To see or not to see

Perception Challenges in MSL

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Introduction

- Line detection
- Ball detection
- Obstacle detection

Line Detection

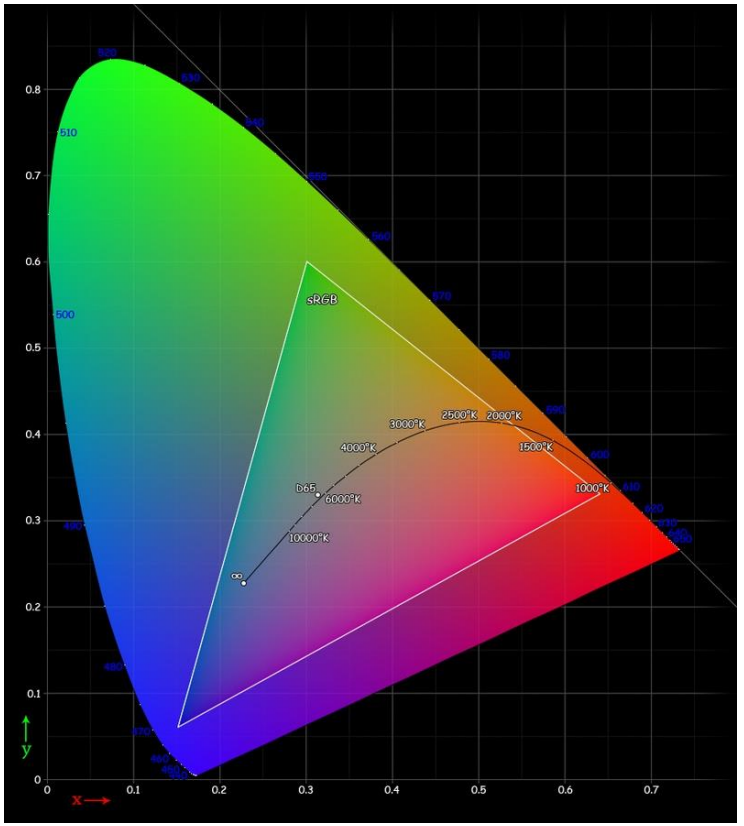
Line Detection

Color segmentation is the most common method for feature extraction in MSL

Automated techniques typically use Yuv or RGB color spaces

Assisted offline techniques typically use HSV, HSL or HSI color spaces

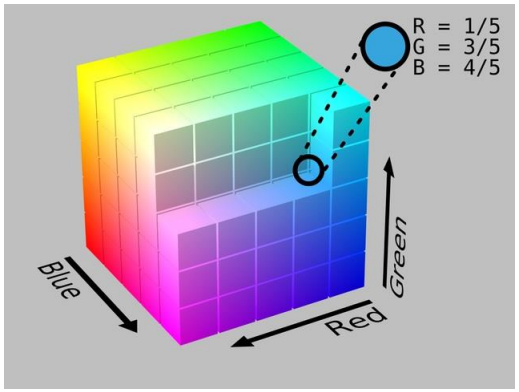
These can be performed offline to generate LUTs for time efficient segmentation

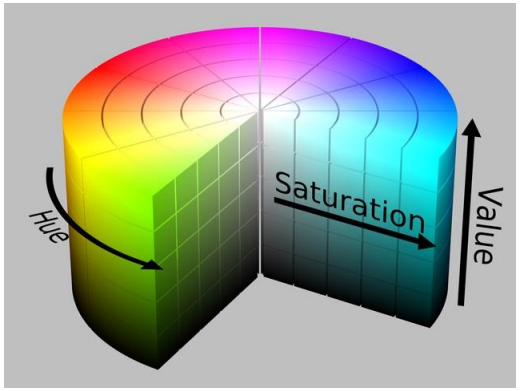


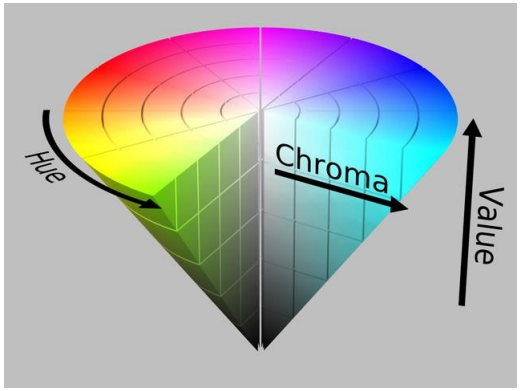
CIE 1931 with delimited sRGB space

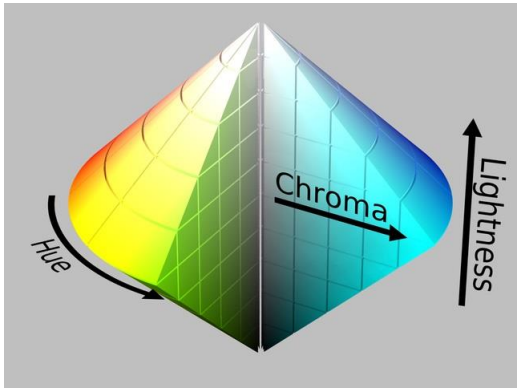
Line Detection

Examples of well know color spaces









Hue: Spectrum related color value relative to CIE
Lightness, value: “Brightness relative to the brightness of a similarly illuminated white".
Chroma: Colorfulness relative to the brightness of a similarly illuminated white".
Saturation: Colorfulness of a stimulus relative to its own brightness.

Line Detection

CAMBADA segmentation strategy

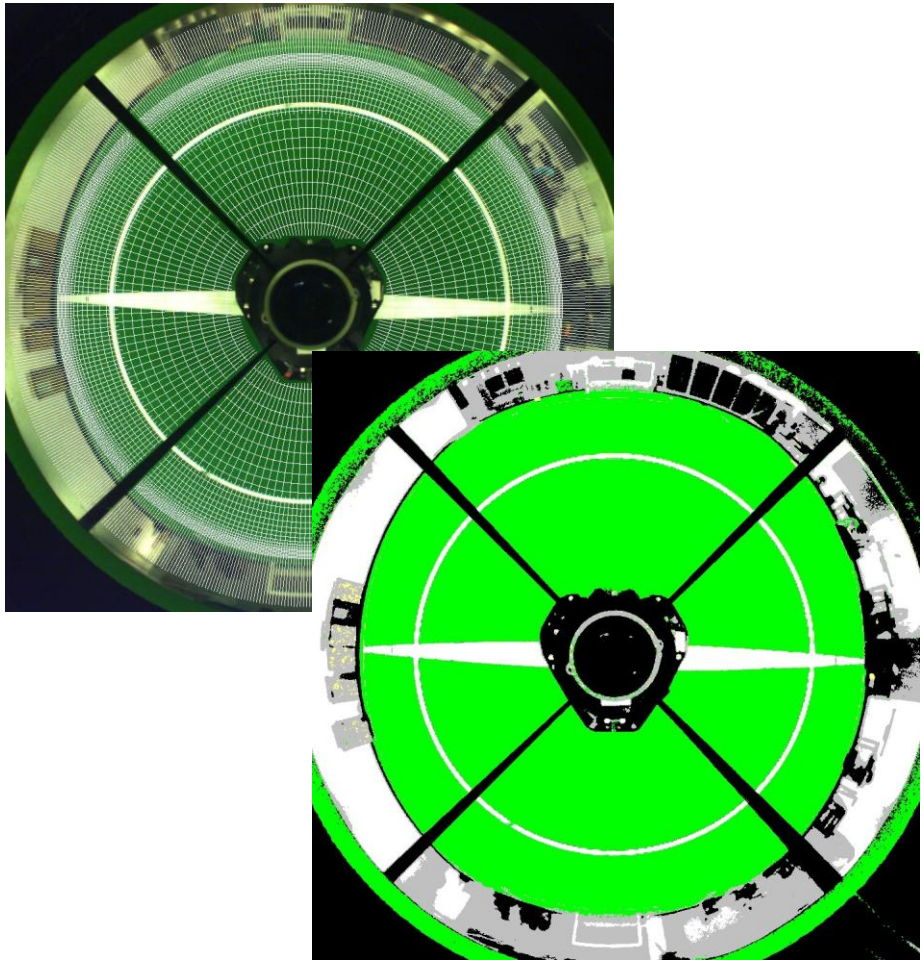
Assisted offline segmentation

Color space is HCY' where

$Y' = 0.21R + 0.72G + 0.07B$

Feature extraction uses radial and circular sensors over the segmented image

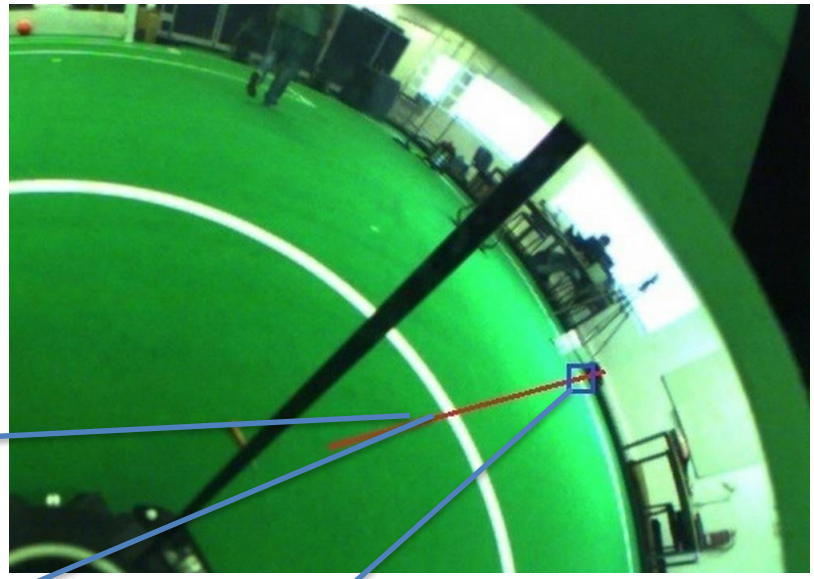
Segmented pixel has 1 byte with flags for 8 different colors



Line Detection

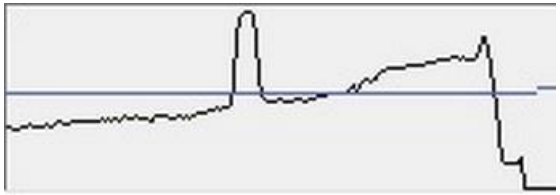
CAMBADA segmentation strategy

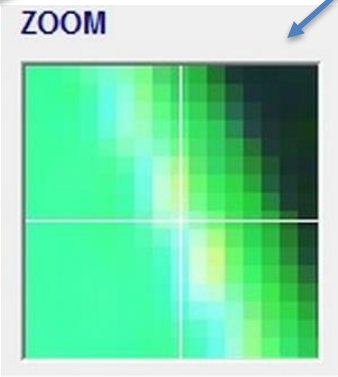
Use of Y' has advantages over V:
over exposed areas;
blooming and Bayer pattern effects;



Using V

Using Y'





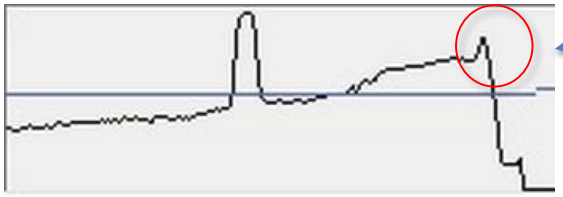
White line at 6m

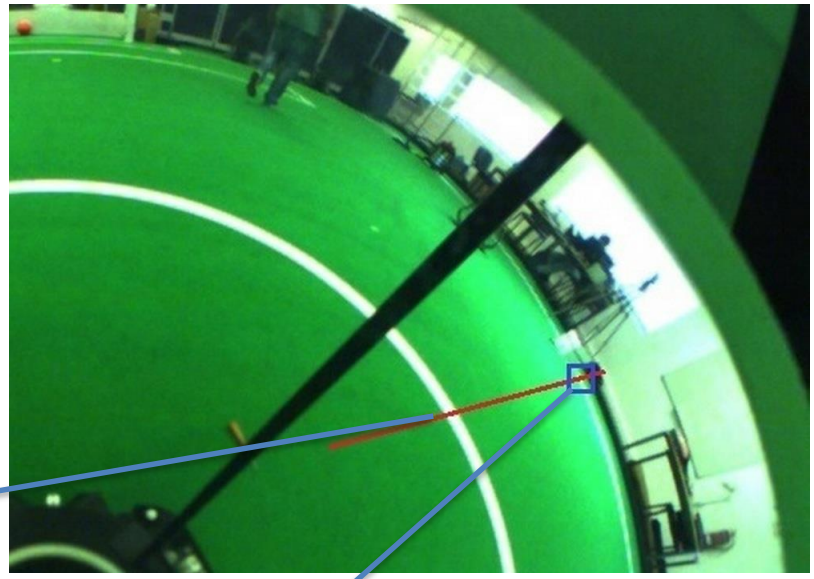
Line Detection

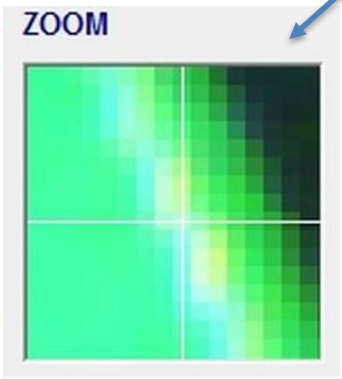
CAMBADA line segmentation strategy

Looking at Y':

Combination of Color Segmentation and Y' analisys can be used to improve line detection







White line at 6m

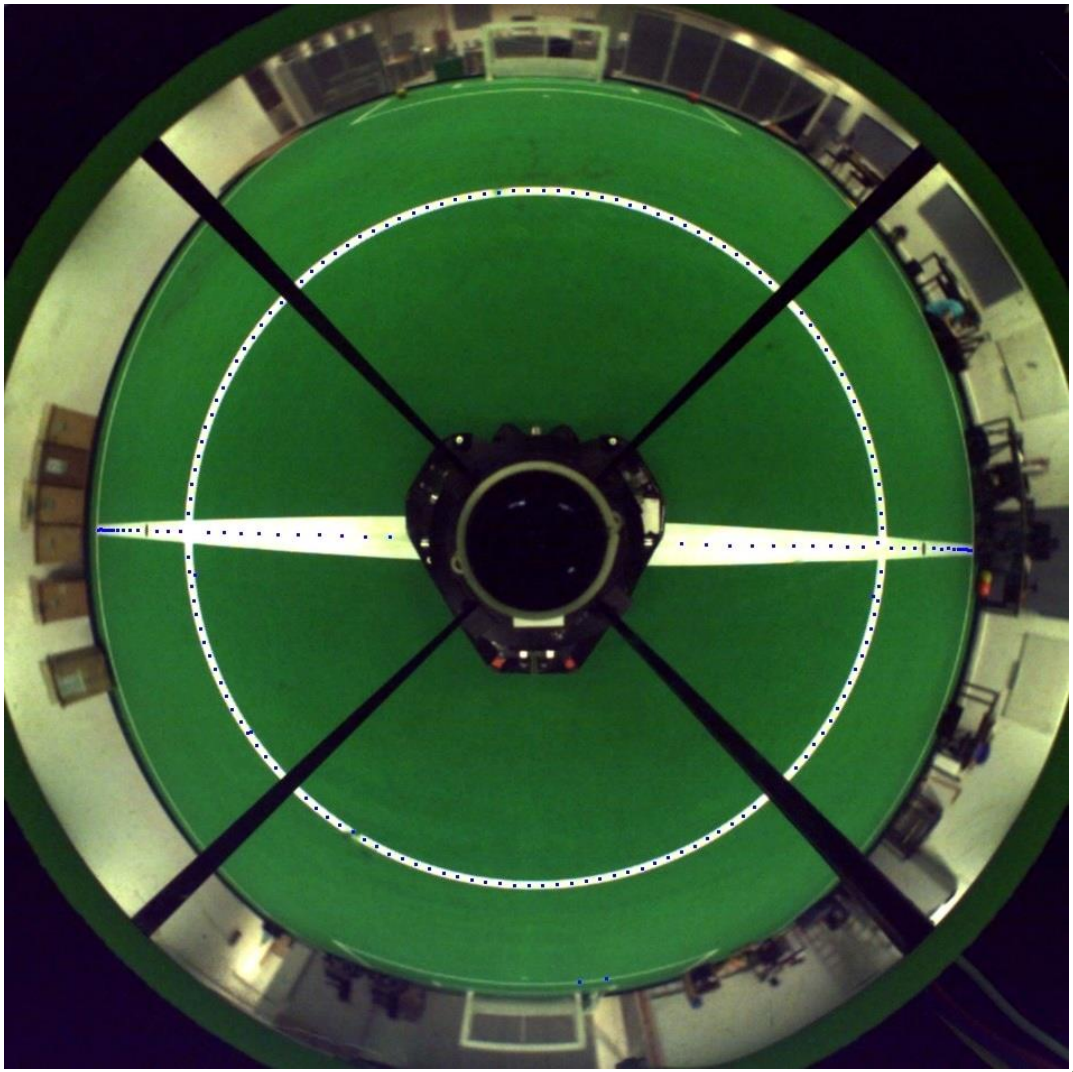
Line Detection

CAMBADA line segmentation strategy

RLE of color sensors

Simple validation algorithms can produce white spot candidates

Blue spots on image



Line Detection

CAMBADA line segmentation strategy

↓

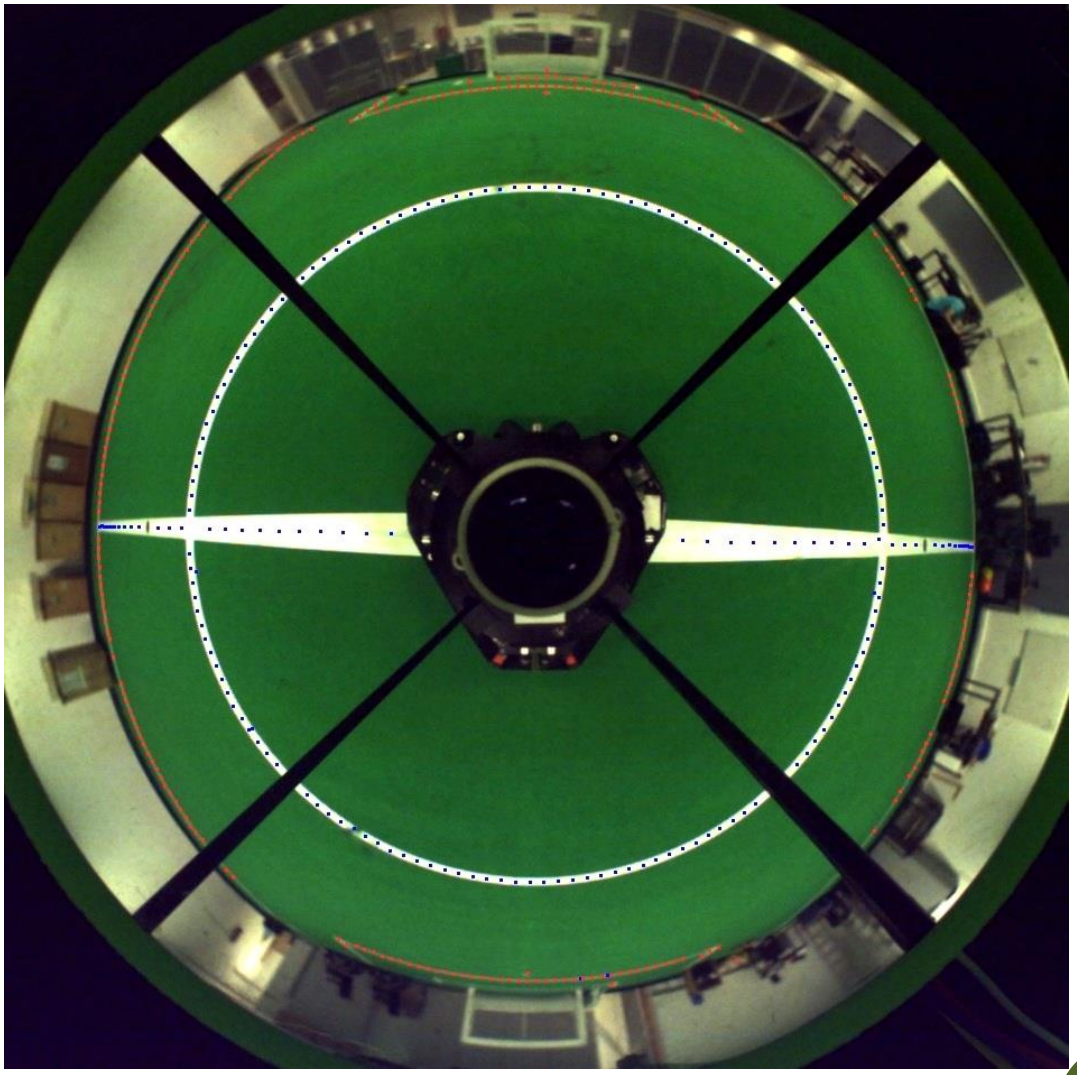
Derivative analysis on Y’

↓

Q factor of far lines +
Color boundaries

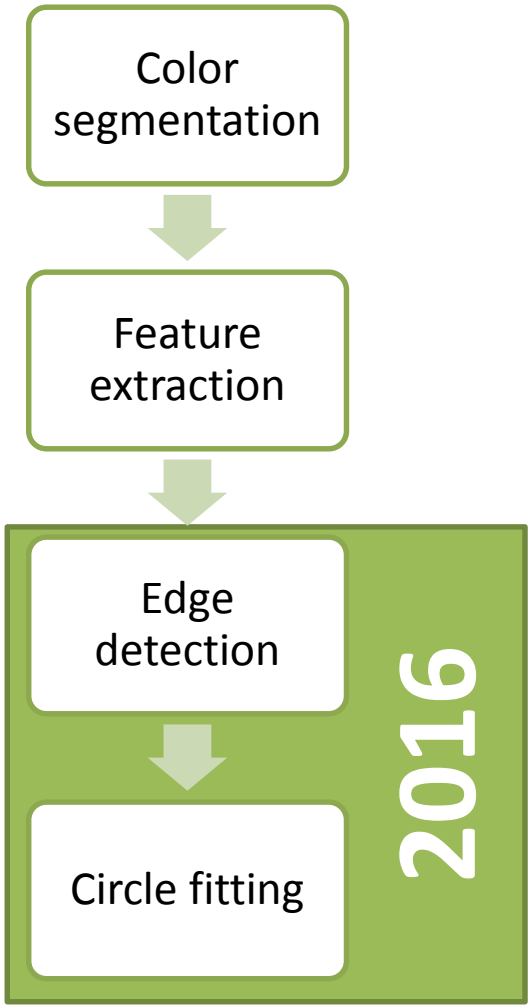
↓

Red spots on image



Ball Detection

Ball Detection



Ball Detection

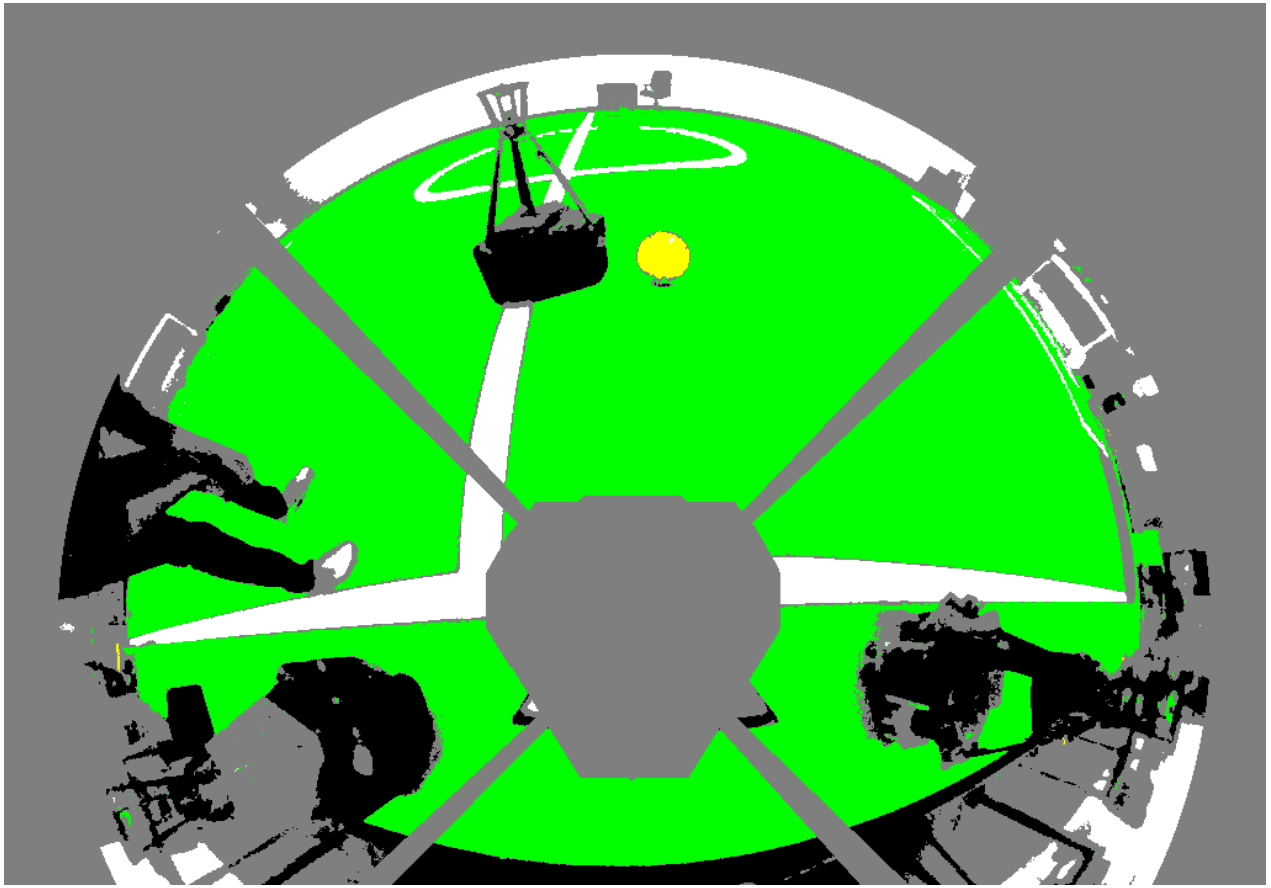
Color segmentation

Feature extraction

Edge detection

Circle fitting

- Hue/Saturation/Value ranges



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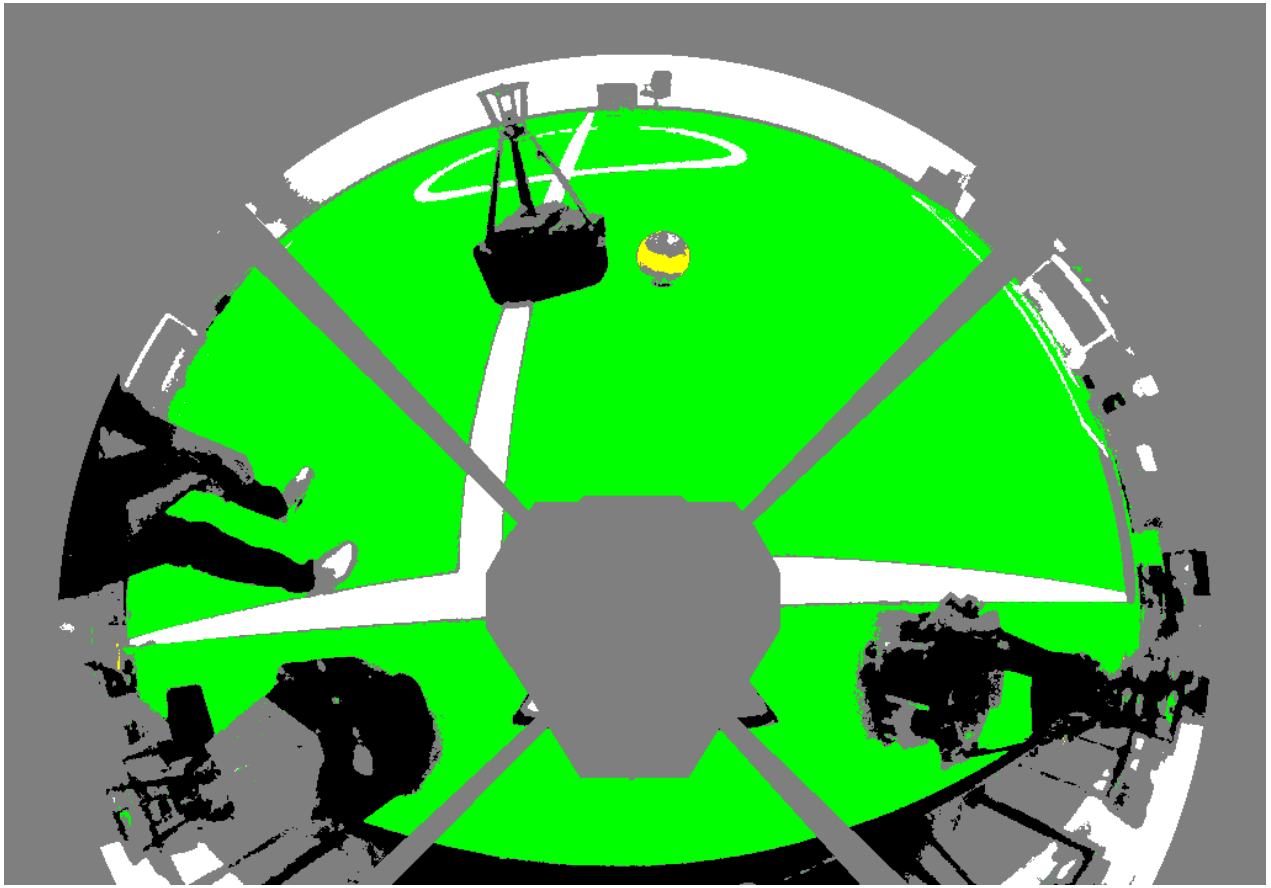

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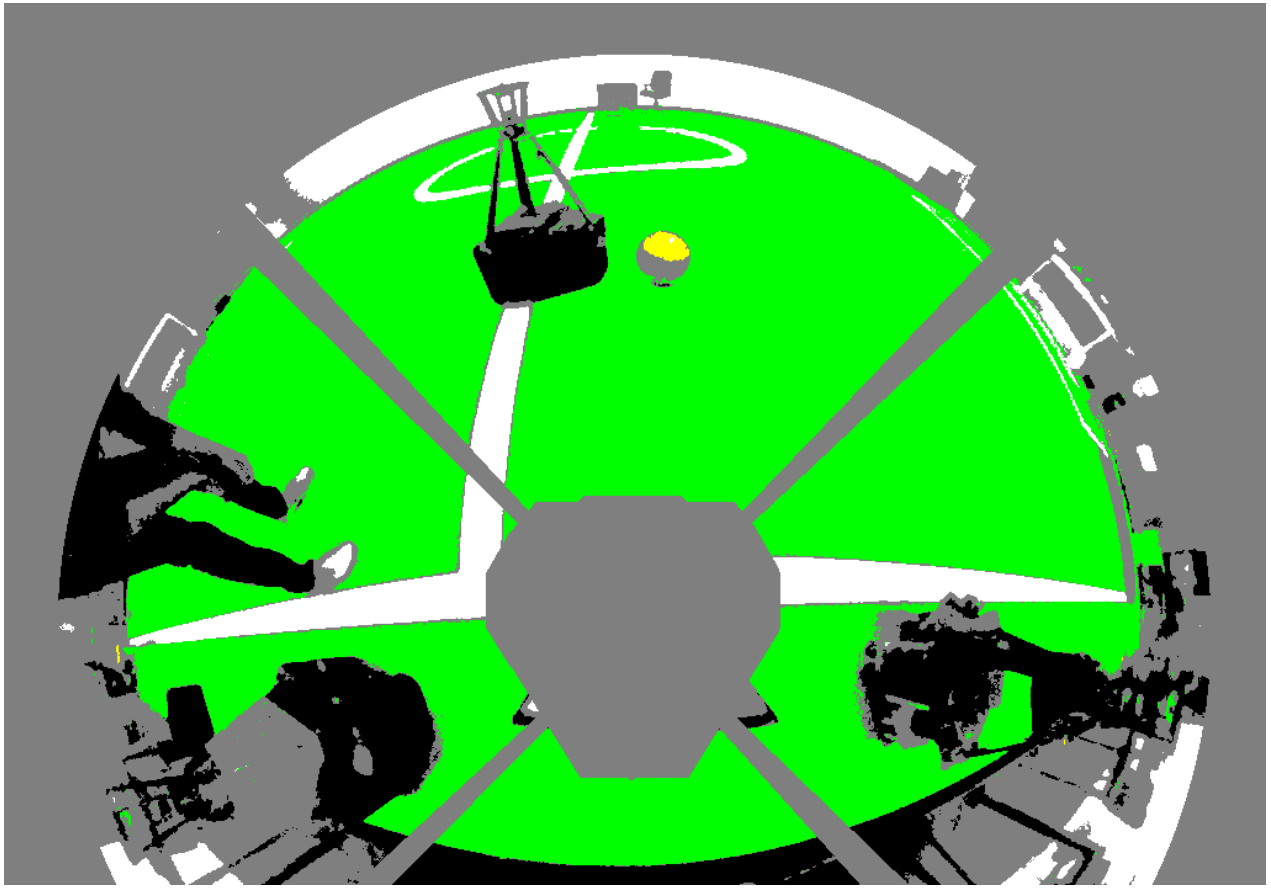


Ball Detection

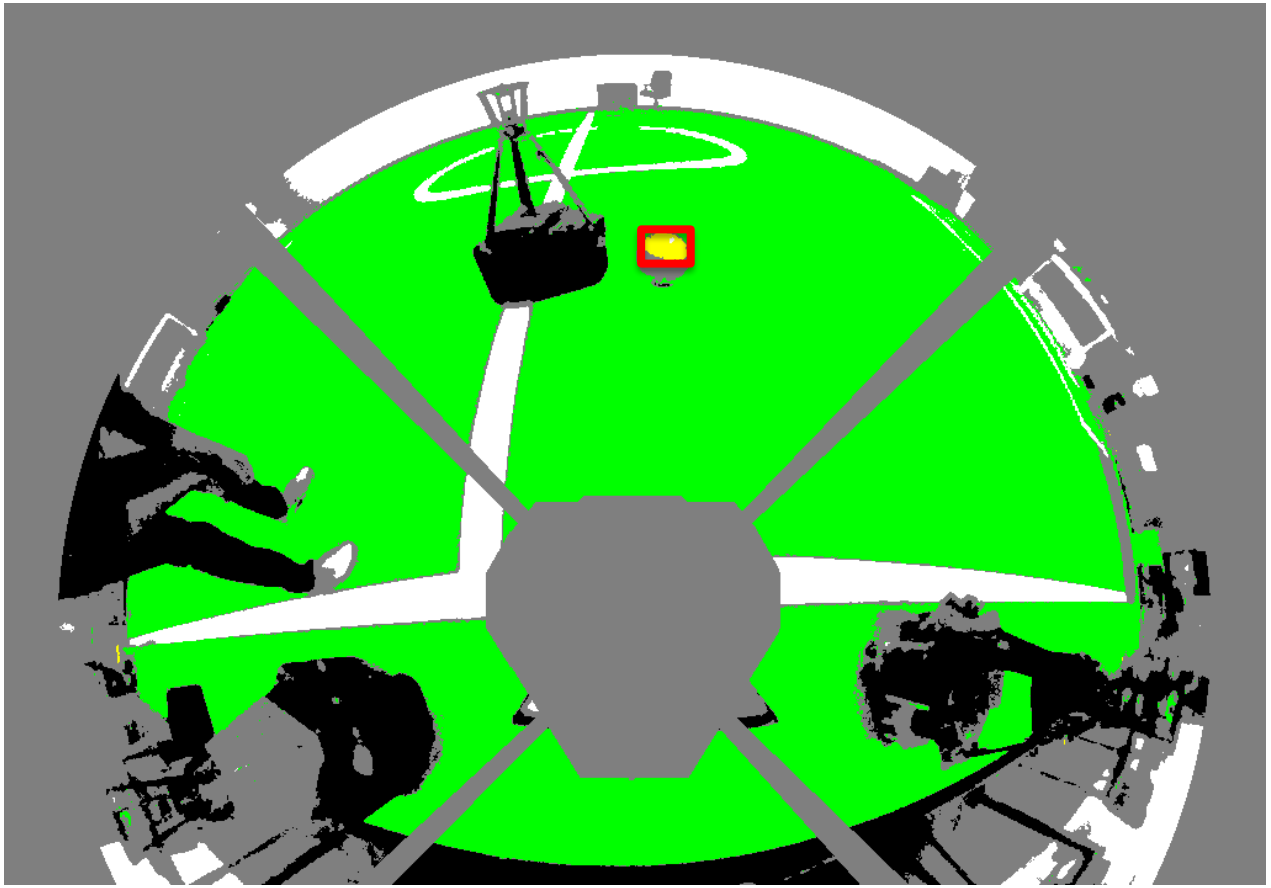
Color segmentation

Feature extraction

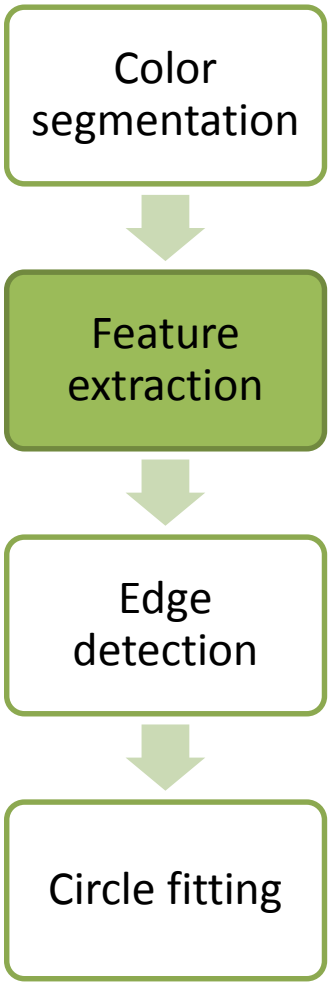
Edge detection

Circle fitting

- Blobs of “ball color” (e.g. yellow)



Ball Detection



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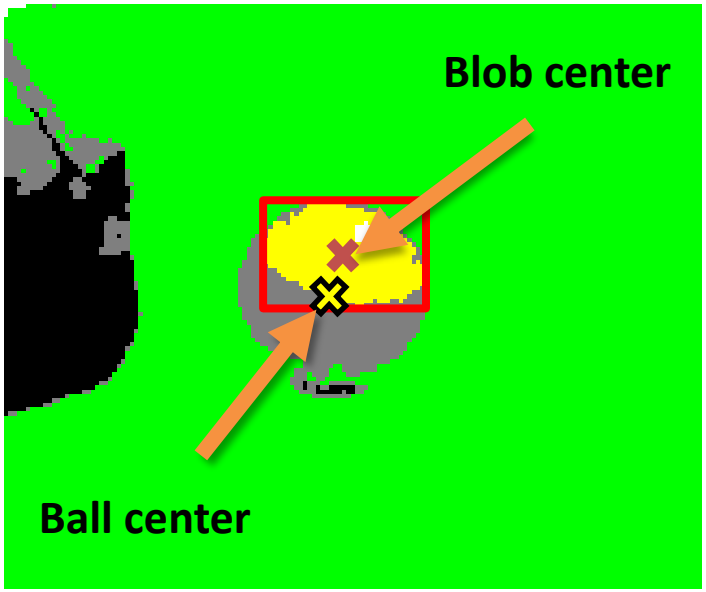

Ball Detection

- Color segmentation
- Feature extraction
- **Edge detection**
- Circle fitting

Ball Detection

- Color segmentation
- Feature extraction
- **Edge detection**
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Ball Detection

- Color segmentation
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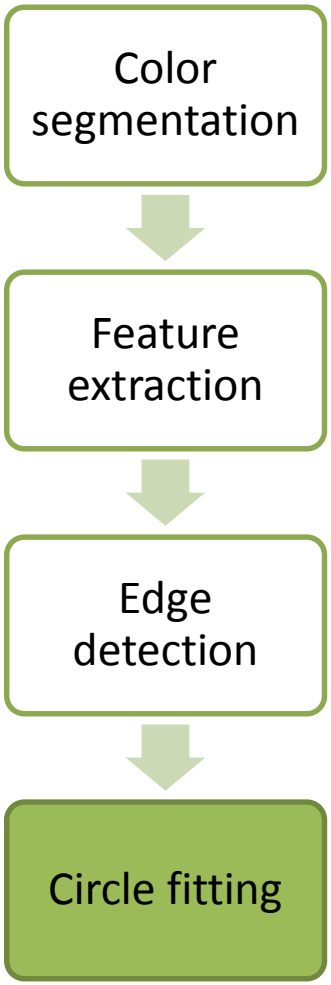
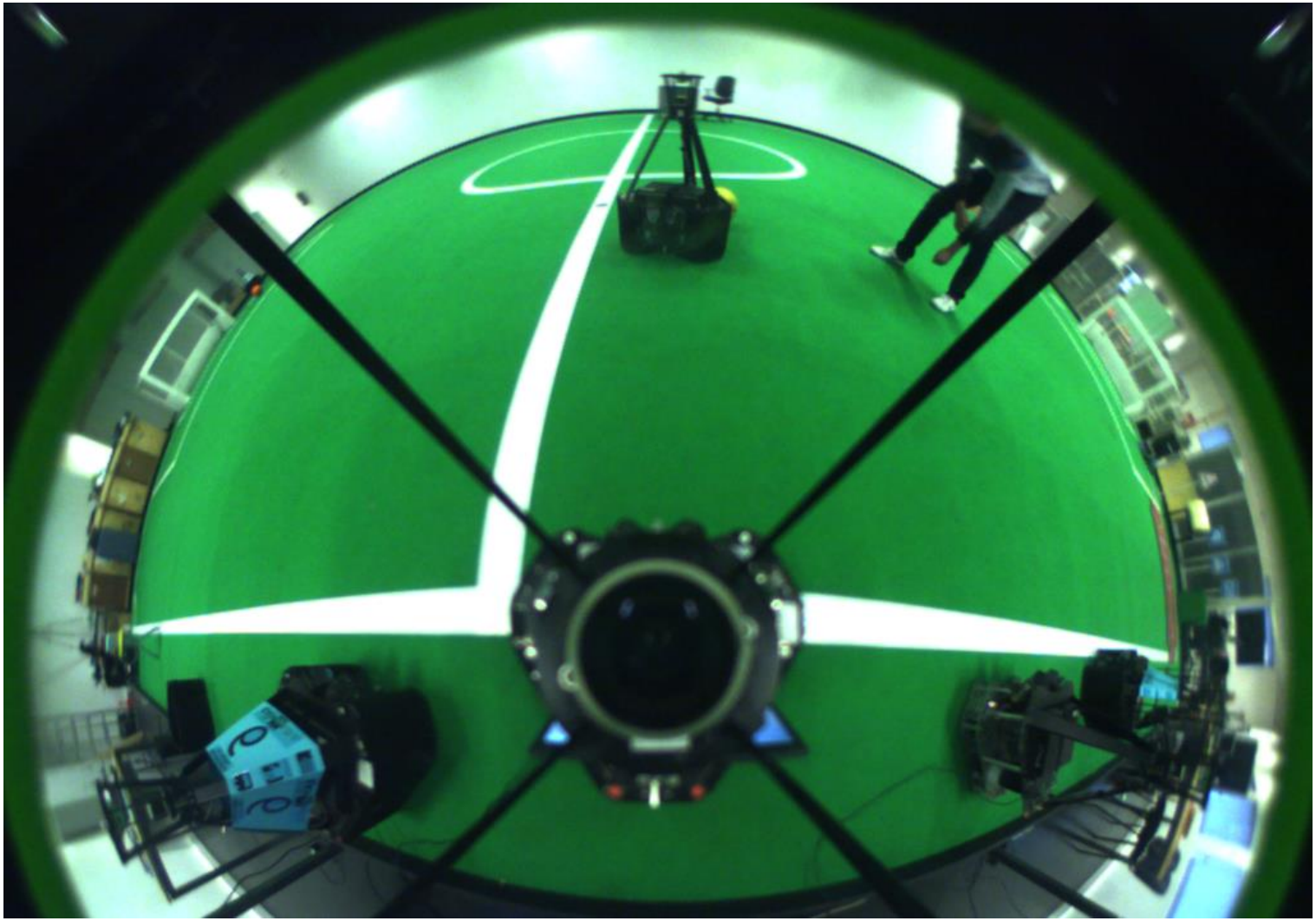
Ball Detection



- RANSAC Circle Fit
  - 80 iterations
    - Sample 3 points
    - Fit a circle
    - Measure the “error”/score
  - Weighted average

Ball Detection

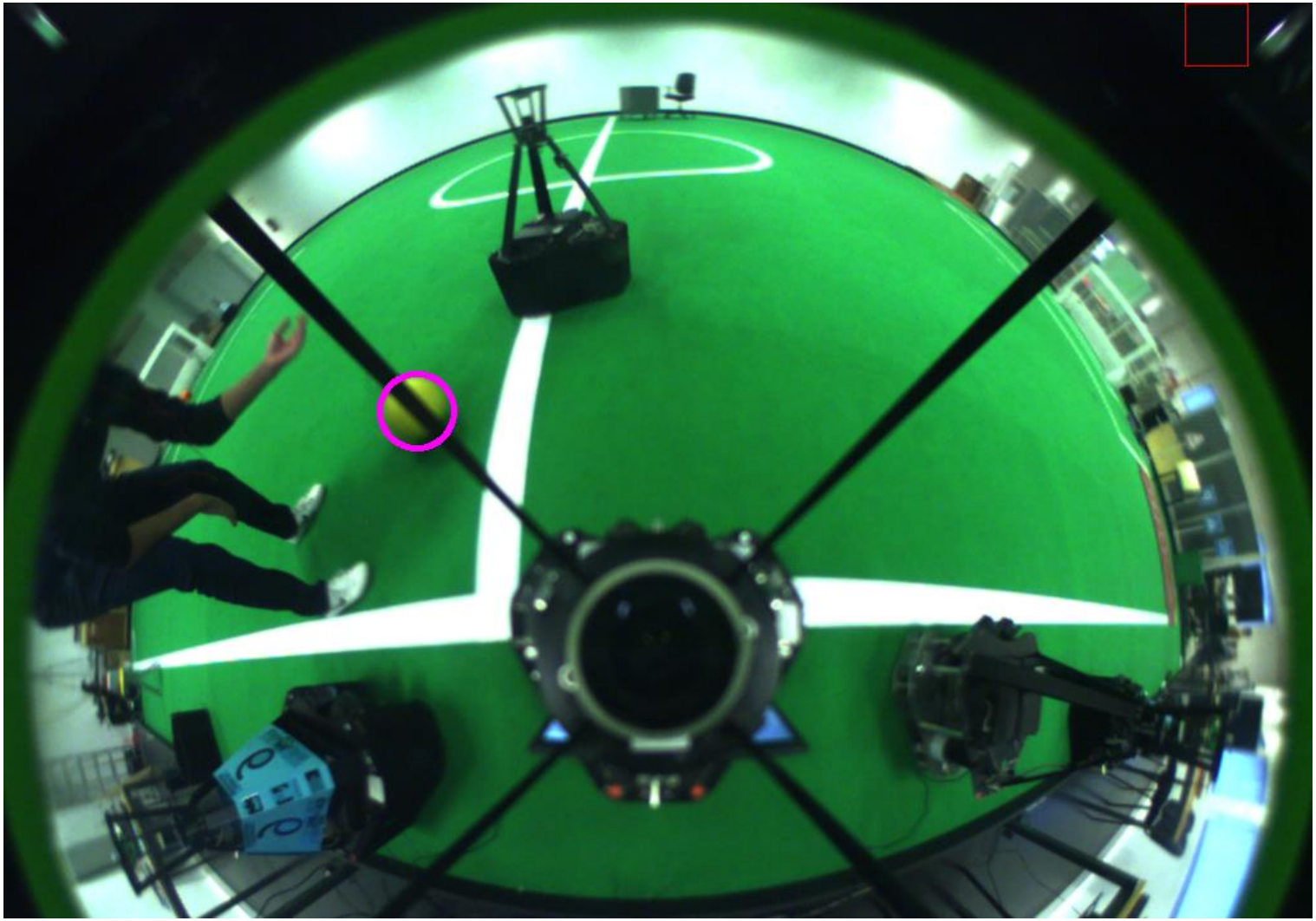


Ball Detection

Ball Detection

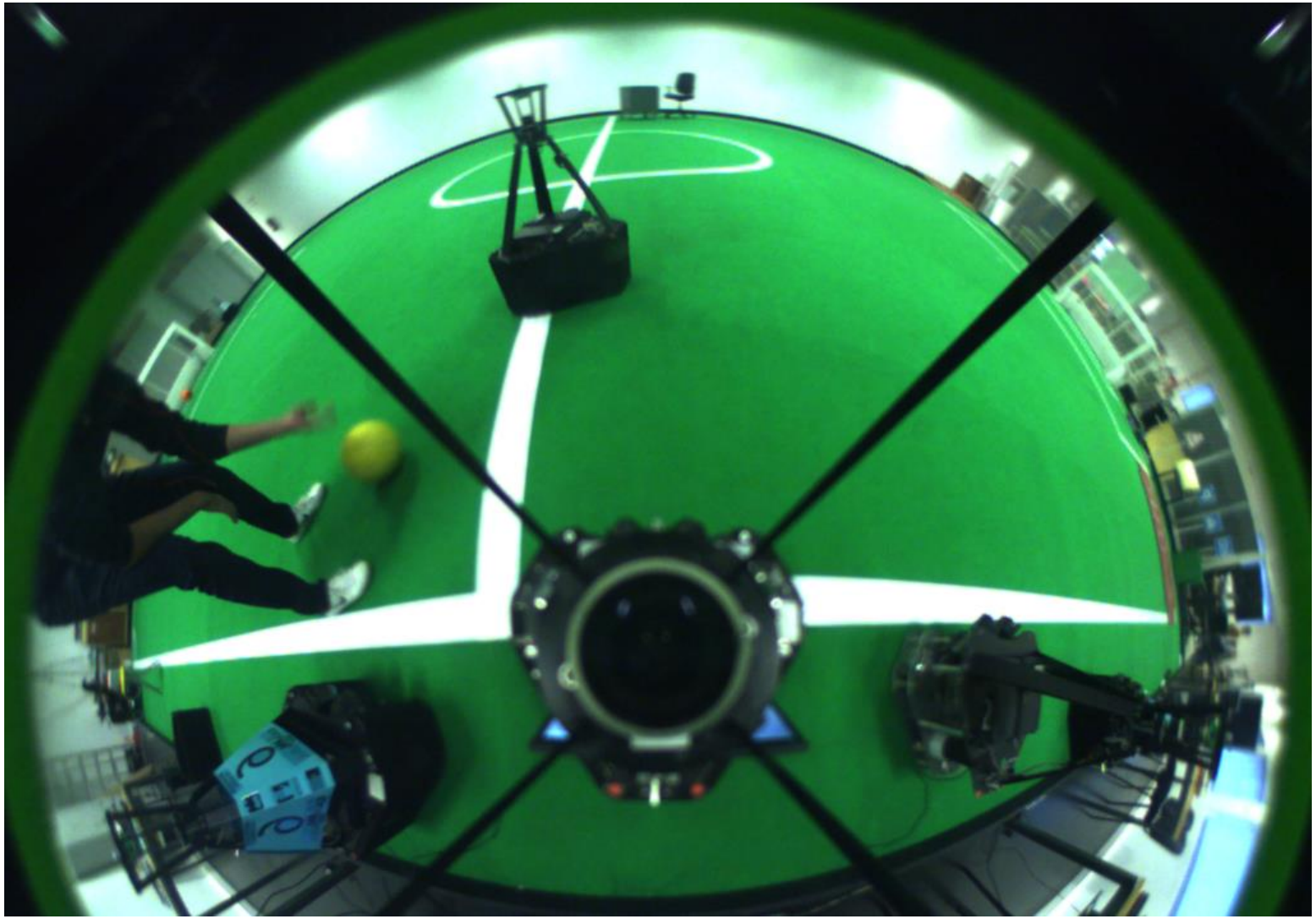
Ball Detection

Ball Detection

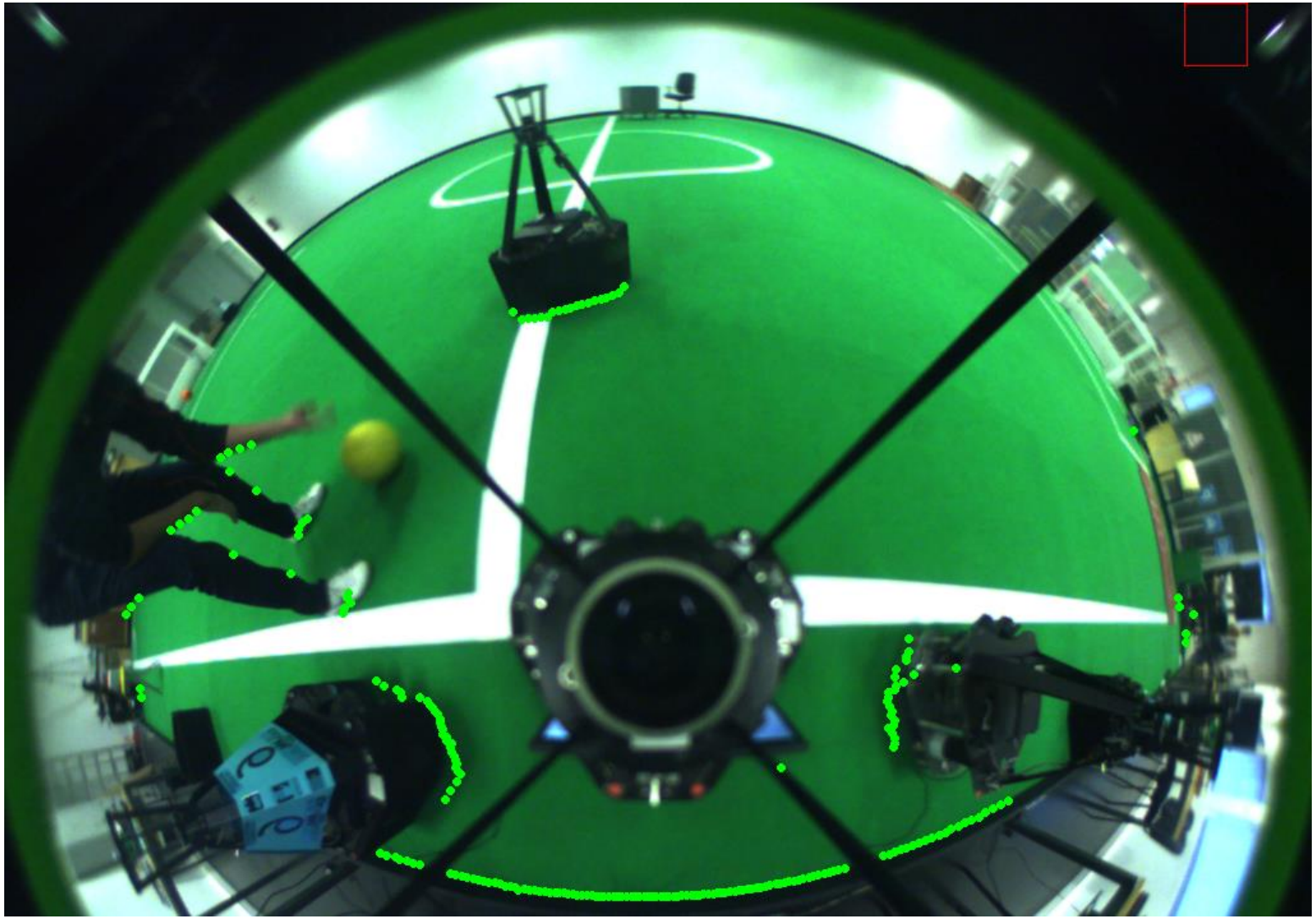


Obstacle Detection

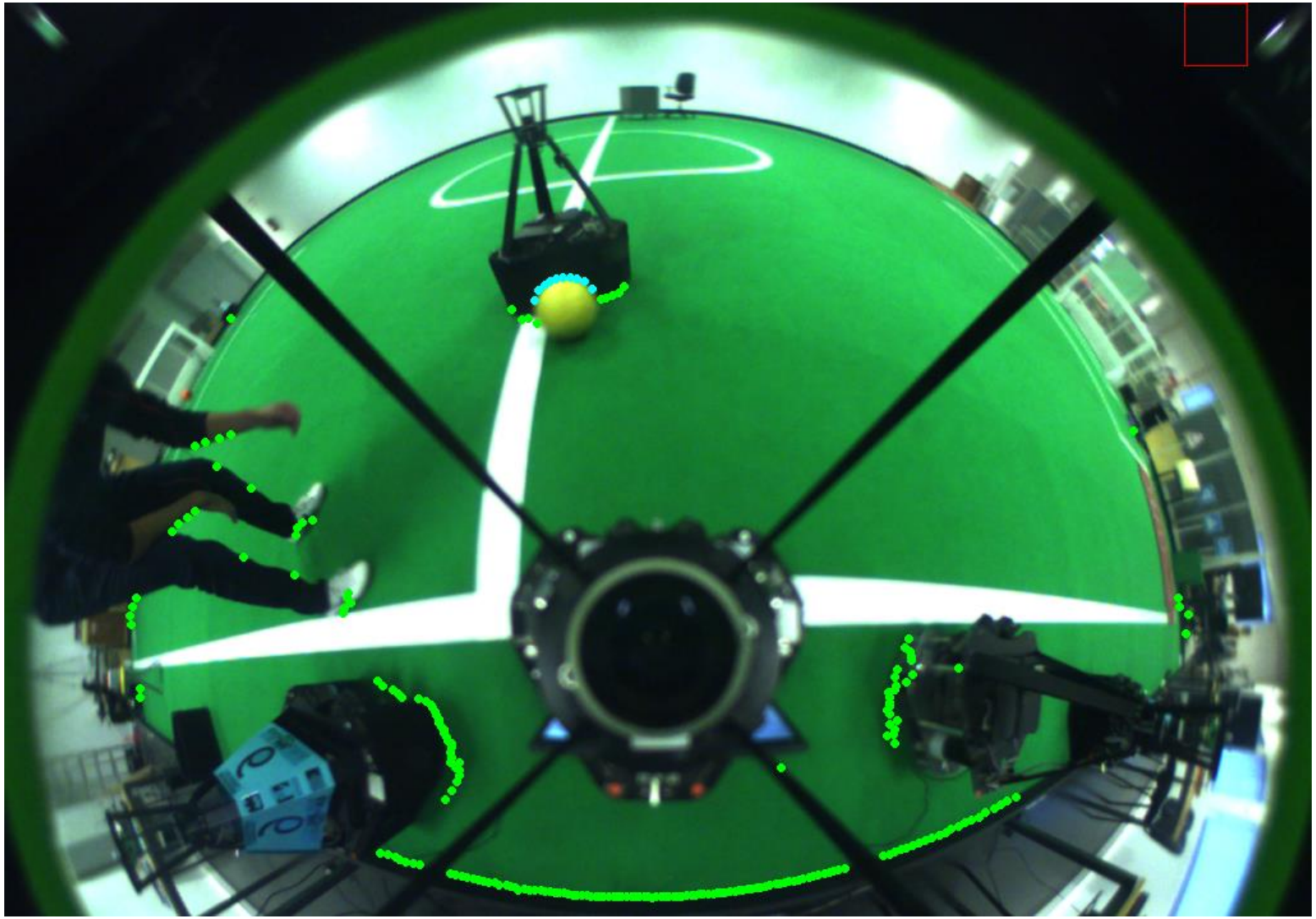
Obstacle Detection



Obstacle Detection



Obstacle Detection



Obstacle Detection

Obstacle Detection

Conclusions

Conclusions

- Improve line detection at further distances
- Improve ball detection accuracy while dealing with occlusions
- Obstacle detection that accounts for partial occlusion by the ball

Without significantly increasing computational cost

Thanks for your attention!

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