Harnessing AI for Enhanced Performance

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A Study on the Integration of Artificial Intelligence in NFL Franchises

Gabriele Battistella

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1. Key Findings

As the most-watched sport in the United States, American football stands to gain significantly from Artificial Intelligence (AI)-driven innovations. The integration of AI and Machine Learning (ML) within the National Football League (NFL) represents a transformative shift in how teams strategise, analyse performance, and safeguard player health. This section examines the current landscape of AI applications in NFL teams, explores the impact of AI tools on player performance metrics and team outcomes, and forecasts future trends in AI implementation within the sport. Beyond strategy and performance, AI is also set to play a critical role in player safety. Moreover, due to the average career length of an NFL player being approximately 3.3 years (Nguyen, 2022), primarily due to the physically demanding nature of

the sport and the high risk of injury, AI and ML are used for injury prediction and prevention.

A Map of the Current Landscape of AI Application in NFL Teams

Football, being one of the most schematic, tactical and data-driven team sports, is no stranger to the use of data. AI is currently being implemented in game analysis and preparation along with player health and safety. NFL franchises often have budgets exceeding $500 million annually (Forbes, 2023), meaning the franchises of this league are able to invest in the best and latest technologies. The analysis of team practices and games, in other words the development of the tactical side of a team's game, along with player longevity due to improved health and reduced injury risks, should be and are the main focus for the implementation of AI technologies within NFL franchises.

The integration of AI and ML in the NFL is progressively transforming the laborious process of annotating and analysing American Football footage, significantly enhancing coaching strategies by improving the accuracy and efficiency of player and squad-formation analysis, which ultimately benefits team performance, game preparation and the spectator experience (Newman et al., 2023). Traditionally being a labour-intensive process, coaches and analysts manually reviewed and annotated video recordings of games—a process both time-consuming and prone to human error. Now, AI-driven systems, utilising computer vision and deep learning, automatically detect and label player positions and formations with over 90% accuracy (Lu et al., 2013; Atmosukarto et al., 2014). This reduces preparation time, allowing coaches to focus on strategy. Moreover, the ability to accurately analyse and predict player movements and formations through AI, not only enhances the preparation process but also has the potential to improve in-game decision-making. This current dynamic shows that AI is becoming an indispensable tool for NFL teams, providing a competitive edge in both player development and game strategy (Atmosukarto et al., 2014).

The integration of AI in the NFL, particularly through the Digital Athlete platform (Safety and Health Practitioner, 2023), marks a significant advancement in player safety and performance optimisation. Developed in collaboration with Amazon Web Services (AWS), the platform utilises complex ML algorithms and computer vision to process and analyse extensive datasets captured during each play. The data inputs, including player positions, velocities, accelerations, and impact forces, are fed into the system, which then runs millions of simulations to predict outcomes under various conditions. These simulations are not generic; they are tailored using specific parameters like player biomechanical data, environmental factors, and even equipment variations, enabling precise identification of high-risk scenarios that could lead to injuries (Ibid.; Motivair, 2024).

At the core of this system is the use of deep learning techniques, such as convolutional neural networks (CNNs), which are particularly effective in image and video analysis. These CNNs are trained on vast amounts of game

footage to automatically detect and label players, identify formations, and recognise patterns of play that might be hazardous. For instance, the system can reconstruct a play in three dimensions, analysing it from multiple angles to pinpoint the exact moment and cause of an injury (PH&S, 2019). By understanding the forces and motions involved, the Digital Athlete can suggest modifications in player technique, training loads, or protective gear to mitigate future risks.

Additionally, the platform employs reinforcement learning mechanism, where the AI models continuously improve their predictions by learning from each simulation's outcomes. This iterative process improves injury risk prediction and optimises performance. Real-time data from the NFL's Next Generation Stats system integrates with these models, providing insights to adjust strategies and tailor recovery protocols, enhancing safety and extending players' careers (Motivair, 2024; Kelly, 2024). By analysing this information, franchises can identify signs of stress, fatigue, or increased injury risks. This data enables trainers and medical teams to intervene

proactively and implement rest periods and better-tailored recovery programs along with modified training regimens to minimise further risks.

AI Tools and Their Impact on Player Performance Metrics and Team Outcomes

In the NFL, advanced AI systems are revolutionising player identification and game analysis, an example of such systems is the Automated Player Identification and Indexing System (Liu et al., 2023). The system utilises a two-stage deep learning network specifically designed for the crowded and dynamic environment of American football games. The first stage employs a Detection Transformer (DETR) network, which excels in detecting

players even in complex, overlapping scenarios by analysing spatial relationships between objects on the field (Carion *et al.*, 2020). The second stage focuses on jersey number recognition using DETR and RetinaNet for player detection (Ibid.). The procedure accurately identifies players and synchronises data with the game clock for detailed logs (Lin et al., 2020; Wu et al., 2019), with an average precision of 87.9% for player detection and 91.7% for jersey number recognition (Liu et al., 2023).

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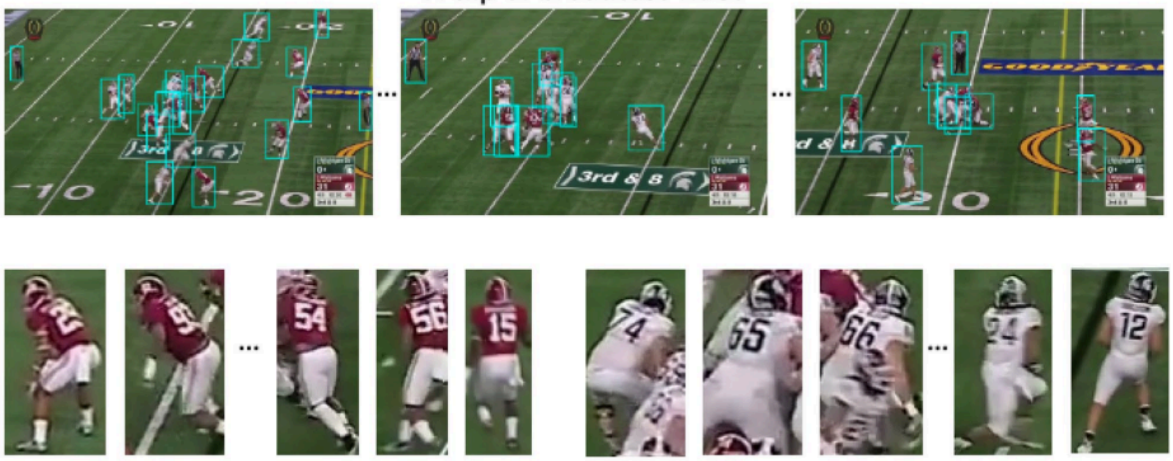

Play number	Quarter	Start time	End time	Home	Away	Participating players of Home team
65	4	11:38	10:20	Alabama	Michigan State	15: Ronnie Harrison 29: Minkah Fitzpatrick 54: Dalvin Tomlinson 56: Tim Williams .....

Figure 1: An example of the system being used for player detection, jersey number recognition, and corresponding game logs (Liu et al., 2023).

The Catch Analysis System, developed by Hollaus, Reiter and Volmer (2023), focuses on the automated analysis of catch attempts in American football, which integrates advanced ML techniques. The system aims to enhance the accuracy and efficiency of performance evaluation in training environments. In the context of automated American football training, a mechanism, combining CNN and Long Short-Term Memory (LSTM) networks has been developed to classify catch attempts, operating audiovisual recordings, where CNN processes image data whilst LSTM handles temporal sequences. Before classification, the data, as demonstrated in *Figure 2*, is processed into a synchronised format, which is crucial for achieving the high accuracy of 92.19% in distinguishing between successful and failed catch attempts (Ibid.).

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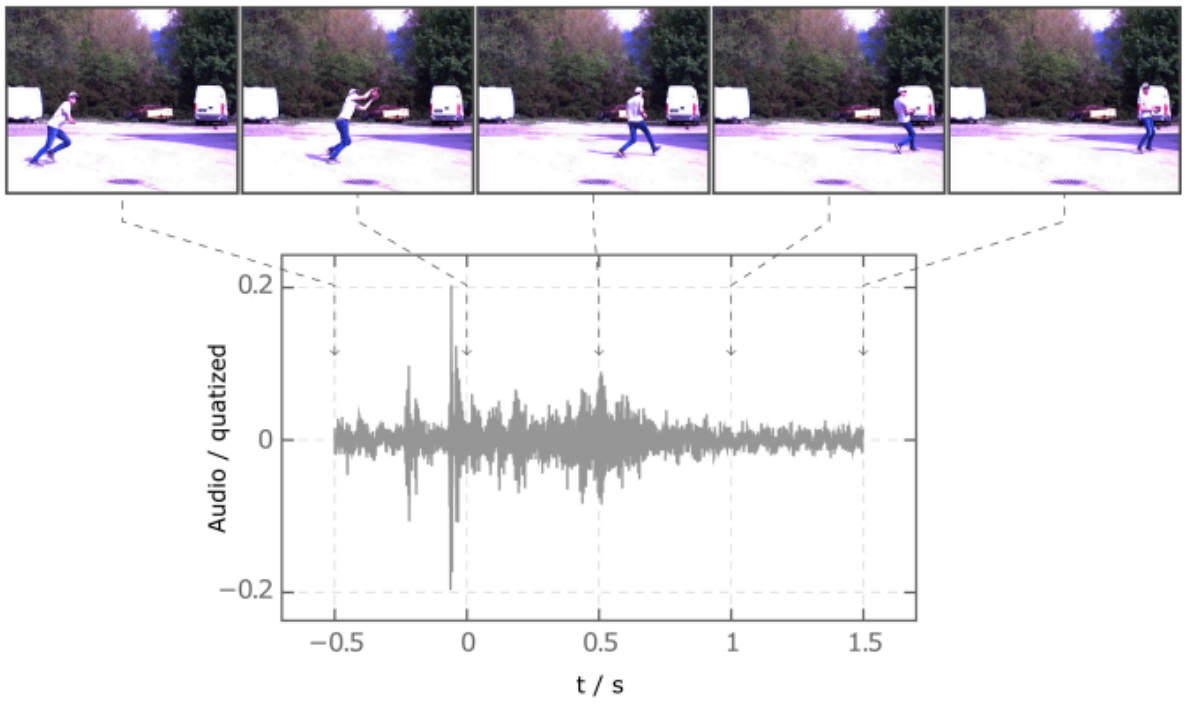

Figure 2: CNS in action (Hollaus, Reiter and Volmer, 2023).

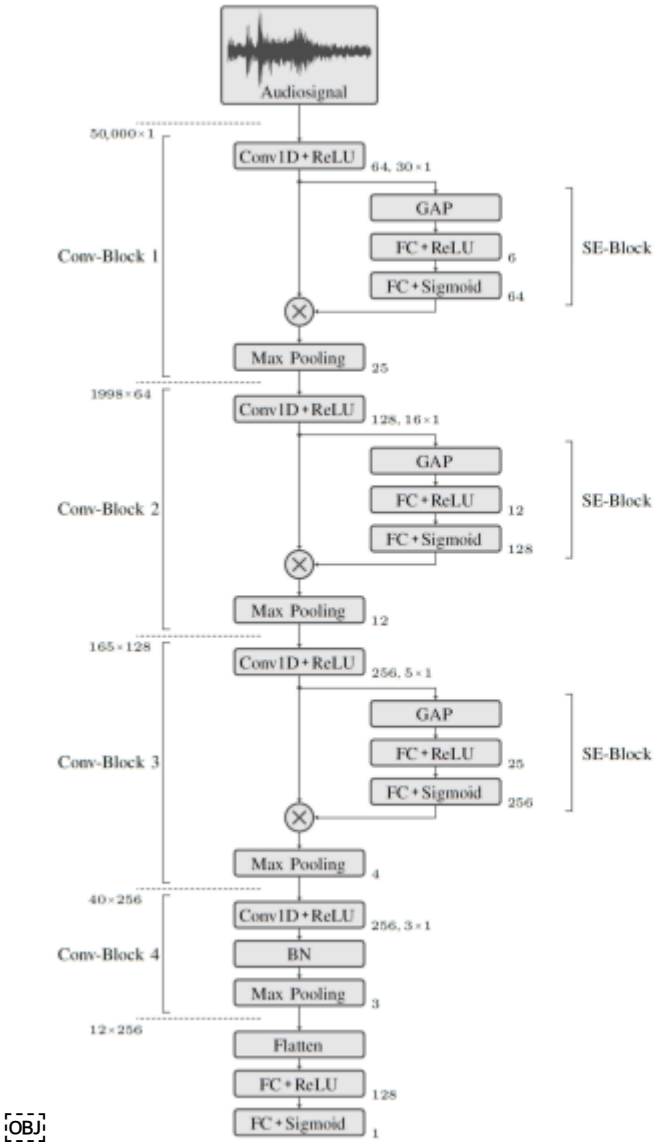

Figure 3: Network structure used for video classification (Hollaus, Reiter and Volmer, 2023).

Alternatively, Newman et al. (2023), introduce their own advanced AI system, which has automated pre-play analysis of American football formations, utilising a deep learning mechanism. This system integrates

three modules: player localisation, player labelling, and formation identification. For real-time player localisation, the YOLOv3 framework is employed, achieving 90.3% accuracy in detecting player positions. ResNet, a deep neural network architecture, is utilised for both player labelling and formation identification, with the latter achieving an impressive 99.2% accuracy % (Newman et al., 2023). The combination of these modules enables a comprehensive analysis of football formations with an overall accuracy of 84.8% (Ibid).

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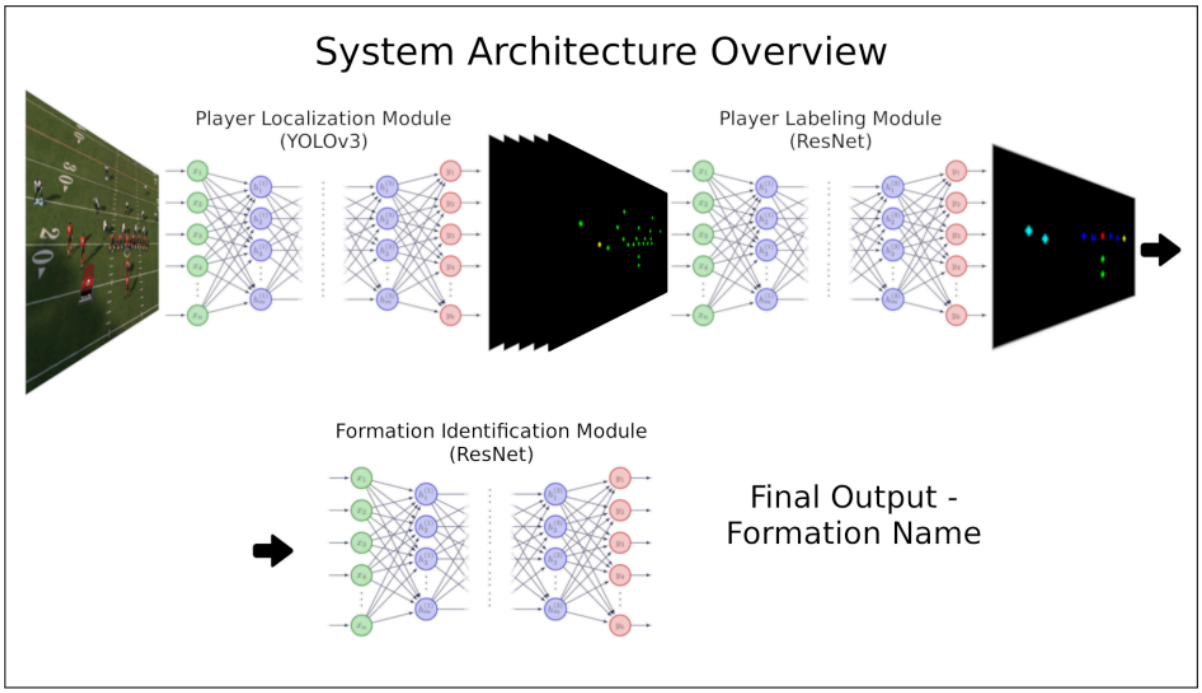


Figure 4: YOLOv3 and ResNet system architecture illustrated (Newman et al., 2023).

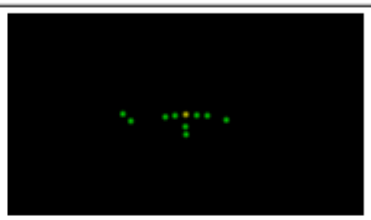
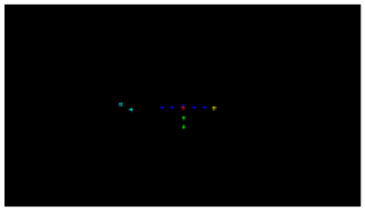
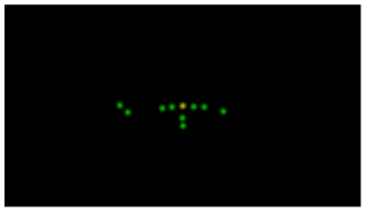
Method	Input	Accuracy
Yolov3: Player Localization Module	 Raw Image	90.3%
ResNet: Player-Labeling Module	 Player Localized Image	98.8%
ResNet: Formation Identification Module	 Player Labeled Image	99.2%
ResNet: Player Labeling Module and ResNet: Formation Identification Module	 Player Localized Image	99.5%
Yolov3: Player Localization Module and ResNet: Player Labeling Module and ResNet: Formation Identification Module	 Raw Image	84.8%

Figure 5: Overall accuracy of various methods in the system (Newman et al., 2023).

Defense wins championships (Foxworth, 2018)

This is an old adage used by many in the world of American football who believe that a great offense will win games, but a great defense wins championships. In an attempt to fight back against defenses in the NFL, Schmid, Blauberger and Lames (2021) have developed a deep imitation learning system (a subset of ML), introduced to be a sophisticated data-driven ghosting model designed to simulate defensive trajectories in American football, aimed at predicting league-average defensive movements and therefore helping offenses in their decision-making. Utilising deep imitation learning, the model replicates the decision-making processes of defensive players by analysing high-fidelity tracking data from actual NFL games. This approach employs a multi-agent framework, enabling the simulation of complex, realistic defensive behaviours across

various game scenarios. The model is trained on extensive datasets, capturing diverse defensive strategies and formations, and is validated through a pass completion probability model, which achieved an accuracy rate of 81% in predicting defensive movements, closely aligning with real-world data (Schmid, Blauberger, and Lames, 2021).

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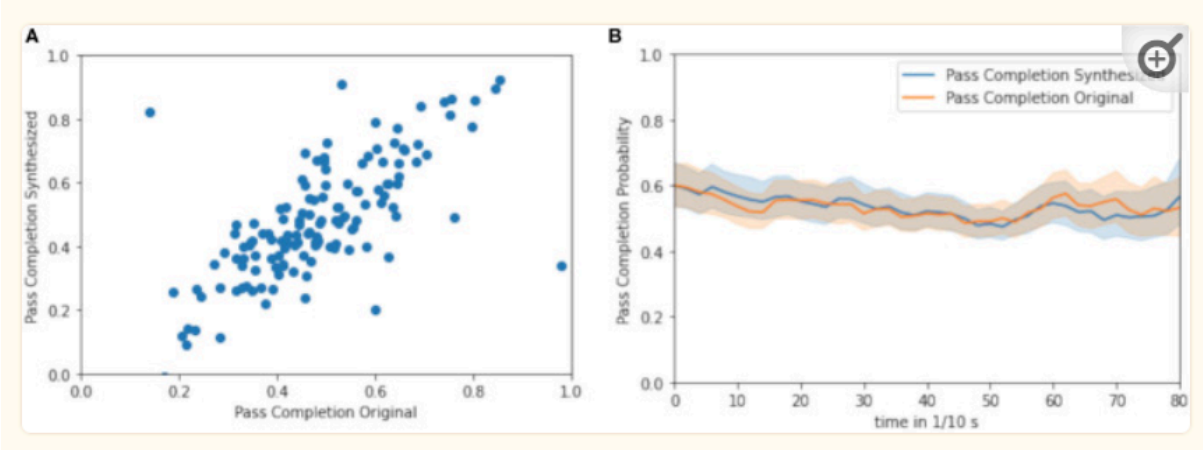

Figure 7: illustrates the ghosting model's accuracy by comparing synthesised and actual defensive trajectories. Panel A shows the correlation between predicted and actual pass completion probabilities, while Panel B compares average probabilities over time (Schmid, Blauberger and Lames, 2021).

The ghosting model's strength lies in its ability to generalise across different teams and situations, and to do so accurately at that, offering a robust tool for analysing defensive strategies. By simulating defensive reactions, the model provides insights into optimal defensive positioning, enhancing coaching strategies. This innovative model not only advances AI-driven analysis in the NFL, but also provides us with insights into which AI and ML systems are being created and utilised to impact team outcomes on the field.

A Forecast of Future Trends in AI Deployment in American Football

The rapid advancement of AI and ML technologies is revolutionising American football at an unprecedented pace. Looking ahead, it is impossible to accurately predict which new ML systems or AI models will be created to enhance player health or better team and player performances, yet there are indicators that may help understand in which general direction this artificial revolution is taking professional football.

Future of Health

Part of the future of AI in American football is athlete injury prediction, ML algorithms have already shown significant potential. By analysing player metrics such as age, performance, and injury history, these algorithms predict injury risks with increasing accuracy. The XGBoost algorithm, used in hockey, achieved 94.6% accuracy in predicting injuries, outperforming traditional methods (Ramkumar et al., 2021). These advancements offer NFL teams a proactive approach to injury prevention, allowing them to optimise player health management and reduce downtime through early interventions. As more granular data from official league sources becomes available, these ML models are expected to become even more accurate and reliable in preventing injuries. Wearable health technology is a major driver of AI in sports. Devices like smartwatches provide granular data, allowing athletes to track health metrics and train AI systems to enhance performance, prevent injuries, and improve recovery times. With the sports

wearable industry valued at over $13 billion in 2019 (Grand View Research, 2024), AI's role in interpreting this data is only expected to grow. The widespread adoption of wearable technology is likely to fuel further advancements in AI-driven health management for both amateur and professional athletes (Ramkumar et al., 2021). This of course, applied to existing injury-prevention tools already in use such as the Digital Athlete Platform, can prove to help take the NFL's player health to the next level.

Future of Performance

As AI continues to evolve, new advancements promise to further revolutionise the future of performance. One emerging trend is the ongoing development and validation of tracking systems. Future research will focus on refining the accuracy of NFL's tracking systems that are already in place, ensuring that player positioning data, for example, is even more reliable, which is crucial for effective analysis and decision-making. A particularly exciting development is the potential use of graph neural networks (GNNs),

which are gaining attention for their ability to process spatio-temporal data. GNNs could address current limitations in data loss during model training, allowing for more accurate analysis and predictions (Zhou et al., 2018). Moreover, these networks could help extend AI's predictive capabilities beyond pre-throw trajectories, enabling models to analyse player movements after the catch, offering deeper insights into both offensive and defensive strategies (Dutta et al., 2019). Another promising possibility is that of real-time player sketching and fully automatic game analysis, where coaches could compare team performance to league averages, conduct hypothetical analyses, and identify underperforming defenders in real-time, offering a powerful tool for strategy optimization for offensive coordinators and strategists (Seidl et al., 2018; Schmid, Blauberger, and Lames, 2021). These trends suggest team and player performance models will be upgraded, more precise, and used in real-time to offer greater advantages.

2. Recommendations

Recommendations for Improved Practice

While AI has demonstrated impressive capabilities, several key challenges must be overcome before it can fully manage an NFL team autonomously. The complexities of human decision-making, real-time adaptability, and emotional intelligence remain significant barriers for AI systems. Football requires nuanced, context-sensitive decision-making, which AI struggles to achieve without a deeper understanding of the environment. Moreover, high-pressure scenarios in sports demand emotional intelligence and intuition, traits that AI systems lack. As a result, AI struggles with the psychological dynamics of motivating players and making judgment calls in unpredictable situations. Developing AI models in collaboration with sports psychologists could help bridge this gap by creating systems that recognise and respond to emotional cues in athletes. To address the limitations of AI in managing an NFL team, a hybrid approach is recommended. AI can be leveraged as a powerful decision-support tool rather than a fully autonomous system. Combining AI's data-driven insights with human

intuition would allow teams to make more informed decisions while retaining the adaptability and emotional intelligence required for high-pressure situations. Additionally, research should be invested in developing emotion-aware AI systems, which can recognise and respond to emotional cues, improving their interaction with players and coaches. While AI may never fully replicate human emotional intelligence, enhancing its capacity to understand and respond to the emotional states of athletes could provide a more holistic approach to team management.

Recommendations for Further Research: Mental Health

While AI systems have demonstrated significant value and promise in areas like injury prevention, further research is necessary in mental health management for NFL athletes. Given the high-pressure nature of professional sports, the mental health of players is as critical as their physical wellbeing. Mental health issues are becoming a growing concern within the NFL, as players deal with the physical and emotional toll of

professional football. Research has shown that NFL players are at an elevated risk for mental health struggles, such as depression, anxiety, and cognitive impairments, which can often be exacerbated by concussions and other injuries sustained during their careers (McGraw et al. 2018). AI-powered tools could be developed to monitor and manage stress levels, fatigue, and overall mental health, using data from wearable devices and player feedback to offer real help to athletes of the NFL.

3. Critical Reflection on Methodology and Suggestions for Future Research

This dissertation has provided valuable insights into the integration of AI in the NFL, but several factors affected the robustness of the data and analysis.

One notable issue is the variability in the quality and standardization of data across NFL teams. AI systems like player tracking platforms and injury prevention tools often rely on proprietary data collected by individual franchises, which can vary in accuracy and completeness. Fragmentation complicates the creation of a comprehensive, league-wide analysis. Data collection methods may vary significantly between early adopters of AI and those lagging behind, potentially introducing biases that impact the reliability of player tracking systems. Moreover, many AI systems examined are new, and their long-term efficacy is yet to be evaluated in diverse game conditions.

To address these limitations, future research should focus on standardised, longitudinal data collection across all NFL teams. A unified framework for gathering player performance, health metrics, and game footage would improve the consistency and reliability of AI models. A, mixed-method approaches could also offer deeper insights. Interviews with coaches, data scientists, and medical staff would provide context to the challenges of integrating AI into the high-pressure, real-time environment of American

football. Testing AI models under more unpredictable conditions, such as different weather, playoff intensity, or following player injuries, would further enhance understanding of the models' robustness and adaptability. Addressing these methodological concerns in future studies will strengthen conclusions about AI's role in shaping NFL strategies and player health management.

4. Conclusions

The integration of AI and ML in the NFL represents a paradigm shift in how teams operate, analyse performance, and safeguard player health. This dissertation has explored AI's current applications, the impact of AI-driven tools on player metrics and team outcomes, and the potential future trends that may further revolutionise the sport. Reflecting on the methodology used, the research highlights both the transformative potential of AI and the

limitations arising from fragmented data and emerging technologies. AI’s automation of game footage annotation has improved coaching efficiency. This finding aligns with prior studies, such as those by [Author], which similarly noted AI's positive impact on coaching strategies, though my research emphasises the need for more longitudinal data to measure long-term efficacy. Systems like YOLOv3 and ResNet allow teams to identify player positions, formations, and strategies with high accuracy in real-time analysis.

Equally important is AI's role in improving player safety, particularly through innovations like the Digital Athlete Platform. By analysing biomechanical data, this platform can predict high-risk injury scenarios and suggest modifications to training loads and recovery protocols. This proactive approach can extend careers by minimizing injury risks and optimizing health. The forecasted expansion of wearable technologies and AI-driven injury prediction tools further underscores AI’s critical role in safeguarding athlete health. Despite the challenges of fragmented data and

the evolving nature of AI tools, the trajectory for AI in the NFL remains promising. As more standardised data becomes available and AI systems continue to refine their predictive capabilities, these tools will undoubtedly reshape the future of American football. In summary, AI's integration has proven transformative, offering teams a competitive edge. With further advancements and improved methodologies, AI will evolve, leading to more precise, real-time applications that push player performance and safety.

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