Milestone Report – Dartboard Calibration Module

Project: Dart Detection and Classification
Milestone: Prototype for image processor was completed
Date: July 10, 2025

Objective

Develop a calibration system for a steel-tip dartboard using webcam input and **ArUco markers** to geometrically define the dartboard's rings and sectors. The goal is to handle distortion and perspective skew from camera placement and enable precise field classification.

📌 Key Features Achieved

1. ArUco Marker-Based Detection

- **Usage**: Four ArUco markers are placed around the dartboard to define a reference quadrilateral.
- **Purpose**:
    - Provides **accurate spatial reference** for the dartboard.
    - Enables **automatic center estimation** and initial scaling.
    - Compensates for **camera tilt and distortion**.
- **Library**: OpenCV's `cv2.aruco` module used for detection and pose estimation.

2. Concentric Ring Calibration

- **Input**: User manually adjusts outermost ring to match dartboard boundary.
- **Automatic generation**:
    - The five inner rings (Triple, Inner Single, Outer Bull, Bullseye) are created using standardized **dartboard ratios**.

3. Sector (Line) Calibration

- **Sectors**: 20 radial lines divide the board into scoring areas.
- **Adjustable parameters**:
    - `line_rotation`: Aligns sectors correctly (between 20 and 1).
    - `line_scale`: Controls line length based on outer ring.
    - `offset_x`, `offset_y`: Shift center from marker-based estimate if needed.
    - `stretch_x`, `stretch_y`: Handle elliptical distortion (e.g. camera tilt).

4. Data Structure

- All calibration results are stored in structured format:
    - `rings`: List of ellipses.
    - `line_rotation`, `line_scale`: Sector info.
    - `offset_x`, `offset_y`: Center shift.
    - `stretch_x`, `stretch_y`: Aspect ratio correction.

Accuracy Notes

- Visual inspection confirms:
    - Radial lines match dartboard sectors.
    - Ring sizes correspond well to true regions even with elliptical distortion.
- Click-test diagnostics reveal correct (though still being fine-tuned) ring and sector classifications.

In Progress / Next Steps

- Refine ring classification logic (currently drifting into adjacent regions slightly).
- Integrate with dart detection phase.

Screenshots