



PRESENTED BY  RTX

Autonomous Navigation for INTO THE DEEP

Introduction to Color Blob detection

9/7/24 Kickoff, SoCal FTC

Autonomous Navigation



Overview of FTC Vision

AprilTag Review

OpenCV Demonstration

Previews

Camera as Color Sensor

Color Blob Concepts

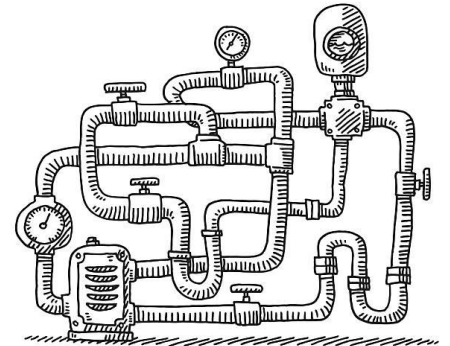
Color Blob Detection



Overview of FTC Vision



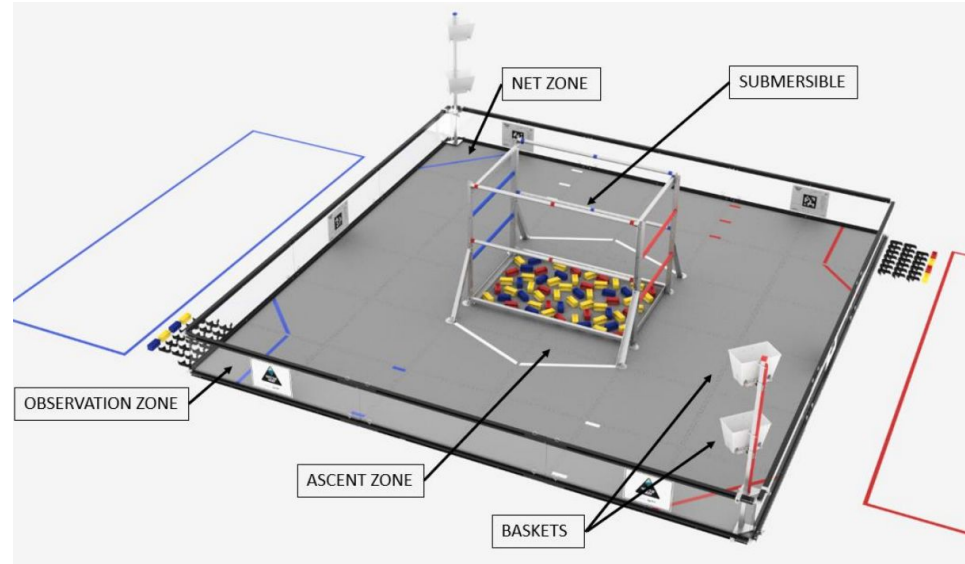
- VisionPortal - new in 2023
- included EasyOpenCV features
- 2024: may add some OpenCV features



Overview of FTC Vision



- no TensorFlow/ML this year
- no Vuforia (previous year)
- 2024: VisionPortal may manage
AprilTag and **Color Blobs**
- RC phone camera, USB webcam(s)

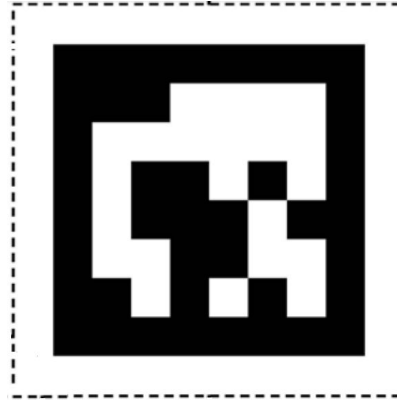


ftc-docs.firstinspires.org

Overview of FTC Vision

AprilTag

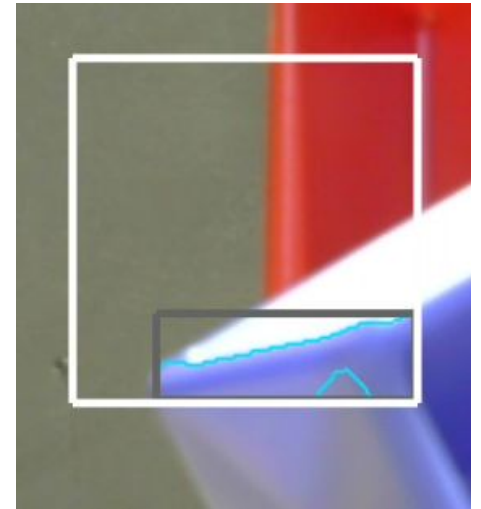
- square flat image, "visual fiducial"
- detect ID Code
- estimate **pose** (position and rotation)



TAG ID: 11

Color Sensor & Blob Detector - *may add in 2024*

- report the color of a region
- create Blobs: clusters of similar-colored pixels
- tools to evaluate Blob data, for navigation



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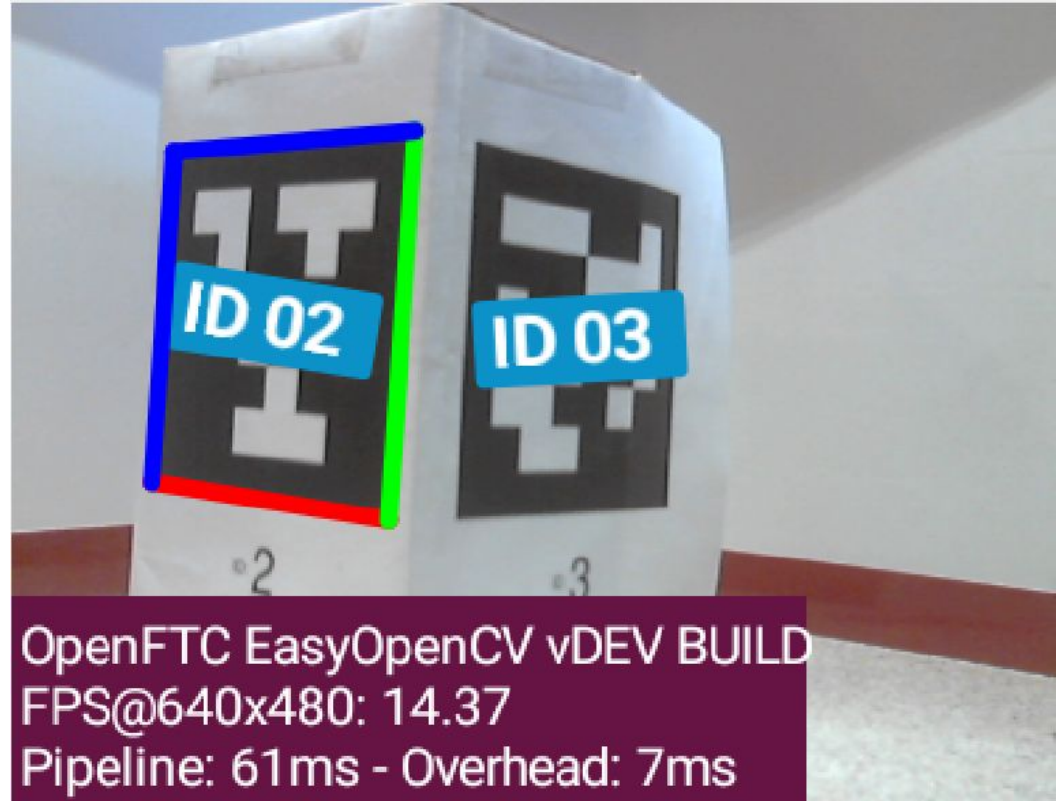
Color Blob Detection



AprilTag Review

AprilTag Detection

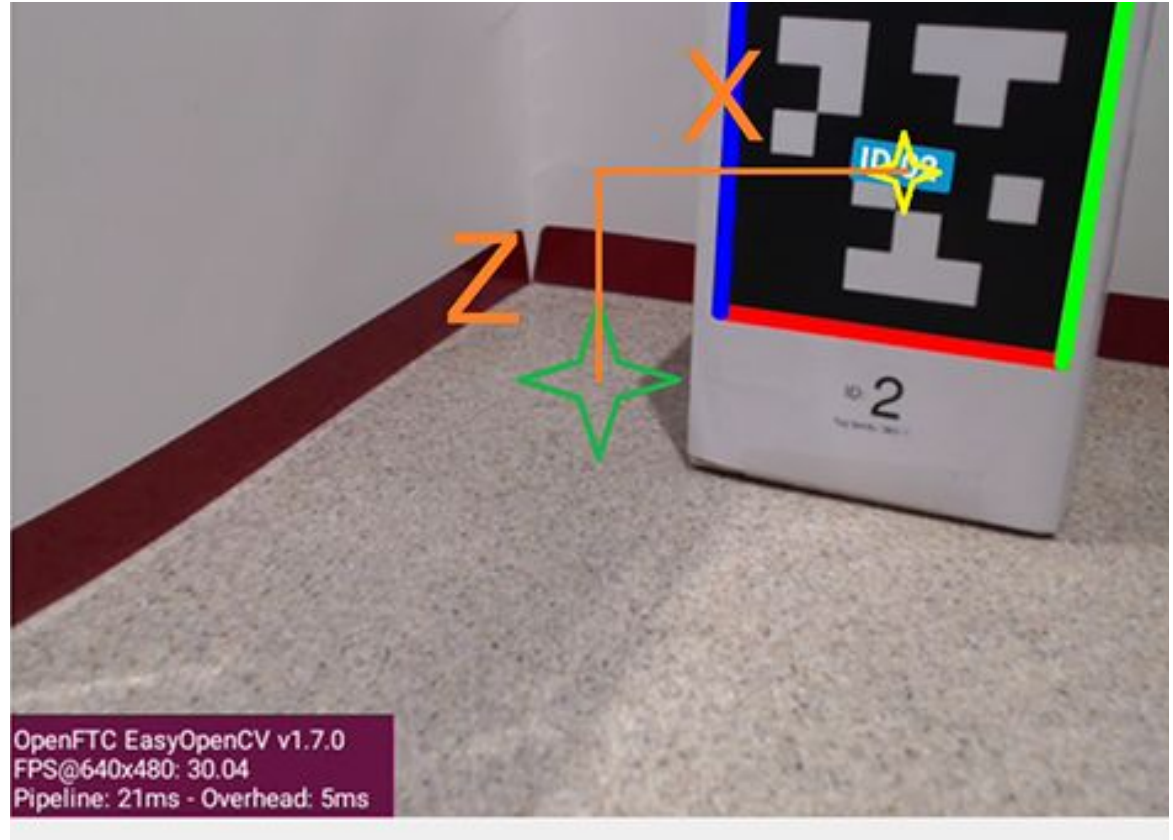
- family 36h11 only
- always ID Code (0 - 586)
- colored border:
 - library tag,
 - name & size known,
 - pose estimate available



AprilTag Review

AprilTag Pose

- position/displacement
- from lens to tag:
 - X to the right
 - Y outward
 - Z upward
- real distance, not pixels



AprilTag Review

AprilTag Pose

- orientation/rotation:

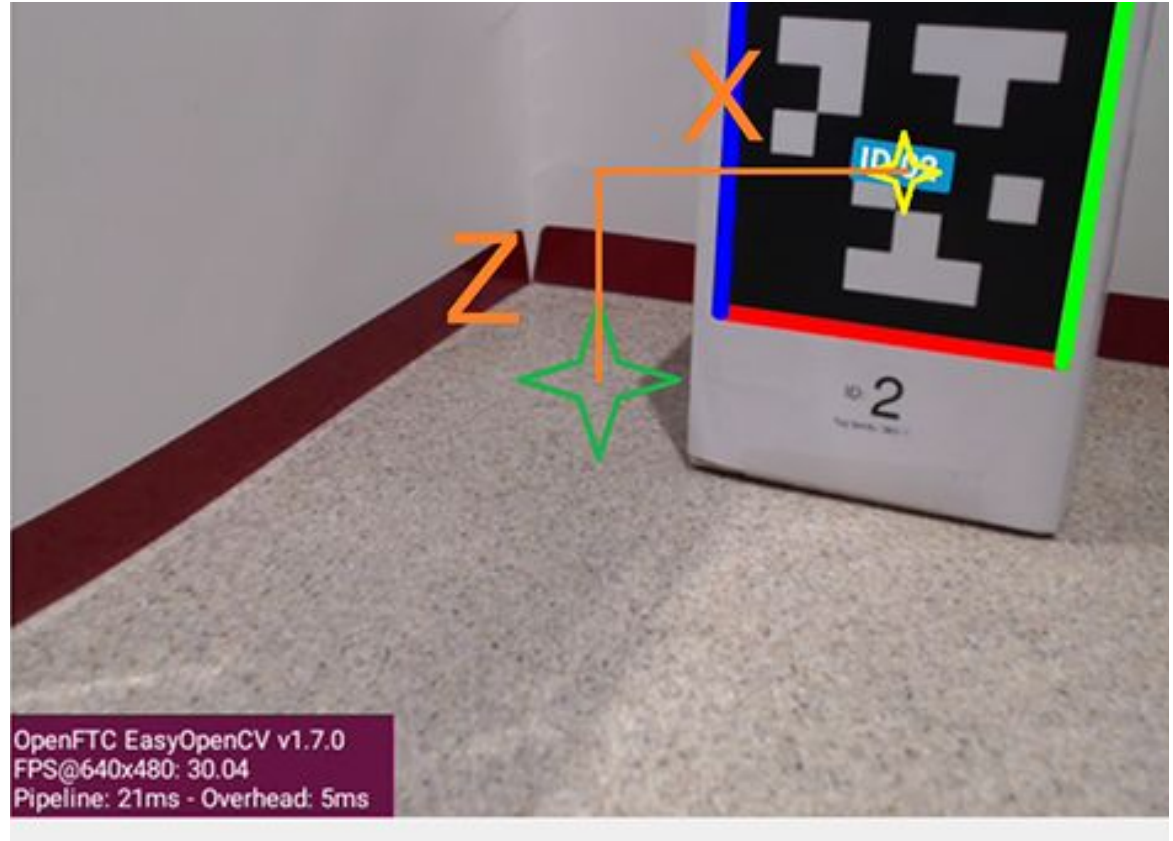
Pitch (about X)

Roll (about Y)

Yaw (about Z)

- right-hand rule

- in degrees



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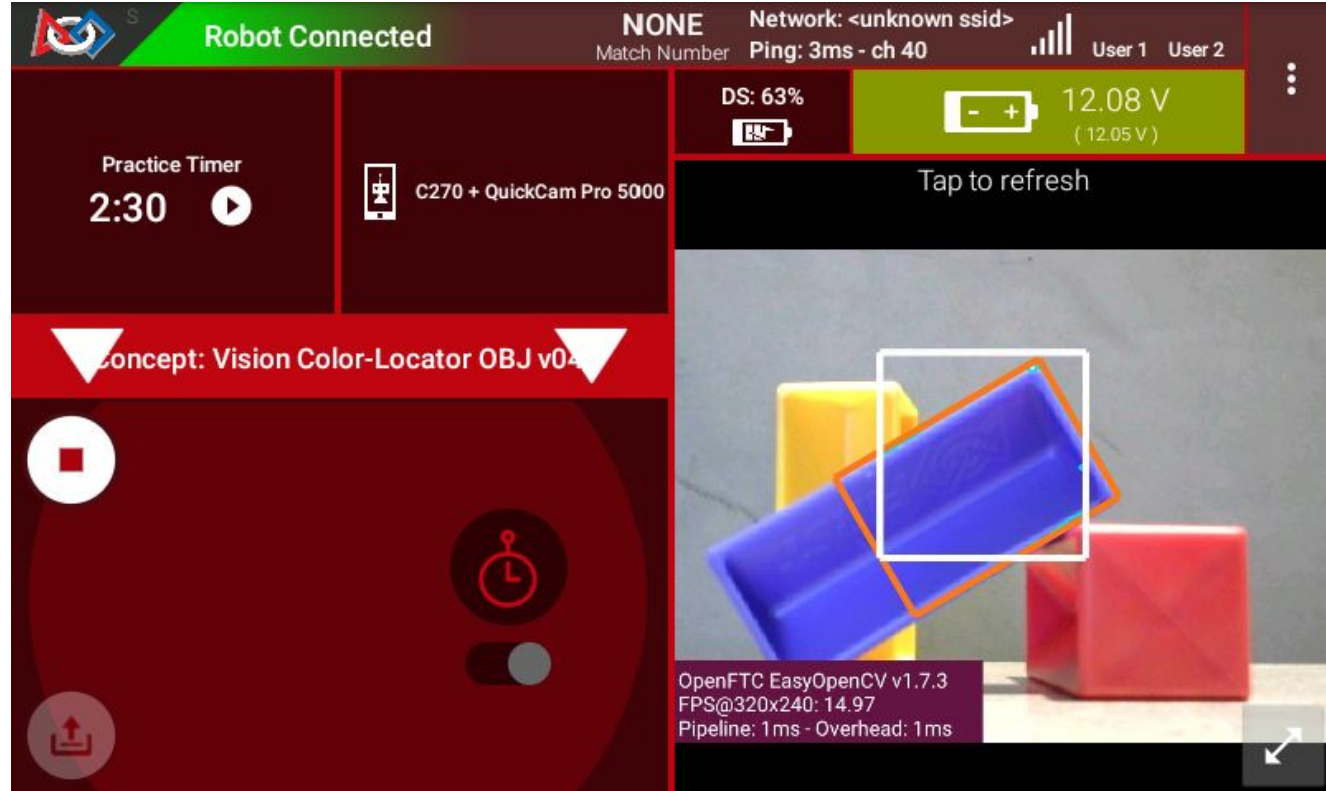


Previews



Driver Station app

- 3-dots menu
- Camera Stream
- tap to refresh
- arrows to enlarge

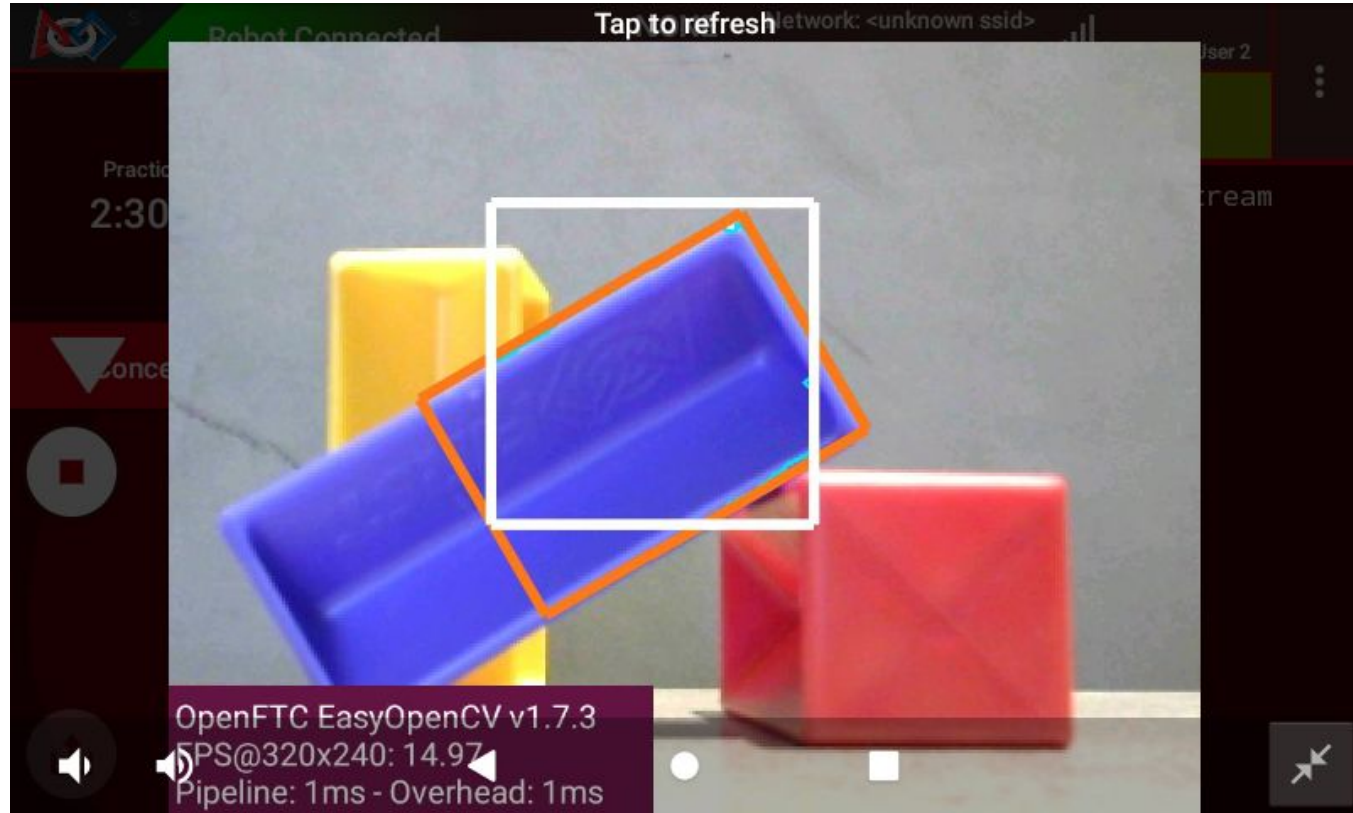


Previews



Driver Station app

- enlarged preview
- tap to refresh
- arrows to return



Previews



Robot Controller app

- RC preview is called LiveView
- live video
- Android phone: preview is automatic
- REV Control Hub: use HDMI monitor or **SCRCPY** "screen copy"

Previews



Control Hub v1.0

- □ ×



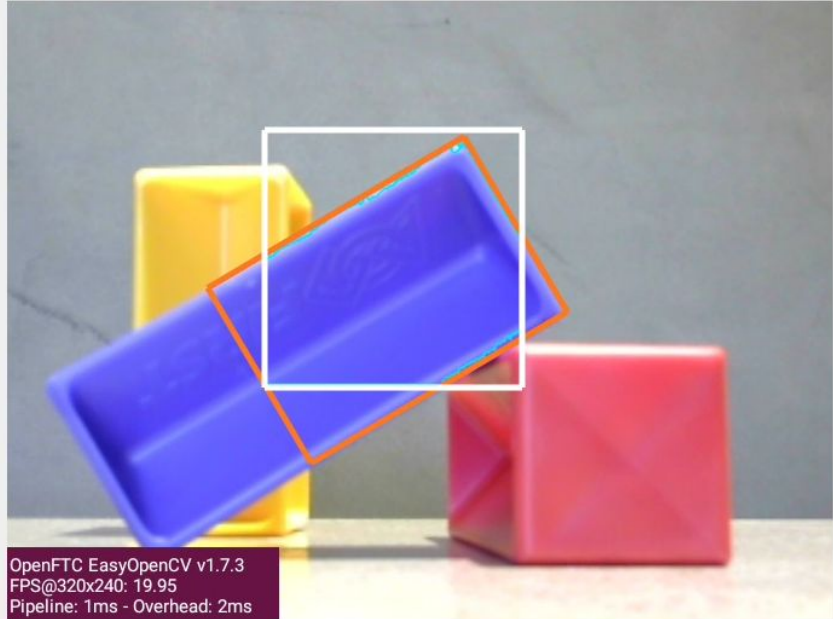
9999-C-RC



Active Configuration:

C270 + QuickCam Pro 5000

Network: active, connected
Robot Status: running
OpMode: Concept: Vision Color-Locator OBJ v04



OpenFTC EasyOpenCV v1.7.3
FPS@320x240: 19.95
Pipeline: 1ms - Overhead: 2ms

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Camera as Color Sensor

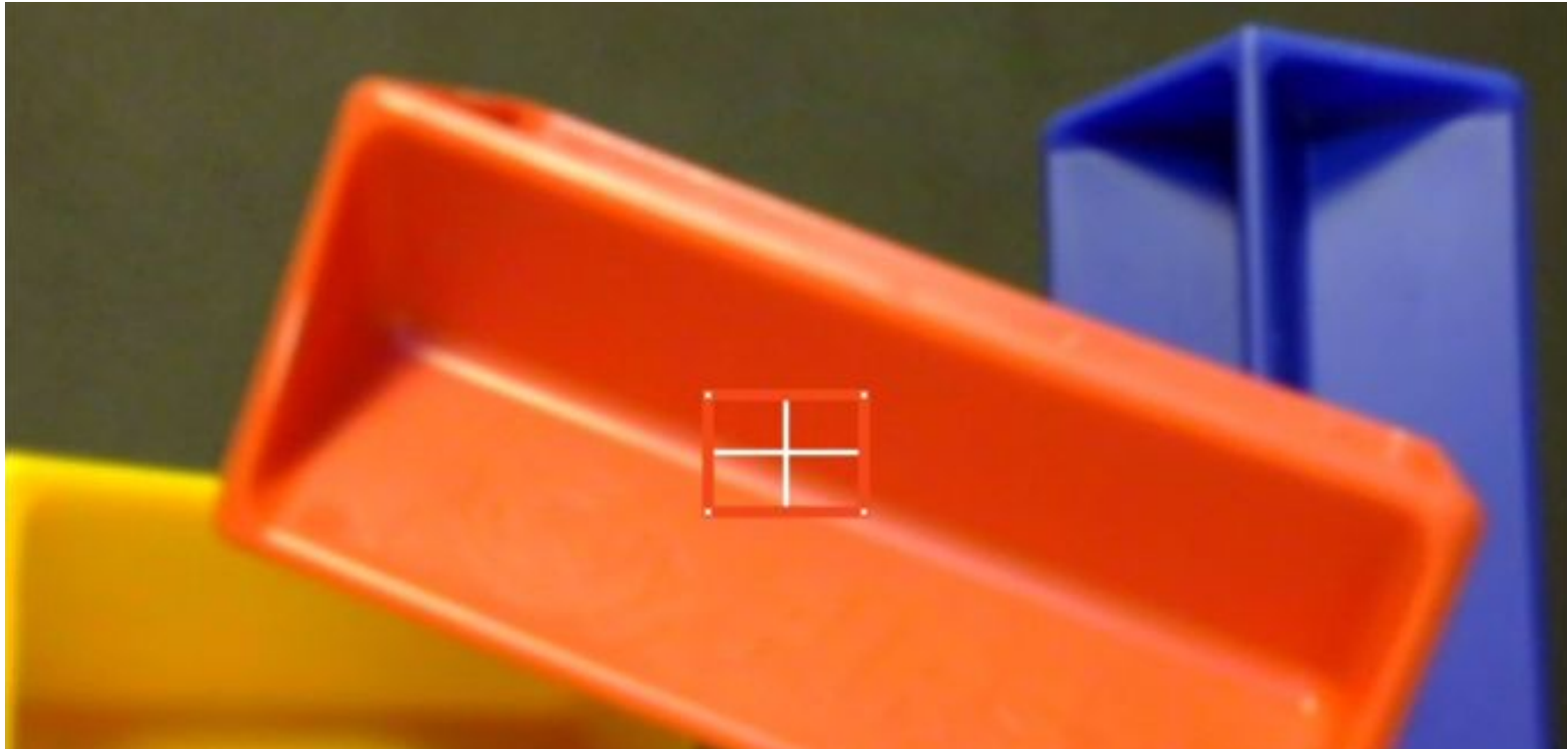
Consider a "Color Sensor" process

- define a rectangle, Region of Interest (ROI)
- select eligible matching colors, using Swatches
- available Swatches:

RED, ORANGE, YELLOW, GREEN, CYAN, BLUE,
PURPLE, MAGENTA, BLACK, WHITE

Camera as Color Sensor

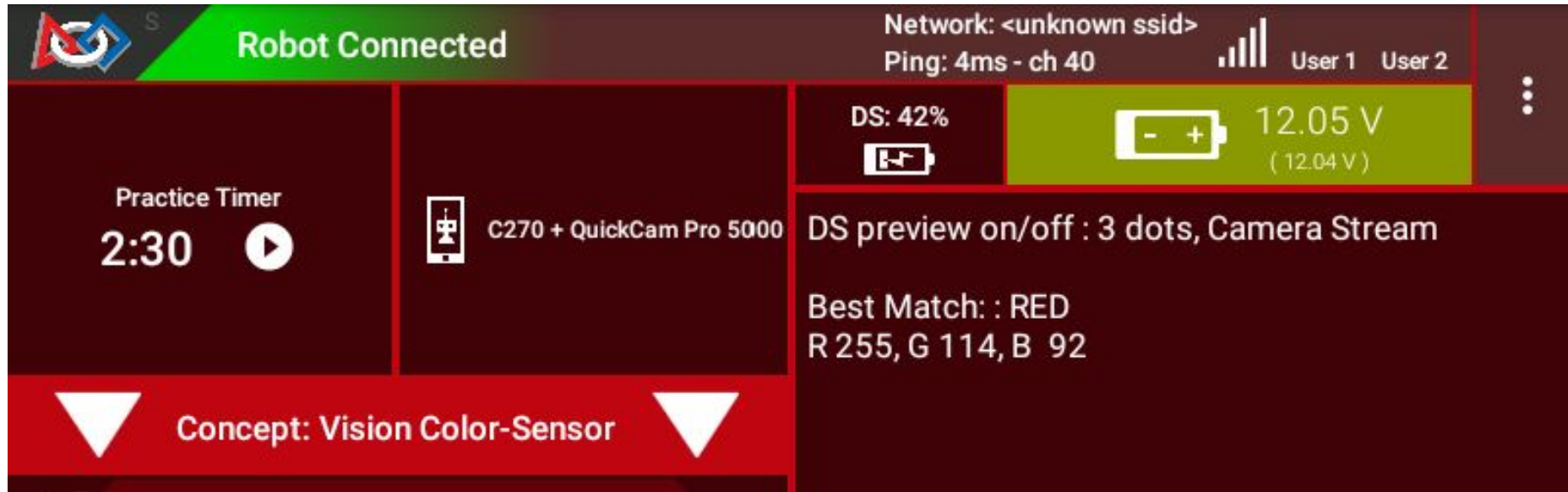
Color Sensor Preview - ROI in predominant color, plus white markings



Camera as Color Sensor

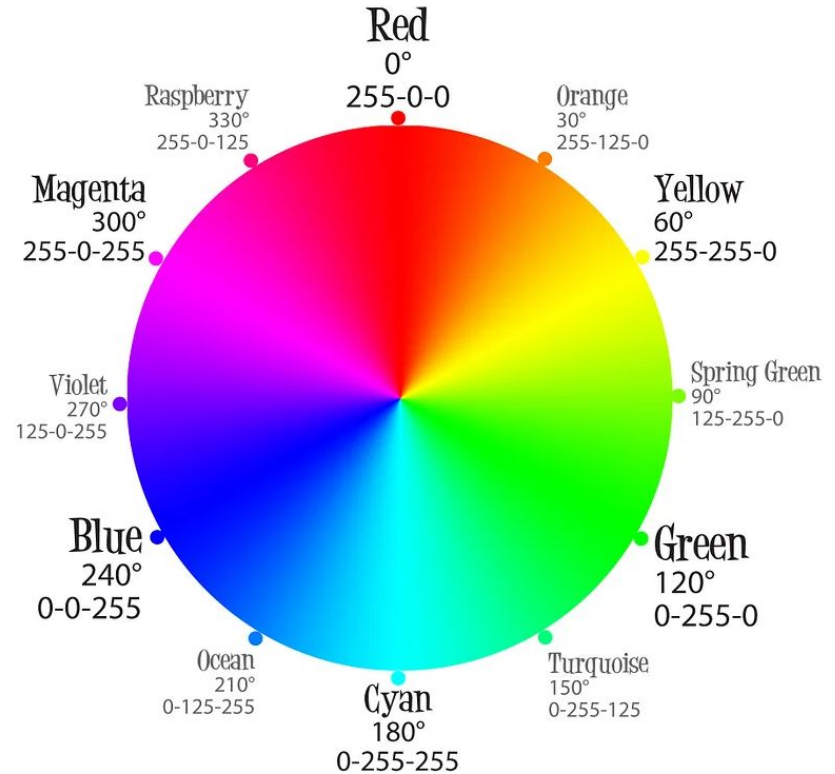
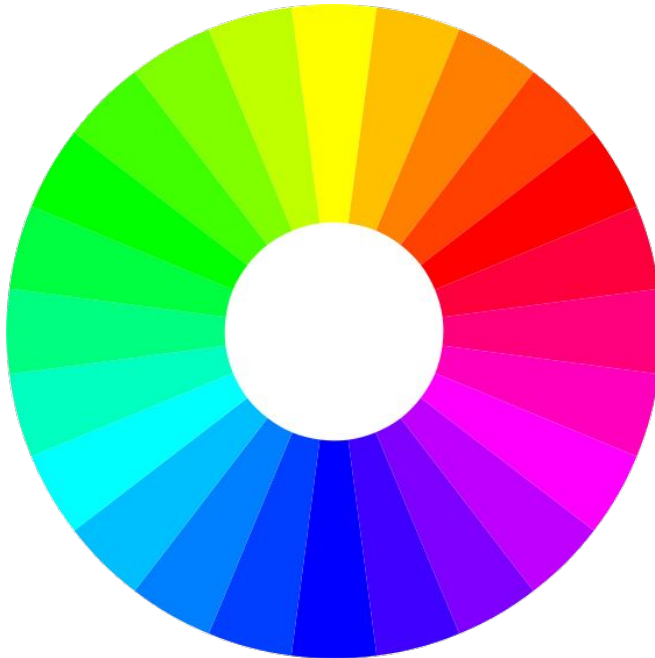
Color Sensor Telemetry

- matching Swatch and predominant color (set of RGB values)

A screenshot of a robot's telemetry interface. The top bar is green and says 'Robot Connected'. The top right shows network status: 'Network: <unknown ssid> Ping: 4ms - ch 40' and signal strength. Below this, there are sections for 'DS: 42%' with a battery icon, and a battery voltage section showing '12.05 V (12.04 V)'. On the left, there is a 'Practice Timer' set to '2:30' with a play button. In the center, there is a camera icon and the text 'C270 + QuickCam Pro 5000'. On the right, there is a 'DS preview on/off : 3 dots, Camera Stream' section and a 'Best Match: : RED R 255, G 114, B 92' section. At the bottom, there is a red bar with the text 'Concept: Vision Color-Sensor' and two white triangles pointing down.

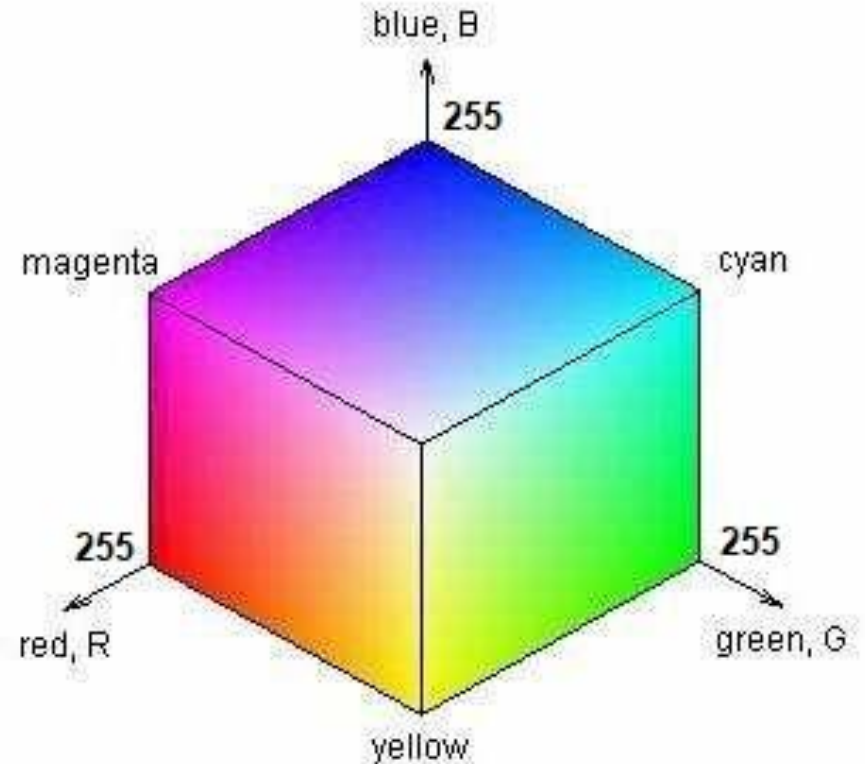
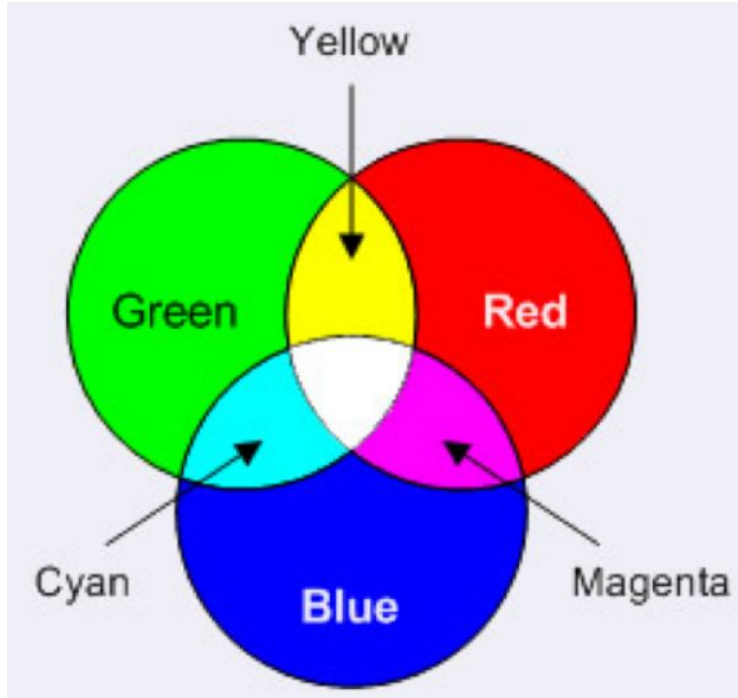
Camera as Color Sensor

Color Space "RGB" - color wheel



Camera as Color Sensor

Color Space "RGB" - 2D and 3D

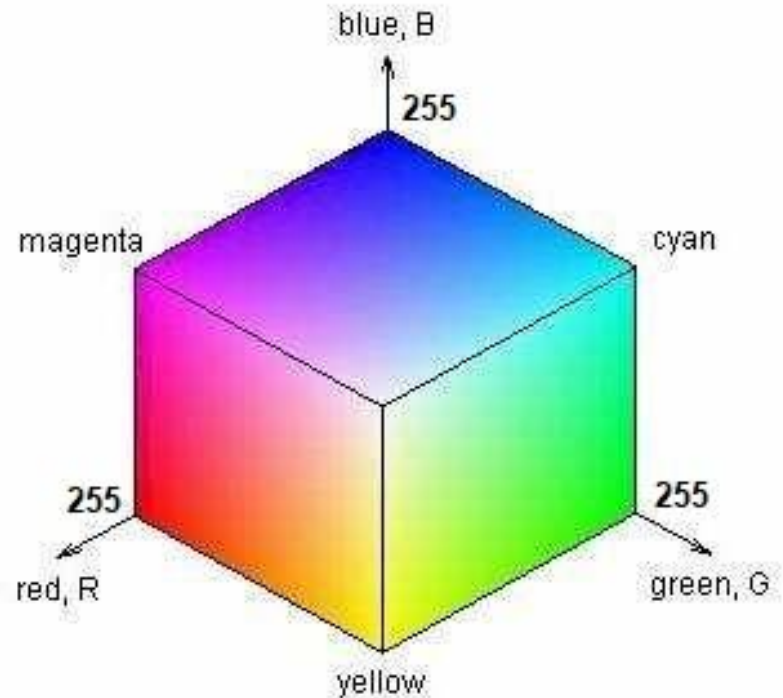


Camera as Color Sensor



In the RGB cube,
where is the color WHITE?

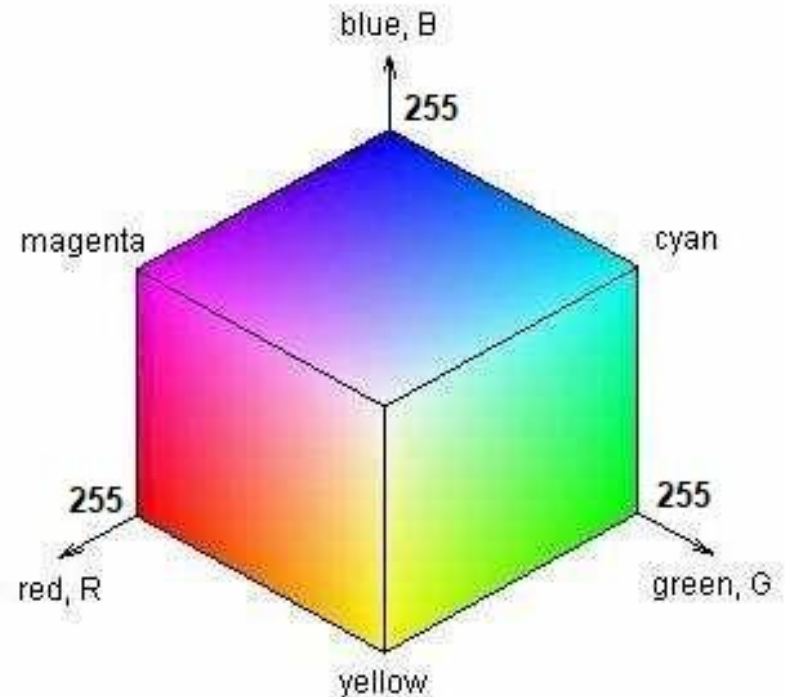
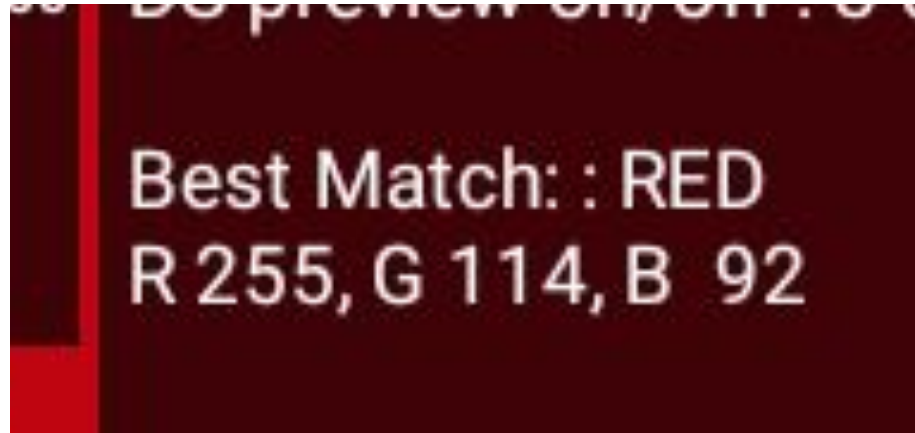
Where is BLACK?



Camera as Color Sensor

Where is this color in the RGB cube?

(maximum is 255)

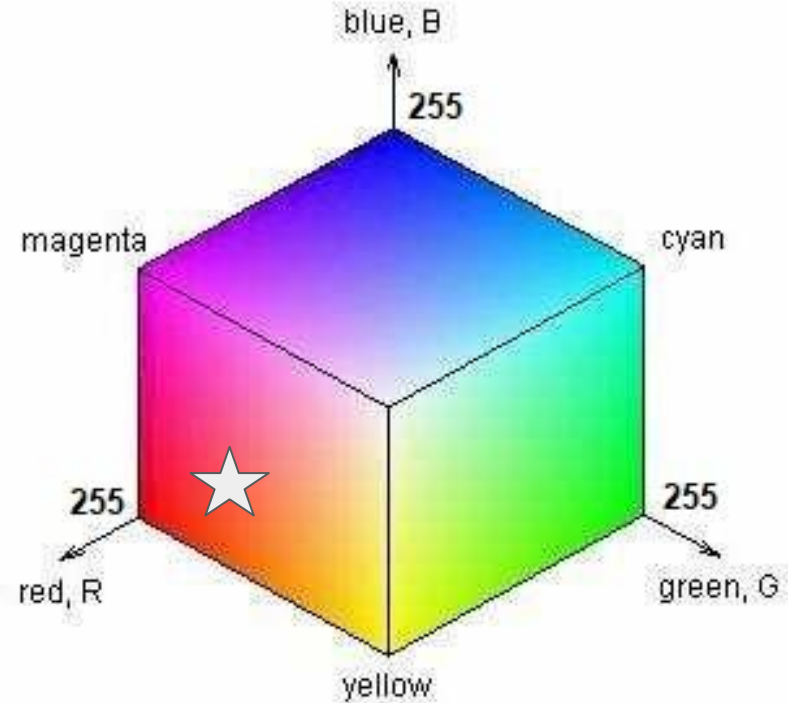
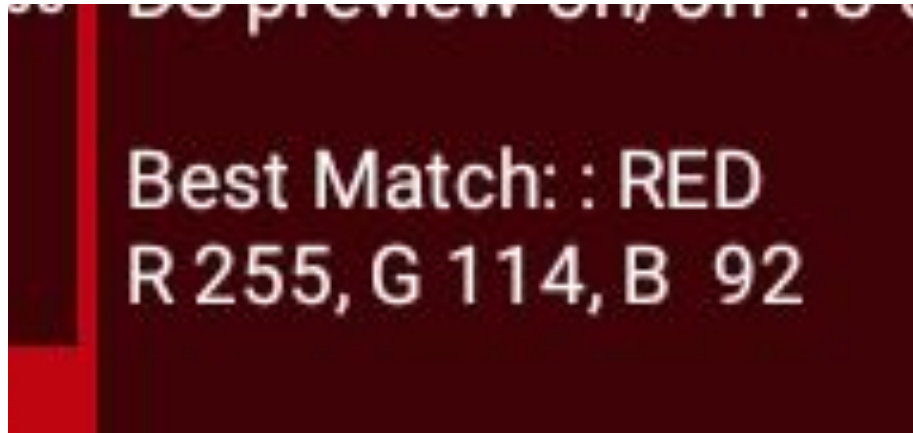


Camera as Color Sensor



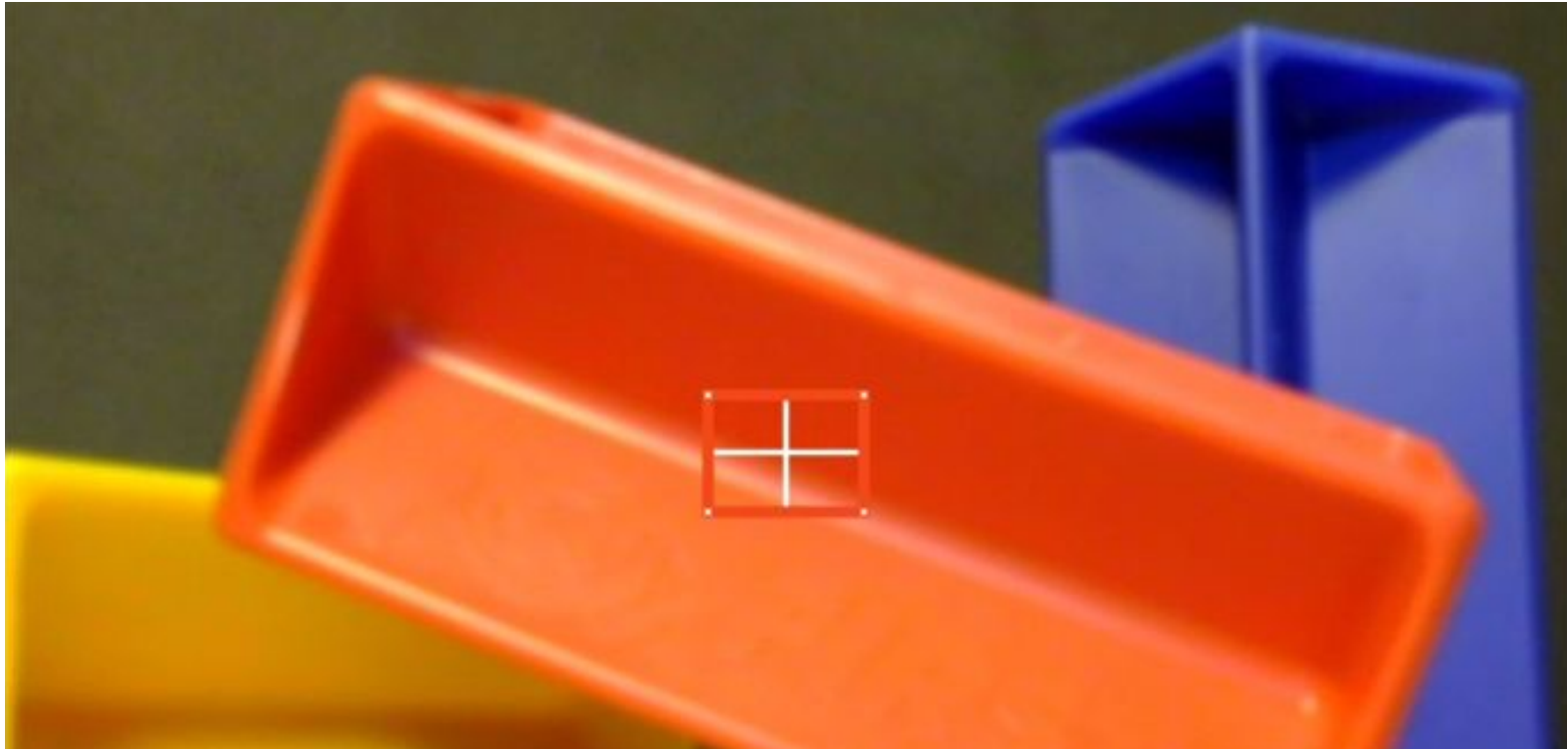
Where is this color in the RGB cube?

(maximum is 255)



Camera as Color Sensor

Color Sensor ROI - choose size & location based on expected camera view





Camera as Color Sensor

Color Sensor Summary

- identifies the single main color in the Region of Interest
 - as Swatch and RGB values
- depends on camera aim, and ROI size/location
- caution: might return the background color!

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Color Blob Detection

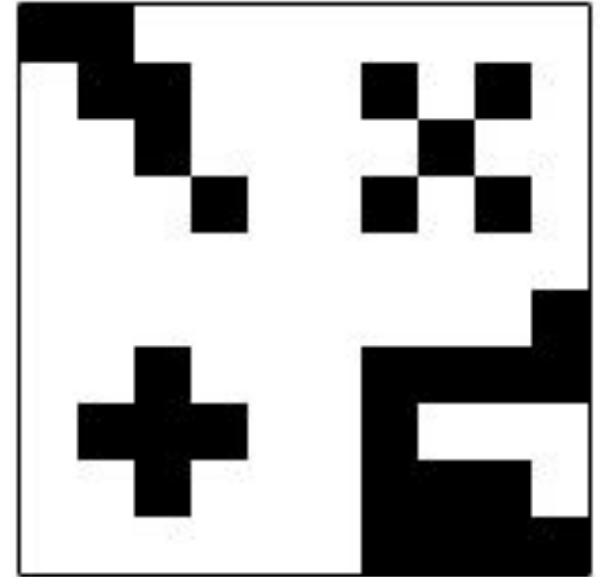


Color Blob Concepts



Blob: contiguous group of similar-colored **pixels**

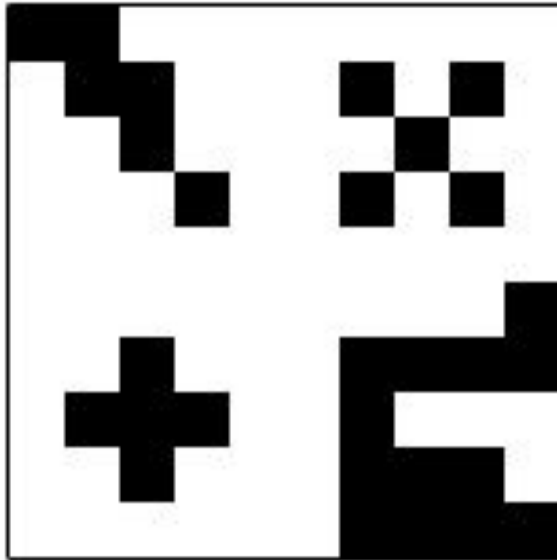
How many blobs of Black would be formed here?



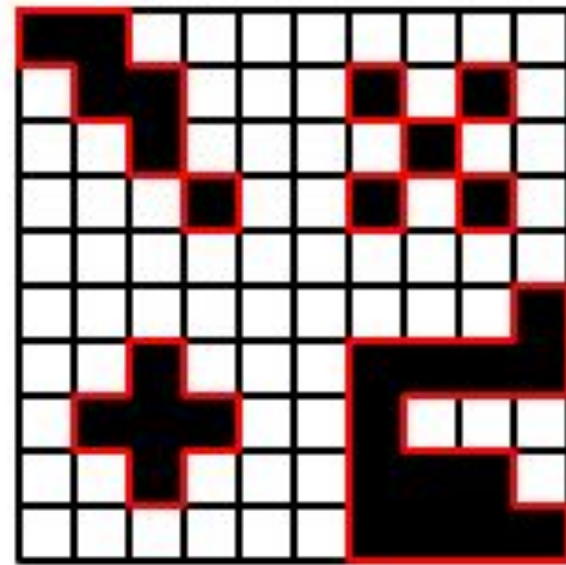
Original Image

Color Blob Concepts

Blob: contiguous group of similar-colored **pixels**



Original Image



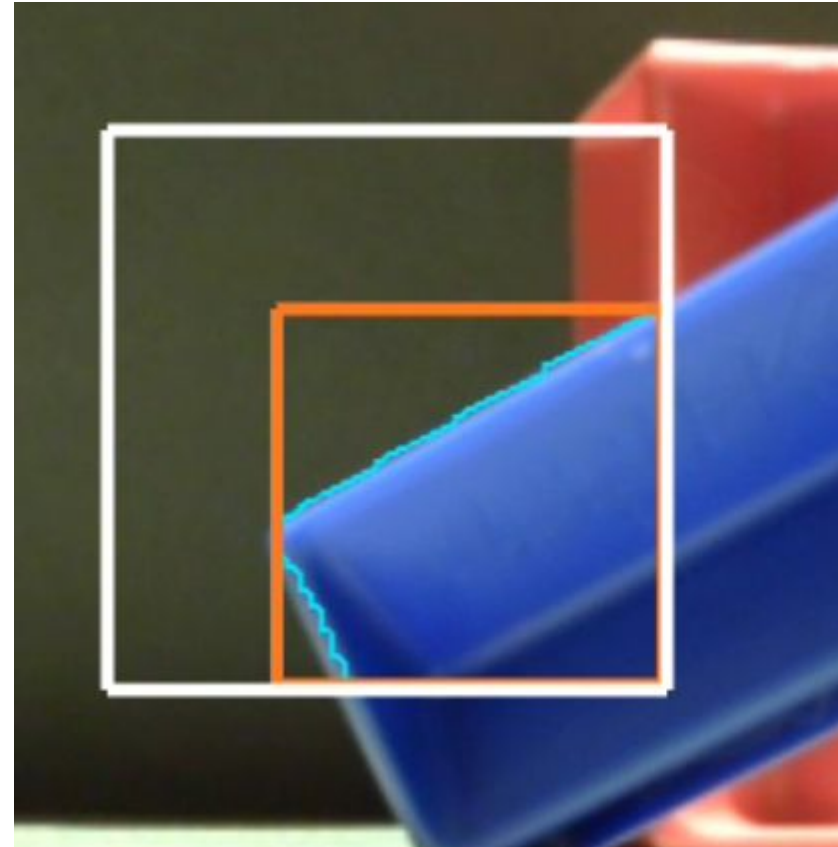
Blobs Selected

Color Blob Concepts

Working with OpenCV

- choose ROI and target color
- move camera, observe Blob formation

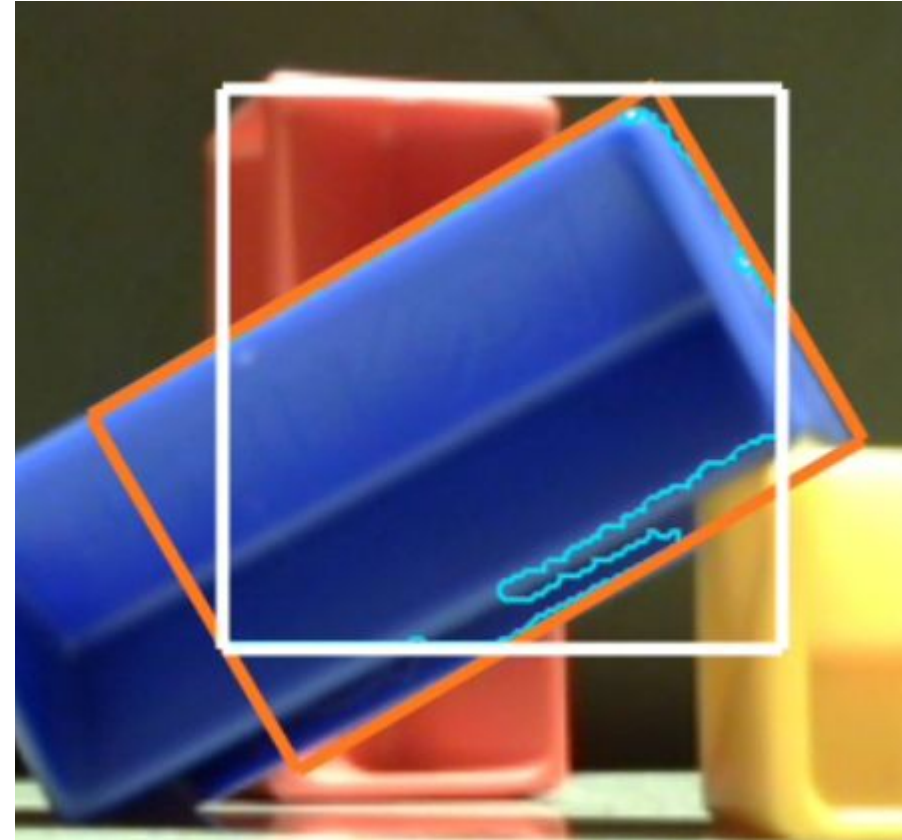
- white rectangle: Region of Interest (ROI)
- thin green line: contour (of Blob)
- red rectangle: bounding box ("fitBox")



Color Blob Concepts

Working with OpenCV

- contour is exact outline, often rough
- contour always inside ROI
- "fitBox" rectangle encloses contour
 - not constrained to ROI
 - can be tilted

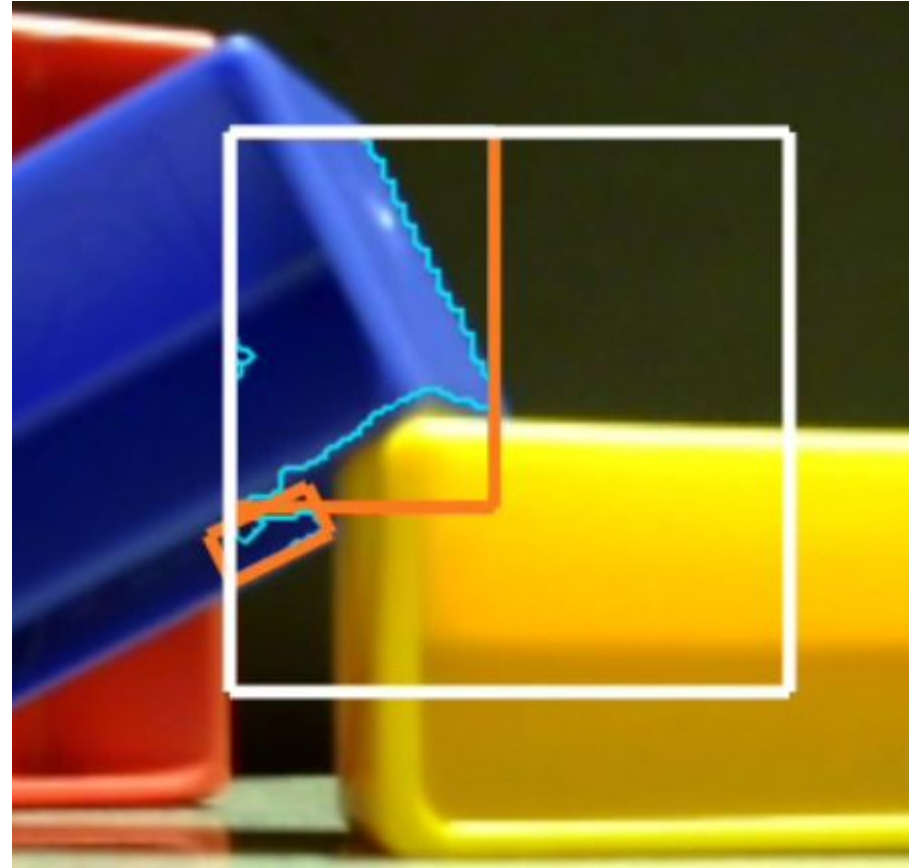


Color Blob Concepts

Working with OpenCV

- multiple blobs, contours, fitBoxes

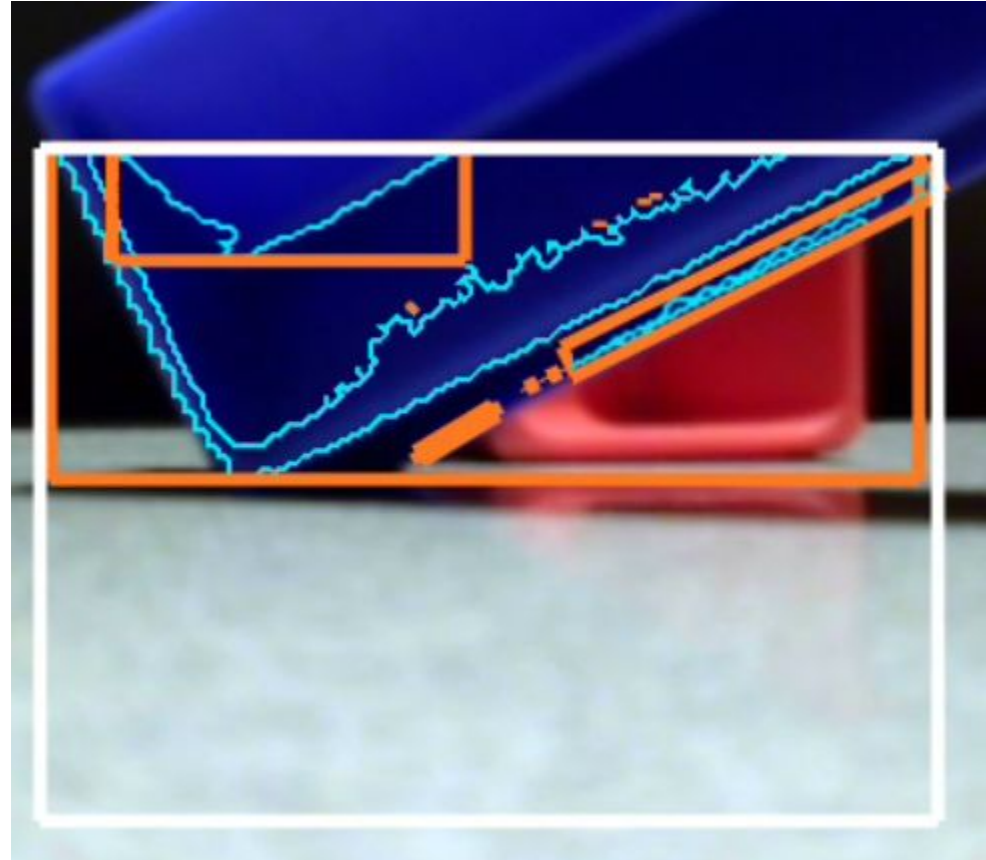
- which one(s) to evaluate?



Color Blob Concepts

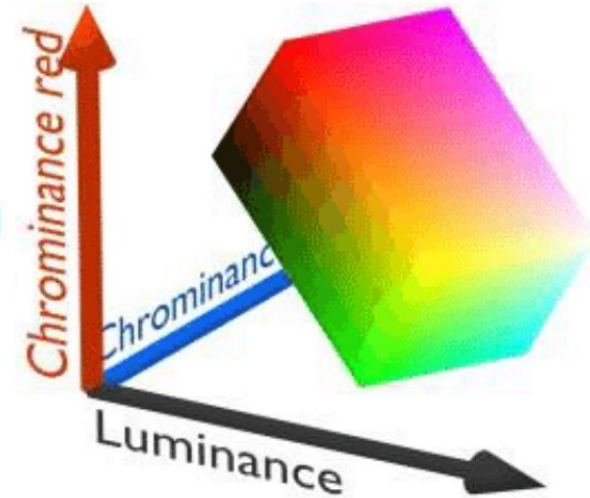
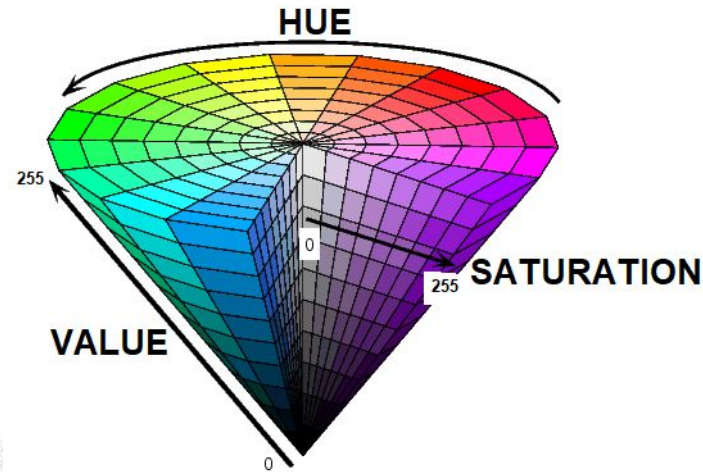
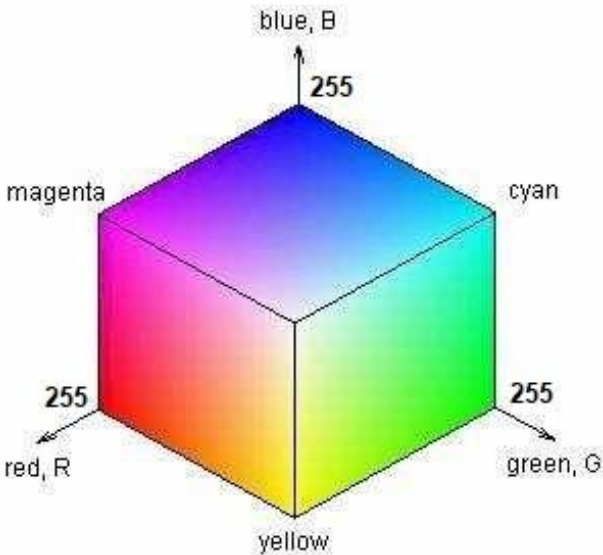
Working with OpenCV

- without controls, dozens of blobs can form
- which one(s) to evaluate?
 - ignore some?
 - prioritize the rest?



Color Blob Concepts

Color Spaces RGB, HSV, YCrCb



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Color Blob Detection

Consider a "Color Locator" process

- define a Region of Interest (ROI)
- select a target color
- use OpenCV to find Blobs of that color
- report the Blobs' shape and position

Color Blob Detection



Color Locator input

- two ways to specify target color: Swatch or values
- available Swatches: BLUE, RED, YELLOW and GREEN.
- range of color values, in one of these color spaces:

YCrCb, HSV, RGB

Color Blob Detection

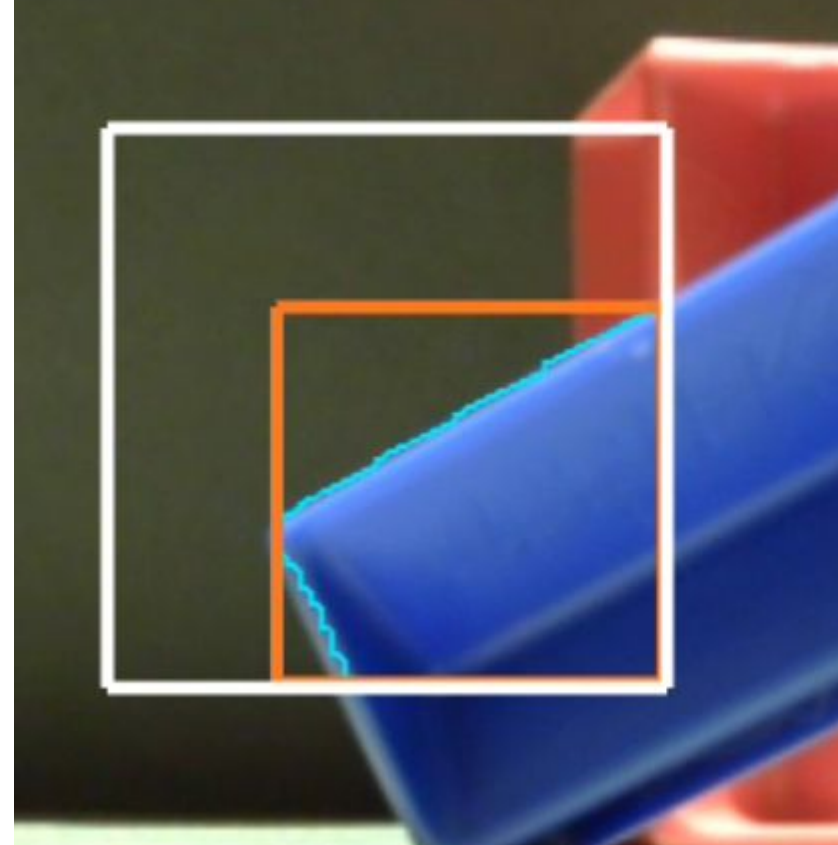


desired Color Locator output

- returns all Blobs of target color, only within ROI
- draws a preview of ROI, contours and bounding boxes
- provides tools to improve the raw data
- provides **fitBox** data

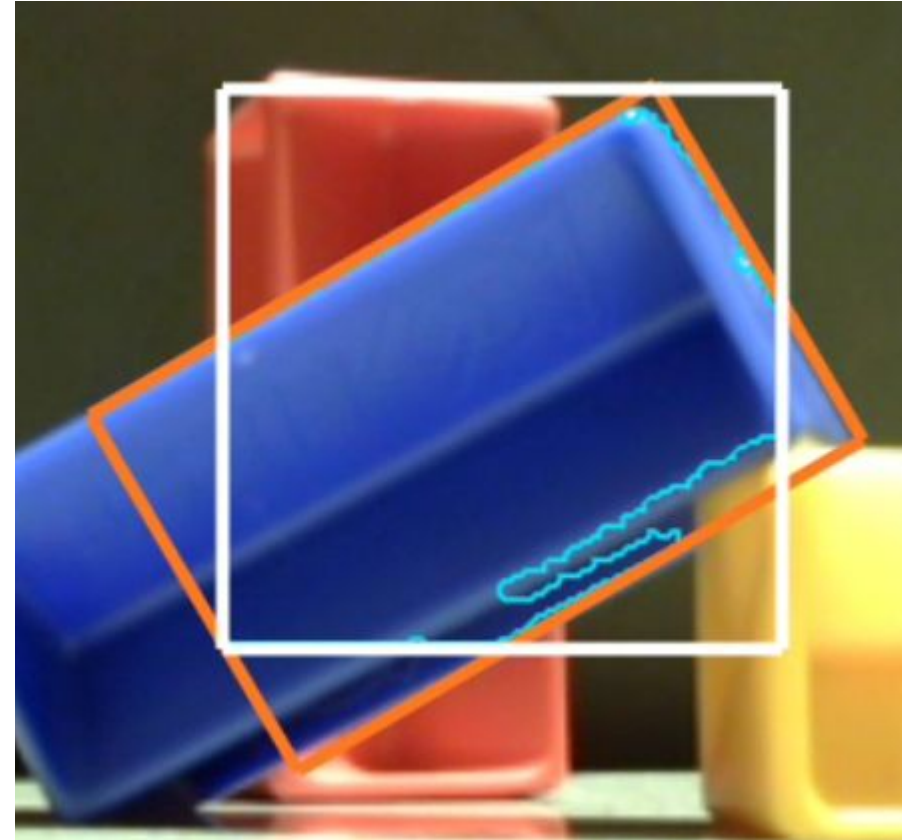
Color Blob Detection

- choose ROI and target color
- move camera, observe Blob formation
- white rectangle: Region of Interest (ROI)
- thin green line: contour (of Blob)
- red rectangle: bounding box ("fitBox")



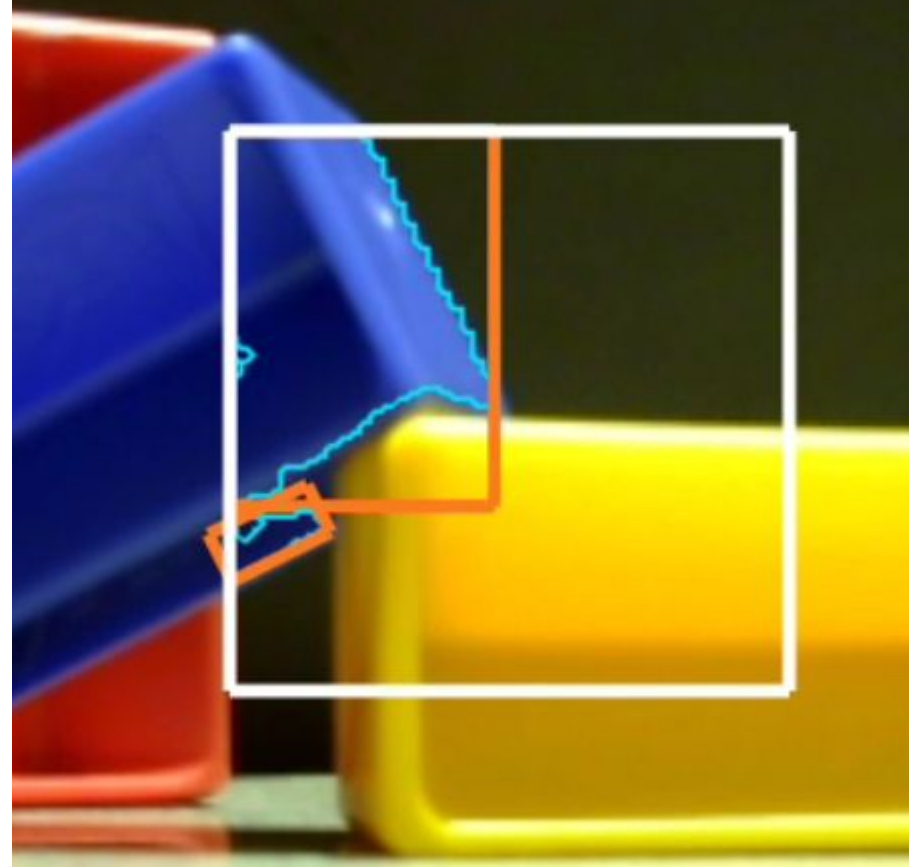
Color Blob Detection

- each blob has **fitBox** around contour
- may read fitBox **data**:
 - corners, size, position, angle



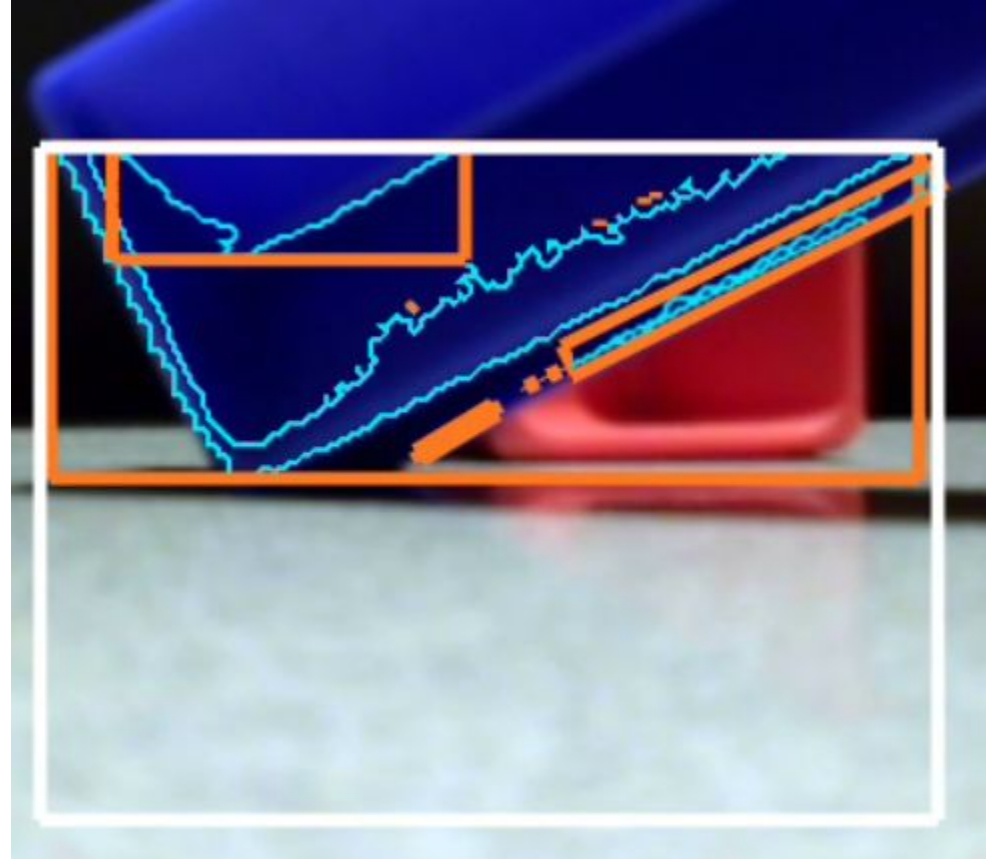
Color Blob Detection

- **multiple** blobs, contours, fitBoxes
- may **filter** contour results:
 - * Area (pixels)
 - * Density (% of convex hull area)
 - * AspectRatio (boxFit long / short side)



Color Blob Detection

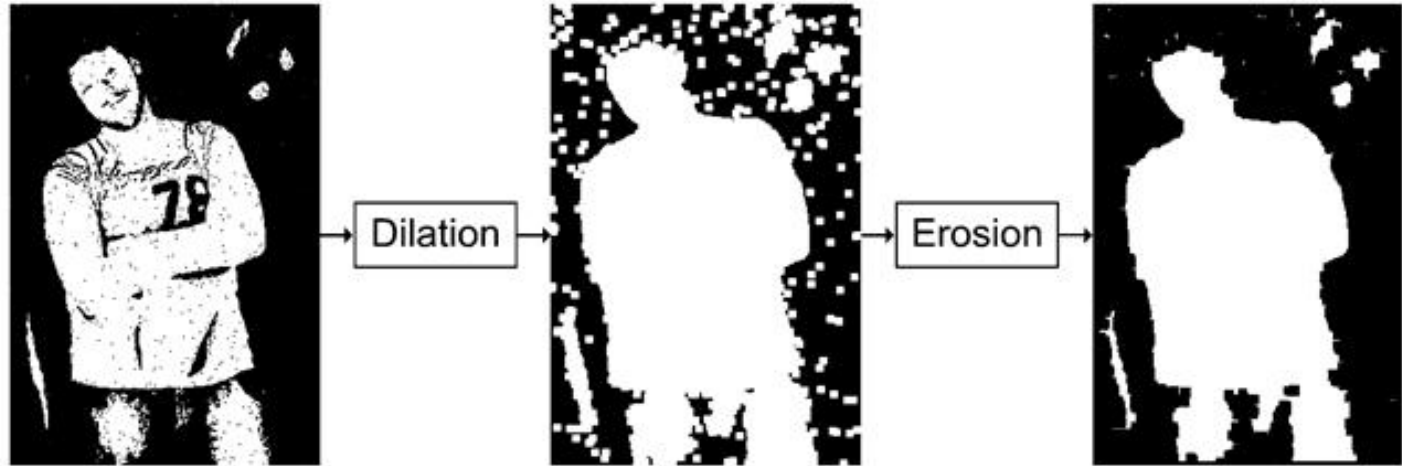
- without filtering, **dozens** of blobs can form
- may **sort** results by Area or Density or AspectRatio



Color Blob Detection

OpenCV also offers three advanced tools for pre-processing Blobs:

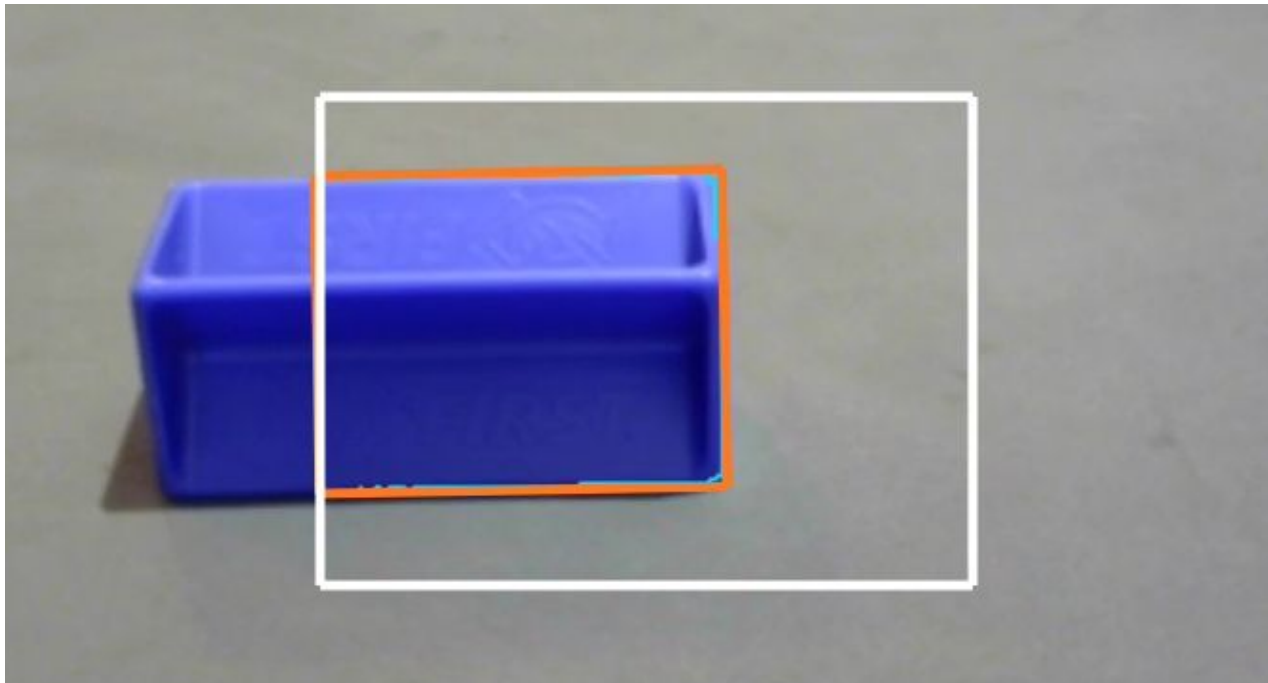
- Blur
- Erode
- Dilate



Color Blob Detection



Your intake is directly underneath your camera, looking forward. Would this fitBox (red rectangle) help line up the robot, to collect the Sample?

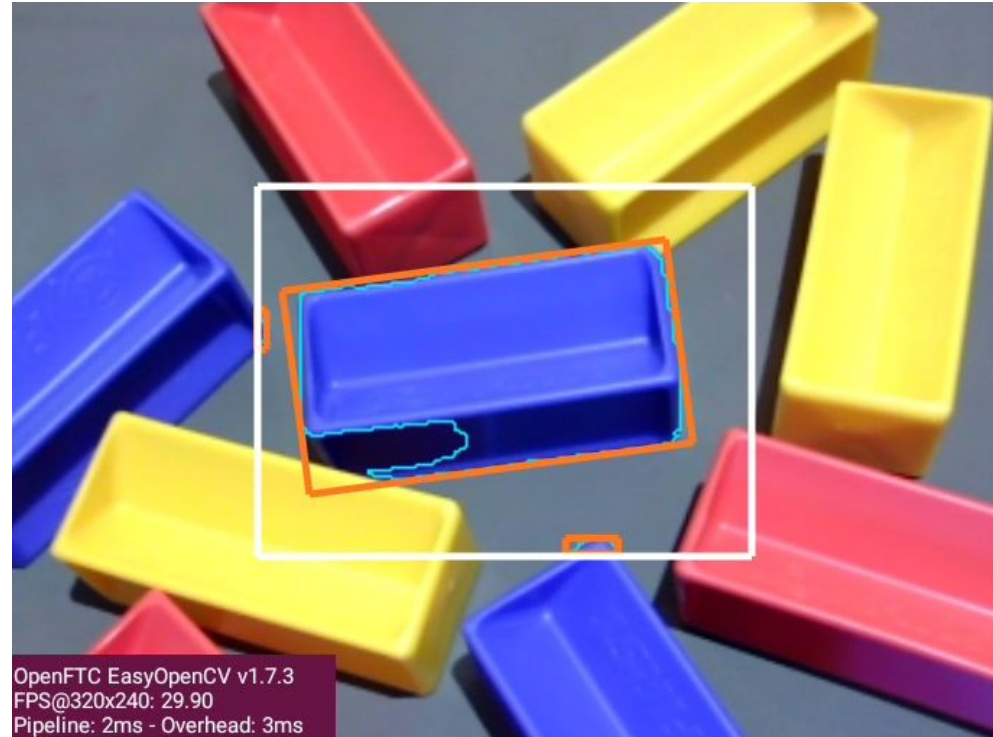


Color Blob Detection



Advanced teams: your webcam
is on an arm, looking down.

Would this fitBox (red rectangle)
help you grab the Sample?





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Best of luck this season!

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