In the Slot – Umpire Training Tool

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W COMOTION
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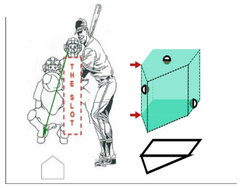
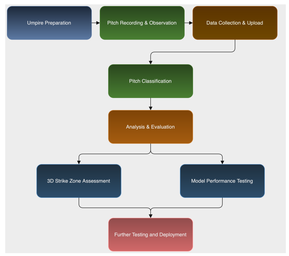
Motive / Objective

- Status Quo: No tool available for umpires to learn the strike zone from personal perspective
- Goal: Develop a training system that allows for umpire strike zone evaluations to be done from the umpire's perspective
- MVP: Create a model that can determine whether a pitch is strike/ball from an uploaded video



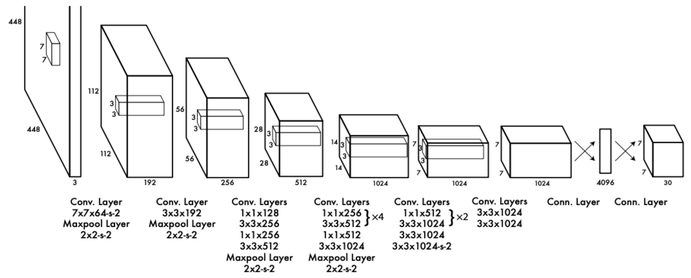
Requirements

- System will provide an end-to-end user experience where an umpire will upload a video of a pitch, and then be returned a visualization of their strike zone.
- System will detect whether a pitch is a ball or a strike based on video captured from the umpire's perspective. Minimum 50% accuracy
- System will provide an interactive visualization of an umpire's accuracy



ML Ball Detection

- Machine learning based object detection is used to detect the baseball over the course of its trajectory during a pitch
- A custom model was trained to detect baseballs, and ping pong balls based on the YOLOV8 algorithm
- Captured videos under different lighting conditions to compile a baseball and ping pong ball custom dataset ~5.7 GB.



3D Strike Zone

- Photogrammetry is used to estimate the position of balls in the frame relative to camera
- Ping pong balls are used to mark the boundaries of the strike zone
- Algorithm is run at each frame to check if a baseball has entered the strike zone

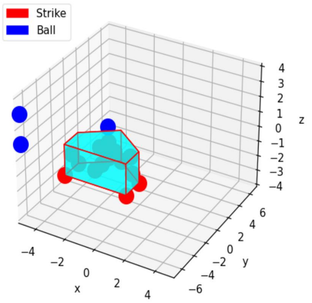
$$\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

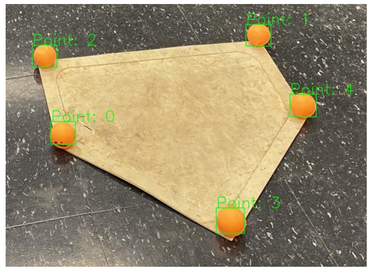
PIXEL COORDINATES — CAMERA MATRIX — REAL WORLD COORDINATES

$$Z = \frac{f_x * (d_{inches})}{d_{pixels}}$$

$$Y = \frac{(u - c_x) * Z}{f_x}$$

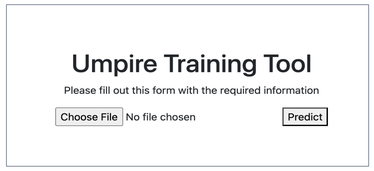
$$X = \frac{(v - c_y) * Z}{f_y}$$

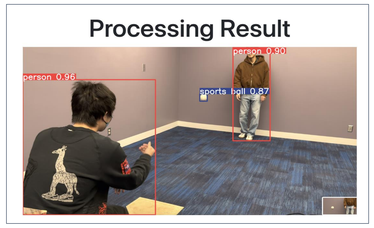




Web Application

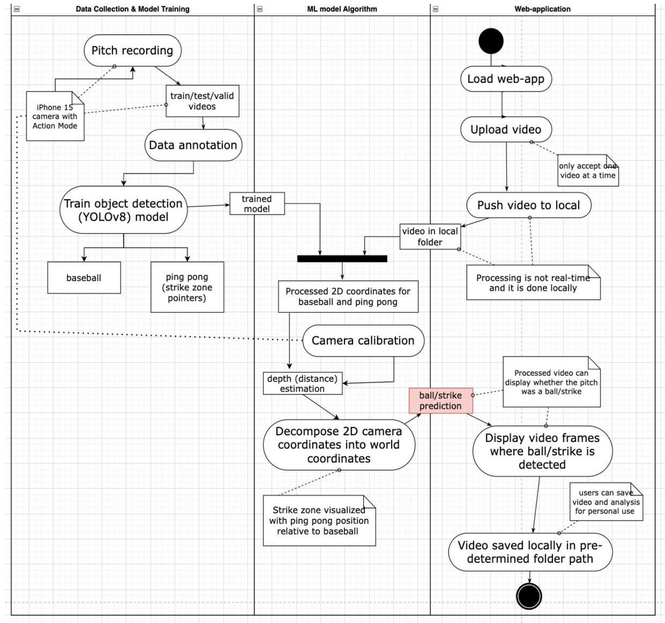
- Our primary objective in this project is to develop a user-intuitive platform interface, ensuring accessibility for both new and experienced users
- Users can upload media files meeting pre-defined parameters, such as .mov and .mp4 formats
- Upon selecting 'Predict', uploaded media undergoes processing through our model
- A sample image at the top right shows a home page where users can upload media
- A sample image at the bottom right shows a sample result page





Results

- Custom object detection model: Detect baseballs and ping pong balls in varying lighting and pitching speeds
- High detection accuracy: Detect baseballs within 10 feet of the camera in 85% of frames
- 3D strike zone calculation: Determine if a pitched ball is within the strike zone.
- Web app: Users can upload videos to analyze pitch results
- Interactive 3D visualization: Display the strike zone and overlay detected ball positions



Future Work, References, and Acknowledgments

- Improve UI/UX design to enhance usability, integrate login and data management, and simplify video uploads.
- Enhance the object detection system's accuracy and reliability under challenging lighting, for consistent performance.
- Acquire cameras and sensors with higher resolution to improve the system's accuracy and performance.
- Train LLM to automatically demarcate each pitch from an umpire training session
- Integration with wearable sensors to capture biometric data
- Real-time analytics and insights to provide instant feedback to players and teams as well as actionable insights

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