



POLITECNICO
MILANO 1863

Ping Pong Ball 3D Trajectory

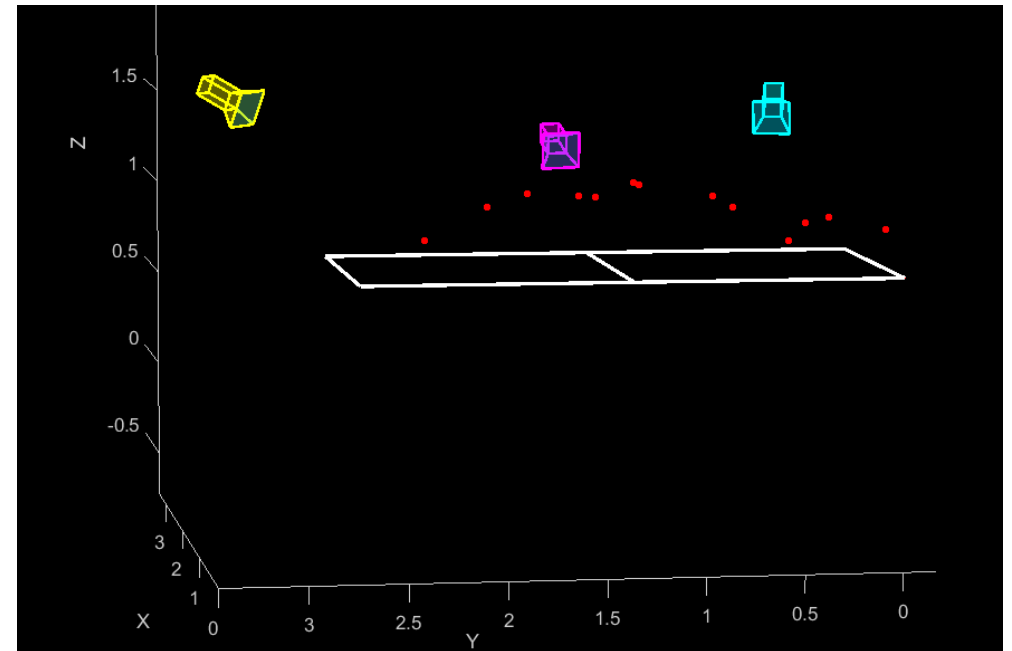
Image analysis and Computer vision Project

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Project Overview

- Detect and track **ping pong ball** across multiple frames using background subtraction and feature detection.
- 3D trajectory calculated with triangulation techniques.



Tools and Technologies

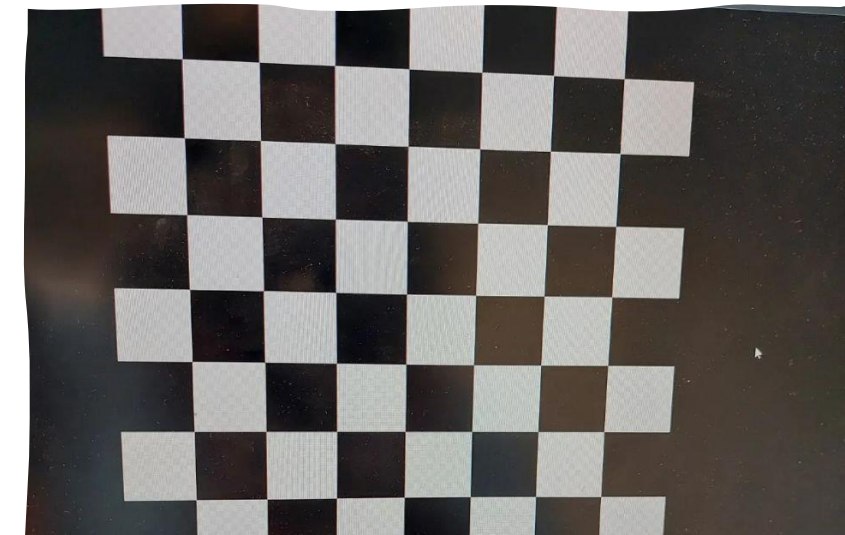
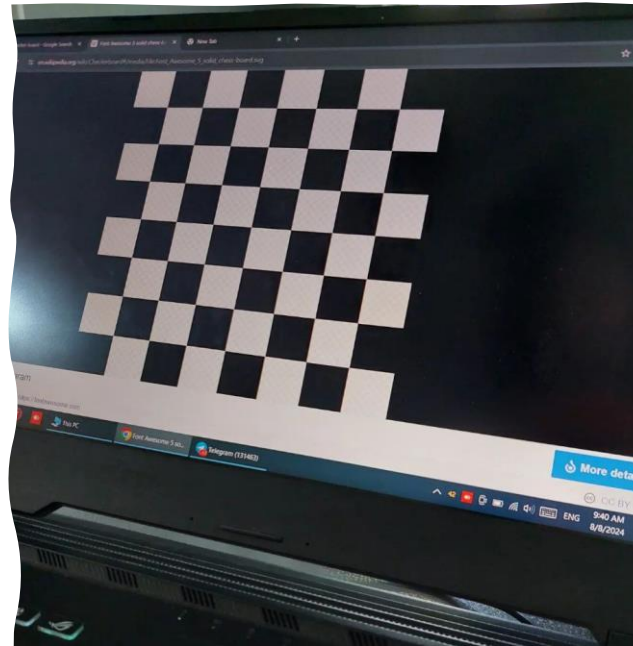
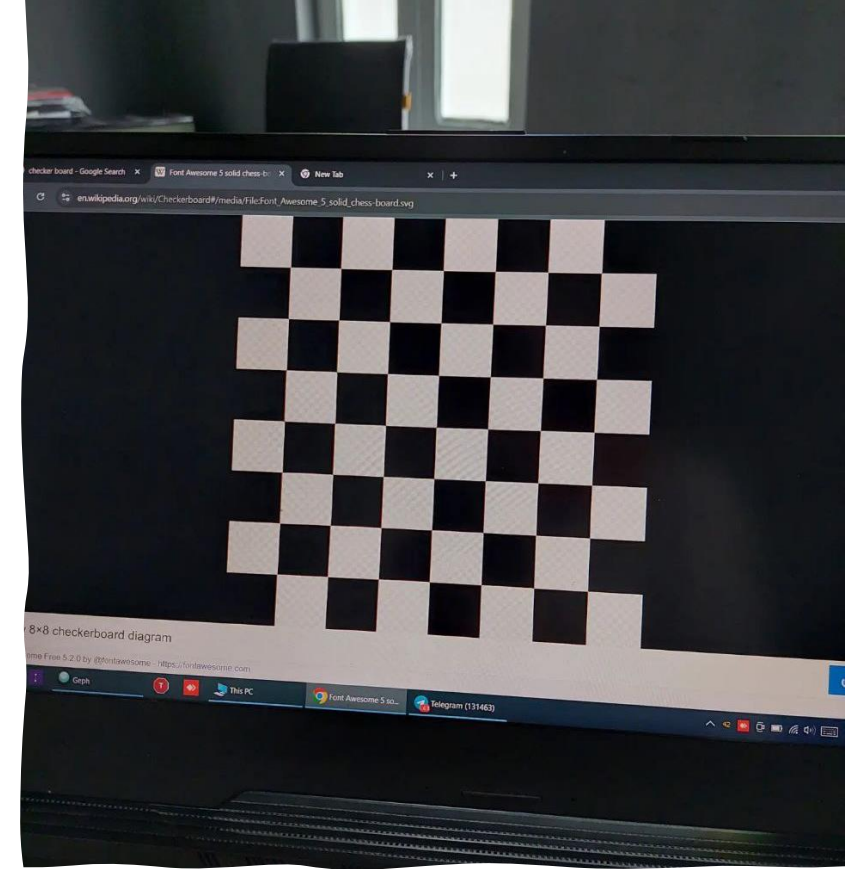
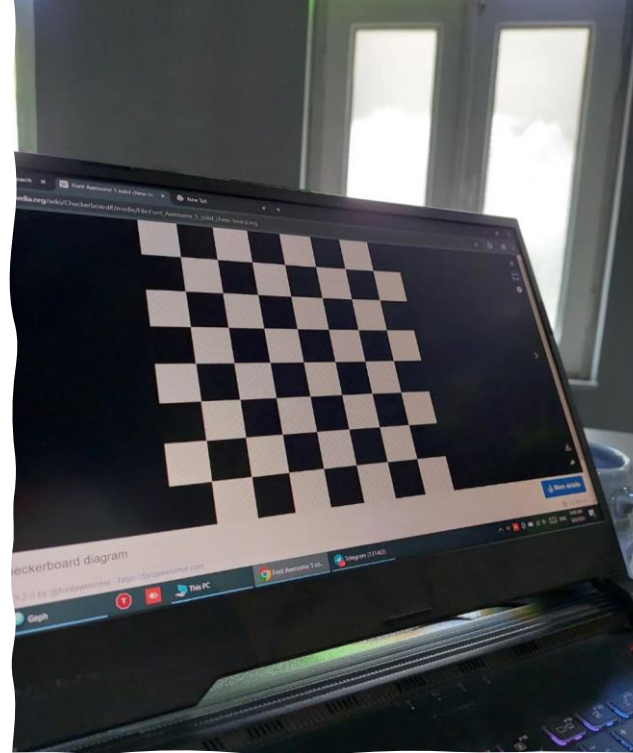
- Three cameras (Samsung A59, A70, iPhone X).
- Processing tools: MATLAB, Computer Vision Toolbox.



Preprocessing

- Camera Calibration

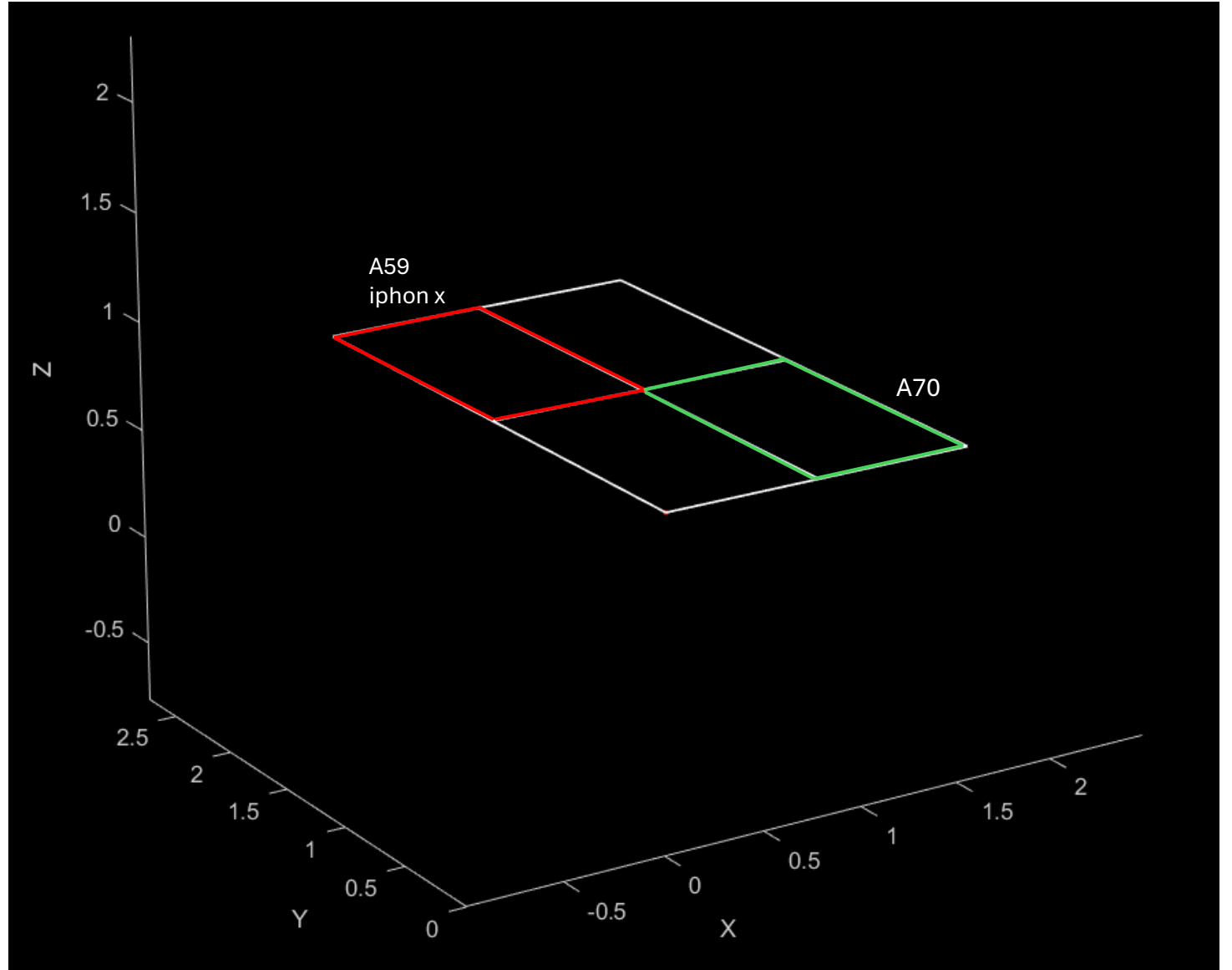
Estimating camera parameters by using images that contain a calibration pattern.



Preprocessing

- Camera Localization

Determining camera extrinsic parameters, the positions, and orientations relative to the world reference frame.



Processing

- Ball Detection
 - Background subtraction
- Foreground mask using the Gaussian mixture model.

```
% Background subtractor
foregroundDetector = vision.ForegroundDetector('NumGaussians', 50, ...
                                              'LearningRate', 0.05);
```

ForegroundDetector



Morphological Operation



Processing

- Ball Tracking
 - Finding corners in the video
 - Choosing the strongest corners

```
% Parameters for corner detection
maxCorners = 2;
qualityLevel = 0.6;
minDistance = 25;
blockSize = 9;

% Convert frame to double and detect corners
frame_double = double(frame);
corners = detectMinEigenFeatures(frame_double, ...
    'MinQuality', qualityLevel, ...
    'FilterSize', blockSize);

% Filter the detected corners based on distance and quality
if ~isempty(corners) && corners.Count >= maxCorners
    strongestCorners = selectStrongest(corners, maxCorners);
    pos = strongestCorners.Location;
    x = pos(1, 1);
    y = pos(1, 2);
    % Store the location of the ball
    ballLocations = [ballLocations; x, y];
    oframe = insertShape(oframe, 'Circle', [x, y, 8], 'Color', ...
        [250, 0, 0], 'LineWidth', 2);
end
```

end

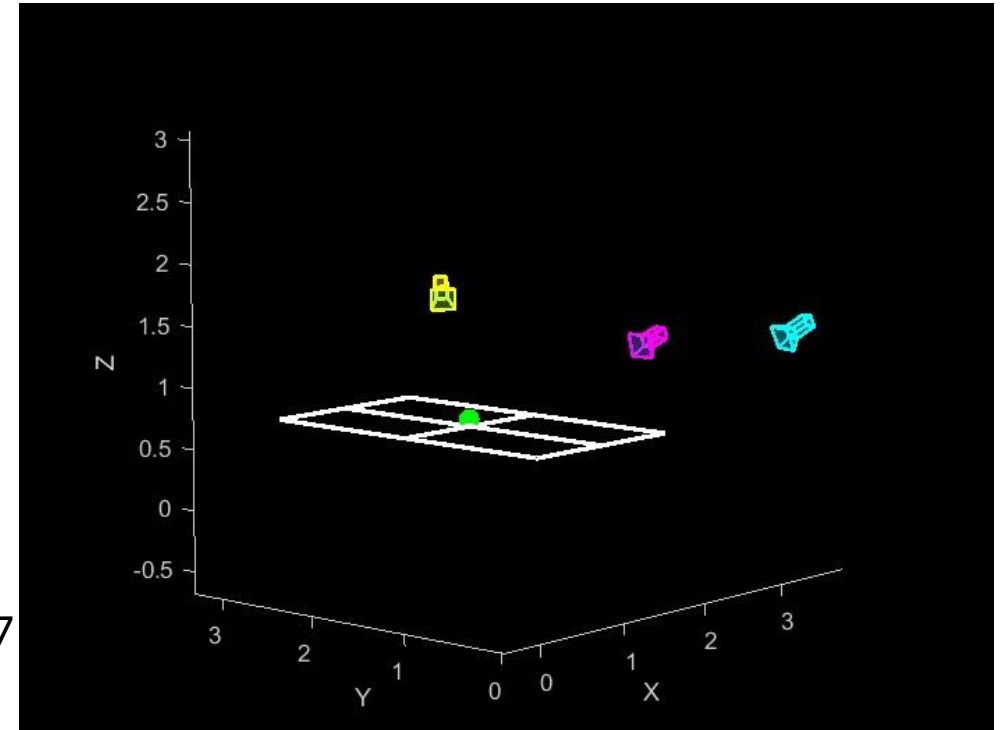


3D Trajectory

Triangulation



Reprojection error = 17



3D Trajectory

Triangulation of ball candidates:

The reprojection error is thresholded (< 45), and the x and y coordinates of the points are constrained to lie within the boundaries of the table.

