systems that enhance the precision and depth of data analysis. Advanced tracking technologies can monitor a player's every move, providing insights into their behavioural patterns, efficiency on the pitch, and potential future actions. These systems are crucial for developing tactical approaches that anticipate rather than merely react to in-game situations, thereby optimizing team performance.

Analyst (4S): "Companies like Skill Corners, iScout, Status Perform, and Opta employ computer vision techniques to extract massive amounts of data from broadcast footage." By leveraging AI, these companies have transformed the data capture landscape, automating what was once a labour-intensive process. The use of computer vision allows for detailed analyses of player positioning and game events, leading to insights that were previously unattainable. This technology not only enhances the understanding of player interactions during the game but also feeds into simulations and training programs, thus improving preparation and strategic planning.

Analyst (3F): "AI is used not just as a tool for automation but as a critical component for enhancing decision-making and player evaluation." At Club F, the

integration of AI extends beyond mere data processing; it is pivotal in dissecting complex game data into actionable insights. This approach transforms raw data into strategic tools, enabling coaches to make decisions backed by detailed analyses of player performance under various conditions. Such capabilities are particularly valuable in scenarios requiring quick decisions about player lineups, substitutions, and formations based on current game dynamics and player conditions.

Analyst (5G): "The club has recognized the significant value that advanced data analytics, machine learning, and other AI-driven tools bring to modern football." This comprehensive embrace of AI technologies at Club G illustrates a commitment to embedding advanced technological tools across all facets of football operations. From tactical analysis and player development to scouting and health management, AI's influence permeates, driving enhancements that touch upon every aspect of the sport. For example, machine learning models are used to predict player injuries and fatigue, thereby informing training schedules and game-day rosters to optimize player performance and minimize health risks.

2. Perceived Usefulness of AI and Advanced Analytics in Football Coaching:

Analyst (1C): "These technologies lead to qualitative improvements, such as more informed strategic decisions in game preparation, player development, and overall team management." This analyst emphasizes the role of AI in enhancing the depth and quality of strategic decisions. For instance, by simulating various game scenarios, AI allows coaches to experiment with different team formations and strategies in a virtual environment before implementing them in actual matches. This not only improves preparation but also helps in tailoring training sessions to address specific weaknesses or capitalize on opponent vulnerabilities, ensuring that players are optimally prepared for every game scenario.

Analyst (2B): "These technologies enable technical teams to make more informed decisions by providing a detailed breakdown of player actions and their outcomes." AI's impact here is profound in that it extends beyond mere data collection to a sophisticated analysis of player movements and interactions on the pitch. By analysing movement patterns, teams can optimize player positioning and role assignments, which are crucial during high stakes matches. This kind of analysis helps in crafting bespoke tactics that leverage the strengths of individual players while mitigating team weaknesses, enhancing both the tactical adaptability and overall effectiveness of the team.

Analyst (4S): "This includes the creation of heat maps, player positioning, and other strategic metrics that help in refining team tactics and player effectiveness on the field." The Team S analyst highlights the utility of AI in visualizing complex game

data through heat maps and player positioning charts. These tools are invaluable for assessing how players occupy and use space, which can influence coaching decisions related to pressing, spacing, and marking. Heat maps, for example, can reveal patterns in player movements that suggest optimal ways to disrupt the opposition's strategies or to strengthen a team's defensive positioning.

Analyst (3F): "It includes advanced predictive models that help in assessing potential game outcomes, player performance probabilities, and even strategic game developments." Club F use of predictive analytics exemplifies AI's forward-looking capability. By forecasting game scenarios, these models allow coaches to anticipate the flow of the match and adapt their tactics in real-time, thereby adopting a proactive stance towards game management. This capability is crucial during matches when split-second decisions about substitutions or tactical shifts can significantly impact the outcome.

Analyst (5G): "By integrating AI tools, Team V can process and analyse large volumes of data more efficiently than traditional methods, leading to quicker and more accurate decisions both on and off the field." The Club G analyst points to the efficiency and speed enhancements provided by AI, which are vital in today's fast-paced football environment. With AI, data from numerous sources can be integrated and analysed swiftly, enabling real-time insights that inform tactical decisions and strategic planning. This rapid processing leads to more dynamic gameplay and enhances competitive strategies, as coaches can adjust their tactics based on up-to-date, comprehensive data analyses.

3. Specific Improvements in Team Performance or Decision-Making:

Analyst (1C): "These technologies have introduced a more data-driven approach, reducing reactionary decisions such as premature coaching changes based on short-term results." This insight highlights a fundamental shift towards more objective, evidence-based decision-making within football teams. AI and analytics help establish a culture where decisions are grounded in data, not just instincts or immediate game outcomes. This approach fosters stability and consistency in coaching strategies, allowing for development based on long-term performance trends rather than fluctuating results. This strategic patience is crucial for building a cohesive team and implementing complex game strategies effectively.

Analyst (2B): "With advanced analytics, Team B has been able to pinpoint specific areas of improvement by analysing success rates in various play types, such as crosses and shots." This example showcases how targeted data analysis can directly enhance specific tactical elements of play. By quantifying the effectiveness of different types of plays, coaches can fine-tune training sessions to focus on improving weak

areas, such as crossing accuracy or shot selection, ultimately elevating the overall skill level of the team. Such focused improvements are critical in turning marginal gains into significant competitive advantages over time.

Analyst (4S): "AI and analytics provide more comprehensive data that enhances understanding of the game. This includes better insights into territorial occupation, player pressure points, and overall team dynamics." This depth of analysis allows for a granular understanding of how teams and players perform within different contexts of a match. Understanding territorial control can help coaches design plays that maximize control over key areas of the pitch, while insights into player pressure points can inform strategies for both exploiting opponent weaknesses and reinforcing one's own defensive strategies.

Analyst (3F): "AI-driven insights allow the coaching staff to make informed decisions regarding player positioning, tactical adjustments during matches, and even substitutions based on real-time performance data and predictive outcomes." This capability underscores the real-time benefits of AI in football coaching, enabling immediate tactical responses that are informed by live data streams. Such capabilities mean that decisions such as substitutions or formation changes aren't just reactive but are proactively planned based on ongoing performance metrics and predictive modelling, enhancing the team's ability to respond dynamically to the flow of the game.

Analyst (5G): "AI has made a measurable impact on team performance at Team V by providing detailed insights that influence both strategic planning and real-time decision-making during matches." The integration of AI at Club G exemplifies how deep data analysis and real-time insights translate into enhanced game planning and execution. By analysing performance trends and player conditions, AI helps in crafting strategies that are not only reactive to immediate game conditions but also aligned with longer-term performance optimization.

4. Perceived Ease of Use of AI Technologies:

Analyst (1C): "Integrating AI and advanced analytics into football coaching is complex and often challenging." The analyst points out the inherent complexities involved in adopting these technologies, stressing that success depends significantly on clear role definitions within the club concerning who will use the data. This challenge is addressed by ensuring that end-users are not only equipped with the necessary tools but also fully prepared to integrate these insights into their daily routines. Effective implementation thus relies on a combination of technical readiness and organizational alignment, where the integration of data insights becomes a part of the strategic operations rather than an isolated set of tasks.

Analyst (2B): "The successful implementation of these technologies requires sophisticated infrastructure and also necessitates a team of highly skilled professionals." This statement from the Team B analyst underscores the dual requirements of advanced technological infrastructure and expert personnel to manage and interpret complex data sets effectively. The ongoing challenge for clubs is not just in adopting the latest technology but also in ensuring they have adequately trained data analysts who can bridge the gap between raw data and actionable football insights. This scenario often requires significant investment in both training current staff and recruiting new talent skilled in data science and analytics.

Analyst (4S): "Integrating AI and advanced analytics into daily football operations is described as challenging." The Team S analyst highlights the difficulties related to the complexity of the technology itself and the initial resistance from those accustomed to traditional methods of coaching and management. Resistance often stems from a lack of understanding and scepticism regarding the reliability of AI-generated insights, particularly when these insights contradict established football strategies or practices. Overcoming these challenges requires a cultural shift within the organization towards a more data-driven approach, facilitated by education and demonstrating the tangible benefits of AI applications.

Analyst (3F): "While initially challenging, the integration of AI technologies at Team F has been streamlined through continuous training and adaptation by the technical staff." The Club F analyst discusses the evolution of AI integration processes within the team, emphasizing the role of continuous training and the development of user-friendly interfaces. These efforts make advanced analytics more accessible to coaching staff and reduce the intimidation factor associated with complex software, ultimately enhancing the usability of data-driven tools in everyday coaching decisions.

Analyst (5G): "Integrating AI technologies into daily operations is initially challenging, requiring significant training and adjustment." However, the integration pays off by significantly enhancing operational efficiency and decision-making speed. The Club G analyst acknowledges the steep learning curve associated with these technologies but argues that the effort is justified by the subsequent improvements in efficiency and agility in decision-making. Once teams overcome the initial barriers, AI tools can transform coaching and strategic operations, making them more dynamic and responsive to real-time data.

5. Challenges Faced While Using These Technologies:

Analyst (1C): "Several challenges have been faced while implementing these technologies, including the complexity of data and the need for specialized knowledge to interpret and apply the insights effectively." The analyst emphasizes the dual

challenges of the inherent complexity of advanced analytics and the expertise required to leverage these tools fully. Beyond technical challenges, there is also cultural resistance within clubs, necessitating robust communication channels to bridge the gap between data analysts and coaching staff. This resistance can stem from a lack of familiarity with data-driven approaches, making education and clear demonstration of the benefits essential to fostering acceptance.

Analyst (2B): "The main challenges in using advanced analytics include the high quality of data required and the rapid pace at which football decisions must be made." This analyst highlights the need for high-quality data inputs to ensure reliable outputs, which is a significant challenge given the fast-paced nature of football decision-making. Furthermore, Team B faces difficulties in integrating disparate data sources, such as GPS and event data, into a coherent analytical tool that provides accurate and actionable insights during matches. The ability to quickly synthesize and act on data is critical in a sport where tactical adjustments need to be made in real-time.

Analyst (4S): "A significant challenge is bridging the gap between what technology can offer and its acceptance among the football staff." The Team S analyst details internal resistance as a major hurdle, particularly when new metrics like expected goals contradict traditional evaluations. This scepticism often arises from misunderstandings about how such metrics are calculated and their practical relevance, underscoring the need for ongoing education and clear communication about the advantages and methodologies of advanced analytics.

Analyst (3F): "The primary issues include the substantial financial investment required to access cutting-edge technologies and the need for significant data infrastructure." The Club F analyst points out the substantial financial and infrastructural demands of implementing AI and analytics. These technologies require not just initial investment, but also ongoing expenses related to system maintenance and data management. Integrating various data streams into a cohesive framework is another technical challenge that requires substantial resource allocation.

Analyst (5G): "Despite the benefits, several challenges persist. The high cost of acquiring state-of-the-art AI technologies and maintaining the latest data analytics platforms can be prohibitive." In addition to financial hurdles, the Club G analyst addresses the need for continual training and updates for technical staff to keep pace with technological advancements. Another critical concern is data security and privacy, especially when handling sensitive player and team information, which requires rigorous safeguards to prevent breaches.

6. Utilization of Predictive Analytics and Real-Time Data During Training and Matches:

Analyst (1C): "Predictive analytics and real-time data are crucial during both training sessions and matches. These tools are used to make real-time tactical adjustments during games and to manage player loads during training to prevent injuries." This statement underscores the integral role these technologies play not only in enhancing game-day tactics but also in optimizing training protocols to maintain player health. By analysing data gathered during training and matches, teams can dynamically adjust player workloads and strategies, thereby minimizing injury risks and maximizing performance efficiency. This proactive management approach is pivotal in maintaining an optimal balance between player readiness and health conservation.

Analyst (2B): "While predictive analytics and real-time data are starting to be utilized during matches, their current use is relatively basic and not yet fully integrated into the live decision-making process." This reflection points to the initial stages of adoption at Team B, where the potential of real-time data is acknowledged but the full integration into tactical decisions during matches is still evolving. The analyst's observation highlights the need for further development and training to fully exploit the capabilities of these technologies, suggesting that future advancements could significantly enhance live strategic adjustments.

Analyst (4S): "Technical and tactical real-time data collection is limited to a few elite clubs that have the necessary infrastructure." Here, the disparity in technological adoption among clubs is emphasized. Team S notes that while some elite clubs have successfully integrated these advanced data systems into their operations, many others lag due to infrastructural and financial constraints. This gap signifies a broader challenge within the sport, where the ability to leverage real-time analytics can provide significant competitive advantages to those who can afford the necessary technology.

Analyst (3F): "Team F leverages predictive analytics and real-time data extensively during training sessions and matches." Club F approach showcases an advanced stage of integration where analytics inform both the planning and reactive strategies during games. This extensive use allows Club F to adapt quickly to in-game dynamics, using data-driven insights to make informed decisions on player positioning, substitutions, and tactical shifts, thereby enhancing the team's responsiveness and strategic depth.

Analyst (5G): "During matches, these technologies provide the coaching staff with real-time insights into player fatigue levels, potential injury risks, and opponent tactics." Club G employs real-time data to achieve a granular understanding of player conditions and tactical opportunities as they unfold. By monitoring fatigue and injury risks, the coaching staff can make pre-emptive changes to safeguard player health

while also exploiting tactical insights to adjust game plans effectively against opponent manoeuvres.

7. AI's Contribution to Injury Prevention and Player Health Management:

Analyst (1C): "AI plays a significant role in injury prevention and player health management." By leveraging comprehensive player data, AI technologies at this club are used to predict potential injury risks and implement preventive measures. This includes sophisticated adjustments to training loads and game-time strategies, aimed at minimizing risks and enhancing player recovery. This proactive management leads to fewer injuries and better overall team health. For example, predictive analytics might suggest reducing the training intensity for a player showing signs of potential overuse injuries, thus preserving their long-term health and performance capabilities.

Analyst (2B): The analyst expresses scepticism about the direct benefits of AI in preventing injuries, highlighting the inherent unpredictability of injury factors that extend beyond measurable loads or physical stress. "Managing fatigue through data is feasible, yet predicting injuries remains unreliable due to the multitude of uncontrollable variables involved." This perspective underscores the limitations of current AI technologies, where despite advances, the complex nature of human injuries still presents significant challenges for predictive accuracy.

Analyst (4S): Echoing similar concerns, the Team S analyst notes the "high incidence of false positives and the complexity of predicting injuries with a high degree of accuracy." The difficulty arises from the unpredictable elements that contribute to injuries, which are often not solely dependent on quantifiable data like training loads or physical exertion. This scepticism highlights the challenges in fully relying on AI for injury prevention, pointing to the need for improved algorithms that can better handle the multifaceted aspects of injury risks.

Analyst (3F): In contrast, the Club F analyst illustrates a more positive utilization of AI, where "AI significantly contributes to injury prevention by enabling more personalized approaches to player health management." By analysing data from wearable technology, Club F can tailor training and recovery programs to individual player needs, which effectively minimizes downtime and optimizes performance throughout the season. This approach allows for a more nuanced understanding of each player's health, leading to customized interventions that proactively address potential injury risks.

Analyst (5G): Similarly, at Team V, "AI technologies play a crucial role in injury prevention and health management." The use of data from wearable fitness devices

enables the club to monitor physical conditions and workloads meticulously, identifying potential injury risks before they manifest into more serious conditions. This proactive strategy enhances player management by allowing for adjustments in training loads and recovery protocols tailored to individual player profiles, thereby optimizing performance, and preventing injuries.

8. Value of Investing in These Technologies:

Analyst (1C): "Despite their high costs, the analyst advocates for the investment in AI and advanced analytics, arguing that the long-term benefits of these technologies outweigh the expenses." The analyst emphasizes the strategic nature of investments in AI, pointing out that they lead to more effective strategic decisions, enhanced player performance, and potentially more successful seasons. The rationale is that, although initial costs are significant, the payoff in terms of improved decision-making and competitive advantage makes these investments worthwhile. This approach positions data analytics as a crucial asset, more impactful than the cost of individual player signings, by enabling a broader and more sustained impact on the team's overall capabilities.

Analyst (2B): "The investment in AI and advanced analytics is seen as valuable for the strategic advantages it can offer, particularly in scouting and player recruitment." Team B analyst recognizes the power of AI to analyse a vast array of players across multiple leagues, providing a competitive edge in player acquisition. However, there is a cautionary note that for smaller clubs with tighter budgets, the return on investment may not justify the high costs. This perspective highlights the need for a balanced approach, considering each club's financial capabilities and strategic goals, acknowledging that the benefits of AI need to be weighed against the financial realities of the club.

Analyst (4S): "Despite the challenges, the investment in AI and advanced analytics is justified, especially for clubs operating at a high level where the financial stakes are significant." This analyst acknowledges that while the cost can be prohibitive for smaller clubs, for those with the necessary resources, the potential to minimize risks in player acquisitions and improve tactical decisions provides substantial returns. This view suggests that for clubs in a position to invest, AI and analytics offer a strategic advantage that can translate into both on-field success and off-field financial management.

Analyst (3F): "The strategic investment in AI and analytics is seen as highly beneficial for Team F." This perspective underscores that AI technologies not only enhance tactical and strategic aspects of football management but also yield considerable returns in player recruitment, retention, and overall team performance.

The insights gained from these technologies support more informed decision-making, leading to better competitive outcomes and increased financial efficiency in player management and game strategy.

Analyst (5G): "The investment in AI and emerging technologies is seen as highly strategic at Team V, offering long-term benefits that outweigh the initial setup costs." The Club G analyst points out that these technologies drive significant improvements in player scouting, game strategy, performance analytics, and health management. They furnish a competitive edge in the rapidly evolving football world, where data-driven decisions can lead to superior performance and tactical superiority on the pitch.

Analyst/Club	Role of AI in Coaching	Benefits Identified	Challenges Faced	Strategic Value
Analyst 1C	Enhancing strategic decisions, player performance, and team management.	Improved decision-making, long-term strategic planning, fewer knee-jerk reactions.	Complexity of implementation, cultural resistance, need for role clarity.	High; strategic investments lead to better overall team success.
Analyst 2B	Optimizing player acquisition and tactical planning.	Competitive edge in player acquisition, more informed decisions.	High data quality requirement, rapid decision-making needs, integration issues.	Medium; valuable but dependent on the club's financial capabilities.
Analyst 4S	Limited to a few elite clubs due to infrastructure requirements.	Enhanced understanding of game dynamics and player performance.	Resistance from traditional staff, complexity of technology, acceptance issues.	High for elite clubs; justified by minimizing risks and improving tactics.
Analyst 3F	Extensive use in training and matches for tactical adjustments.	Tailored training regimens, responsive game-time decision-making.	Financial and infrastructural investments, integration of data sources.	Very high; substantial returns in player management and game strategy.
Analyst 5G	Comprehensive in scouting, player development, and health management.	Enhanced game strategy, performance analytics, player health management.	High costs, need for continual technology updates, data security concerns.	High; long-term benefits outweigh initial setup costs.

Table 4. Interviews Resume

5 RESULTS AND DISCUSSION

In an expanded analysis of the role of AI and advanced analytics in football coaching, the perspectives shared during interviews with representatives from clubs like Team V, Team F, Team B, Team C, and Team S offer a rich tapestry of how data-driven technologies are embedded within different football cultures and financial contexts. Each club's approach not only reflects their resource allocation but also their strategic priorities and long-term vision for technology in football.

Adoption Timeline and Technological Evolution

All analysts recognize 2014 as a pivotal year marking the integration of sophisticated analytics into football. This transition period is noted by the analyst from Team C, who highlights the shift from basic statistics to complex metrics such as xG and threat levels. This evolution has allowed for deeper insights into player contributions and game dynamics, shifting the analytical focus from descriptive to predictive and prescriptive analytics. Team B analyst corroborates this timeline, observing a move towards more intricate tracking systems, which not only gather but also interpret motion and tactical patterns in real-time. Team S discussion of third-party companies like Opta facilitating this transition underscores the industry-wide adoption of these technologies, highlighting the significant improvement in data collection and application accuracy. Each club's journey, while aligned in timing, illustrates different facets of technological adoption, from data collection enhancements to strategic application in game tactics and player management.

The analysts' timeline aligns with Bauer & Anzer (2021), who noted a pivotal shift towards data-driven methods in the early 2010s, including the adoption of counter-pressing analysis. This shift is also supported by Linke et al. (2020), who discussed the integration of TRACAB's optical video tracking systems around the same period, enhancing the capture and analysis of detailed performance metrics. This evolution from descriptive to predictive and prescriptive analytics marks a significant milestone in the technological adoption across football clubs.

Utility of Advanced Analytics

The universal praise for AI's usefulness underscores its transformative impact across various football coaching aspects. Team C focuses on strategic decision-making enhancement due to AI mirrors Team B's emphasis on the revolution in understanding team performances and individual player actions. Team S and Club F delve deeper into technical applications, noting how AI supports the creation of heat maps and player

positioning strategies that refine on-field tactics. Club G takes a broader view, highlighting AI's pervasive impact across tactical analysis, player development, and even health management. These perspectives illustrate a collective acknowledgment of AI's critical role in elevating the analytical capabilities of teams but also reflect varied emphasis on different aspects of the game, from tactical to operational enhancements.

The utility of AI in enhancing tactical insights is corroborated by Gudmundsson & Wolle (2010), who demonstrated how AI algorithms can dissect historical and real-time game data to uncover opponent tendencies. Ks (2020) highlighted the diverse applications of AI across different football cultures, emphasizing its role in reshaping tactical insights and strategy formulation. The collective acknowledgment of AI's critical role reflects its widespread impact on elevating the analytical capabilities of teams, as discussed in the literature.

Tangible Improvements and Decision-Making

AI's impact on team performance and decision-making is noted across all clubs, albeit with nuanced differences in perceived benefits. Team C and Team B discuss how AI has facilitated a shift towards more data-driven approaches, significantly reducing reactionary tactics and fostering a more strategic outlook in managing teams. Team S's cautious acknowledgment of AI's indirect benefits suggests a more measured appreciation, highlighting the broader, sometimes less immediately visible impacts of comprehensive data analysis. Club F and Club G's comments about the use of AI for real-time tactical adjustments during matches point to practical, on-the-ground applications that enhance adaptability and responsiveness during live play.

The effectiveness of real-time data analysis in dynamic decision-making is supported by "In-play forecasting in football using event and positional data," which explores AI's capacity to offer instant strategic insights. These findings align with the analysts' experiences of using AI to make immediate tactical adjustments during matches, reflecting the practical applications discussed in the literature.

Challenges and Barriers to AI Integration

Despite the enthusiasm for AI, integrating these technologies presents significant challenges, as noted by all analysts. The complexity of AI systems, the need for specialized training, and the initial resistance from traditional coaching staff are common themes. Team C and Team S discussions on cultural and operational hurdles echo a broader issue within the sport—balancing traditional coaching methods with cutting-edge technology.

Team B's focus on the high demands for data quality and rapid decision-making capacity highlights technical challenges, while Club F and Club G's mention of substantial financial investments points to economic barriers. These insights reflect a multifaceted challenge landscape that clubs must navigate to harness AI's full potential effectively.

These challenges reflect the findings of Taddeo & Floridi (2018), who emphasized the need for ethical frameworks and addressing biases in AI systems. Vlahovich et al. (2017) highlighted data privacy concerns, particularly in the context of AI's reliance on personal and performance data. The educational gaps among coaching staff regarding AI tools, as mentioned by Eastabrook & Collins (2022), align with the challenges noted by the analysts.

Strategic Value and Long-Term Benefits

All analysts affirm the strategic value of investing in AI, citing long-term benefits that outweigh the formidable upfront costs. The discussions range from improved tactical decision-making and player performance to enhanced scouting and player recruitment efficiencies. Club F and Club G's broader outlook on AI's role in refining strategic aspects of football management and achieving competitive advantages encapsulates the overarching sentiment that, despite the challenges, the forward-looking investments in AI and analytics are not only beneficial but essential for maintaining and enhancing competitive edge in modern football.

The strategic benefits of AI in football are highlighted by Lawlor et al. (2021), who emphasized AI's role in both immediate performance assessment and long-term career planning. This dual focus on current performance and future talent pipeline planning aligns with the perspectives shared by the analysts, supporting the literature's view on AI's strategic value in football.

AI in Injury Prevention and Player Health

AI's role in injury prevention and player health management is another crucial aspect highlighted by the interviewees. Team C mentions AI's role in assessing injury risks and optimizing recovery processes, while Team B highlights the real-time biomechanical feedback provided by AI systems to prevent injuries. Team S notes how AI tools help monitor player health and manage workload to prevent overtraining. Club F discusses the use of AI in developing personalized injury prevention programs, and Club G emphasizes AI's contribution to a more effective and efficient rehabilitation process for injured players.

AI's application in injury prevention is supported by the study "An Overview of Machine Learning Applications in Sports Injury Prediction" Amendolara et al. (2023), which discusses the use of machine learning algorithms for injury risk assessment. Ramkumar et al. (2022) also emphasize the role of AI in providing real-time biomechanical feedback and optimizing recovery processes, aligning with the insights shared by the analysts.

Innovation in AI-Driven Training

The role of AI in innovating training methods is well-recognized. Team C discusses AI's role in developing customized training programs based on individual player data, while Team B highlights the use of AI to enhance performance analysis during training sessions. Team S emphasizes the integration of AI with VR and AR to create realistic training environments. Club F mentions AI tools providing immediate feedback on training execution, improving skill development, and Club G discusses AI's role in mental preparation and decision-making skills during training.

The role of AI in developing customized training programs is supported by Bodemer (2023), who discussed AI's capacity to tailor training plans to individual athlete needs. The integration of AI with VR and AR, as highlighted by S. Wei et al. (2021), aligns with the analysts' insights on creating immersive training experiences. AI's contribution to real-time performance analysis and immediate feedback, enhancing skill development, is further emphasized in the literature.

AI in Talent Scouting and Recruitment

AI's transformative impact on talent scouting and recruitment is another key area of discussion. Team C discusses AI's role in identifying and assessing potential recruits through data-driven insights. Team B highlights the use of AI to optimize recruitment strategies and ensure new recruits fit team dynamics. Team S mentions how AI tools help evaluate players' market values and aid negotiation strategies. Club F emphasizes AI's contribution to long-term player development and career planning, while Club G highlights AI's role in enhancing the objectivity and efficiency of scouting and recruitment processes.

The role of AI in talent identification is supported by Barron et al. (2018), who demonstrated the use of artificial neural networks in predicting career trajectories of professional footballers. The optimization of recruitment strategies, as discussed by Kreitzer et al. (2022), aligns with the analysts' insights on using AI for informed decision-making. AI's application in market value assessment and negotiations, though indirectly

discussed by Gomes et al. (2016), supports the practical experiences shared by the analysts.

Challenges and Ethical Considerations in AI for Football Coaching

The analysts also highlight several challenges and ethical considerations in integrating AI into football coaching. Team C emphasizes data privacy concerns and the need for transparent AI practices. Team B discusses potential biases in AI algorithms and the importance of fairness. Team S points out the educational gaps among coaching staff regarding AI tools. Club F mentions the need for clear guidelines on data responsibility and ethical use of AI, and Club G discusses the importance of accountability and responsible use of AI in coaching.

These challenges reflect the findings of Vlahovich et al. (2017), who discussed data privacy concerns and the ethical implications of AI in sports. Taddeo & Floridi, (2018) underscored the necessity for ethical frameworks and addressing biases in AI systems, aligning with the analysts' perspectives on the challenges and ethical considerations in AI integration.

6 CONCLUSIONS AND FUTURE WORKS

The discussion underscores a significant trend: the integration of AI and advanced analytics is reshaping football across all levels.

The utilization of AI and advanced analytics in football underscores a broader trend towards data-driven decision-making across all levels of the sport. While financial disparities create a varied landscape of technology adoption, the commitment to integrating AI into football operations is clear across the board. Clubs are progressively recognizing the value of these technologies in gaining competitive edges, whether through enhanced game-day tactics, improved player health management, or more efficient scouting and recruitment.

The future trajectory for AI in football looks promising, with potential equalizing effects as these technologies become cheaper and more accessible. As clubs continue to innovate and adapt, the playing field may level, allowing smaller clubs to compete more effectively with financial giants, not just on the pitch but in strategic and operational capacities as well.

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APPENDIX A



This is to certify that

Project No.: **OTHER2024-6-289675**

Project Title: **Artificial Intelligence in Football: Coaching and Decision Support**

Principal Researcher: **Mijail Naranjo**

according to the regulations of the Ethics Committee of NOVA IMS and MagIC Research Center this project was considered to meet the requirements of the NOVA IMS Internal Review Board, being considered **APPROVED** on 6/28/2024.

It is the Principal Researcher's responsibility to ensure that all researchers and stakeholders associated with this project are aware of the conditions of approval and which documents have been approved.

The Principal Researcher is required to notify the Ethics Committee, via amendment or progress report, of

- Any significant change to the project and the reason for that change;
- Any unforeseen events or unexpected developments that merit notification;
- The inability of the Principal Researcher to continue in that role or any other change in research personnel involved in the project.

Lisbon, 6/28/2024

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