# Table Tennis object tracking and analysis

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## 1 Problem Statement

We aim to build an AI - driven sports analytics system to track fast moving objects such as the ball and the players in a Table Tennis match from a video footage of the match. If possible, we would like our system to do this in real time, that is, with a live stream video of a table tennis match, our system will track objects and label key events. If time permits, we wish to expand this system to provide relevant metrics and captions that can help the viewer to analyze the match footage.

## 2 Motivation

In a table tennis match, manually analyzing ball movements and key events is a tedious task. Table tennis is a high-speed sport in which manual analysis is impractical, leading to inaccuracies in performance evaluation and refereeing. By developing an AI-based ball tracking and analysis system, our aim is to provide automated, precise, and real-time insights into player movements, ball trajectory, and game patterns.

## 3 Use Cases and Stakeholders

### *3.1 Use Case*

- **Performance Analysis –** Players and coaches can analyze movement patterns, ball speed, and type of shots to refine techniques.
- **Automated Scoring –** AI-based scoring can assist referees to ensure fairness in the game.
- **Sports Broadcasting –** Enhanced visualization of game dynamics using AI-driven tracking to provide engaging replays and breakdowns.
- **Augmented Reality Applications –** AR overlays can highlight key aspects of the match in real time for training purposes.

### *3.2 How this system can benefit the Stakeholders*

- **Players and Coaches –** Can use such a system to gain insights into game performance and improve strategy.
- **Referees and Umpires –** Will find this useful in automated decision-making and reducing human error.
- **Broadcasters and Analysts –** To provide data-driven match breakdowns for enhanced viewing experience.
- **Game Developers –** To create AI-driven training simulators and realistic sports simulations.

## 4 Related Work

Some of the prominent studies that are related to sports object tracking using deep learning

- **You Only Look Once: Unified, Real-Time Object Detection** - a new approach to object detection that uses classifiers to perform detection. Instead, we frame object detection as a regression problem to spatially separated bounding boxes and associated class probabilities.
- **DeepBall** - [1] A deep network based object detector specialized for ball detection in long shot videos
- **Table Tennis Net-based Tracking System** –[2, TTNet] A deep learning-based tracker designed for real-time ball and event detection in table tennis matches.

## 5 Background

Table tennis presents unique challenges for object tracking. The ball is small and moves very fast, requiring high frame rates and precise algorithms. Player movements are also rapid and complex. Therefore, many existing object detection techniques that gave good results with sports like football failed to give comparable results when trying to achieve the same goals with Table Tennis. By making modifications to existing approaches and applying novel techniques suited specifically to the domain of Table Tennis researchers have gained impressive results and were able to perform Table tennis ball detection and events detection with good accuracy.

## 6 Key Findings and Trends

In [2, TTNet] the researchers achieved a remarkable accuracy of 97 % in spotting game events as well as tracking the ball . They developed an architecture that simultaneously solves the tasks of event spotting, object detection, and semantic segmentation . Their implementation works on downscaled full HD videos and is able to detect the ball with pixel-level accuracy, using a cascade of two detectors, working on different resolutions; spots fast in-game events and predicts semantic segmentation masks while processing 120 fps with a single consumer-grade GPU.

## 7 Gaps and Challenges

Despite the advancement introduced by TTNet, there can be several gaps in table tennis object tracking and analysis

- **Occlusion Handling –** Ball can get obstructed by players and nets which causes problems in detections.
- **Camera Angle Dependency –** TTNet relies on fixed camera perspectives limiting its adaptability to different camera angles.
- **Generalization to Different Playing Conditions –** The model might struggle with variations in lighting and colors, reducing its effectiveness in diverse environments.
- **Lack of Multi Object Tracking –** Only focuses on tracking the ball, ignoring other environmental objects.
- **Dataset Limitations –** Training dataset is relatively small and lacks diversity, limiting the model's ability to generalize across different playing styles, ball speeds, and match conditions.

## 8 Conclusion

- The development of AI-driven table tennis tracking systems represents a significant advancement in sports analytics, offering automated, precise, and real-time insights into the game.

- Existing research, such as TTNet, demonstrates the feasibility of deep learning-based tracking for high-speed sports, achieving accurate ball detection, event recognition, and semantic segmentation.

## 9 References

[1] J. Komorowski, G. Kurzejamski, and G. Sarwas, "Deepball: Deep neural-network ball detector," *ArXiv*, vol. abs/1902.07304, 2019.

[2] R. Voeikov, N. Falaleev, and R. Baikulov, "Ttnet: Real-time temporal and spatial video analysis of table tennis," 2020.