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Artificial Intelligence in Performance Analysis of Football Matches and Players

Dr. Ravinder Singh

Maharaja Surajmal Institute, India

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ABSTRACT

Football is a widely followed sport and has developed into a major industry in which performance analysis is important for improving team tactics and player development. Artificial intelligence (AI), computer vision [1], [2], [3], machine learning, wearable sensors, and tracking technologies provide new ways to analyse matches and player performance. This review examines the use of these technologies for football performance analysis, including player and ball tracking, tactical analysis [3], [4], [5], [8], match prediction, player valuation, and health monitoring. The reviewed literature includes studies published between 2016 and 2023 and identified through Scopus, Google Scholar, and ScienceDirect. The review covers methods such as YOLO, SORT, Deep SORT, convolutional neural networks, support vector machines, random forests, Naive Bayes, reinforcement learning, and wearable sensor systems. The reported results show that AI-based approaches can support real-time tracking, tactical analysis, match prediction, and health monitoring. The review also indicates that accuracy, computational requirements, data quality, and system reliability remain important challenges.

Keywords: Artificial intelligence; football analytics; computer vision; player tracking; ball tracking; machine learning; wearable sensors

INTRODUCTION

Artificial intelligence has become increasingly important in many application areas, including sports. Recent advances in reinforcement learning and computer vision have enabled systems that can analyse complex environments and provide useful information for decision-making. In football, performance analysis traditionally depends on match footage, statistical records, and observations by coaches. AI can extend these approaches by automatically identifying players, tracking movement, analysing ball position, and extracting tactical information.

Computer vision-based systems often require high-resolution cameras, high bandwidth, and substantial computing resources. Real-time and recorded video may also require significant processing. Previous work has investigated player and ball tracking using background modelling, YOLO, SORT, and related deep-learning methods. These approaches can detect players and referees, although problems such as missed detections and merged detections may occur.

Football performance can be evaluated through several complementary approaches: statistical analysis of match events, GPS trackers, wearable technologies, video analysis, and computer vision. Together, these methods can provide information about speed, acceleration, workload, position, technical skills, tactical behavior, and health-related measures.

Computer Vision in Football Performance Analysis

Computer vision enables computers to process and interpret visual information. In football, it can be used for player identification, player tracking, ball tracking, pitch extraction, feature extraction, tactical analysis, and detection of selected game events. Convolutional neural networks are widely used for object detection and

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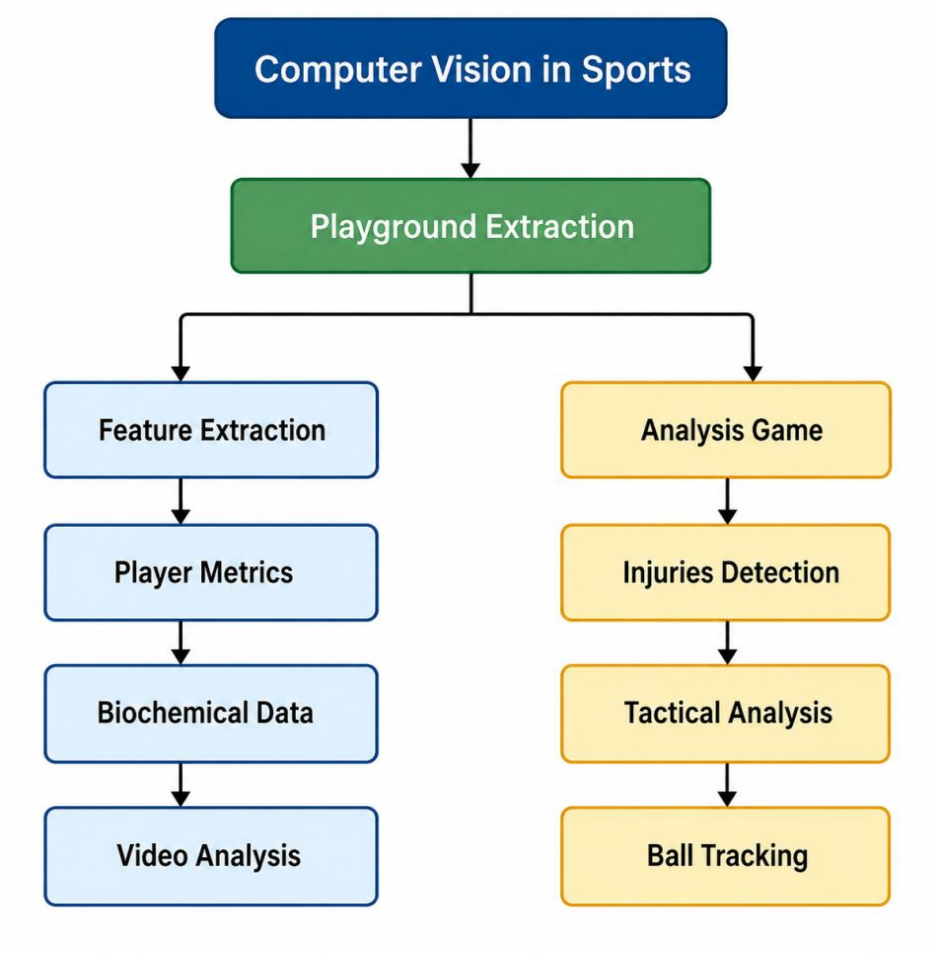
tracking, while other approaches include recurrent convolutional networks, autoencoders, generative adversarial networks, Siamese neural networks, and customized neural networks.

Figure 1. Computer vision Applications in Sports



A simplified view of the applications discussed in the source paper is shown below:

Computer Vision in Football

Pitch Extraction	Feature Extraction	Game analysis
Player Metrics	Injury detection [11]	Tactical Analysis
Biochemical Data	Video Analysis	Ball Tracking

Fig. 2. Simplified applications of computer vision in football.

REVIEW METHOD

The source paper describes a review of research published between 2016 and 2023. Studies were searched using Scopus, Google Scholar, and ScienceDirect. The review considered 11 research papers covering software and hardware solutions for football performance analysis, player and ball tracking, tactical analysis, prediction, and health monitoring. The reviewed technologies included computer vision, machine learning [6], [7], reinforcement learning, wearable sensors, and big-data approaches.

Analysis of Studies

The reviewed studies demonstrate several uses of AI in football [9], [10]. Real-time ball-position measurement has been investigated using multiple cameras, appearance and motion features, and support vector machine-

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based trajectory features. One reported system processed parallel results at approximately 33 ms (30 fps), while its evaluation reported an average ball-position error of 5.3 m and a time rate within 10 m error of 87.4%.

Machine learning has also been applied to football match prediction. A Naive Bayes-based system trained using publicly available football data reported a prediction accuracy of 85.43% in the study described by the source. Other studies examined player tracking using YOLOv4 and Deep SORT, reinforcement learning for football decision-making, random-forest and ranking methods for team ability, and PPO and SAC algorithms for simulated football agents.

AI and sensor systems have also been investigated for athlete health monitoring. Wearable devices can provide information related to physiological measures and player workload. The reviewed work highlights the need for effective data acquisition, transmission, integration, storage, and security when sensor data are used in performance systems.

Another study evaluated machine-learning methods for predicting football player market values. The source reports that random forest regression produced an RMSE of 1.64 and an R-squared score of 0.95, outperforming the other regression approaches considered in that study.

Deep-learning approaches have also been used for player and ball detection. A YOLOv3-based study using the IAUFD dataset reported an AUC of 0.812. Another study used ResNet50 and VGG-M CNN methods for recognising football players from a large image dataset.

RESULTS AND DISCUSSION

The reviewed literature shows that AI is being applied to football performance analysis from three major perspectives: visual analysis, predictive analytics, and physiological monitoring. Computer vision is particularly useful for extracting player and ball information from match videos. Machine-learning models can use historical and match-event data for prediction and evaluation. Wearable sensors can provide additional information about player health and workload.

The results reported in the reviewed studies vary according to the task, dataset, algorithm, and evaluation measure. For example, ball tracking has been evaluated using distance error and time within a specified error range, while classification and regression tasks use measures such as accuracy, AUC, RMSE, and R-squared. This makes direct comparison between studies difficult.

Table 1. Selected findings reported in the reviewed studies.

Study area	Method / technology	Dataset or data	Reported result
Player tracking	YOLO and SORT	Football match video	Approx. 25 fps and 4 fps reported for two approaches
Ball tracking	SVM with motion/appearance features	4,500 ball images; professional match video	5.3 m average error; 87.4% within 10 m error
Match prediction	Naive Bayes	Public football datasets / 2018 World Cup context	85.43% prediction accuracy
Football simulation	PPO and SAC	Unity-based simulated futsal environment	SAC reported as more stable than PPO
Player valuation	Linear regression, multiple regression, decision tree, random forest	17,980 player records	Random forest: RMSE 1.64; R^2 0.95
Player/ball detection	YOLOv3	IAUFD dataset	AUC 0.812

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Health monitoring	Wearable sensors / AI	Athlete sensor data	High accuracy reported in the reviewed study

Across the reviewed work, dataset size ranged from relatively small image or video samples to large collections containing tens of thousands of player records or approximately 100,000 images. The source also notes that football tactical analysis can use large tracking datasets.

These findings suggest that AI can support coaches and analysts, but performance depends strongly on the quality and scale of the available data.

CONCLUSION AND FUTURE WORK

This review examined software and hardware approaches for monitoring football player performance [12] and health using artificial intelligence and sensor systems. The reviewed studies indicate that player tactics and performance are important factors in achieving better match outcomes.

AI-based computer vision can assist with player and ball tracking, while machine learning can support prediction and player evaluation. Wearable sensors can provide additional information for health and workload monitoring.

Despite these developments, challenges remain in accurate detection, real-time processing, data quality, system reliability, and secure management of sensor data. Future work described in the source paper includes developing systems for monitoring football player performance and analysing games so that tactical decisions can be improved.

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