APPLICATION OF AI IN SPORTS

ARTIFICIAL INTELLIGENCE FOR BUSINESS AND SOCIETY (BBA 653A)

CIA 3

Submitted By

Devanaboina Rohit

(Register Number – 1920181)

Sonakshi Massey

(Register Number - 1920449)

Submitted To

Dr. Manu K.S.

Assistant Professor, School of Business and Management

CHRIST

(DEEMED TO BE UNIVERSITY)

BANGALORE · INDIA

School of Business and Management

CHRIST (Deemed to be University)

BENGALURU

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TABLE OF CONTENTS

APPLICATION OF AI IN SPORTS PREDICTION

I. INTRODUCTION

Since ancient times, people have sought to predict the future. The Mesopotamians made primitive attempts to predict Lunar Eclipses as early as the mid-seventh century BC [1]. Modern prediction and forecasting techniques make use of Statistical, Machine Learning and Data Mining. This field of study is known as Predictive Analytics. [2]

Sports Prediction is one application of predictive analytics. Its objective is to accurately predict the proceedings and/or outcomes of a sporting event. Modern Sports Prediction relies on statistical modelling of sporting events. [3] However, AI in Sports has a far wider reach than just prediction. AI in sports has 4 major areas of application [21]:

- **Pre-Game Preparation** - Training & Coaching, Injury Management, Strategic/Tactical Game Planning, Team Selection etc.
- **In-Game Activity** - Umpiring, Specialist Coaching etc.
- **Talent ID and Selection** - Deals with the recruitment side of sports
- **Post-Game Analysis**

Artificial intelligence is a field of computing that focuses primarily on the transmission of anthropomorphic intelligence and thinking into machines that can assist humans in many ways. [4]. Artificial Intelligence was born in 1956, when the term was first coined by John McCarthy. Artificial Neural Networks (ANNs), computing systems inspired by the biological neural networks that constitute animal brains, are a common form of AI.

The main advantage of using neural networks (NNs) is their ability to autonomously learn the relationship between inputs and outputs upon presentation of examples. It is necessary only to provide a set of sample data to the network and apply a learning algorithm in order to train a

Neural Network. The ANN automatically “learns”, adjusting itself to better model the problem domain. [5]

As you will see in the upcoming sections, AI techniques have been applied to the field of Sports with significant success, often outperforming their traditional counterparts in common tasks and opening the door to novel applications.[7] Through the latest techniques in AI (such as Computer Vision), AI has opened the door to more advanced applications in Sport tasks. [25] This includes the prediction of ball trajectories and umpire decisions based on video/image data and even the prediction of game outcomes based on the posture of players.[21][23][24] In the following section, we shall demonstrate the impact of AI in Sports.

II. LITERATURE REVIEW

[6] (Aoki et al, 2017)

The primary reason why Sports prediction is a difficult task is that all major sports have a certain level of **unpredictability** involved in determining the outcome of match-ups. This is colloquially referred to as "**Luck**”. This unpredictability in match outcomes cannot effectively be modelled and incorporated into current predictive models. Thus, the “luck” factor acts as a hurdle to improvement in the power of predictive models, and more advanced techniques are required to overcome this.

[18] **(Claudino et. al., 2019):** The review covered 58 papers, with 11 artificial intelligence approaches or strategies being used in 12 team sports. A total of 6456 participants (97 percent male, 25 years old; 3% female, 21 years old) were included in the pooled sample, with 76 percent of them being professional athletes. Artificial neural networks, decision tree classifiers, support vector machines, and Markov processes were the most often utilised AI techniques or methodologies, with good performance metrics for all of them. The team sports with the most AI applications were soccer, basketball, handball, and volleyball. Based on the number of published papers, the findings of this review imply that AI approaches are widely used in team sports. The current state of advancement in the field points to a bright future for AI in team sports. To

establish the prediction performance of specific AI approaches and procedures, more evaluation study based on prospective methods is required.

[20] **(Delen et. al., 2012):** The researchers developed both classification- and regression-type models in this study, using eight years of data and three popular data mining techniques (namely artificial neural networks, decision trees, and support vector machines) to assess the predictive abilities of different methodologies (classification versus regression-based classification). Finally, the results showed that classification-type models predict game outcomes better than regression-based classification models, and decision trees gave the best results of the three classification strategies, with a prediction accuracy of more than 85% on the 10-fold holdout sample.

[19] (Bunker et. al., 2019): A critical analysis of the existing literature in machine learning with a major focus on the application of Artificial Neural Networks (ANN) on sports prediction was conducted. Through this various learning methodologies, data sources and appropriate model evaluation techniques in the domain sports prediction were identified. As a result, a new sports prediction framework through which machine learning can be utilised as a learning strategy was proposed.

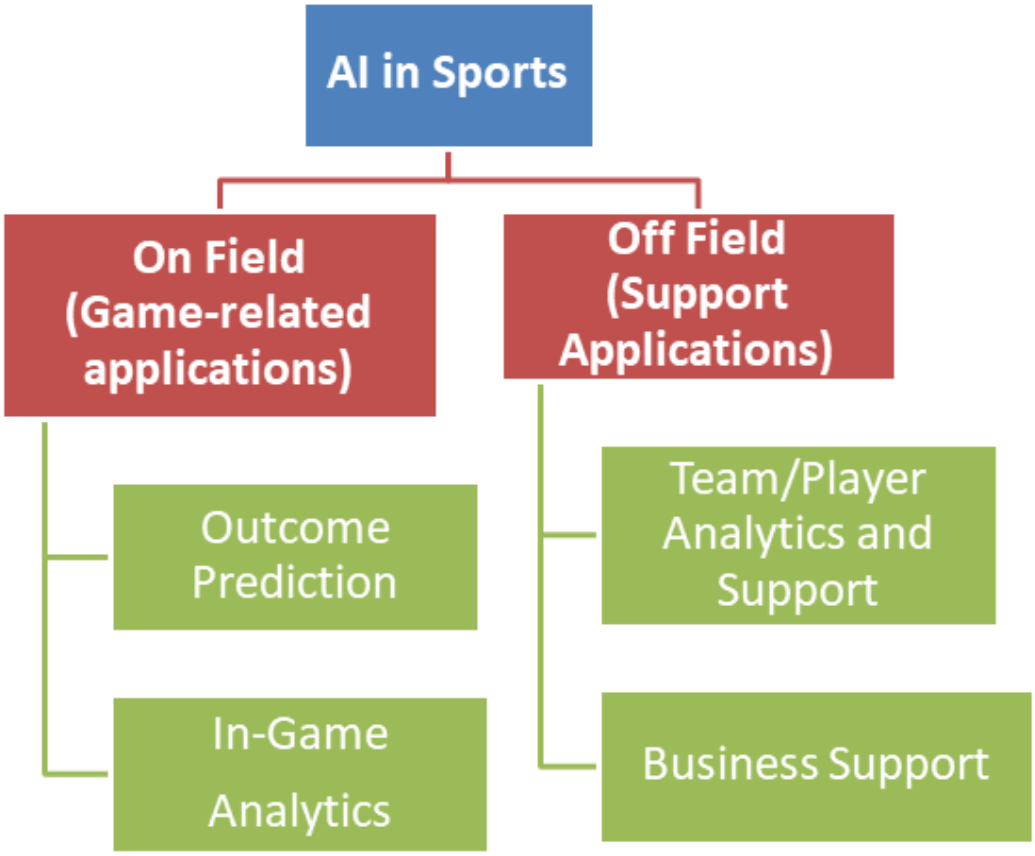
[17] **(Joseph et. al., 2006):** The researchers evaluated the performance of an expert-constructed BN to other machine learning (ML) techniques for predicting the outcome (win, lose, or draw) of Tottenham Hotspur Football Club matches in this publication. The study period was 1995-1997, and the expert BN was created at the outset of that time period, virtually entirely based on subjective judgement. The goal of this study was to compare the expert BN's accuracy to that of some alternative ML models constructed utilising data from a two-year timeframe. MC4, a decision tree learner; Naive Bayesian learner; Data Driven Bayesian (a BN whose structure and node probability tables are entirely learned from data); and KNN were among the additional ML techniques investigated. The results demonstrate that the expert BN outperforms the other strategies in terms of predicting accuracy in this domain. The results are even more impressive for BNs, given that the study assumptions put them at a disadvantage in a number of crucial areas.

III. APPLICATIONS OF AI IN SPORTS [21]

We have divided the applications into 2 major types:

- **On-Field Applications -** These deal directly with the sports matches, and their outcome. Primarily deals with analytics related to the sports, matches, teams, players etc.

- **Off-Field Applications** - These are applications of AI in the "back-end" supportive operations that are found in sports - the business side of sports teams, the training and coaching activities, media etc.



1. ON FIELD APPLICATIONS

A. Outcome Prediction

Refers to those applications related to the prediction of a sports match and the events that take place in it, such as

- the outcome of a shot
- the outcome of a round
- the outcome of the overall game

using Machine Learning, Artificial Neural Networks and Deep Learning techniques.

APPLICATIONS:

1. **Prediction of Football Matches [5]:**

In 2008, an attempt was made to test the power of AI in predicting the outcome of various sporting events, including Association Football. The study found that it is possible to create AI-based sports prediction models that have greater predictive power than that of human experts.

The general AI sports prediction model developed by them won 1st place at the major international tipping (Prediction) competition called TopTipper, beating thousands of (human) contestants of varying skill levels, from year to year.

2. **Cricket Score Forecasting [7]:**

In one study, researchers created a comprehensive AI-based system to forecast Cricket Scores based on a wide range of variables, with the intention of achieving a greater accuracy rate than existing Run-Rate based models.

The system works as follows:

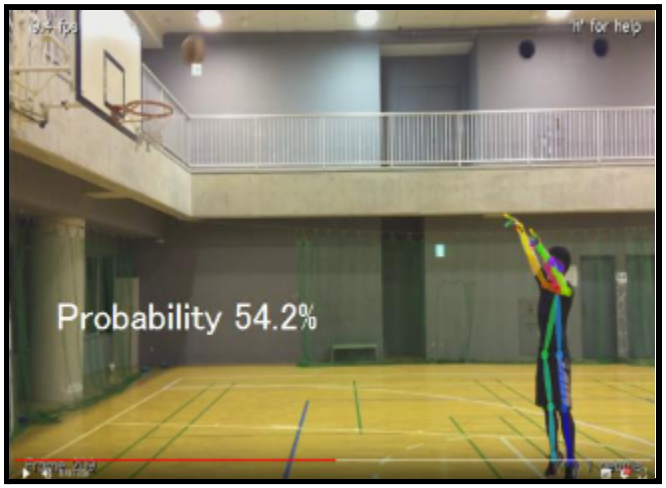
I. Data on T20 matches is scraped from reliable sources on the internet. The data includes game statistics as well as commentary. 66 features were extracted for the purpose of modelling.
II. The features were passed through a **multi-layered Neural Network based on the LSTM model,** with the final node being an activation function that outputs the predicted number of Runs.

Their model produced a Root Mean Square Error of 7.0 as compared to 18.11 generated by the run rate-based prediction, a significant improvement.

3. **Prediction of Basketball Freethrows** [22]:

OpenPose is an open source Computer Vision platform that uses a simple web camera to capture real-time motion photos and recognises the skeletons of the people in these images.

The Researchers in this project use OpenPose to predict the probability of a shooter successfully making a basketball free throw based solely on their posture. The model was significantly accurate in this task, while costing a fraction of what traditional systems would in terms of money and time. **This shows that AI methods can make advanced analytics more accessible to the masses.**



Example of the application in use [22]

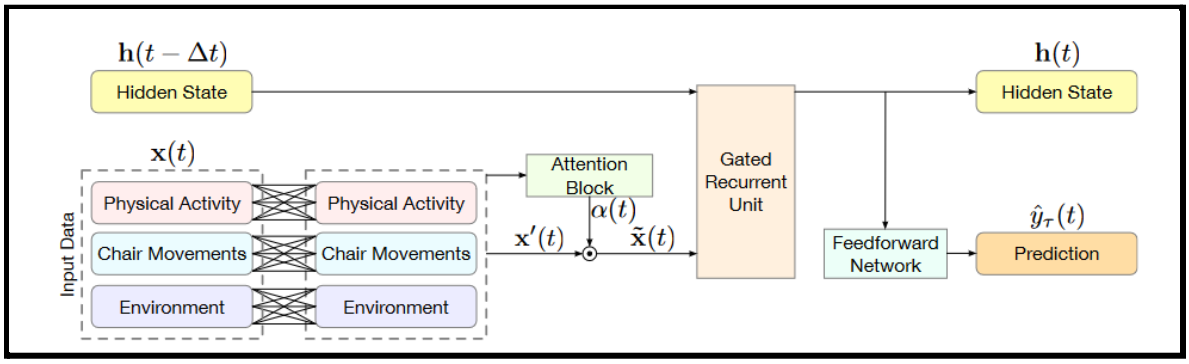
4. **Football Prediction [15]**

In the game of football, researchers have attempted to predict the outcomes of the football premier league by utilising various deep learning models such as LSTM & 3-layer Artificial Neural Network trained on data related to each Team in a given match-up.

It was found that the 3-Layer ANN achieved the highest classification accuracy of 51%. This is a significant improvement over the ~33% accuracy of a random guesser, indicating that the ANN was able to learn from past data in order to make an intelligent guess. Also, both AI models outperformed their ML counterpart, indicating AI models have the potential to out-learn and out-perform ML models in the task of Sports Prediction.

5. **eSports Prediction [11]:**

In this study, researchers took a unique approach to eSports Prediction. Researchers attempted to predict the performance of players based not on in-game data, but on how players moved in their chairs. Using sensors, researchers collected data on players' chair movements, physiological signs and environment conditions.



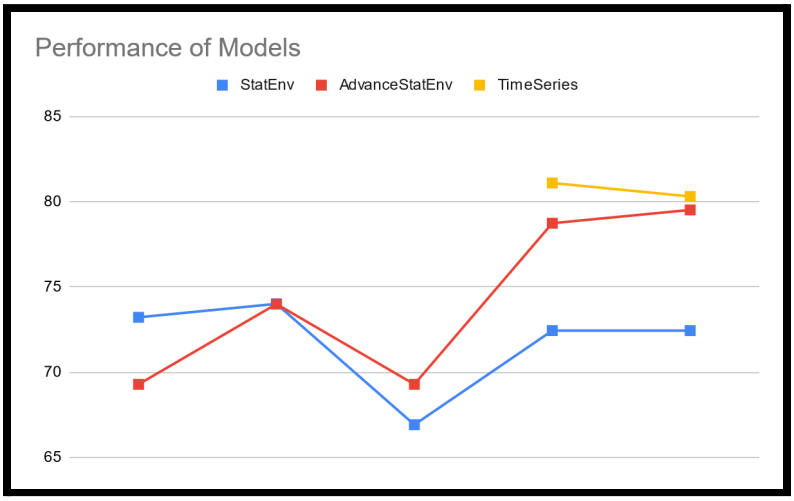
The Recurrent Neural Network Architecture used in the Study [11]

They then used Recurrent Neural Network (RNN) and RNN with attention - along with non-AI models - to predict players' performance in Counter Strike: Global Offensive, a popular eSport.

The results show that both AI models outperformed their peers in this task. The RNN with attention performed the best across all time horizons, indicating that the attention mechanism provides the RNN with a significant improvement to predictive power.

6. Tennis Match Prediction [8]:

AI methods such as the Multi-Layer Perceptron (MLP) model have been successfully used to predict the outcome of professional Tennis matches. In one study, MLP models were trained on historical data, most of which was related to the players' success rates: success rate for serves and return of serves, success rate for break points (match points), success rate for games played etc.. Three MLP models were tested, with the primary difference between the models being the number features used to train the model. The simplest model (StatEnv) used only 3 features, whereas the most complex model used 27 features (TimeSeries).



7. Performance of the 3 Models (Authors' Diagram) [8]

As you can see in this chart, the model's performance is correlated to the number of features, with the TimeSeries model outperforming the more simple models with an average accuracy rate of ~80%.

7. Basketball Match Prediction [12][13][14]:

In the game of basketball, researchers have utilised upgraded Back Propagation Neural Network to construct a mathematical prediction model.

The difference between the expected and actual results was modest, indicating that the technique is theoretically feasible for practical applications. The model can provide better service for basketball development and can be applied to other sectors after constantly refining and updating the internal data of the model. [12]

Some researchers believe that the application of AI in basketball is still in its infancy. We can call on relevant industries to increase their research investment in this area, and promote the improvement of the level of basketball, making the game increasingly exciting as its worldwide popularity continues to increase. [13]

A combination of Artificial Neural Network (ANN) and a new Concurrent Neuro - Fuzzy System (CNFS) was suggested by some researchers which showed an accurate prediction rate of 79.2%. Moreover, the results of the models developed were compared with each other and previous studies predicting the game results. At the conclusion of the comparisons, it was observed that the CNFS model had a remarkable talent in predicting the game results. [14].

B. In-Game Analytics

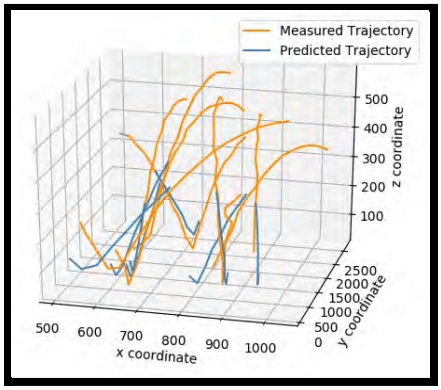
This refers to real-time analysis conducted live, while a match is being played. These types of applications typically use Video and Image data and Artificial Neural Networks (ANNs) based Computer Vision to process the data and output analysis in real-time.

APPLICATIONS:

1. **Prediction of the Trajectory of a Ping Pong Ball [9]:**

In this study

1. Convolutional Neural Networks were used to track a **Table Tennis** Ball in a given video and output its position as an XYZ coordinate.
2. Then, a **Long Short Term Memory** (LSTM) model was applied to predict the trajectory of the ball based solely on the XYZ coordinate generated by the CNN.



Left: Example of CNN Tracking the Ping Pong Ball [9]

Right: Diagram depicting the Actual Trajectory of ball & Trajectory predicted by LSTM [9]

2. AI Referee [21]

The AI Referee in Action [21]

The so-called fine margins—line calls in tennis, handballs in football, and offensive fouls in the NBA—have altered the outcome of games since sports began. Thousands of instances have been mistakenly called by referees over the years, causing coaches, supporters, and clubs to become enraged.

AI-based Computer Vision systems can help improve the accuracy of referring in sports. Computer Vision can assist in identifying potential penalties across sports so as to reduce mistakes, controversies and prevent games from swaying one way or another due to a poor refereeing decision.

3. **Ball Tracking [23][24]:**

The use of Computer Vision to

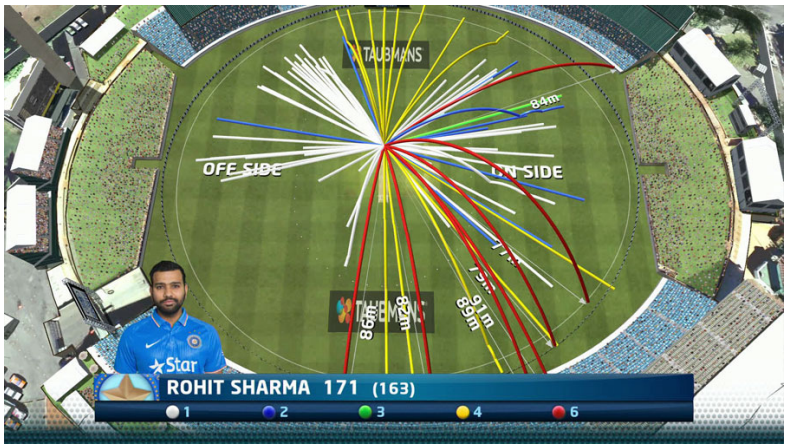
- Highlight ball in play to help viewers follow the action
- Collect tracking data and use it to generate insights into the game for viewers and analysts

There are two popular systems for Ball Tracking:

[23] VirtualEye:

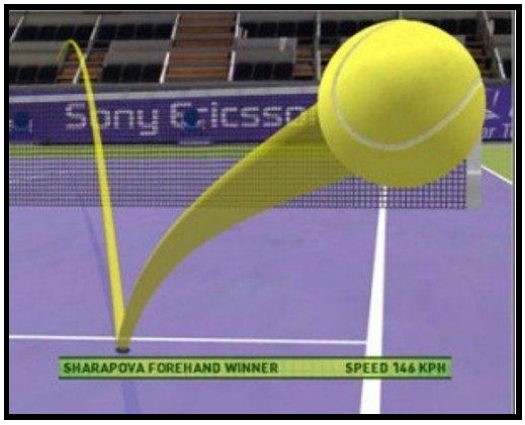
On November 24, 2009, during a Test match between New Zealand and Pakistan at Dunedin's University Oval, the Virtual Eye Cricket system was first introduced. It is a ball tracking software to provide viewers a "what might have occurred" viewpoint on the game, and the ICC (International Cricket Council) swiftly adopted it as part of the "DRS" (Decision Review System).

Virtual Eye's Cricket ball-tracking and analytics product which can keep track of all the balls hit by a batsmen and visualise them on the fly.



VirtualEye's Ball Tracking in Cricket [23]

[24] Hawk Eye: Hawk-Eye is a computer vision system that visually tracks the trajectory of the ball and displays a profile of its statistically most likely path as a moving image in a variety of sports including cricket, tennis, Gaelic football, badminton, hurling, rugby union, association football, and volleyball. **Shot Spot** is the onscreen display of the trajectory findings.

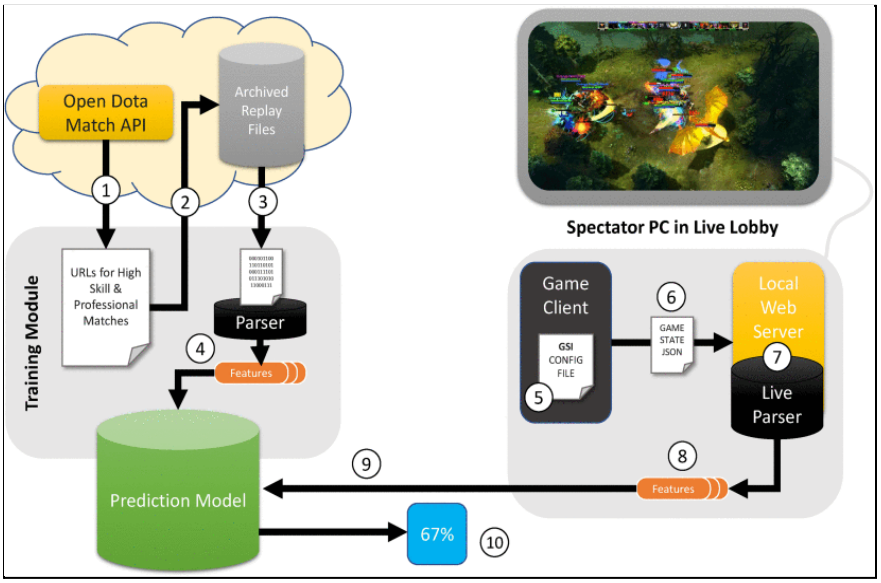


Hawk Eye's Ball Tracking in Tennis [24]

Hawk-Eye employs at least six computer-linked television cameras strategically placed around the court. The computer reads the film in real time and follows the tennis ball's progress through each camera. These six different viewpoints are then integrated to provide an accurate three-dimensional picture of the ball's route.

4. Live eSports Prediction [10]

In one study, researchers attempted to create a Model that could predict the outcome of DOTA 2 (a popular eSport) round. To the right is the workflow used by the researchers to collect data, train the models and generate predictions.



The Prediction Workflow [10]

A compilation of models tested in earlier research papers was created as a part of this paper to determine the models to be tested. The compilation revealed that ML models such as Logistic Regression and Random Forest models outperform Neural Network based Models in this particular scenario. One reason given by the researchers for this underperformance of AI models is the large amounts of data required for deep learning to be effective.

Such live predictions are used in major tournaments to add to the viewers' experience, providing an added level of excitement to the game as well as insights into the impact that players' actions have on the outcome of the game .

2. OFF FIELD APPLICATIONS

C. Team/Player Analytics and Support

The application of AI to provide support to Teams and their players off the field. Applications include Training and Coaching support, Game Strategy development, player selection (for team sports where the team composition can be varied) and so on.

APPLICATIONS:

1. **Player Performance Analysis [25][16]**

Screenshot of the Handball Player Tracking System (e)

In this application, a computer system for tracking players movements has been created for handball. Cameras capture data on player motions in this system, and the output is spatio-temporal trajectories for all players. These player trajectories provide significant information about a player's ability and performance to coaches.

3 Different tracking methods were tested:

- Tracking using just motion detection
- Colour tracking
- Combination of colour and template tracking

In comparison to other systems, the combination of colour and template tracking was found to be the most suitable, due to its speed and little human operator intervention.

Coaches can obtain insights into their teams' strengths and weaknesses using such data and visualisations on any given day, allowing them to make tactical and strategy modifications to exploit their opponent's shortcomings.

In a study, it was illustrated how the combination of game theory and statistical learning could be used to advance classical results in football analytics, with an in-depth case study using a dataset comprised of over 15000 penalty kicks, and subsequently combined with the Player Vectors analysis of Decroos and Davis (2019) to discern kicking styles. [16]

2. Personalised Training [26] [27]

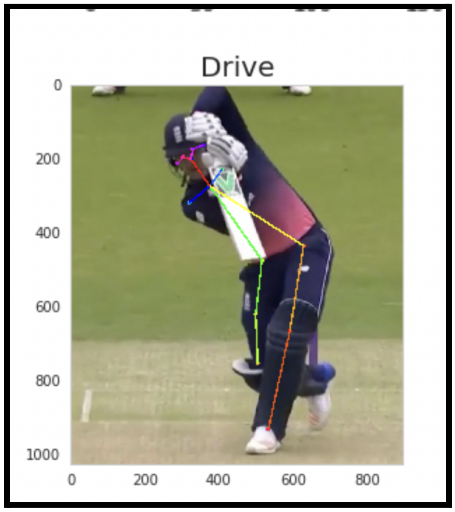
Personalised Training is the norm for professional athletes. However, AI techniques have shown to be useful in automating (and sometimes improving) this task.

[26] In one research paper, an AI based video analysis system that could provide individuals with advice on their weight training was developed. The output or recommendations of the system were verified by professional human trainers.

The data came from 15 somewhat unskilled volunteers who did 3-5 sets of 10-12 repetitions on a leg press machine. Professional trainers' evaluations (using video analysis) revealed good performance and predicted outcomes. It demonstrated the viability and effectiveness of AI approaches in automatically measuring performance on weight training equipment and providing athletes with timely guidance.

[27] Another application of AI in Exercise is Pose Estimation. Human Pose Estimation (HPE) is a method of recognising and classifying human joints. Essentially, it's a method of capturing a collection of coordinates for each joint (arm, head, torso, etc.) that may be used to describe a person's pose.

Pose detection can assist players in honing their skills and achieving greater results. Pose detection can also be used to study and learn about the opponent's strengths and shortcomings, which is extremely useful for professional athletes and their coaches.



To the right: An example of AI Pose Estimation used in Cricket to analyse a Batsmen’s form [27]

D. Business Support

The application of AI in the operations of business in the Sports Industry. Businesses include Stadium Operators, Media Outlets, Professional Sports Organisations and so on.

Applications:

1. **Stadium Entry Management [28]**

Elite sports teams are still facing admission delays in 2021. After thousands of supporters were left stuck outside after the game began, Southampton FC (an English Football Club) was forced to issue refunds. [30] At major sporting events, fans struggling to get inside stadiums in time for the game is not new. However, some sports organisations that have adopted an AI solution to this problem have seen improvements.

For example, the Columbus Crew (a US soccer team) uses Wicket's facial recognition technology to allow spectators to enter the stadium without having to show their ticket.

The Wicket Facial Authentication Platform uses smart cameras and computer vision techniques to identify individuals and match them to their ticket. In addition to Touchless fan ticketing and entry, Wicket can provide clients with Actionable audience insights for sponsor ads & Crowd density measurement. It can even identify individuals with their mask on, allowing clients to adhere to Covid Protocols.

To the Right: Wicket's Platform in Action

2. Automated Sports Journalism [29]

NDC, a regional media company in the Netherlands, is employing artificial intelligence to help it **cover 60,000 soccer matches in a year**, which is about equivalent to **every** local match. They accomplished this by using AI techniques to automate the article writing process using crowdsourced data such as photos, outcomes of matches, comments from coaches etc.

NDC has developed the crowdsourcing platform with the help of United Robots, a Swedish news automation company that already offers a similar service in Sweden, where team coaches are asked to remark by text message after each match. In the instance of NDC, the portal allows coaches to remark as well as share stats on goal scorers, as well as upload match images by both coaches and people on the pitch. The article itself is written by "robots", or AI systems with Natural Language Processing (NLP) capabilities.

Example of AI generated Article by NDC [29]

From a business point of view, NDC is able to generate engagement at a higher level than if it simply ignored local matches due to manpower constraints. Though additional coverage is free to read, NDC believes this coverage will help drive readers down their funnel and into their paid services, potentially increasing revenue.

IV. DISCUSSION

A. **Our Observations -**

- Machine Learning Models are the more common method in statistical Sports Prediction, with Neural Networks being an emerging technology.
    - This is largely due to a lack of Big Data in Sports, a requirement for effective application of ANN techniques such as Neural Networks and Deep Learning.
    - Another reason may be the complexity of the ANN models capable of modeling such complicated and dynamic events.

- Advanced AI techniques are being more readily adopted in more narrow, data-rich applications and in areas where video data is to be analysed
    - This may be attributed to the fact that when dealing with a narrow problem such as these, it becomes more feasible to effectively use ANNs to model these micro-events.
    - It also becomes more feasible to gather the large amounts of complex data required to train these ANN models.
    - Video Analytics using Computer Vision is a particularly popular application of ANNs in Sports. ANNs are more prevalent compared to ML techniques in use cases dealing with video data as the latter are not as effective as the former in this task.

Factors determining Effectiveness of AI in Sports

So, based on these observations we suggest those considering applying AI techniques in Sports to consider the following factors:

- **Data**
    - **Availability of Big Data -**

      High Volume, Complex and Information Rich data is required for effective modelling

- **Type of Data -**
  ANN methods outperform ML methods in analysing Video Data (e.g., CNNs) and Data in which the trends and relationships are highly complex (e.g., LSTM). More basic data may be better suited to ML and Statistical models.

    - If the Volume and Complexity of data being collected can be improved through the use of IoT devices and sophisticated Video Analytics, effective ANN and Deep Learning based Sports applications may prove to become more feasible.

- **Complexity of Event being Modelled** -
  Events that have limited scope and occur frequently within a Sport (Pitching, Batting, Attempting to Goal, Facial Detection at Stadiums for entry etc.) are good candidates for effective modelling, as they are easier to model compared to more complex events (such as the outcome of the overall game).

Future of AI in Sports

- **Integration of AI Sports Applications in Broadcasts** - AI-based analytics can be used to improve the viewing experience of sports fans. For example, in an AI-integrated broadcast of a Cricket Match:

    - CNN based Video Analytics can be used to track the cricket ball from the time it is pitched all the way till it returns to the pitcher, making it easier for fans to follow the action

    - Natural Language Processing can be used to automatically generate commentary for each ball, especially useful for fans following the action through their favourite cricket site

    - AI Umpires can improve the accuracy and fairness of human umpires and their decisions

    - Projections of individual and team scores can help fans gauge the performance of teams. Ball-by-Ball predictions can help fans gain insights into the mindset of pitchers and batsmen, and add an extra level of suspense to the innings.

- **Player-side Analytics** - Teams can make use of these AI models to better understand their own gameplay and that of their opponents, gaining valuable insights along the way. These insights could make or break their game.

- **Application to Real-World Events** - Advances made in AI in Sports could help researchers and businesses to improve predictive models used in more vital areas. For example, insights and advances generated by research in Foul detection in Football Video Analytics could be used by researchers to improve the performance of Video Analytics models used to monitor large crowds for violent behaviour.

REFERENCES

[1] Steele, J. M. (2000). Eclipse Prediction in Mesopotamia. Archive for History of Exact Sciences, 54(5), 421–454. http://www.jstor.org/stable/41134091

[2] *Predictive Analytics*. IBM. https://www.ibm.com/analytics/predictive-analytics

[3] McCall, A., Fanchini, M., & Coutts, A. J. (2017). Prediction: The Modern-Day Sport-Science and Sports-Medicine "Quest for the Holy Grail". *International journal of sports physiology and performance*, *12*(5), 704–706. https://doi.org/10.1123/ijspp.2017-0137

[4] Benko, A., &Lányi, C. S. (2009). History of artificial intelligence. In Encyclopedia of Information Science and Technology, Second Edition (pp. 1759-1762). IGI Global

[5] McCabe, A., & Trevathan, J. (2008). Artificial Intelligence in Sports Prediction. *Fifth International Conference on Information Technology: New Generations (Itng 2008)*. https://doi.org/10.1109/itng.2008.203

[6] Aoki, R. Y., Assuncao, R. M., & Vaz De Melo, P. O. (2017). Luck is Hard to Beat. *Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*. https://doi.org/10.1145/3097983.3098045

[7] Gupta, P., Joshi, N. S., Tahlan, R., Gupta, D., & Agrawal, S. (2021, June). Cricket Score Forecasting using Neural Networks. *International Journal of Engineering and Advanced Technology (IJEAT)*, *10*(5), 366 - 369. https://crossmark.crossref.org/dialog/?doi=10.35940/ijeat.E2821.0610521&domain=www.ijeat.org

[8] Somboonphokkaphan, A., Phimoltares, S., & Lursinsap, C. (2009). Tennis Winner Prediction based on Time-Series History with Neural Modeling.

[9] Haoxuan Liet al., Video-based Table Tennis Tracking and Trajectory Prediction Using Spatial-Temporal CNNs based on Deep Learning,Fractals,doi: 10.1142/S0218348X22401569

[10] Hodge, V. J., Devlin, S., Sephton, N., Block, F., Cowling, P. I., & Drachen, A. (2021). Win Prediction in Multiplayer Esports: Live Professional Match Prediction. *IEEE Transactions on Games*, *13*(4), 368–379. https://doi.org/10.1109/tg.2019.2948469

[11] Smerdov, A., Burnaev, E., Somov, A., & Stepanov, A. (2020). AI-enabled Prediction of eSports Player Performance Using the Data from Heterogeneous Sensors. *arXiv preprint arXiv:2012.03491*.

[12] Li, C. (2013). Predict the neural network mathematical model of basketball team scores based on improved BP algorithm. *BioTechnology: An Indian Journal, 8*.

[13] Li, B., & Xu, X. (2021). Application of Artificial Intelligence in Basketball Sport. *Journal of Education, Health and Sport.*, *11*(7), 54 - 67. http://dx.doi.org/10.12775/JEHS.2021.11.07.005

[14] Ozkan, I. A. (2020). A Novel Basketball Result Prediction Model Using a Concurrent Neuro-Fuzzy System. *Applied Artificial Intelligence - An International Journal*, *34*(13), 1038 - 1054. https://www.tandfonline.com/doi/full/10.1080/08839514.2020.1804229

[15] Goddijn, S., Moshkovich, E., & Challa, R. (2018, Winter). A Sure Bet: Predicting Outcomes of Football Matches. *CS230: Deep Learning*, *0*(0), 1 - 6.

[16] Tuyls, K., Omidsha ei, S., Muller, P., Wang, Z., Connor, J., & Hennes, D. (2021). Game Plan: What AI can do for Football, and What Football can do for AI. *Journal of Artificial Intelligence Research*, *71*(0), 41 - 88.

[17] Joseph, A., Fenton, N. E., & Neil, M. (2006). Predicting football results using Bayesian nets and other machine learning techniques. *Knowledge-Based Systems*, *19*(7), 544 - 533. 10.1016/j.knosys.2006.04.011

[18] Claudino, J. G., Capanema, D. d. O., de Souza, T. V., Serrão, J. C., Pereira, A. C. M., & Nassis, G. P. (2019). Current Approaches to the Use of Artificial Intelligence for Injury Risk Assessment and Performance Prediction in Team Sports: a Systematic Review. *Sports Medicine - Open*, 5(1), 1-12. http://dx.doi.org/10.1186/s40798-019-0202-3

[19] Bunker, R. P., & Thabtah, F. (2019). A machine learning framework for sport result prediction. *Applied Computing and Informatics*, *15*(1), 27 - 33. https://doi.org/10.1016/j.aci.2017.09.005

[20] Delen, D., Cogdell, D., & Kasap, N. (2012). A comparative analysis of data mining methods in predicting NCAA bowl outcomes. *International Journal of Forecasting*, 28(2), 543-552. 10.1016/j.ijforecast.2011.05.002

[21] Rizzoli, A. (2022, May 13). 7 Game-Changing AI Applications in the Sports Industry. Retrieved from https://www.v7labs.com/blog/ai-in-sports

[22] Nakai, M., Tsunoda, Y., Hayashi, H., & Murakoshi, H. (2018). Prediction of Basketball Free Throw Shooting by OpenPose. JSAI-isAI Workshops

[23] Virtual Eye Cricket.. Retrieved from https://virtualeye.tv/the-sports/virtual-eye-cricket

[24] Hawkeye Tennis Line-Calling System. Retrieved from https://www.topendsports.com/sport/tennis/hawkeye.htm

[25] Perš, J., & Kovacic, S. (2000). A System for Tracking Players in Sports Games by Computer Vision

.

[26] Novatchkov, Hristo & Baca, Arnold. (2013). Artificial Intelligence in Sports on the Example of Weight Training. Journal of sports science & medicine. 12. 27-37.

[27] Barla, N. (2022, May 13). A Comprehensive Guide to Human Pose Estimation. Retrieved from https://www.v7labs.com/blog/human-pose-estimation-guide

[28] Wicket. (2021, November 16). Sports & Entertainment | Ultimate Fan Experience Software. Retrieved from https://www.wicketsoft.com/sports-and-entertainment/

[29] PressGazette. (2021, July 6). Automated journalism: Tech allows media group to cover 60,000 matches. Retrieved from https://pressgazette.co.uk/automated-journalism-united-robots/

[30] BBC News. (2021, August 23). Southampton FC refunds fans after St Mary's entry delays. Retrieved from https://www.bbc.com/news/uk-england-hampshire-58303011