Player Detection and Clustering in Sports Matches

Utku Murat ATASOY
Artificial Intelligence Engineering Department
TOBB University of Economics and Technology
Ankara, Turkey
u.atasoy@etu.edu.tr

***Abstract*—This project aims to automatically detect players in sports matches and cluster the detected players based on their jersey colors. The YOLOv8 model is used for object detection, and the VGG16 model is used for feature extraction. Clustering is performed using K-Means and Agglomerative Clustering algorithms. The accuracy of the model is tested and evaluated using various performance metrics.**

***Index Terms*—Object tracking, Agglomerative clustering, Sports analysis**

I. Introduction

Detecting players in sports matches and determining which team they belong to is an essential step for analysis and statistics. This process, when performed manually, is highly time-consuming and prone to errors. This project aims to accelerate and improve the accuracy of this process using automated detection and clustering techniques.

A. Motivation

The goal of this study is to automate the player detection and clustering processes in sports matches, enabling faster and more accurate data analysis and statistical studies.

B. General Methodology

The key methodologies used in this project are as follows:

- **Object Detection:** Detecting players in sports matches using the YOLOv8 model. YOLOv8 is a deep learning object detection model known for its speed and high accuracy.
- **Feature Extraction:** Extracting features from detected players using the VGG16 model. VGG16 is a widely used deep learning model for image classification.
- **Dimensionality Reduction:** Reducing the dimensions of extracted features using PCA (Principal Component Analysis). PCA reduces data dimensions to ease computation and facilitate data analysis.
- **Clustering:** Clustering players based on their jersey colors using K-Means and Agglomerative Clustering algorithms. K-Means is a popular algorithm for partitioning data into clusters, while Agglomerative Clustering hierarchically merges data points based on their similarity.

C. Objectives and Goals

The objectives include automatically identifying and distinguishing players from different teams, testing the accuracy of the detection model, and visualizing the results.

D. Performance Metrics

The model's performance is evaluated using metrics such as accuracy, precision, recall, and F1-score.

II. Literature Review

The YOLO (You Only Look Once) model is widely used for real-time object detection [1]. VGG16 is a common deep learning model for image classification and feature extraction [2]. PCA is frequently used to reduce data dimensions and computation load [3]. K-Means is a popular algorithm for clustering data [4].

III. Dataset and Data Characteristics

A. Data Source

A total of 11,489 images were collected, featuring individuals identified in sports matches. The images were obtained from objects labeled as "person" using the YOLOv8x model.

Fig. 1. Detected players from the dataset.

B. Dataset

The images include various angles and conditions from sports matches and may contain referees, technical staff, and spectators. The aim is to cluster players based on their jersey colors and other attributes.

C. Preprocessing Steps

- **Resizing Images:** All images were resized to 224x224 pixels to meet the model's input requirements.
- **Color Format Conversion:** Images in BGR format were converted to RGB format.
- **Normalization:** Images were normalized to match the input requirements of the VGG16 model.

D. Feature Extraction and Dimensionality Reduction

Feature vectors of size 4096 were extracted from each image using the 'fc1' layer of the VGG16 model. This process was performed in batches to avoid memory overload. PCA was then applied to reduce the dimensions to 50 components, which decreased computational load and facilitated data analysis.

E. Clustering Process

Initially, images were divided into 10 clusters using the K-Means algorithm. Subsequently, smaller clusters with sizes ranging from 3 to 10 were adjusted using Agglomerative Clustering.

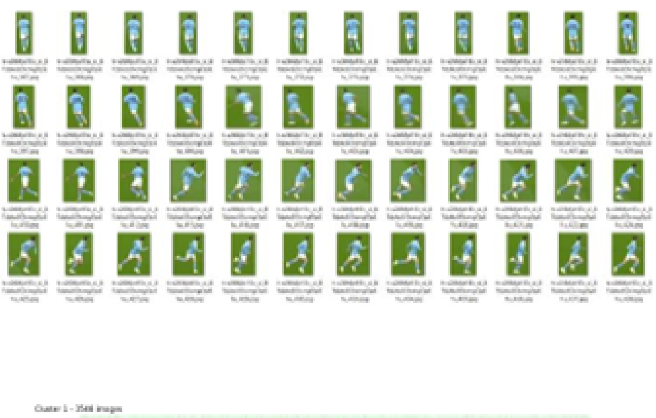

Fig. 2. Clustering results using K-Means.

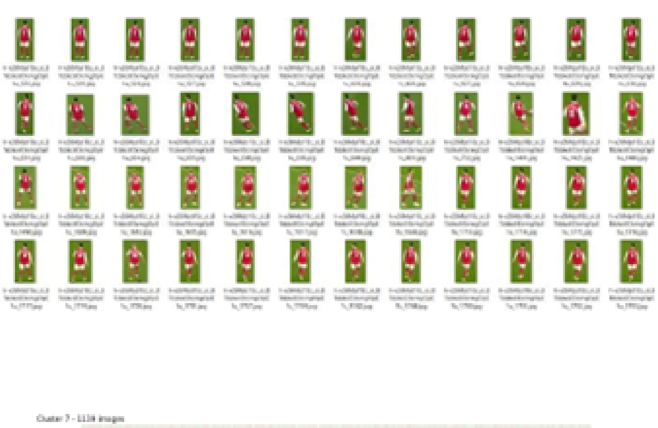

Fig. 3. Clustering results using Agglomerative Clustering.

IV. Methodology

A. YOLOv8 Model

YOLOv8 is a deep learning model developed for real-time object detection. It is known for its high accuracy and fast processing capability. The model is trained on a large dataset for detecting various objects.

B. VGG16 Model

VGG16 is a widely used deep learning model for image classification and feature extraction. The model is trained on the ImageNet dataset and features a 16-layer convolutional neural network architecture.

C. Principal Component Analysis (PCA)

PCA is a statistical technique used to reduce the dimensions of high-dimensional data while retaining the most significant information. PCA creates components that maximize the variance in the data.

D. K-Means and Agglomerative Clustering

K-Means is a clustering algorithm that partitions data into k clusters. The algorithm determines the center of each cluster and assigns data points to the clusters closest to these centers. Agglomerative Clustering hierarchically merges data points based on their similarity. In this project, K-Means and Agglomerative Clustering were used together to cluster players based on their jersey colors.

V. Test Results and Analysis

A. Performance Metrics

The model's performance was evaluated using metrics such as precision, recall, and F1-score:

- **Precision:** The ratio of correctly classified players among those detected by the model.
- **Recall:** The proportion of actual players correctly detected by the model.
- **F1-Score:** The harmonic mean of precision and recall, reflecting the model's overall performance.

B. Test Results and Graphical Analysis

The confusion matrix indicates that the model classified Arsenal and ManCity players with high accuracy, with very few misclassifications.

The training loss metrics reveal that "train/box_loss," "train/cls_loss," and "train/dfl_loss" decreased rapidly during training, indicating efficient learning.

The F1-Confidence Curve demonstrates that the model's F1-score increased with higher confidence levels, highlighting better performance at higher confidence thresholds.

The Precision-Recall Curve shows that the model maintained high precision and recall values, indicating a high true positive rate and a low false negative rate.

The Precision-Confidence and Recall-Confidence curves reveal that the model improved its precision and recall as the confidence threshold increased, demonstrating more accurate detections and fewer missed players.

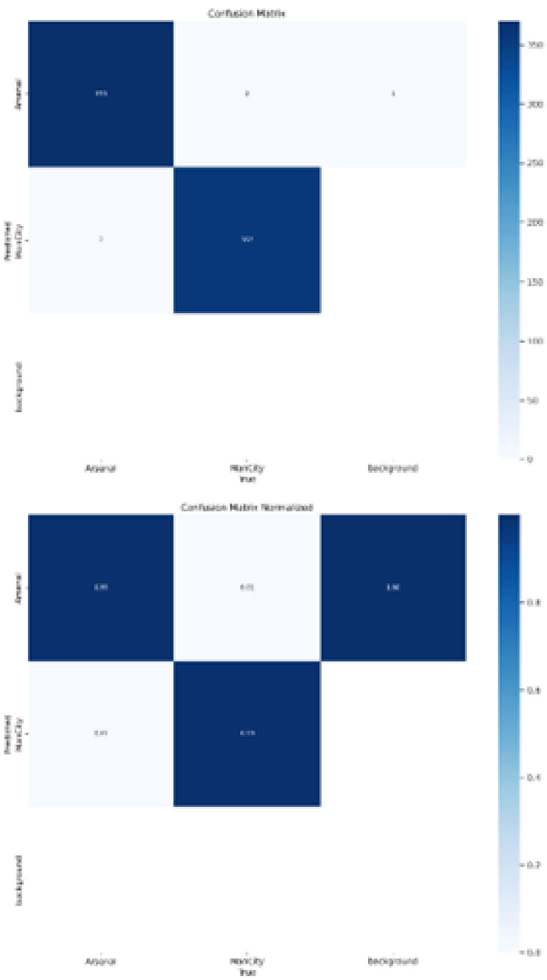

Fig. 4. Confusion Matrix and Normalized Confusion Matrix.

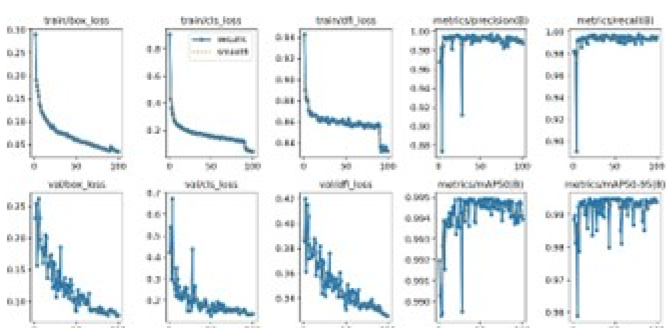

Fig. 5. Training Loss Metrics: Box Loss, Classification Loss, and DFL Loss.

VI. Conclusion

This study aimed to automate the detection of players in sports matches and cluster the detected players based on their jersey colors. YOLOv8 was used for object detection, VGG16 for feature extraction, and K-Means and Agglomerative Clustering for clustering. The results indicate that the model performed successfully with high accuracy, precision, recall, and F1-score.

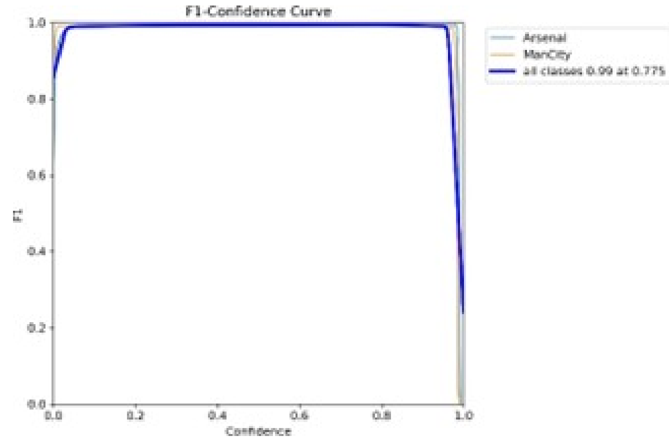

Fig. 6. F1-Confidence Curve.

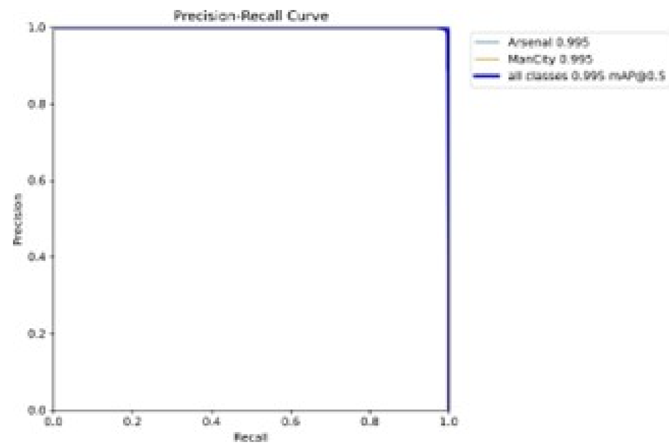

Fig. 7. Precision-Recall Curve.

A. Insights and Contributions

The study demonstrated the effectiveness of deep learning models in automating player detection and clustering. The accuracy and performance metrics confirm the success of the project. Additionally, the study contributes valuable datasets for sports analytics and statistical research.

B. Future Work

Future directions include applying the model to different sports and datasets. Expanding the dataset and optimizing hyperparameters could further enhance the model's performance. Integrating object tracking algorithms could enable the analysis of players' movements for more advanced insights.

Fig. 8. Precision-Confidence and Recall-Confidence Curves.

References

[1] J. Redmon et al., "YOLO9000: Better, Faster, Stronger," *CVPR*, 2017.
[2] K. Simonyan and A. Zisserman, "Very Deep Convolutional Networks for Large-Scale Image Recognition," *arXiv preprint arXiv:1409.1556*, 2014.
[3] I. Jolliffe, *Principal Component Analysis*, Springer Series in Statistics, 2002.
[4] D. Arthur and S. Vassilvitskii, "K-means++: The advantages of careful seeding," *Proceedings of the Eighteenth Annual ACM-SIAM Symposium on Discrete Algorithms*, 2007.
[5] M. Abadi et al., "TensorFlow: Large-Scale Machine Learning on Heterogeneous Systems," *arXiv preprint arXiv:1603.04467*, 2016.
[6] D. P. Kingma and J. Ba, "Adam: A Method for Stochastic Optimization," *arXiv preprint arXiv:1412.6980*, 2014.