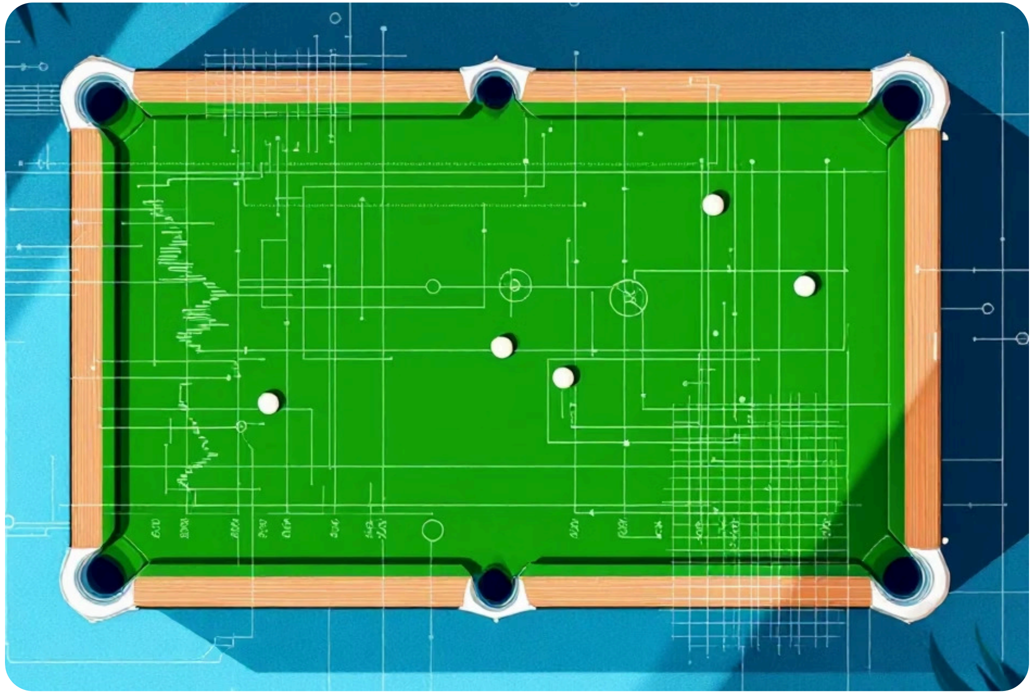
Group 3

Computer Vision for Snooker Tracking



This project employs a powerful sequence of Computer Vision fundamentals to accurately track the position and movement of snooker balls.

Group members:

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Key Computer Vision Fundamentals

These core techniques enable precise object isolation, spatial correction, and location determination required for real-time snooker tracking.

Perspective Warping

Corrects camera angle for accurate spatial measurements.

HSV Thresholding

Isolates objects (balls) from the background in varying light.

Contour Detection

Determines precise location and size of the objects.

Geometric Transformation: Achieving the Top-Down View

When a camera is angled, the image suffers from perspective distortion (e.g., parallel lines converge). To make precise measurements, we use perspective warping to achieve a perfect, overhead view.

01

Define Source Points

Identify the four corners of the snooker table in the original, distorted frame.

02

Define Destination Points

Define four points forming a perfect, rectangular shape (the desired width/height).

03

Calculate Homography Matrix (M)

Use `cv2.getPerspectiveTransform` to map source trapezoid coordinates to destination rectangle coordinates.

04

Apply the Warp

`cv2.warpPerspective` "straightens" the image, providing an accurate, measurable top-down view.

Visualizing the Transformation

first frame

Source Frame (Angled)

result of transformation

Destination Frame (Top-Down)

Object Segmentation: Isolating the Balls

Color Segmentation Theory: A five-step process to separate the snooker balls from the background, leveraging color and morphology techniques for lighting invariance.

Gaussian Blur

Reduces noise and smooths pixel variations to prepare the image for color analysis.

HSV Conversion

Separates color (hue) from intensity (value), enabling lighting-invariant detection.

Table Segmentation

Creates a binary mask isolating the green areas that correspond to the table surface.

Morphological Closing

A technique used to fill small holes or gaps within the generated table mask.

Mask Inversion

Inverts the mask: everything that is NOT the table is considered potential object data (the balls).

Visualizing Segmentation: Mask Generation

The application of morphological operations and mask inversion effectively isolates potential objects from the background table, setting the stage for further analysis.

Made with GAMMA

Contour Detection: Finding Position and Shape

- ## Finding Contours

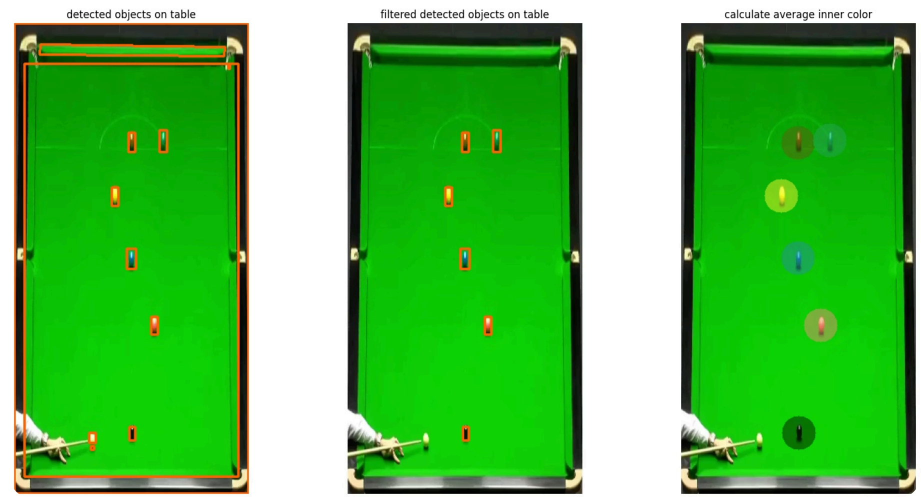
  The `cv2.findContours` function identifies continuous curves of white pixels, which define the boundaries of the snooker balls and table.

- ## Filtering and Analysis

  We filter out noise (small contours) and non-circular shapes. For valid contours, `cv2.minEnclosingCircle` finds the precise centre coordinates (x, y) and radius.

- ## Visualization

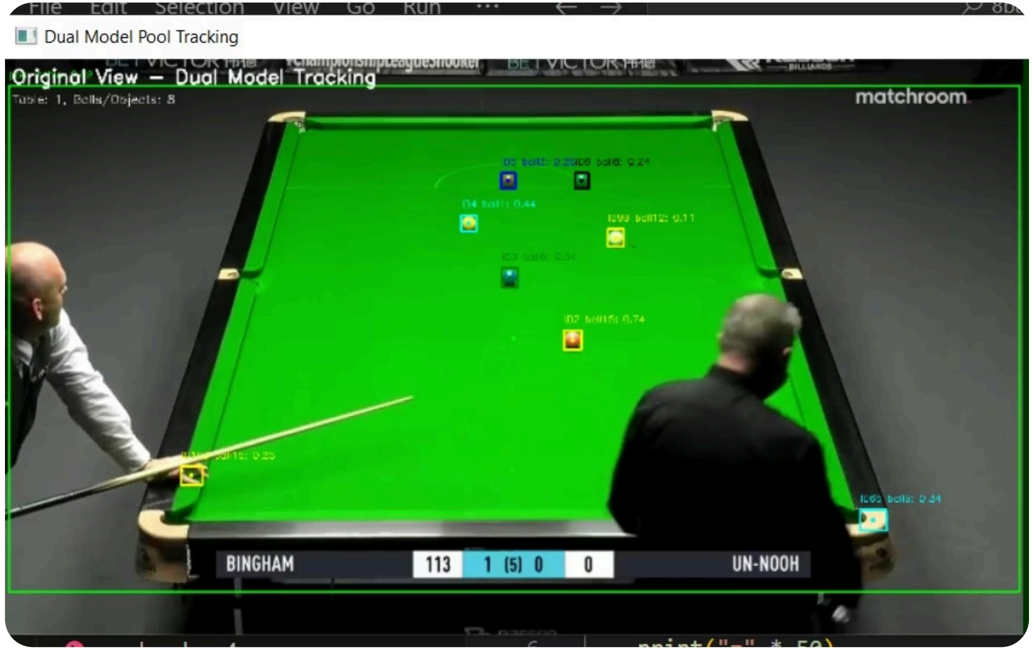
  The detected (x, y) position and radius are used to draw a circle on the original frame, confirming successful object detection.



Advanced Detection: Integrating YOLO

Enhancing Detection Capabilities

In addition to the foundational computer vision pipeline (Warping, HSV, Contours), we have also trained a YOLO (You Only Look Once) model to identify the snooker balls.



Performance Characteristics:

YOLO Only

- **Speed:** Slow
- **Accuracy:** High
- **Lighting Sensitivity:** Low
- **Setup Complexity:** High (model training)

Color Only

- **Speed:** Fast
- **Accuracy:** Medium
- **Lighting Sensitivity:** High
- **Setup Complexity:** Low (parameter tuning)

Hybrid Method

- **Speed:** Medium
- **Accuracy:** Very High
- **Lighting Sensitivity:** Low
- **Setup Complexity:** High