Fast Soccer Ball Detection using Deep Learning

Spring 2017

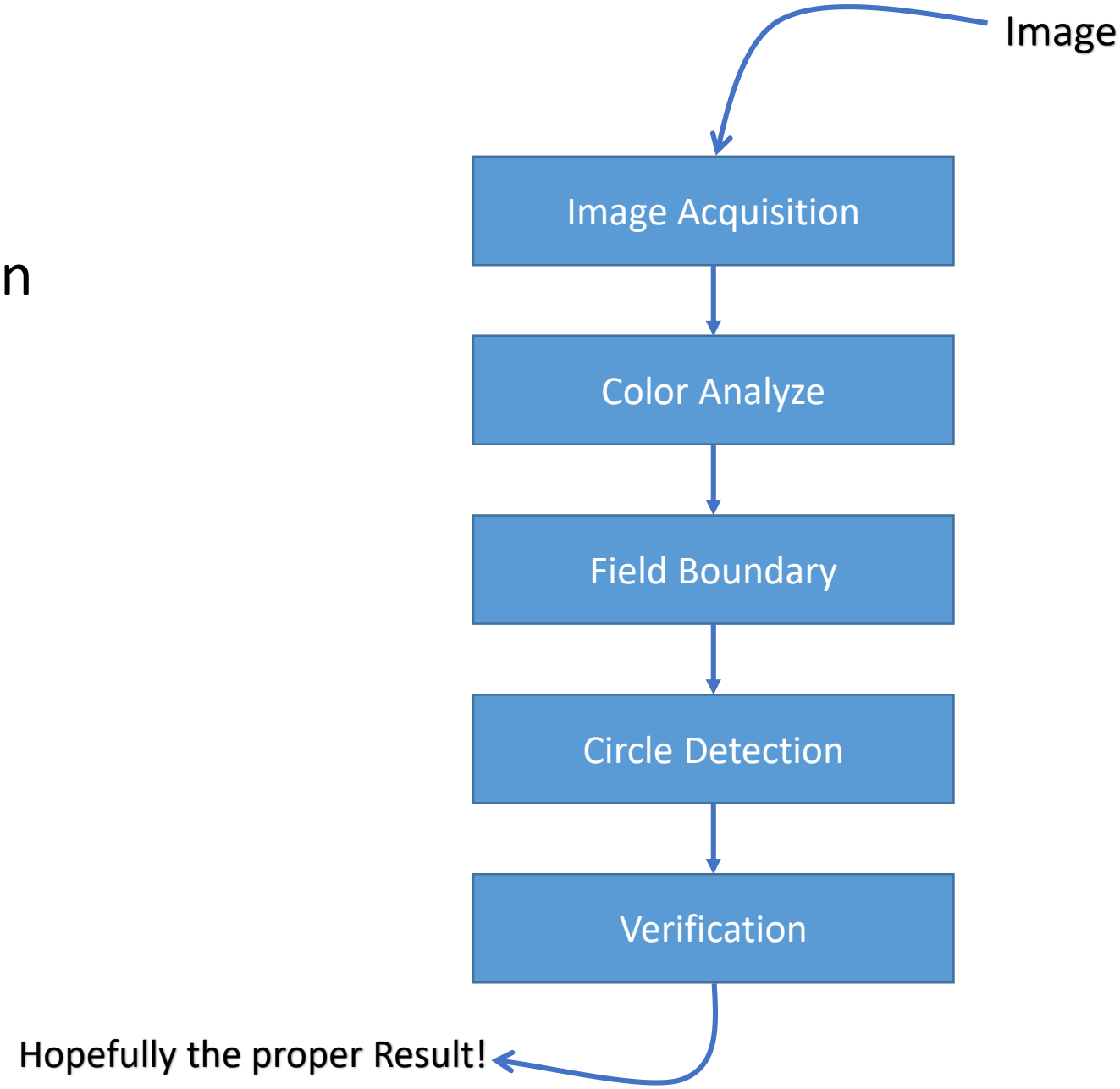
Slides by Aref Moqadam Mehr

Problem Statement

- RoboCup Soccer League
  - NAO
  - HSL
- Field is no longer Color-Coded
- Unspecified Patterns (in HSL)
- NAO white robot in addition to all the problems

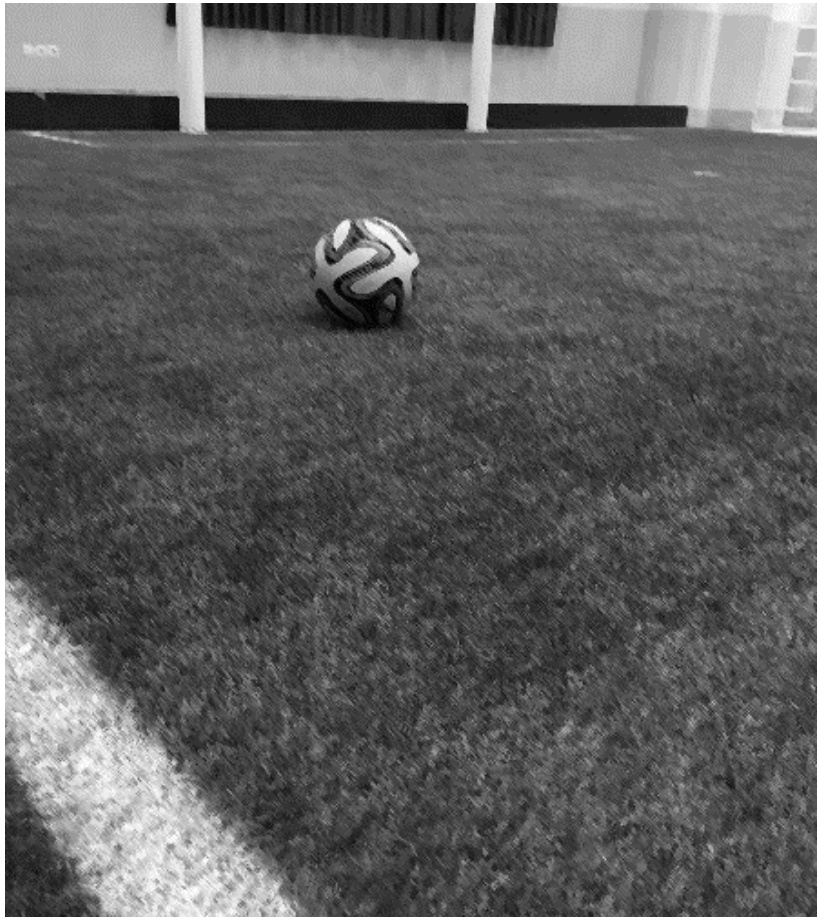
Intuition

- Image Acquisition
- Color Analysis
- Field Boundary
- Circle Detection
- Verification



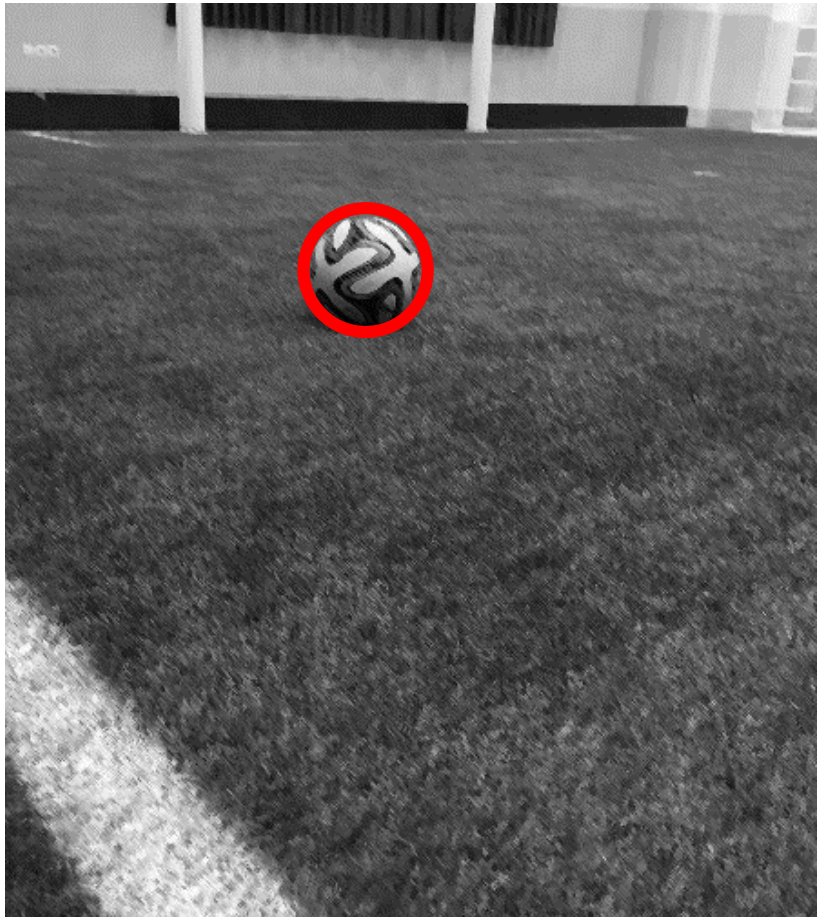
First Things First!

- Circle Detection

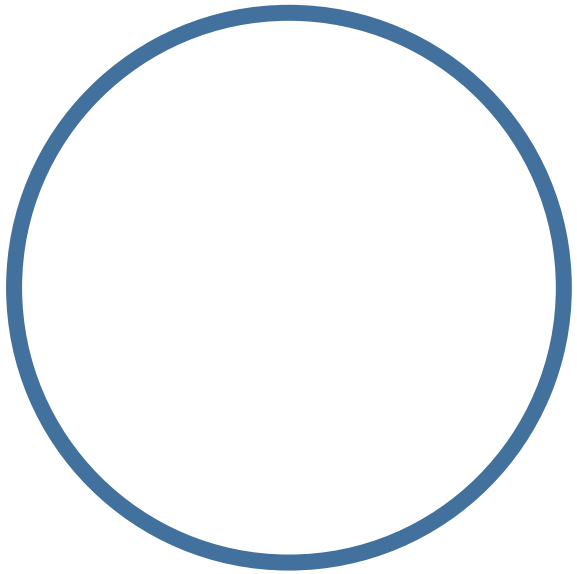


First Things First!

- Circle Detection
  - CHT
  - RHT
  - FRHT



Circle Hough Transform



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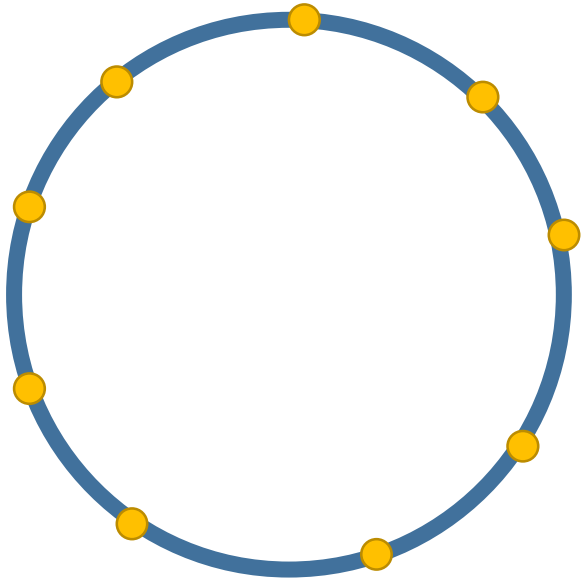

Circle Hough Transform

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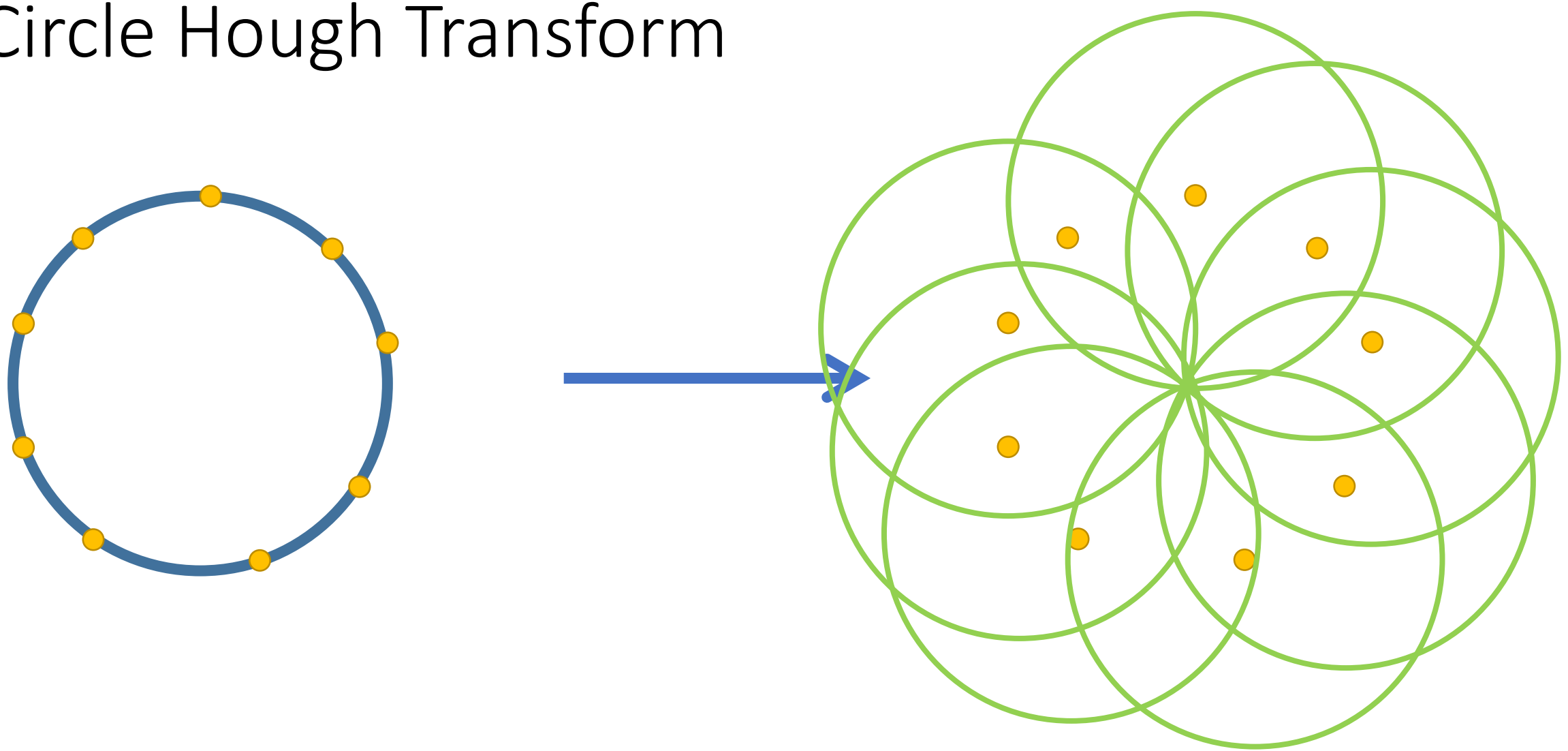

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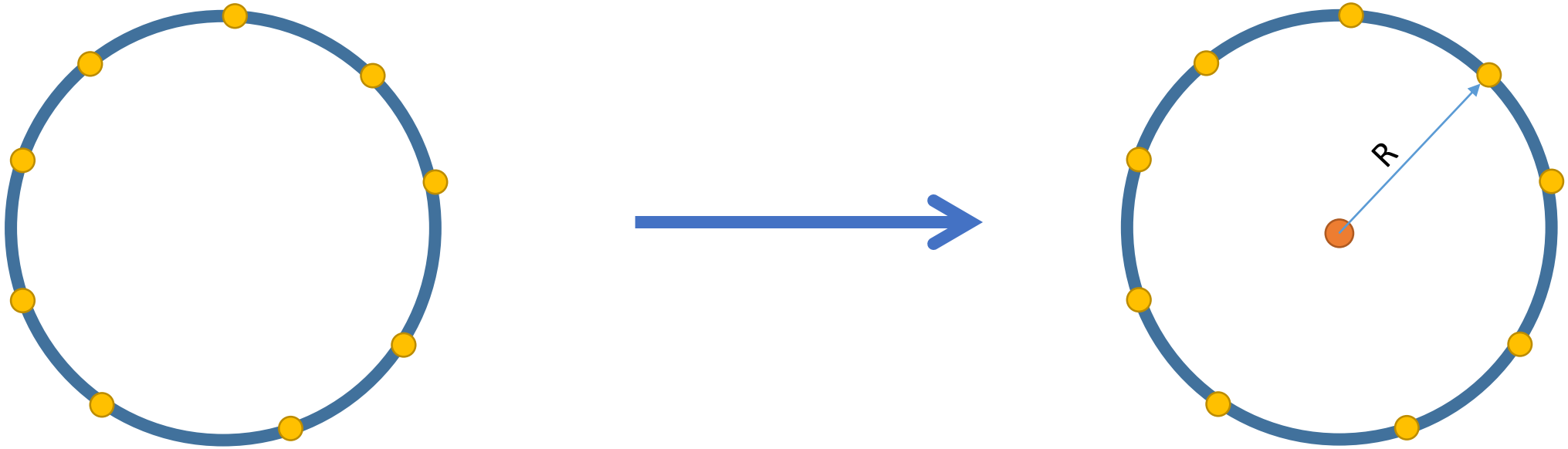

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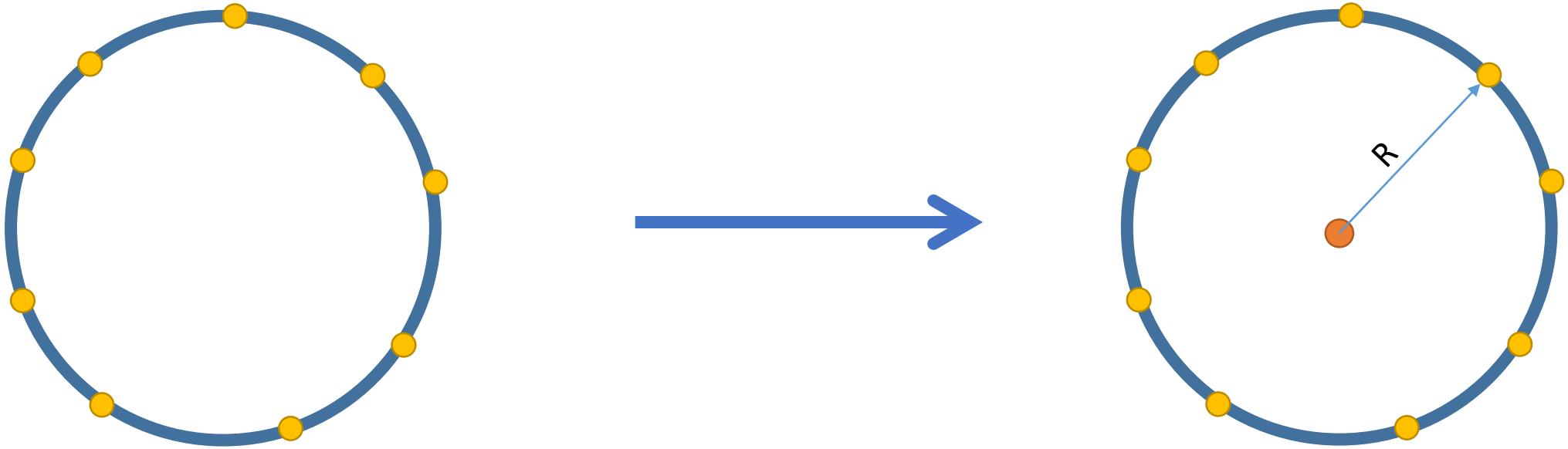


But What is ‘R’?!!

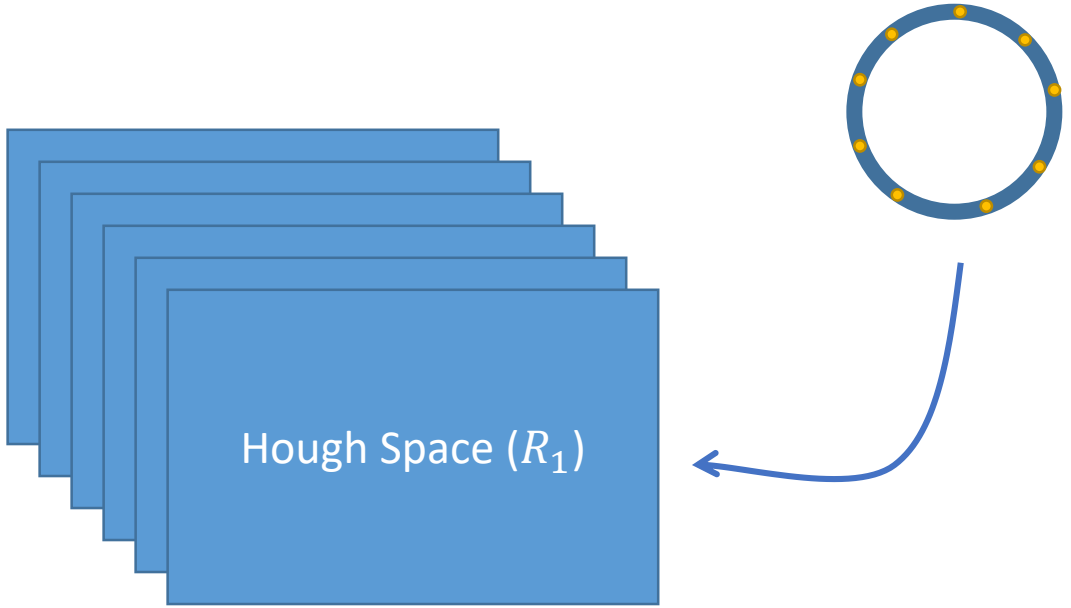
Circle Hough Transform

Since distance effect on the ‘R’ value

But What is ‘R’?!!

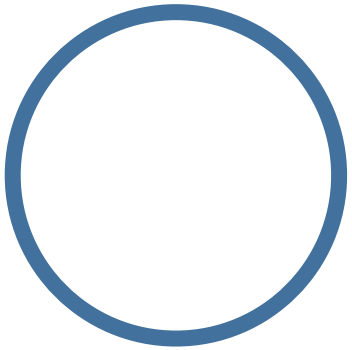
Multi Radius Hough Detection

- **Very inefficient** both in terms of **processing power** and **memory**



Randomized Hough Transform

- How it works?



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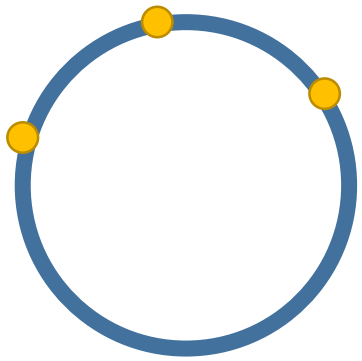

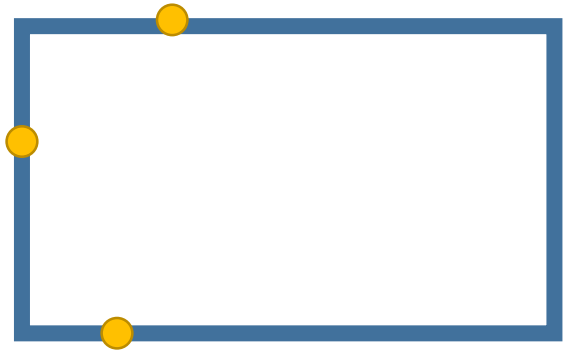

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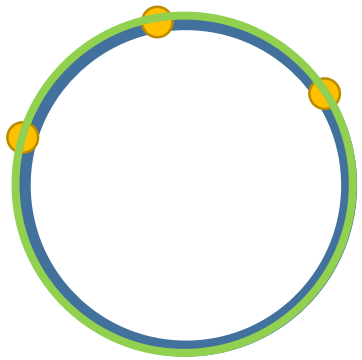

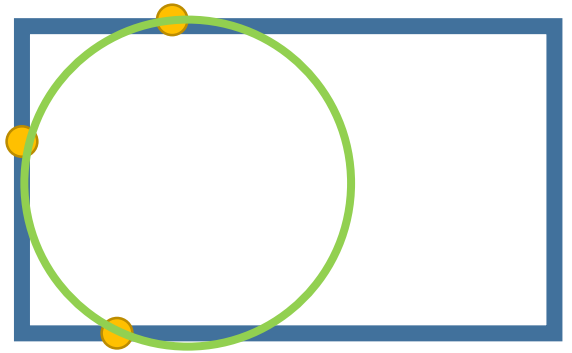

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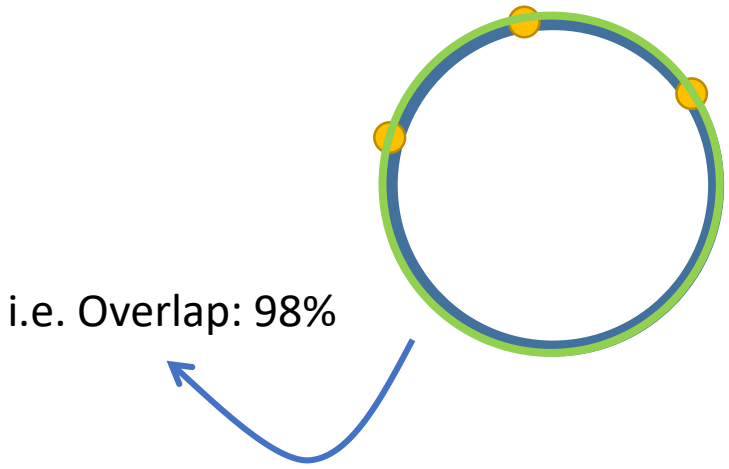
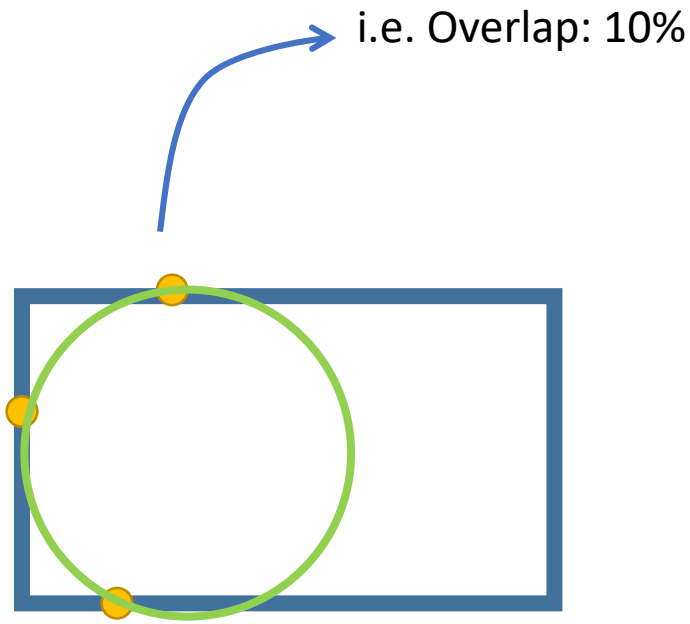




Randomized Hough Transform

- Much Faster
- But does not have enough accurate
- Require lots of iteration to guarantee an acceptable result.

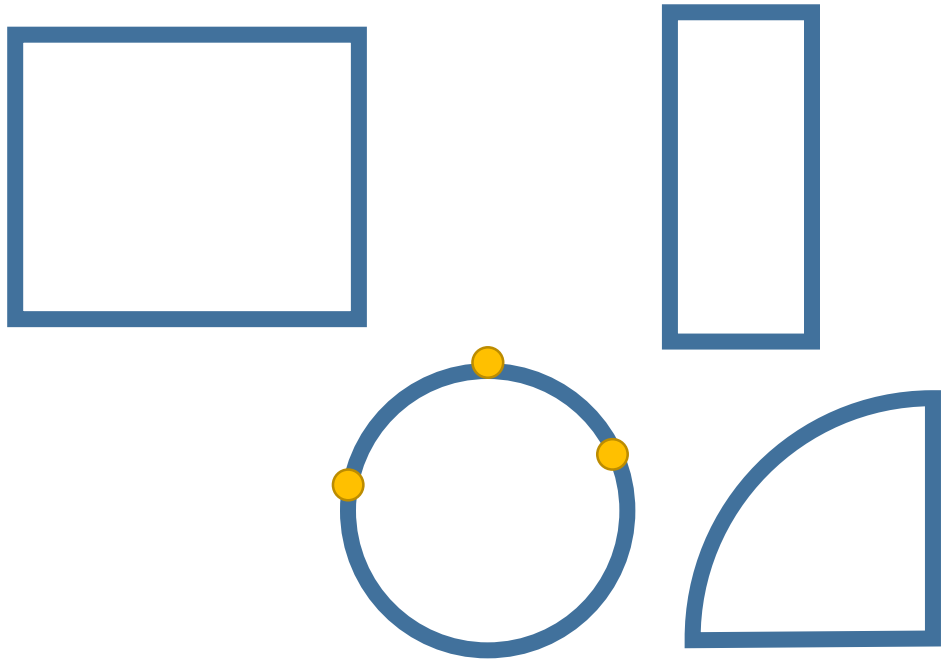
Randomized Hough Transform

Probability of point on the circle: $$P_r = \frac{EdgeArea(circle)}{EdgeArea(total\ edges)}$$

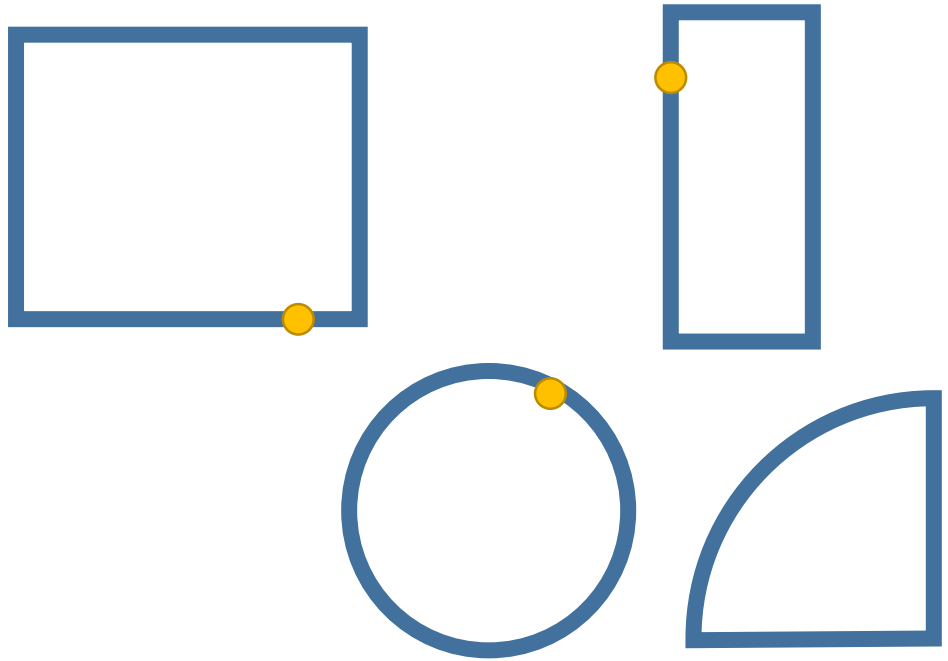
Probability of three points on the circle: $$P_c = P_1 * P_2 * P_3$$

Probability of three everywhere else: $$P_e = 1 - P_c$$

Randomized Hough Transform



Less Probable (i.e. 0.01%)

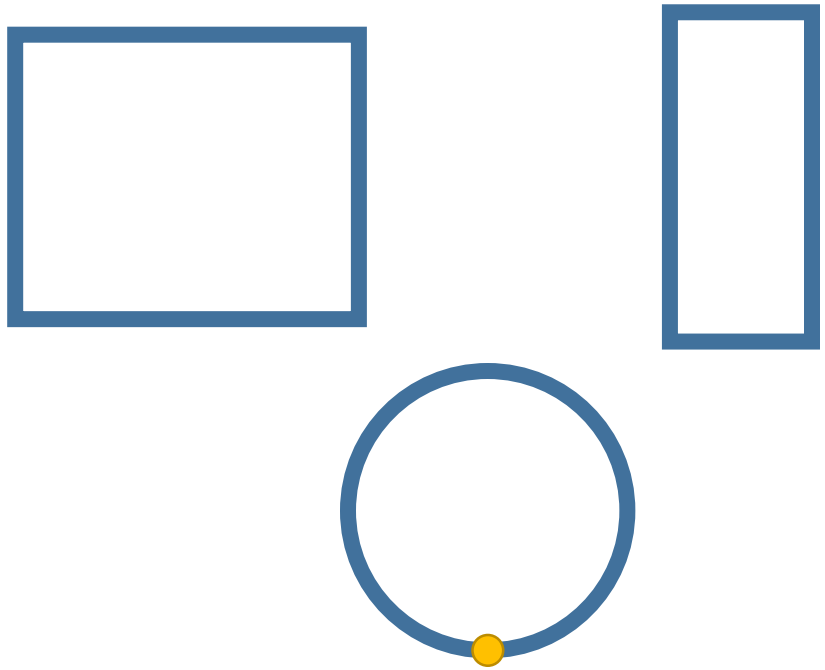


More Likely to happen (i.e. 99.99%)

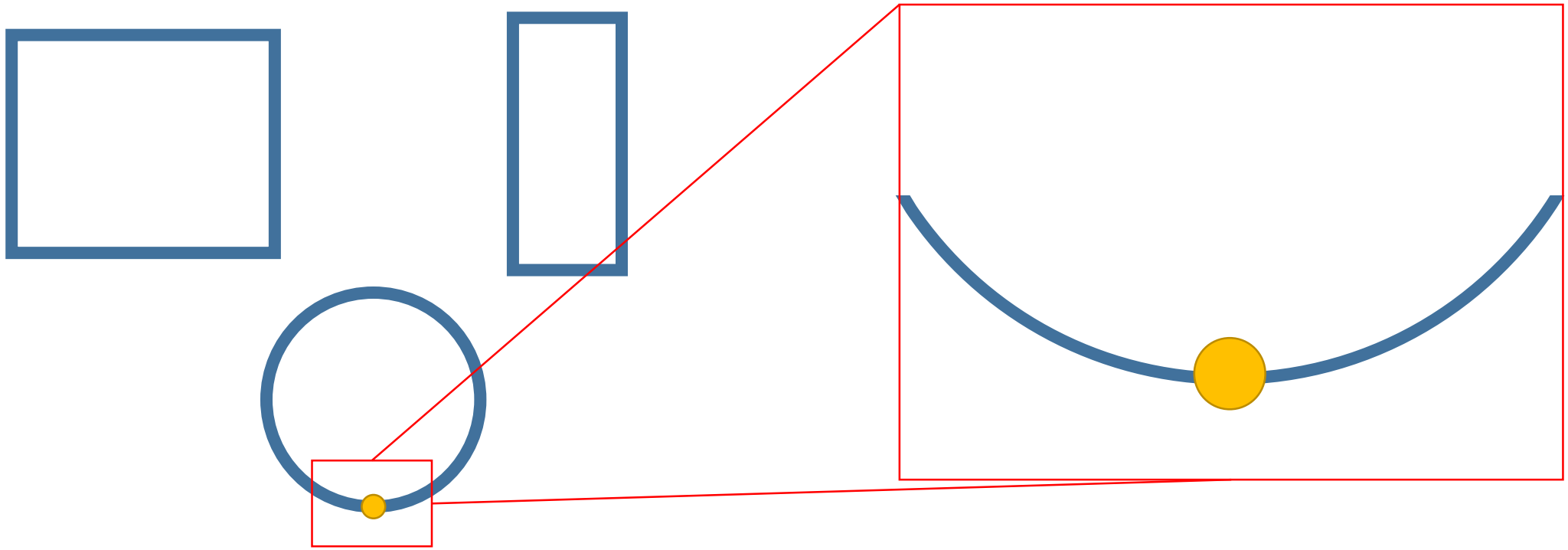
Fast Randomized Hough Transform

- To solve the accuracy.
- Hence, reduce the maximum iteration required
- Thus, become even faster!

Fast Randomized Hough Transform



Fast Randomized Hough Transform



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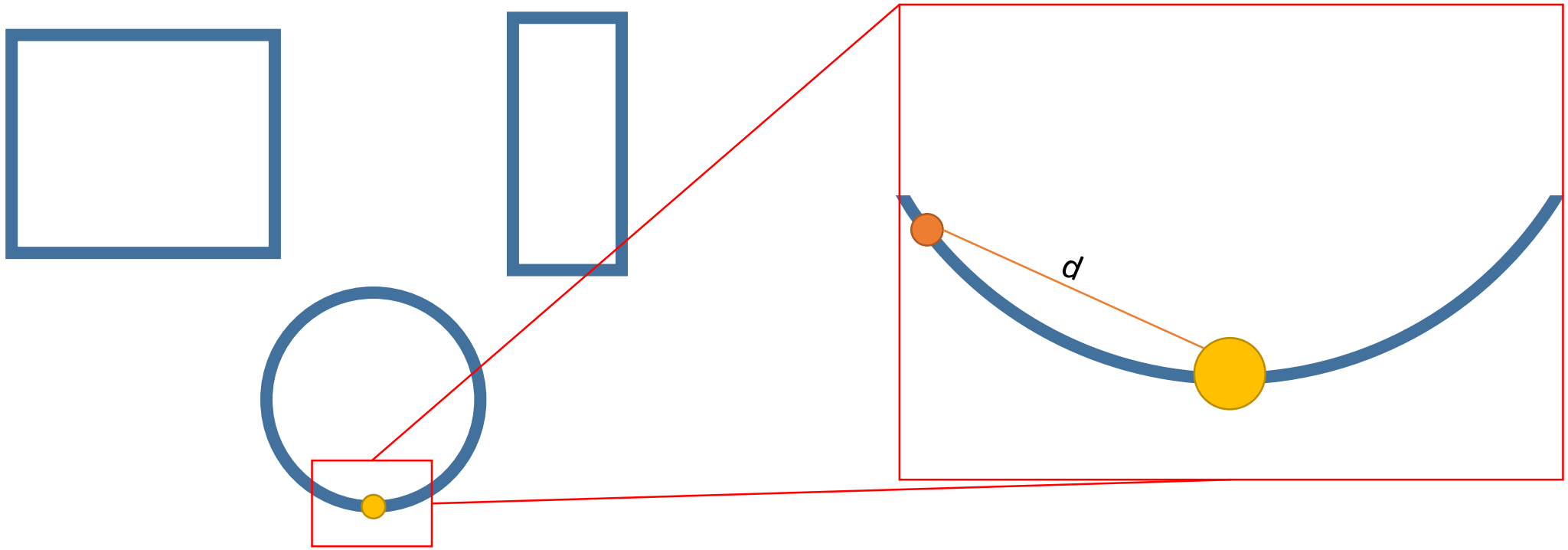

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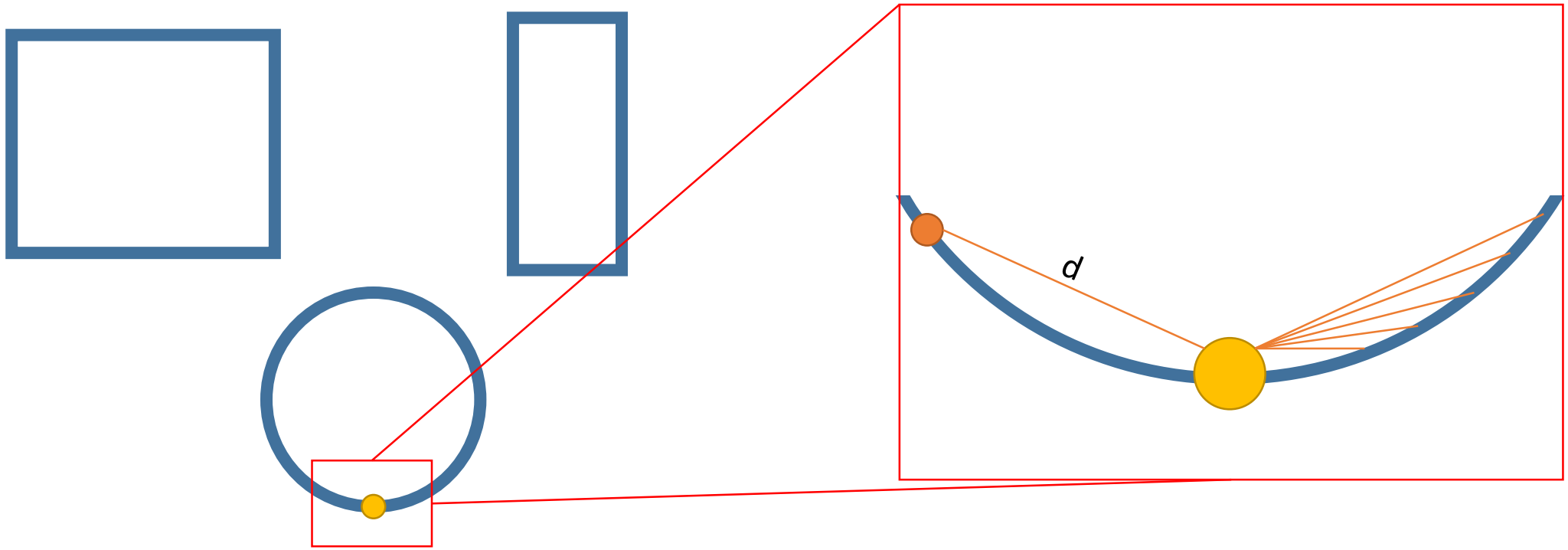

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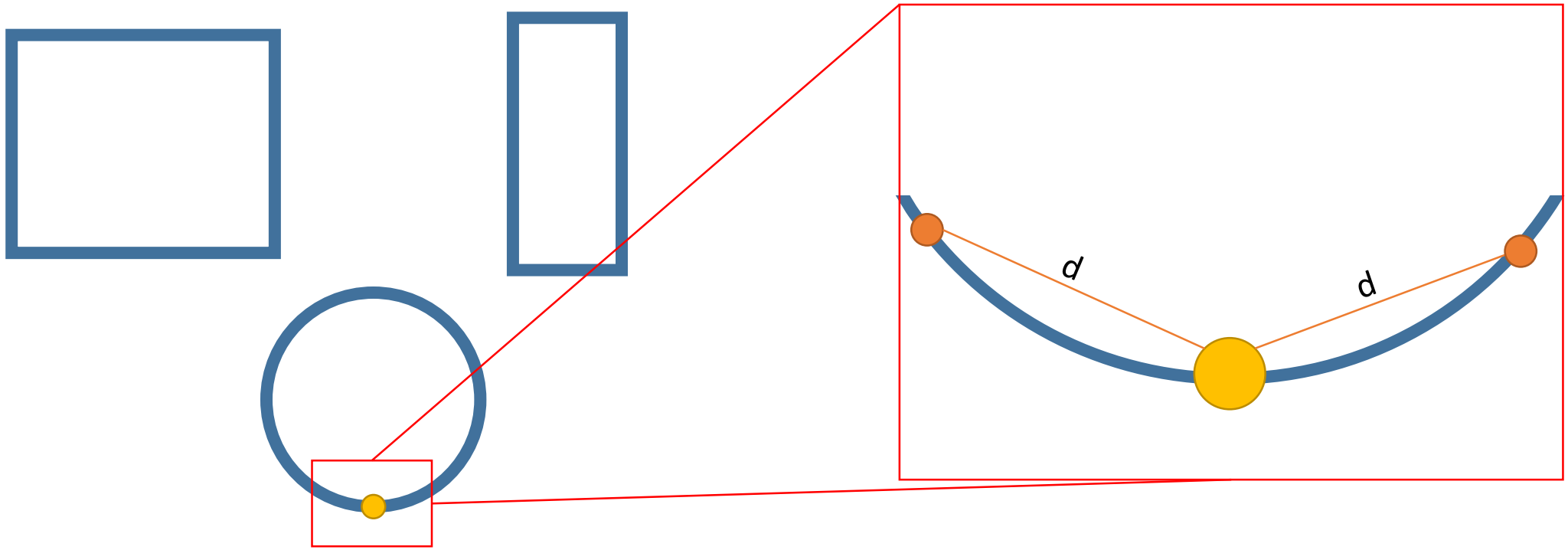

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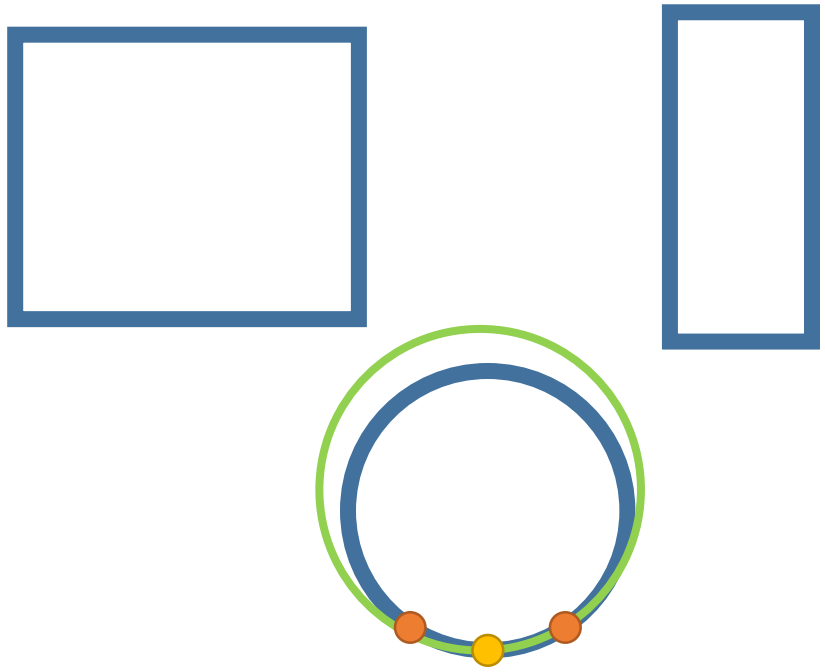

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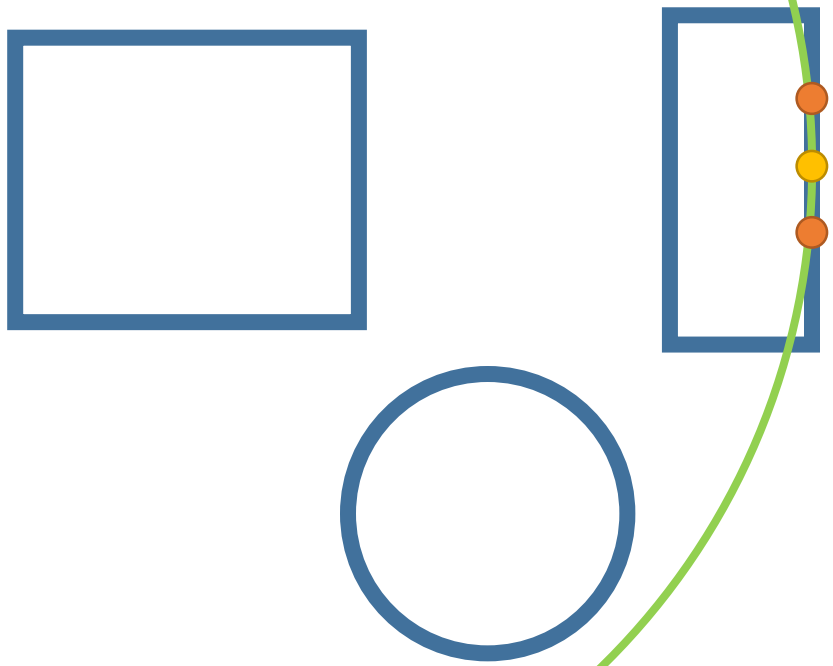
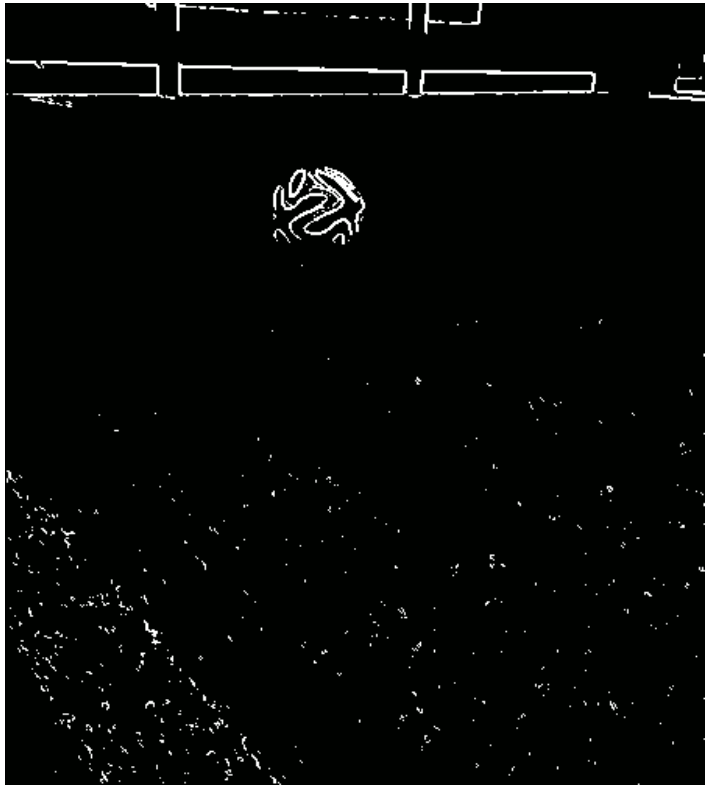


Fast Randomized Hough Transform

- There is an extracted circle for each iteration
- Here in our project:
  - Filter by size
  - Filter by green and non-green pixel percentage inside the circle

Edge Detection



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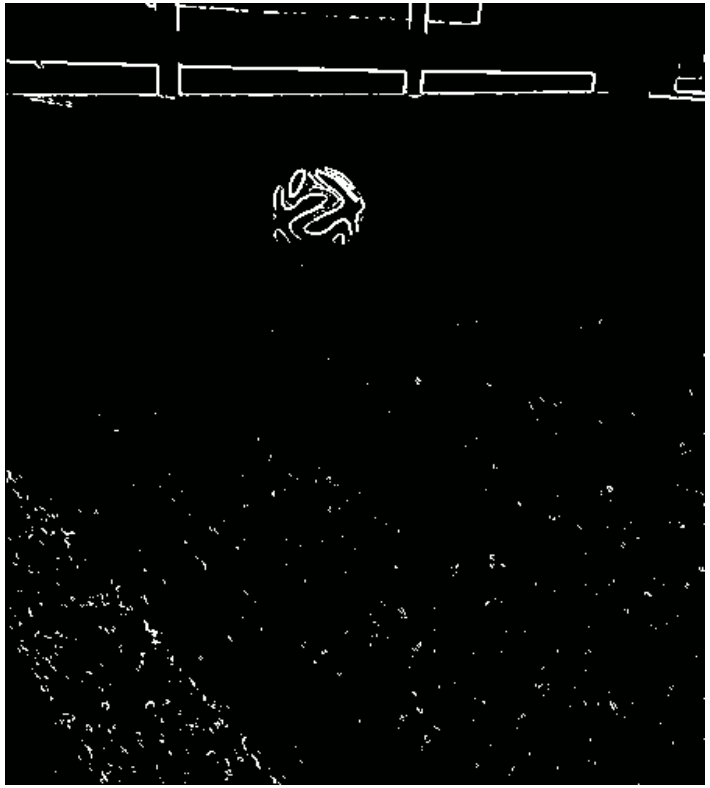
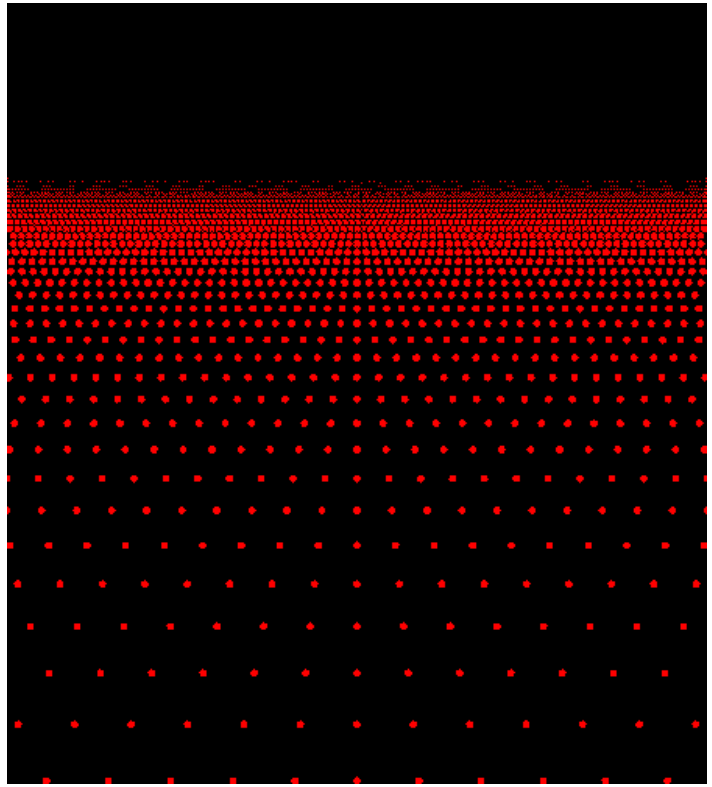
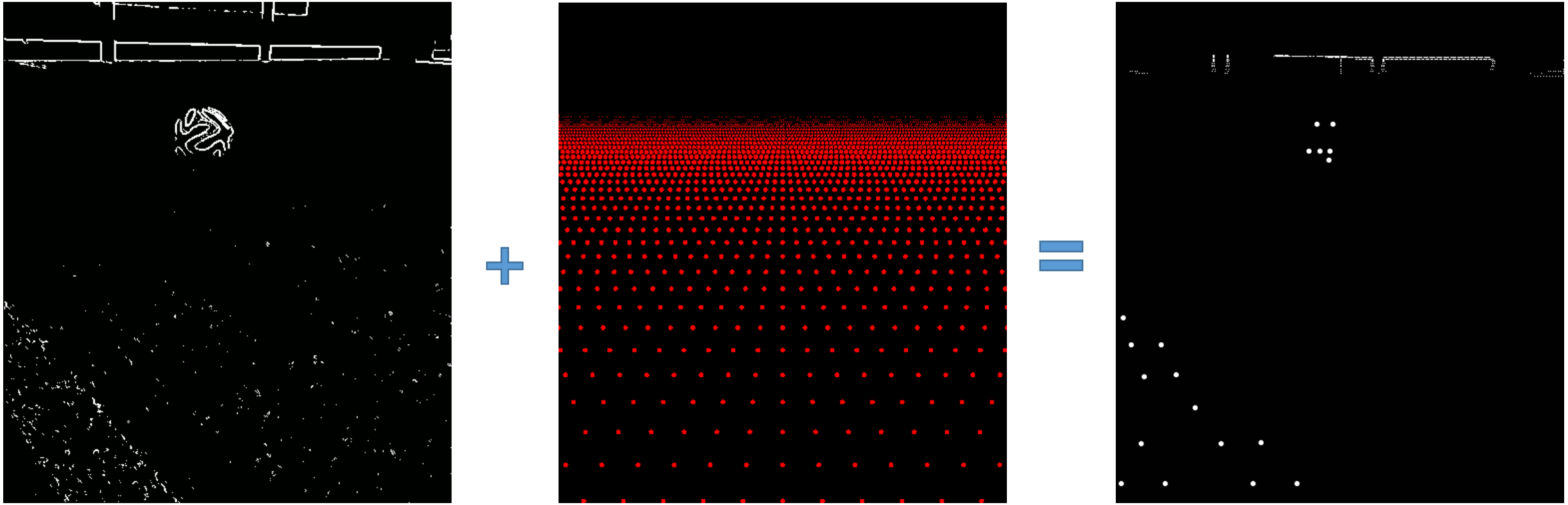


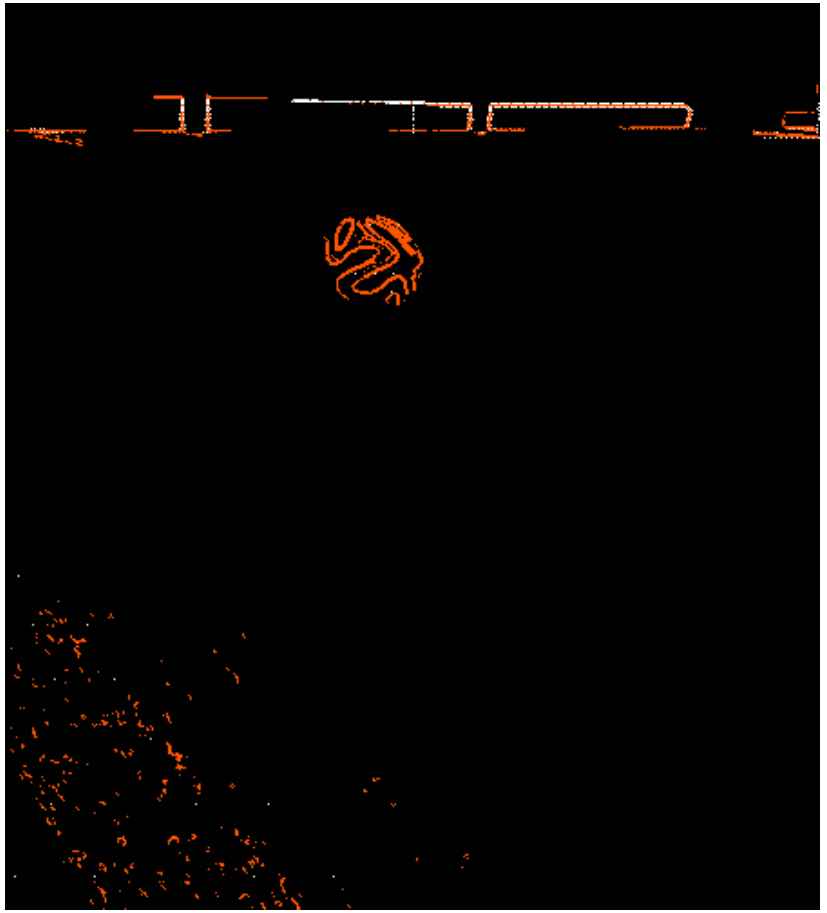


Edge Detection



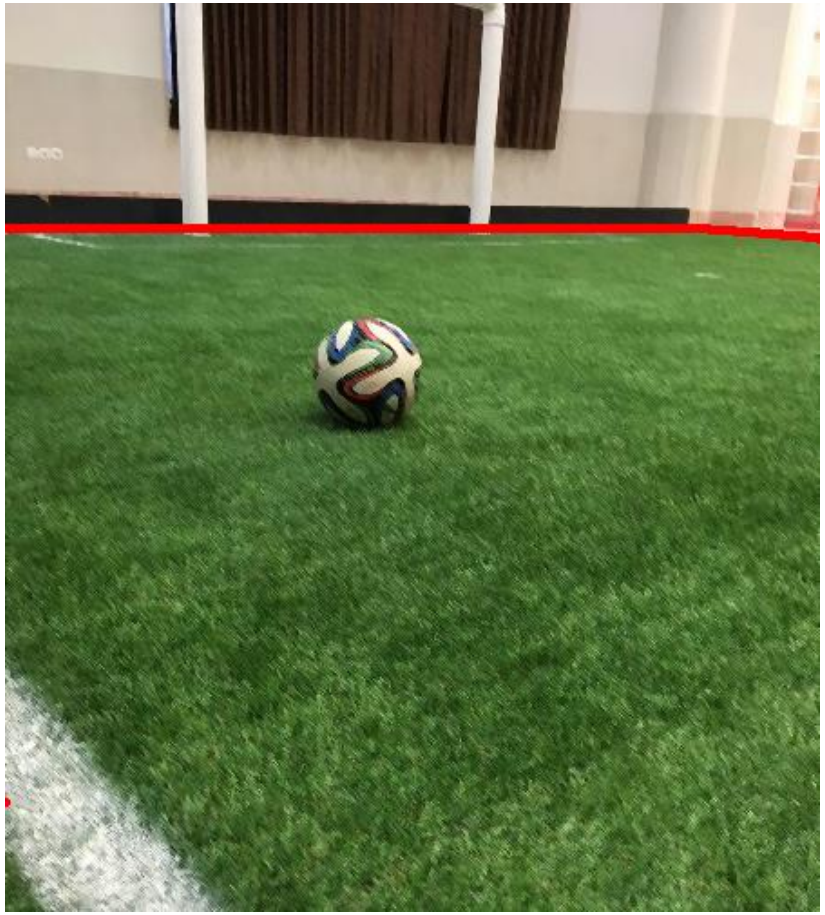
Here is the magic

- Distributed of Random Points
- Very Efficient



Let’s back-up a little bit!

- Field Boundary Detection
  - Ball is always inside the field
  - Outside of the field is usually crowded.



Field-Green Color

- When the robot is inside the field *usually* it see *mostly* green (When the image is cropped below the horizon).

Thomas Reinhardt

Horizon

Horizon

- “In graphical perspective, a vanishing point is a point in the image plane where the projections of a set of parallel lines in space intersect.” -Wikipedia
- Horizon is the projection of the infinity (or a very distanced point)

Photo by: http://wide-wallpapers.net

In our work

- The highest pixel for field boundary in image is when robot is at one corner and observing the diagonal corner of the field.

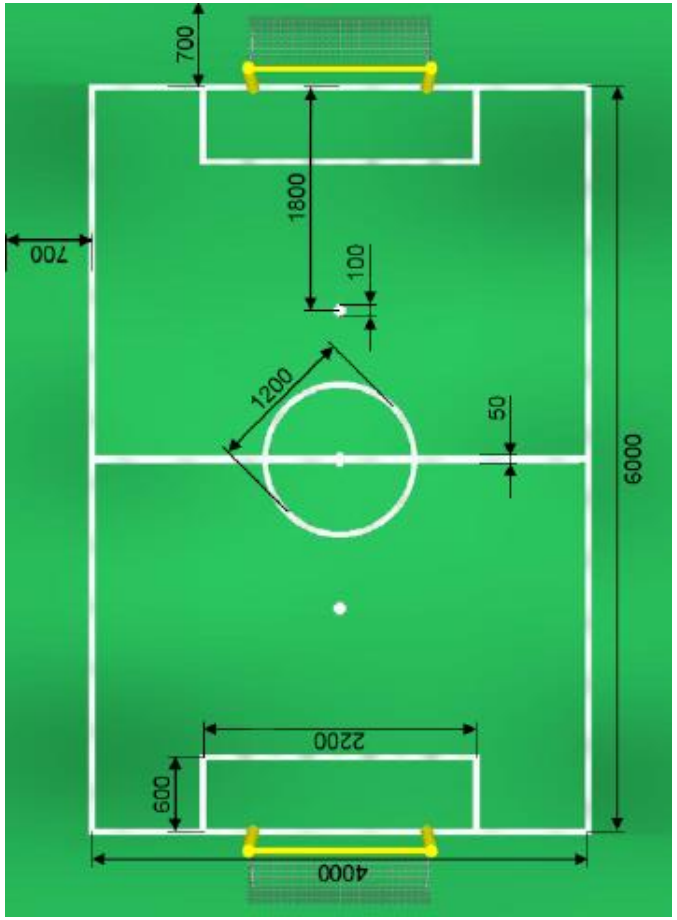
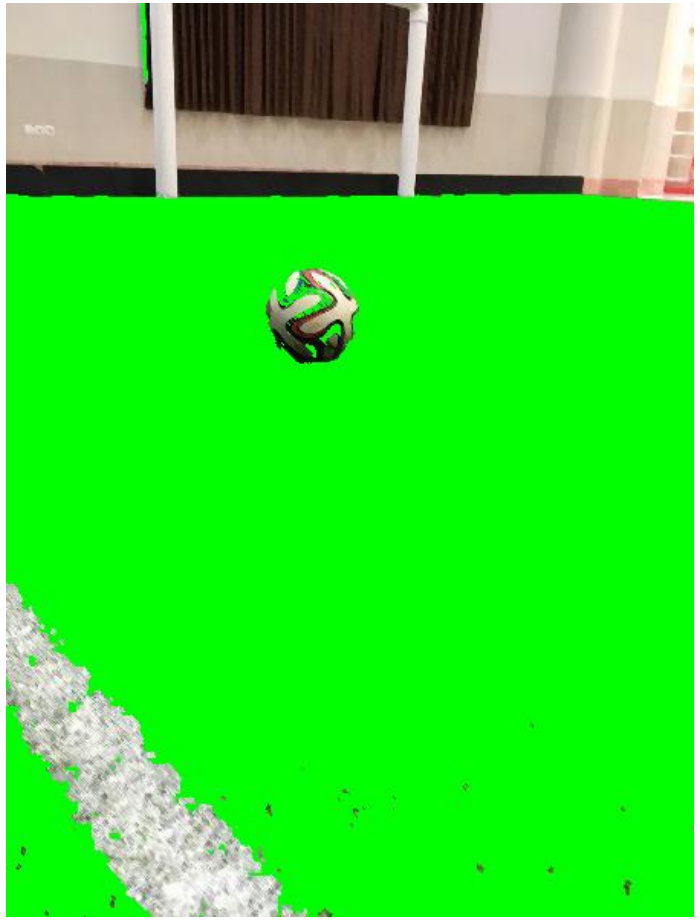


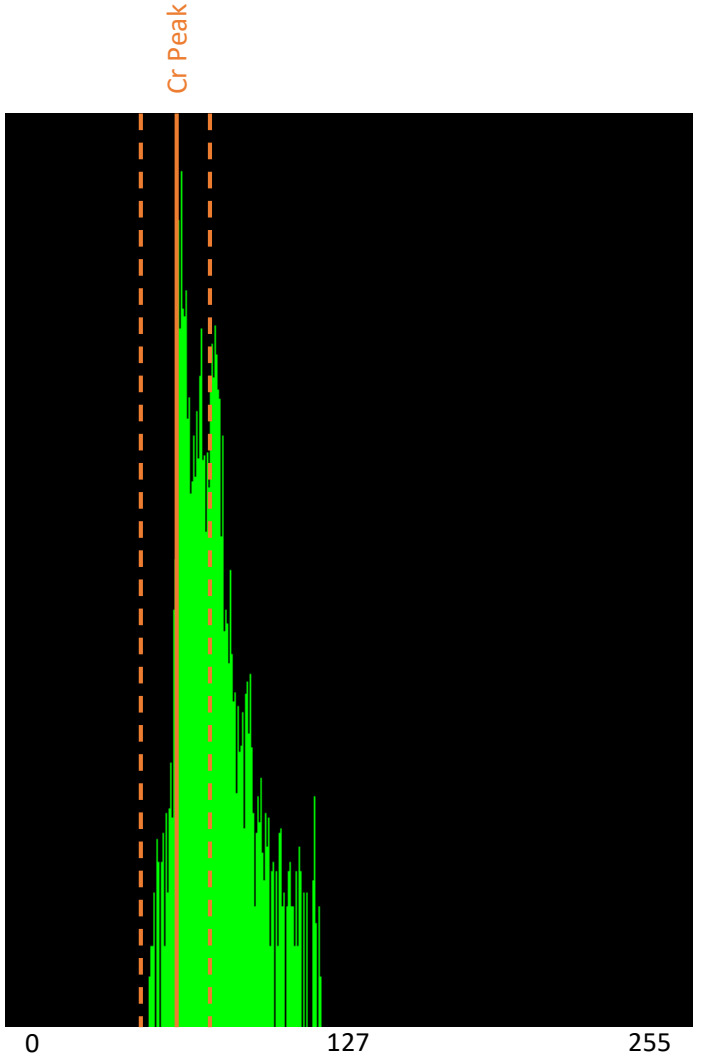
Photo by: http://tzi.de/spl/

Again Field-Green Color

$p = peak(histogram)$

$isGreen(P) = |P - p| < \delta$





Field Boundary

Run Ups Results

Andrew's monotone Results

Finally Filters

- Size
- White Pixels Maximum
- Non-Green Pixels Limit
- Projected Size
- Pattern

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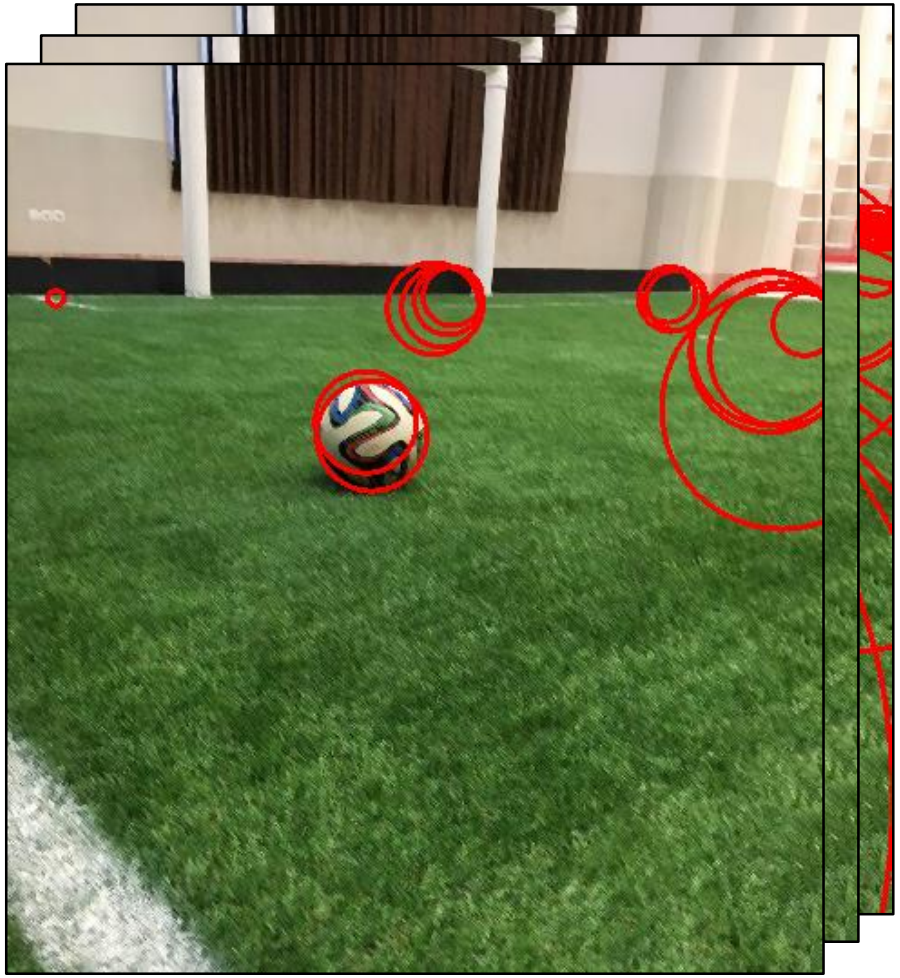

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- Size
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Thanks To

- MRL Humanoid (MRL-HSL)
- MRL Biped Lab. (MRL-SPL)
- MRL3D Soccer Simulation Team

Any Questions?

- The code can be found on my github at:
  - http://github.com/arefmq
- The documentation is available on my profile at:
  - http://mrl-spl.ir/~moqadam
- You can also reach my by email via:
  - a.moqadam@mrl-spl.ir