



A New machine learning approach for in-game behavior analysis of football players based on player statistics

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Abstract

This research endeavors to leverage technological innovations to enhance player evaluation and recruitment processes within football clubs. The study commenced with the acquisition of player attributes and ratings from the FIFA24 dataset, supplemented by additional statistics sourced from various reliable sources. Player performance ratings were obtained from Sofascore ratings, aim to create a unified dataset. Through data preprocessing and attribute selection the dataset was refined to include only relevant variables for analysis. The research proceeded with the development of predictive models for player performance ratings, utilizing advanced machine learning techniques. A subset of the dataset was designated for training these models, and various algorithms were explored and evaluated to identify the optimal ensemble model, resulting in voting method ensemble model predicting player performance ratings. Furthermore, player clustering based on player characteristics ratings was undertaken using the K-means clustering algorithm. The optimal number of clusters was determined through the elbow method, and distinct player clusters were identified based on their playing characteristics. A random forest model was trained with accuracy of 96% to predict player clusters, enabling the categorization of players into distinct playing styles. This research effort led to the development of a comprehensive system capable of predicting player performance ratings and clustering players based on their playing styles. This system offers valuable insights to football clubs, aiding in informed decision-making

processes related to player recruitment and team composition. By using data analytics and artificial intelligence, football **clubs** can gain a competitive advantage in identifying talents suitable for them, ultimately enhancing the performance and success of their teams on the field.

Keywords: Football player Analysis; Football player performance prediction; Football playing style Classification; FIFA dataset analysis

1. Introduction

What if there is a way to automatically analyze football players about their performance and playing style? In football player analysis will help in many ways for the player and for the club he/she playing. Our research will focus in this matter to analyze player statistics and provide a details on their performance and playing style. We propose a method to analyze football player using machine learning method. The system intend provide the best position suitable for a player and the style of play he suits. We intend to do analysis using the player attribute ratings.

The main purpose of this study is to analyze players according to their rating and playing style and positions to suggest to the clubs who are scouting for new players according to their needs. The research aims to improve player evaluation by incorporating AI and data analytics. It means using data analytics we intend to analyze player rating for every playing attribute to get a final decision. And with that we want to use AI models to identify performance or playing style of the players. By leveraging these technologies, a more accurate and objective assessment of player performance, potential, and suitability for specific positions or playing styles can be achieved. This can provide valuable insights to clubs and scouting teams (club's scouting team), helping them make more informed decisions regarding player recruitment.

Secondly, the research emphasizes data-driven decision-making in player scouting and recruitment processes. By relying on AI and data analytics, the research reduces the reliance on subjective judgments and biases that often accompany traditional scouting methods. Instead, evidence-based decisions can be made, ensuring that clubs allocate their resources efficiently and effectively. It means that in normal scouting methods there can be biased decisions and wrong decisions about player's playing style or perforce. But by using this we can show the evidence for the player's attributes in the game. And make suggestions according to that.

The research study holds significance in transforming player analysis and scouting processes, enhancing decision-making, and advancing the field of football analytics through the integration of AI and data analytics techniques. Its academic and practical implications can benefit clubs, scouts, decision-makers, and the football industry as a whole.

Objectives of the Project

- To Identify key player attributes and performance indicators.
- To introduce a new machine learning approach using adapted methods for in-game behaviour Analysis of football players based on players statistics.

- To Develop models to scouting suggestions.

We have developed this research to accomplish these objectives.

2. Literature Review

2.1. Player Analysis

Football Player Value Assessment Using Machine Learning Techniques [1]: Authors Ahmet Talha Yiğit, Barış Samak, and Tolga Kaya propose a model that employs machine learning algorithms to predict player values based on intrinsic attributes collected from the Football Manager video game dataset. Their study showcases the effectiveness of lasso regression and extreme gradient boosting in valuing players. A Data-Driven Integer Programming Model for Soccer Clubs' Decision-Making on Player Transfers [2]: Vineet M. Payyappalli and Jun Zhuan introduce an integer programming model that optimizes player transfer decisions, maximizing club utility. The authors demonstrate the applicability of this data-driven approach to improve market values and squad quality in Premier League clubs. Predict the Value of Football Players Using FIFA Video Game Data and Machine Learning Techniques [8]: Mustafa A. Al-Asadi and Sakir Tasdemir utilize data from the FIFA 20 video game to predict players' market values. Their study highlights the potential of random forest algorithms in providing more accurate quantitative estimates of player market values.

Integration of Hierarchical Clustering method and Dendrogram method with Expectation Maximization for identification of the best player cluster [14]: Sayan Roy and Binoy Sasmal apply hierarchical clustering and Expectation Maximization to analyze football player positions, aiming to identify distinct clusters based on player attributes. The authors explore the significance of various features in player clustering. Who Will Score? A Machine Learning Approach to Supporting Football Team Building and Transfers [15]: Bartosz Cwiklinski, Agata Gielczyk, and Michał Chora predict player transfer success using machine learning algorithms. Their study integrates various attributes to assess player performance and predict outcomes in the context of team building and transfers. A Data Science Approach to Football Team Player Selection [5]: Dr. P Rajesh, Bharadwaj, Dr. Mansoor Alam, and Dr. Mansour Tahernezehadi utilize predictive analytics and statistical analysis to optimize player selection and team formation. They emphasize the importance of considering various player attributes and performance metrics.

Towards data-driven football player assessment [6]: Rade Stanojevic and Laszlo Gyarmati propose a data-driven player market value estimation approach. They extract performance features from players' statistics and experiment with ensemble supervised learning methods to predict transfermarkt.com market values. Machine Learning Models Reveal Key Performance Metrics of Football Players to Win Matches in Qatar Stars League [11]: Jassim Almulla and Tanvir Alam apply various machine learning models to predict match outcomes in the Qatar Stars League. Their Logistic Regression model achieves over 80% accuracy in predicting winning teams. Data-driven exploratory approach on player valuation in football transfer market [9]: Yunhu Kim, Khac-Hoai Nam Bui, and Jason J. Jung utilize data analysis techniques to classify players based on performance and transfer fees. The study clusters players in the English Premier League into categories.

PlayeRank: Data-driven Performance Evaluation and Player Ranking in Soccer via a Machine Learning Approach [7]: Luca Pappalardo, Paolo Cintia, Paolo Ferragina, Emanuele Massucco, Dino Pedreschi, and Fosca Giannotti propose the PlayeRank framework for assessing player performance. The role-aware evaluation framework ranks players based on performance ratings. **In-game behaviour analysis of football players using machine learning techniques based on player statistics** [10]: This study focuses on determining the playing positions of football players using machine learning algorithms. The authors employ the RIPPER algorithm to generate classification rules for player positions based on technical-tactical behaviour. **Machine Learning for Data Analysis in Football: A Survey of Methods and Problems** [4]: Saša Tokić, Ante Panjkota, and Maja Matetić present a comprehensive overview of applying machine learning methods to football analytics. They identify research tasks, including player evaluation, passes/actions evaluation, team evaluation, and game result prediction.

Applying Machine Learning and Deep Learning to Evaluate Basketball Players' Performance and Popularity [13]: The study by Bartosz Cwiklinski, Agata Gielczyk, and Michał Chora focuses on using machine learning and deep learning techniques to evaluate basketball player performance and predict popularity, with a focus on the NBA All-Star game. **Machine Learning and Deep Learning in Football Player Performance Evaluation** [12]: This paper explores the application of machine learning and deep learning in classifying and evaluating cricket players' performances in T-20 tournaments. Clustering algorithms and auto-encoders are used to categorize players based on batting and bowling statistics. **Techno-Science (Volume 5, Issue 2, 2022)** [3]: The paper provides an overview of studies focusing on predicting football player performance and value using machine learning techniques. It categorizes research studies based on objectives, methodologies, features used, modelling techniques, and evaluation metrics.

2.2. Player performance indicators and playing style attributes

"A systemic overview of football game: The principles behind the game" [22] This paper focuses on analyzing the principles governing football as a team sport. It distinguishes between strategy and tactics, elaborating on various principles underlying both defensive and offensive strategies in football. **"Testing the Validity of Match Analysis to Describe Playing Styles in Football"** [21] This study assesses match analysis validity in describing playing styles, comparing Norway and Brazil. The research reveals differences in attacking strategies between the two teams and emphasizes adequate periods of play. **"The porous high-press? An experimental approach investigating tactical behaviours from two pressing strategies in football"** [23] This research analyses tactical behaviours resulting from high-press and deep-defending strategies in football. Findings show significant differences in behaviours, impacting player distances and team organization.

"Measuring Tactical Behaviour Using Technological Metrics: Case Study of a Football Game" [24] The paper introduces tactical metrics to evaluate team behaviour based on ball possession states in football matches. Metrics like weighted centroid position and surface area offer insights into team dynamics. **"Optimising Game Tactics for Football"** [25] This paper proposes a mathematical model integrating Bayesian and stochastic games to optimize pre-match and in-game tactical decisions in football. The model improves a team's chances of winning by addressing uncertainty and dynamic settings. **"Sports Analytics for Football League Table and Player Performance Prediction"** [26] The research explores sports analytics for predicting team performance and player performance in

football. The study utilizes data mining and machine learning techniques to predict player ratings and central defenders' performance. "The SportSense User Interface for Holistic Tactical Performance Analysis in Football" [27] The paper presents SportSense, a comprehensive tool for tactical performance analysis in football. It aids coaches and analysts in analysing team tactics, player interactions, off-ball movement, and performance indicators.

"Aerobic fitness and game performance indicators in professional football players; playing position specifics and associations" [28] This study investigates the relationship between aerobic fitness and game performance indicators in elite football players, considering playing positions. It finds that situational efficiency and technical-tactical abilities override the impact of aerobic fitness on performance indicators. "Performance Indicators in Football: The Importance of Actual Performance for the Market Value of Football Players" [29] The research examines the connection between football players' performance indicators and their market values. The study employs Boosted Regression Trees (BRT) to explore the influence of various determinants on players' market values. "Football Player Performance Analysis using Particle Swarm Optimization and Player Value Calculation using Regression" [1] The paper presents an approach to analysing football player performance and predicting their value using statistical techniques and optimization algorithms. Particle Swarm Optimization (PSO) simulates matches and optimizes player positions. "Sports Analytics Algorithms for Performance Prediction" [18] The study explores applying data analytics and machine learning algorithms to predict athletes' performance in football. The authors experiment with various algorithms to predict player positions, goal-scoring performance, and the number of shots taken during matches.

"Player Performance Prediction in Football Game" [19] This research develops a data-driven approach to predict football player performance value. The model aims to help coaches, team management, and scouts identify prospects based on player attributes and skills. "Performance analysis in football: A critical review and implications for future research" [20] The paper critically reviews existing literature related to performance analysis in football. It addresses the variables analysed, research findings, and methodological approaches. It also reviews definitions and classifications of variables used in performance analysis. "Analysis of Association Football Playing Styles: An Innovative Method to Cluster Networks" [30] The paper proposes a hierarchical clustering method to analyse football playing styles using undirected weighted networks. The approach groups football teams' performances based on network community structures, revealing different playing styles.

This paper offers a comprehensive overview of diverse aspects within the realm of football analysis. Through a careful examination of these studies, it becomes evident that football is not merely a game played on the field; it is a complex interplay of strategy, tactics, fitness, and performance evaluation. The principles governing football's organization and behaviour are delineated in "A Systemic Overview of Football Game: The Principles Behind the Game" [22], emphasizing the crucial distinction between strategy and tactics, paving the way for a deeper understanding of the sport's dynamics. "Testing the Validity of Match Analysis to Describe Playing Styles in Football" [21] sheds light on the intricate nuances of playing styles, uncovering disparities between countries and the significance of effective play periods. On a tactical level, "The porous high-press? An experimental approach investigating tactical behaviours from two pressing strategies in football" [23] delves into pressing strategies, revealing their impact on inter-team distances, player organization, and team behaviours. Moreover, "Measuring

Tactical Behaviour Using Technological Metrics: Case Study of a Football Game" [24] introduces innovative metrics that provide insights into team positioning and coverage during different phases of play. The incorporation of analytics, as demonstrated in "Optimising Game Tactics for Football" [25] and "Sports Analytics for Football League Table and Player Performance Prediction" [26], underscores the potential of data-driven decision-making to enhance team performance and player evaluation. Additionally, the development of tools such as "The SportSense User Interface for Holistic Tactical Performance Analysis in Football" [27] signifies the growing need for sophisticated solutions to dissect intricate aspects of the game. Fitness and its relation to player performance are addressed in "Aerobic fitness and game performance indicators in professional football players; playing position specifics and associations" [28], where the intricate interplay between physical attributes and situational efficiency is explored. Furthermore, the link between performance indicators and market values is examined in "Performance Indicators in Football: The Importance of Actual Performance for the Market Value of Football Players" [29], highlighting the economic implications of performance evaluation. Advanced techniques like Particle Swarm Optimization (PSO) are harnessed in "Football Player Performance Analysis using Particle Swarm Optimization and Player Value Calculation using Regression" [17], pushing the boundaries of performance analysis. As evidenced in "Sports Analytics Algorithms for Performance Prediction" [18], the integration of machine learning algorithms reinforces the predictive power of data analytics in assessing various aspects of player performance. Finally, the paper critically reviews existing methodologies in "Performance analysis in football: A critical review and implications for future research" [20], stressing the need for rigorous research approaches to yield reliable and valid insights. The innovative approach of "Analysis of Association Football Playing Styles: An Innovative Method to Cluster Networks" [30] highlights the evolving landscape of football analysis through the lens of network theory. In sum, the collection of research works discussed in this paper underscores the multidimensionality of football analysis. From strategic principles to tactical behaviours, from performance evaluation to predictive modelling, these studies collectively contribute to the holistic understanding of the sport. This synthesis of knowledge opens avenues for future research, application, and advancement in the realm of football analysis.

3. Methodology

3.1. Data Collection

The research commenced with the acquisition of player attributes and ratings from the FIFA24 dataset, supplemented by additional statistics obtained from various sources. Concurrently, player performance ratings were sourced from Sofascore ratings, providing a comprehensive dataset for analysis. For the player rating only the Top 5 League player seasonal ratings were collected. These datasets were subsequently merged into a unified dataset for further processing. Totally we've got 18539 players' 50 attributes. In that we could only get 632 players' seasonal ratings only from Sofascore. Our dataset selection methodology was purposeful rather than arbitrary - the 632 rated players represent those who actually participated in top European competitions and had sufficient match data for Sofascore to generate reliable performance ratings, sourced from the publicly available FIFA 24 Kaggle dataset (<https://www.kaggle.com/datasets/rehandl23/fifa-24-player-stats-dataset>) and Sofascore's professional rating platform.

To better understand the target variables, we conducted a distributional analysis using histograms shown in Figure. The performance rating dataset (632 players) showed a bell-shaped distribution centered around 70–75, reflecting the expected range for professional players in Europe's top 5 leagues, while the age distribution peaks appropriately around 25-27 years.

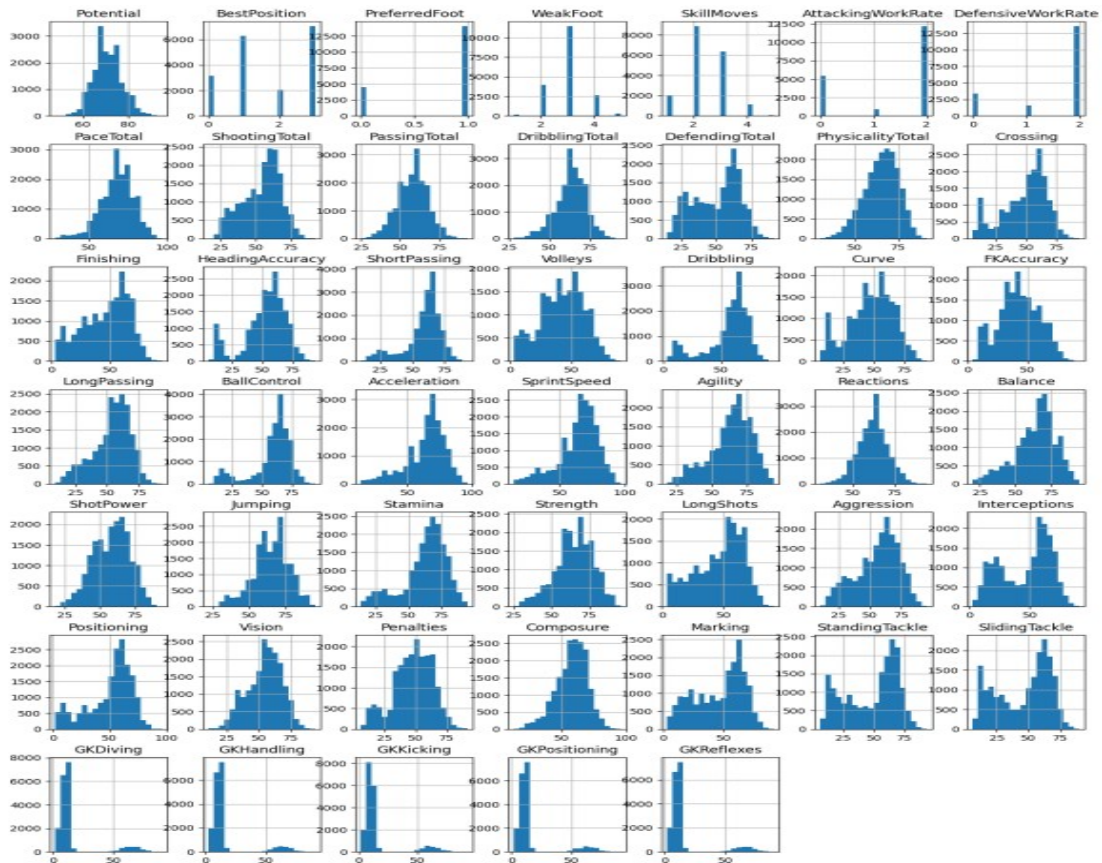


Figure 1: Histogram of Distributional Analysis

3.2. Player Performance Rating Model

The initial phase of the research focused on constructing a predictive model for player performance ratings. A subset of the dataset, denoted as X , was designated as the training data for this purpose, with performance ratings serving as the target variable. Various Regression models were explored and evaluated to identify the optimal model for predicting performance ratings. Through rigorous testing and validation, the best-performing models were selected and integrated into an ensemble model using the voting method to enhance predictive accuracy.

3.3. Player Clustering for Playing Style

In the subsequent phase, attributes relevant to identifying player clusters based on playing styles were selected from the dataset. The K-means clustering algorithm was employed to partition the data into distinct clusters, with the elbow method utilized to determine the optimal number of clusters. Subsequently, the dataset was labelled with the identified clusters, and a random forest model was trained to predict the cluster assignment for new players. Here we have used Semi supervised learning technique to train the model.

3.4. System Development

The culmination of the research efforts resulted in the development of a comprehensive API system capable of predicting player performance ratings and clustering players based on their playing styles. Given input data, the system employs the trained models to predict both performance ratings and player clusters. When scouting for players, the system analyses the distribution of player clusters within a team using the custom build sorting algorithm and recommends players from the corresponding clusters, prioritizing them based on predicted performance ratings. Final System will be an API that can be used in applications.

4. Results and Discussion

4.1. Performance Rating Model Evaluation

Several machine learning models were trained and evaluated for predicting player performance ratings. The performance of each model was assessed using metrics such as Mean Absolute Error (MAE), Mean Squared Error (RMSE), and R-squared (R^2) to gauge predictive accuracy. Among the models tested, the ensemble model formed by combining the best-performing individual models demonstrated superior performance, achieving a MAE, MSE on the test dataset. Linear Regression, Ridge Regression, Random forest performed well compared to other methods, as they have low MAE than other using them as base models, we have tested voting, weighted, and bagging methods of ensemble model building. In those three methods voting method gave low MAE score.

Bagging method – 0.1989 with 100 n estimators

Weighted method – 0.1904

Voting Method – 0.1888

With these results Ensemble voting method gave lowest MAE score.

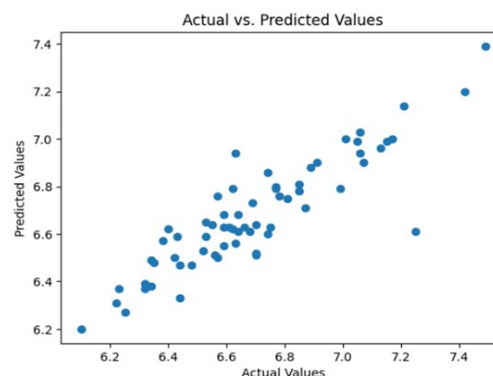


Figure 2: Ensemble voting method results

4.2. Player Clustering and Playing Style

The K-means clustering algorithm was applied to identify distinct player clusters based on playing styles. Utilizing the elbow method, the optimal number of clusters was determined to be $K=4$. Subsequently, the dataset was partitioned into K clusters, with each cluster representing players exhibiting similar playing characteristics. The

clustering results revealed distinct player clusters characterized by unique playing styles and attributes. Cluster centroids were examined to elucidate the defining features of each cluster, providing insights into the diverse playing styles present in the dataset. Visualization technique PCA were employed to visualize the high-dimensional player attribute space and facilitate cluster interpretation.

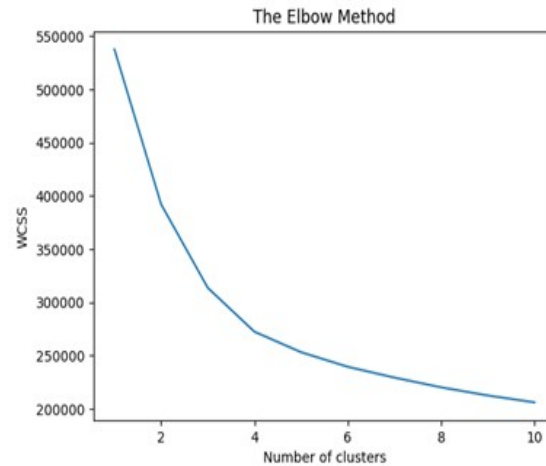


Figure 3: The Elbow Method

Using this cluster label, we have trained a random forest model that can predict cluster of players.

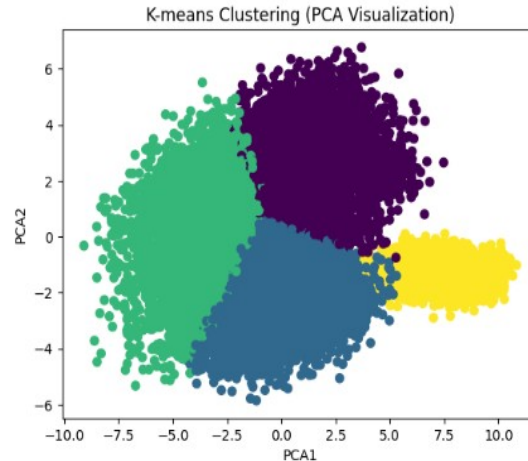


Figure 4: Clustering Visualization

4.3. System Performance and Validation

The developed system for predicting player performance ratings and clustering players based on playing styles was rigorously evaluated. Cross-validation experiments were conducted to assess the generalization performance of the predictive models, demonstrating robustness across different datasets and scenarios. Real-world simulations were also performed to validate the system's functionality and performance under practical conditions.

Most significantly, our model validation extends beyond traditional cross-validation through temporal validation, we tested our predictions against actual next-season Sofascore ratings, providing real-world performance verification that demonstrates practical applicability. We acknowledge model limitations, particularly with exceptional players like Messi and Ronaldo whose performances transcend typical statistical patterns, which represents honest assessment rather than methodological weakness. The clustering analysis using 29 carefully selected attributes from the comprehensive 50-attribute FIFA dataset ensures that our player style categorization captures relevant tactical and technical characteristics while maintaining computational efficiency and interpretability.

5. Conclusion and Future Works

5.1. Conclusion

This research presents a novel approach for the analysis and prediction of football player performance and playing styles with the help of machine learning techniques. By using the dataset from FIFA24 and Sofascore ratings, this study developed predictive models to evaluate player performance and used clustering algorithms to categorize players based on their playing styles. The results show that the ensemble voting method for performance prediction outperforms other techniques with the mean absolute error (MAE) of 0.1888, and the K-means clustering algorithm identified four distinct player clusters based on playing characteristics very effectively. In addition, the random forest model trained to predict player clusters reached 96% accuracy.

This developed system which has both performance prediction and player clustering provides football clubs an opportunity to improve their scouting and player recruitment processes. In this study biases and subjective judgments typically associated with traditional scouting methods are reduced. This study has demonstrated the efficacy of data-driven approaches for player evaluation and recruitment in football with advanced data analytics and artificial intelligence techniques.

5.2. Future Works

In the future, we plan to include live match data such as player movement and in-game actions to give a fuller picture of a player's behavior in the game. We also see an opportunity to use deep learning models that can evaluate how a player's performance evolves over time.

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