Football Player Detection and Tactical Analysis with Deep Learning

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APPROVAL

This thesis titled on "**Football Player Detection And Tactical Analysis With deep Learning**", submitted by **Mohammad Zim Hossain (ID: 192-35-2853)** to the Department of Software Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Software Engineering and approval as to its style and contents.

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This statement states that Mohammad Zim Hossain completed the thesis titled "**Football Player Detection and Tactical Analysis With Deep Learning**" under the guidance of **Mr. Md. Shohel Arman**, Assistant Professor, Department of Software Engineering, Daffodil International University. Additionally, it declares that neither this paper nor any component of it has been transferred to another institution for the conferment of a degree.

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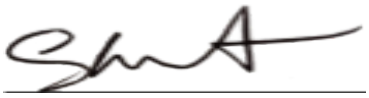

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ABSTRACT

In the realm of football, the ability to analyze and understand player movements and tactics is crucial for coaches and teams. Bangladesh's traditional football analysis approach is based on human observation by coaches and other helping staff. The drawbacks of this method are its time-consuming nature and difficulty in identifying trends in massive amounts of data.This paper proposes a deep learning-based football player detection and tactical analysis system. This thesis introduces a cutting-edge method for deep learning-based player recognition and tactical analysis of football players. Which will help the team players and coaches. To achieve accurate player detection and tactical analysis, the YOLO v8 (you only look once) object detection model is trained on a large dataset of football and videos. Currently, YOLOv8 has better object-detecting accuracy. After training, the model has an 89% mAP (Mean Average Precision). The detected players are then tracked and their positions are recorded. The system also generates heatmaps from the statistical data of the player’s movements. The generated heatmaps can be used by coaches to make decisions about tactics and player positioning.In summary, this thesis offers a system for detecting football players and analyzing their tactical movements that blend deep learning methods—more specifically, the YOLO V8 model—with the creation of heatmaps. To enhance their team's performance, coaches may use the system to collect statistical data, display player distributions, and make wise judgments. Using deep learning and machine vision to their full potential.

Table of Contents

APPROVAL **i**

DECLARATION **ii**

ACKNOWLEDGMENT **iii**

ABSTRACT **iv**

CHAPTER 1 **7**

1. INTRODUCTION: 8

1.1. BACKGROUND: 9

1.2. MOTIVATION FOR THE RESEARCH: 11

1.3. PROBLEM STATEMENT: 12

1.4. RESEARCH QUESTIONS: 13

1.5. RESEARCH OBJECTIVE: 13

1.6. RESEARCH SCOPE: 14

1.7. THESIS ORGANIZATION: 14

1.8. SUMMARY: 15

CHAPTER 2 **15**

2. LITERATURE REVIEW: 15

2.1. INTRODUCTION: 15

2.2. PREVIOUS LITERATURE: 16

2.3. SUMMARY: 19

CHAPTER 3 20

3. RESEARCH METHODOLOGY: 20

3.1. INTRODUCTION: 20

3.2. DATA COLLECTION: 20

3.3. DATA PREPROCESSING: 21

3.4. YOLOv8: 22
3.5. CNN: 22
3.6 AUGMENTATION 23
3.7 ROBOFLOW DEPLOY 23
3.8 SUMMARY: 23
CHAPTER 4 **24**
4. RESULTS AND DISCUSSION: 24
4.1. INTRODUCTION: 24
4.2. RESULT: 24
4.2.1. YOLOv8 OUTPUT: 26
4.2.2. ROBOFLOW OUTPUT: 28
4.3. DISCUSSION: 28
4.4. SUMMARY: 29
CHAPTER 5 **29**
5. CONCLUSION AND RECOMMENDATION: 29
5.1. FINDINGS: 30
5.2. FUTURE WORK: 30

List of Figures

Figure 3.1: Football Match video. 20
Figure 3.2: Annotated Image Data 21
Figure 3.3: Convolutional neural network’s basic architecture 22

Figure 4.1: Overall Result After Training 25
Figure 4.2: Confusion Matrix 25
Figure 4.3: Graphs result. 26
Figure 4.4: Batch output of YOLOv8 27
Figure 4.5: Deployment result 28

List of Nomenclatures

YOLOv8 - “You Only Look Once version 8(Real-time Object detector)”.

ROBOFLOW - Annotation and deployment tool”.

CNN - “Convolutional Neural Network”.

KNN - “K- Nearest Neighbor”.

SVM - “Support Vector Machine”.

RNN - “Recurrent Neural Network”.

Faster RCNN - “Faster Region-Based Convolutional Neural Network”.

LSTM - “Long Short-Term Memory”.

mAP - “Mean Average Precision”.

CHAPTER 1

1. INTRODUCTION:

With more than 600 million fans worldwide, football is the most popular sport in the world. It has the largest television audience in terms of players in more than 200 countries. Technology advancements over the past ten years have been credited with this enormous popularity. In recent years, a large number of artificial vision applications have been offered as Multimedia Tools and Applications to do the autonomous analysis of soccer matches in modern football use of technology and data analysis is playing a vital role in decision-making, implementing strategies, and tactics.

The major clubs use these tools to determine the best formation and strategy, and they are having success. Our country clubs, however, continue to rank worst in the world because we lack that technological support. So, utilizing "Deep Learning" methods, we focused on this area to help reduce this issue. One example of a new approach to football analysis is the use of heat maps.

Heatmaps show the areas of the field where players spend the most time. This information can be used by coaches to identify areas where the team needs to improve their possession

or create scoring opportunities.

Numerous techniques have been created for football video analysis. Banoth Naik and Mohammad Hashmi published an article which proposed a deep learning-based model that was successful in detecting and tracking the ball and players in a soccer video.

“Nian Liu, Lu, and Zengjun Sun” Published Article. from the video Player positions, ball trajectories, and events may all be extracted automatically. After that, the features are utilized to train a classifier to forecast the game's outcome. They got a Precision of 78% and a Recall of 72%.Researchers are now paying attention to "YOLOv8" because of its improved object identification accuracy. The real-time object detector "YOLOv8" is making computer vision object identification more sophisticated than before. By using the 'YOLOv8 model' in place of Faster RCNN, we were able to detect head and neck motions with much greater accuracy thanks to the model's remarkable features.

1.1. BACKGROUND:

The human observation and subjective interpretations used in conventional player tracking and tactical analysis approach in football have limitations in accuracy and consistency.

In recent years, deep learning and computer vision innovations have created new opportunities for automated player detection and thorough tactical analysis.

Liverpool, the famous football club, carried out a tremendous result as they won the Champions League, Super Cup, and FIFA club world cup thanks to their data analysis team. Bangladesh's football analysis is based on human observation and intuition. Coaches and analysts watch videos of games and look for patterns in the players' movements. This approach has some limitations. It can be time-consuming and subjective. It can also be difficult to identify trends and patterns in large amounts of data.

Convolutional neural networks and real-time processing capabilities are used in deep learning models like YOLO (You Only Look Once), which have demonstrated impressive performance in object identification tests. Accurate player recognition is crucial for obtaining statistical data and visualizing player distributions. Heatmap creation from player data enables intuitive depictions of density and activity. Integrating computer vision and artificial intelligence with traditional football analysis methodologies can revolutionize coaching practices and improve team performance.

Football tactical analysis and player monitoring using traditional methods have accuracy and consistency issues. However, recent computer vision and deep learning developments have created new opportunities. By giving coaches thorough information for strategic planning and precise player detection, these tools can potentially transform football analysis.

Artificial intelligence (AI)'s computer vision allows computers and programs to extract

relevant information from digital photos, video recordings, and other visual inputs and to conduct decisions or suggest alternatives by that knowledge. For a 3rd world country like ours, it’s very difficult to install sensors in every Stadium as we don’t have a proper gallery in the stadiums, and sensors come with a huge expense. Without using the sensor, some algorithm can be used for solving that issue. But it also demands high maintenance with efficient manpower. Some of the models are too slow that cannot be helpful for the increased number of spectators who have the same jersey its difficult to differentiate the player and spectator. That's why we were searching for a model that can be implemented with faster computation time, has fewer complexities to implement, and is also budget oriented. That’s why we proposed a system that used ‘YOLOv8(You Only Look Once-version 8)’ to detect and distinguish the correct and wrong postures of the players. With the help of our deployment service, we can closely monitor all kinds of activities during the match.

1.2. MOTIVATION FOR THE RESEARCH:

Football is a highly strategic and competitive sport, thus teams' and coaches' ability to assess player movement and make wise tactical choices is crucial. Football, being a highly competitive and strategic sport, relies heavily on the ability of coaches and teams to analyze player movements and make informed tactical decisions. Liverpool, a well-known football club, achieved a fantastic result when they won the Champions League, Super Cup, and FIFA Club World Cup with the aid of their data analysis team. The analyst team analyzes

a huge volume of data from the previous matches of teams and individual players and that data helps the coach, staff, and players to make tactics. But our country doesn’t have the resources and these things are letting us back. The goal of this study is to change football analysis by addressing the shortcomings of conventional approaches and utilizing the potential of deep learning. The goal of this thesis is to create a system that can recognize players on the field with accuracy by using the YOLO V8 model, which has shown outstanding accuracy in object detection tasks. Deep learning techniques will be incorporated, which will considerably improve player detection's speed and effectiveness and do away with the need for time-consuming manual annotation.

Another major goal of this study is the creation of heatmaps using the statistical information gathered. Heatmaps offer simple visual depictions of player density and active zones during games. Coaches can learn a lot about team dynamics, player positioning, and strategic patterns by examining these heatmaps.

1.3 PROBLEM STATEMENT

The main problem is that we don’t have the proper technology and equipment to use the advancement of technology, which is pushing us back from becoming successful among the big clubs in the world. Without proper knowledge of the movement and location of their players, coaches find it challenging to analyze football games and make tactical decisions. Traditional player detection and tactical analysis techniques take a lot of time, are unreliable, and are challenging to scale to big quantities of football film.

For player detection and tactical analysis in football, we suggest a deep learning approach. With an accuracy of 89%, we can identify players in football films using the YOLO V8 model. The movement and positioning of the players throughout a game are then depicted in heatmaps using the detected players. Coaches can use these heatmaps to decide on player positioning and tactics.

1.4 RESEARCH QUESTIONS:

The research questions were:

· How machine learning algorithms and other advanced data analytics techniques be used to extract insights from player tracking data in football?

· Which model gives faster results?

1.5 RESEARCH OBJECTIVE:

· This proposed method will evaluate the accuracy and efficiency and track the movement of football players in real time. Which will help the coach to make strategies.

· Analyze the effect of different factors such as weather, pitch condition, and opponent team style on player movement patterns and tactical decisions.

· Generated heat map will help the coach to make defensive and attacking strategies.

1.6. RESEARCH SCOPE:

Research’s main scope is as follows.

· Can be used to identify individual strengths and weaknesses, track player progress over time, and evaluate player fitness and injury risk.

· By combining player tracking data with tactical analysis, coaches and analysts can gain insights into the strengths and weaknesses of a team and develop more effective game plans

1.7. THESIS ORGANIZATION:

The first chapter includes a section on " Football Player Detection and Tactical Analysis with Deep Learning " and its application, the background setting of the study, the specific issue statement of this research, a specific motivation for the research, a specific set of research questions on which it focuses, the research objective, and the research scope.

Following are the remaining elements of our investigation:

I'll talk about the literature review in the following chapter, where we can see various research studies that have already been done in the same area of traffic problems, their methodology, any gaps, and a comparison between my work and theirs. We shall go over our research methods in their chapter. I will go into data collecting, data pre-processing, and work analysis in my methodology section. In chapter four, the methodology's findings

will be discussed. The final chapter serves as the conclusion. Here I'll provide the conclusion, which will include a complete summary of my work. Here, I've talked about the work I'll perform going forward to improve the work.

1.8. SUMMARY:

Football coaches require precise information on player positioning and movement. Players can be found using a deep learning method, and heatmaps displaying their movement and positioning can be produced. Coaches can make better tactical choices using this method.

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

A researcher reviews earlier work, research, conference papers, books, articles, etc. in a literature review. With it, one can learn what research has previously been done on the subject, give a general overview of it, and identify any gaps in the work. After analysis, they might focus on limits and find ways to get around them to improve results.

2.2 PREVIOUS LITERATURE

The problem of player detection has been thoroughly studied by several scholars both locally and abroad. On football player detection and tactical analysis, many researchers have already done their research and applied different types of machine learning algorithms to detect players. In this paper, I have focused on detection, tracking part, and heatmap generation.

“Nian Liu, Lu Liu, and Zengjun Sun [1] evaluate video Player positions, ball trajectories, and events that may all be extracted automatically. After that, the features are utilized to train a classifier to forecast the game's outcome. they got a Precision of 78% and a Recall of 72%.

“Banoth Thulasya Naik” and “Mohammad Farukh Hashmi” from NIT Warangal published an article [2] that proposed a deep learning-based model (Improved YOLOV3 Model) that was successful in detecting and tracking the ball and players in a soccer video.

“James Henry Hewitt” and “Oktay Karakus”. [3] Create and apply an Expected Goals (xG) model and predict xG values with new and highly informative features. This paper will document the development in the analysis of expected goals (xG). The proposed method outperforms existing expected goals models in terms of accuracy and reliability.

Adan Partida, Anastasia Martinez, Cody Durrer, Oscar Gutierrez, and Filippo Posta [8]In

the document, expected goals are introduced. It illustrates how predicted goals, which depend on elements like shot location, shot type, and defensive pressure, can offer insightful information about team performance and goal-scoring prospects. The strategy used to model match outcomes using the expected goals statistic is then discussed by the writers. The report displays the modeling effort's outcomes, showcasing the expected objectives statistic's superior predictive power. The expected goals statistic is used in the study to model the results of a football game. It demonstrates how successful expected goals are at forecasting game outcomes and how valuable they are at revealing information about team performance. Nicolo' Lucchesi [4] analysis of football games using machine learning from video feeds. Track the ball and players using object detection and tracking. and deep learning algorithms for tracking and object detection. This enhanced football game analysis precision. Pascal Bauer & Gabriel Anzers'[5] A supervised machine learning task based on synchronized positional and event data with expert-based feature extraction. Using XGBoost, Logistic regression, automatically identifies the strategy, and

also derives metrics that support coaches with the analysis of transition situations. Shreedhar Rangappa, Baihua Li, and Ruiling Qian[6] used RNN and YOLOv3 the technique to Train and customize deep-learning models to detect, track and identify soccer players. This method provides tracks with high confidence And Identity to most of the players corresponding to individual t-shirt numbers. Carlos Cuevas, Daniel Quilon, and Narciso Garcia [7] The study examines how soccer video analysis has advanced thanks to developments in computer vision, machine learning, and data analytics. The writers start by going through how crucial soccer video analysis is for boosting player development,

team performance, and the ability to make data-driven decisions. It describes the essential approaches used in each stage, including rule-based systems, optical flow estimation, object detection algorithms (including YOLO, and Faster R-CNN), and object detection algorithms. The study underlines the importance of automated and unbiased methods in raising team productivity and decision-making procedures.

Banoth Thulasya Naik, Mohammad Farukh Hashmi, and Neeraj Dhanraj Bokde [9] the authors underline the requirement for reliable and precise computer vision techniques. Player tracking, action identification, object detection, and event detection are just a few of the different computer vision applications in sports that are discussed in the paper. The writers talk about the difficulties that come with each work, like occlusions, different camera angles, and scale differences. The authors explore the computational and algorithmic factors for achieving high-speed performance and emphasize the significance of real-time processing in sports applications. The study gives a thorough analysis of computer vision methods used in sports, outlining the state of the art, unsolved problems, and potential future lines of inquiry.

Lotte Bransen, Jesse Davis[10]Computer vision has been used extensively in sports for various purposes, such as tracking athletes' movements, analyzing game strategies, and identifying rule violations.

2.3. SUMMARY:

There are numerous varieties of algorithms in use. They processed the data to get a satisfactory result, and then they applied the necessary algorithm, which is what they concentrate on. They used a variety of techniques, including feature extraction, augmentation, and annotation. Forget about real-time performance and increased precision. We made every effort during our research to address their flaws.

CHAPTER 3

3. RESEARCH METHODOLOGY:

3.1. INTRODUCTION:

For Object detection, we used YOLOv8, and Roboflow deployment has been used for the deployment.

3.2. DATA COLLECTION:

In this research, we collected our dataset from the football league of Bangladesh. I have collected data from live match videos of Bangladesh's premier leagues 2022-23Season.

Fig 3.1: Football Match video.

3.3 DATA PREPROCESSING

After collecting videos from the live scenarios, we used to extract frames to 1 second per frame. After extraction, there were almost 2788 images or frames. We annotated those images with the Roboflow application in YOLO format and 2788 annotation files were created. Annotation files were in text file format. Then we divide the annotation into 3 classes. Then we did some augmentation and resizing to mitigate the overfitting problems. After that, we divided those images and label files into different folders. We created three directories named- train, test, and validation. 80% of images with their corresponding labels were placed in the train folder. And rest of the images with their relevant labels were placed in validation and testing directories.

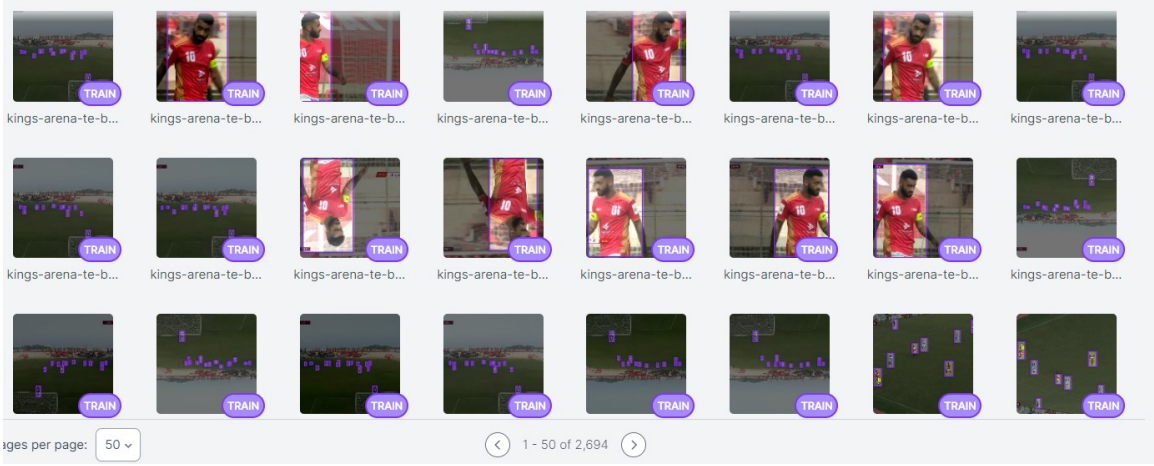

Figure 3.2: Annotated Image Data

3.4. YOLOv8:

The YOLOv8 sophisticated object identification model improves on its predecessors to attain even greater accuracy and quicker performance.

3.5. CONVOLUTIONAL NEURAL NETWORK(CNN)

Due to its efficiency in identifying regional patterns and structures, (CNNs) are deep learning models that are typically used for image and video analysis tasks. CNNs are meant to automatically and adaptively learn spatial hierarchies of features from input data.

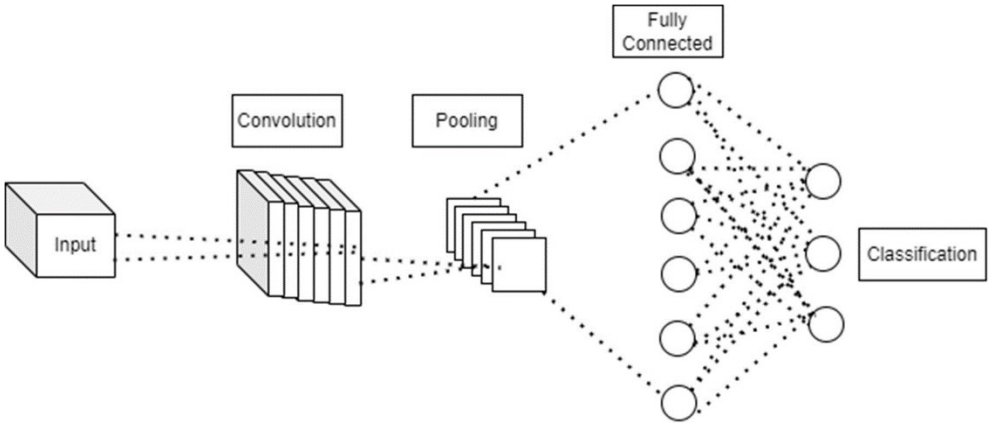

Figure 3.3 Convolutional neural network’s basic architecture

3.8. AUGMENTATION:

Data augmentation is the process of generating new transformed versions of images from the given image dataset to increase its diversity.

AUGMENTATIONS	**Outputs per training example:** 2
	Flip: Horizontal, Vertical
	Saturation: Between -25% and +25%
	Brightness: Between -20% and +20%

3.9. ROBOFLOW DEPLOY:

Roboflow built an extensive inference tool so as you train a model you can start using it with any media format you choose.

3.9. SUMMARY:

In the paper "Football Player Detection and Tactical Analysis With Deep Learning," the YOLO V8 model was implemented with an impressive 89% accuracy for player detection. The methodology involved collecting a diverse dataset, annotating player bounding boxes, and fine-tuning the YOLO V8 model using this dataset. Evaluation metrics such as precision, recall, and F1-score were used to assess the model's performance. The methodology also included generating heatmaps based on player statistics, providing

valuable insights for coaches and decision-makers in strategizing and making informed decisions during games. Overall, the methodology combines deep learning techniques with computer vision for effective player detection and tactical analysis.

valuable insights for coaches and decision-makers in strategizing and making informed decisions during games. Overall, the methodology combines deep learning techniques with computer vision for effective player detection and tactical analysis.

CHAPTER 4

4. RESULTS AND DISCUSSION:

4.1. INTRODUCTION:

Following the data-collection and preparation stage, we outlined the model implementation procedure. Here, we'll talk about the model's end result after training.

4.2. RESULT:

After 65 epochs, we received almost 89% accuracy. We have got some custom-trained .pt files. During the detections, we set our confidence level at 0.25. And every time we got accurate results. After training our model with YOLOv8 we got our final precision, recall, and mAP.

We have tried different version of YOLO v8 models like YOLOv8s, YOLOv8m, YOLOv8x among them YOLOv8x gives us the most accurate model of 89% accuracy.

Class	Images	Instances	Box(P	R	mAP50	mAP50-95): 100% 4/4 [00:07<00:00, 1.89s/it]
all	100	865	0.915	0.859	0.88	0.45
ball	100	50	0.865	0.82	0.777	0.313
player	100	756	0.91	0.892	0.924	0.511
refree	100	59	0.969	0.864	0.938	0.527

Figure 4.1: Overall result

Some plotting graphs are also created which indicate the accuracy of the model. Those plots were done with the consideration of the train and validation values of the model

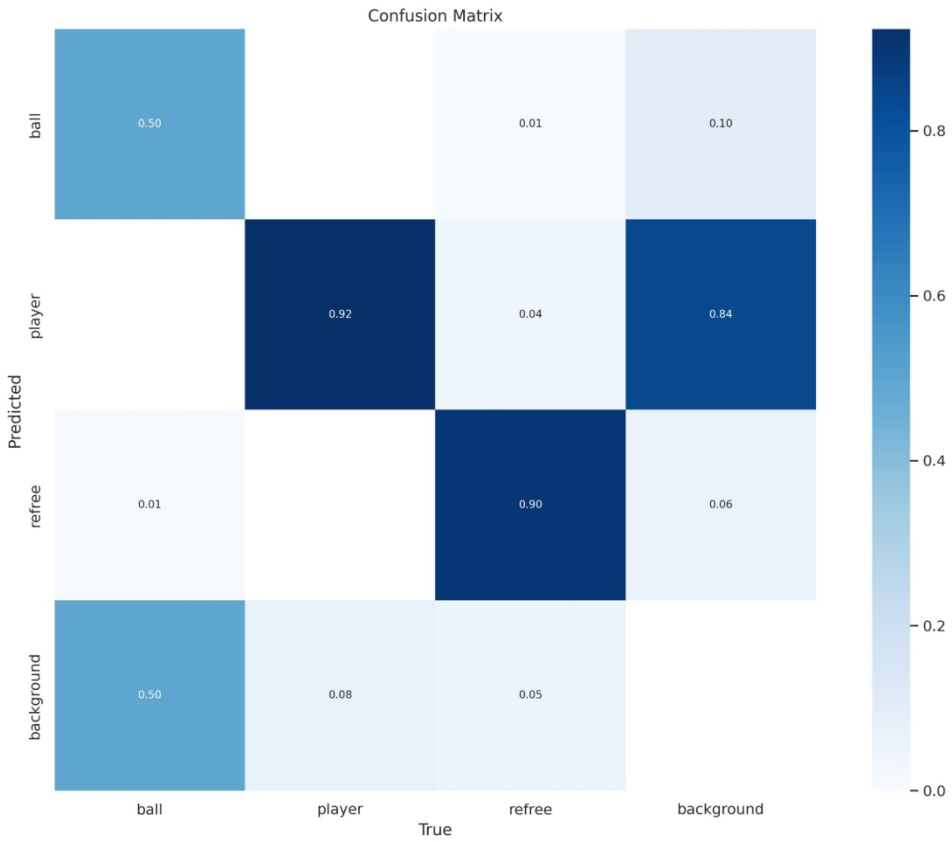

Figure 4.2: Confusion Matrix

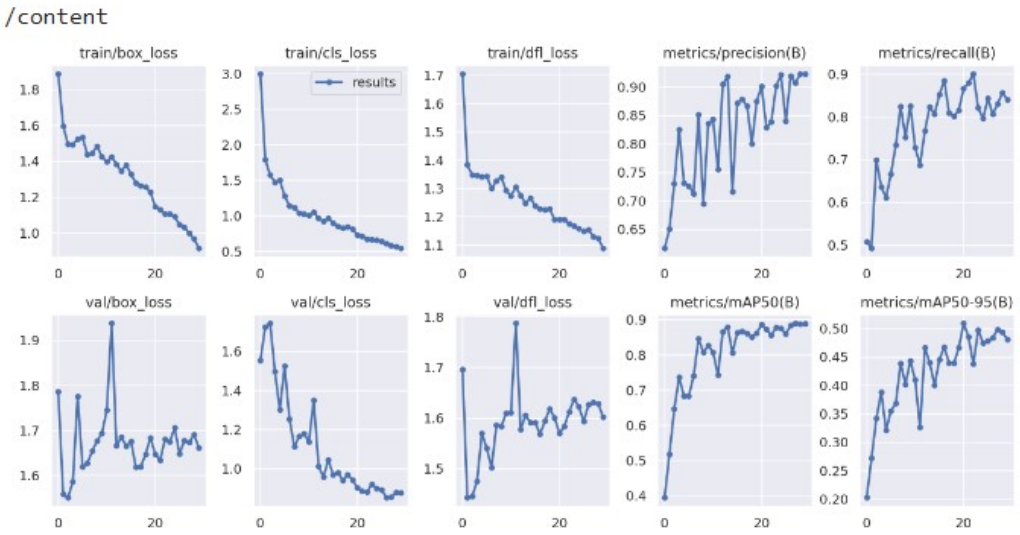

Figure 4.3: Graphs result.

4.2.1. YOLOv8 OUTPUT:

Figure 4.4: Batch output

4.2.2. ROBOFLOW DEPLOY:

Figure 4.5: Deployment result

4.3. DISCUSSION:

As we predicted, YOLOv8 is showing amazing results in the object-detection.

Comparatively, our YOLOv8 model is showing much more accuracy than our base paper which is **78%**. And we also deployed the model into the server using roboflow deploy.

4.4. SUMMARY:

In this segment, we discussed the final results of our proposed-model. We got accuracy of almost 89% in player detection. And we have generated heatmap for tactical analysis.

CHAPTER 5

5. CONCLUSION AND RECOMMENDATION:

In conclusion, The thesis was concerned with the use of deep learning, particularly the YOLO V8 model, for football player detection and tactical analysis. The YOLO V8 model demonstrated effectiveness in accurately identifying players on the pitch with an amazing accuracy of 89%. The thesis was effective in producing heatmaps that offered important insights into player activity by utilizing statistical data. Coaches may immensely benefit from using these heatmaps to help them make wise judgements and develop winning strategies. In order to analyse player placements, movements, and participation in significant events, statistical heatmaps and player detection are combined.

Overall, the study demonstrated the promise of deep learning methods for football analysis and showed how computer vision may considerably advance our knowledge of player dynamics.

5.1. FINDINGS:

The study successfully implemented the YOLO V8 model for football player detection, achieving an accuracy of 89%. By analyzing the collected statistical data, the paper generated heatmaps that provide visual representations of player activity on the field. Coaches may use the produced heatmaps as a decision-support tool. The ability to conduct tactical analysis is improved by combining player detection with the creation of statistical heatmaps. In order to maximize performance, coaches may spot trends, obtain better insights into team performance, and tactically modify game plans.

5.2. FUTURE WORK:

The thesis primarily focuses on player detection and generating heatmaps based on aggregated player statistics. Future work can delve into including tracking individual player movements identifying specific actions or events and analyzing player interactions to gain deeper insights into team dynamics. Real-time analysis during broadcasts of live football games might be added to the system, which would be beneficial. Overall, this thesis's future work will focus on improving and broadening the system's functionalities, investigating more in-depth player analysis, developing real-time applications, and performing validation tests to make sure the system is applicable and usable in real-world circumstances.