# COMPUTER VISION
# INDUSTRIAL IOT

Software and Services Group
IoT Developer Relations, Intel

# MULTIPLE USAGES

## CAPTURE

- Acquire Data from Sensors
- Imaging pipeline
- Initial processing
- Encoding

## "MEDIA"

- Decoding
- Aggregation
- Muxing

## COMPUTER-VISION

- "Traditional' Visual Understanding
- Pre-Processing for Deep Learning

## DEEP LEARNING

- Inference using Deep Learning models
- Different models, tasks, for various models/topologies

## "OUTPUT"

- Generate Insights
- Render to Screen
- Alert
- Store

# CLEAR TRENDS

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LESS STORAGE REQUIRED

FASTER RESPOND TIME, MORE CONTROLLABILITY ON THE EDGE

LESS BAND-WIDTH

MORE ANALYTICS TO THE EDGE

# WHAT IS THE INTEL® CV SDK?

The Intel® Computer Vision SDK is a new software development package for development and optimization of computer vision and image processing pipelines for Intel System-on-Chips (SoCs).

- Intel-optimized implementation of the Khronos OpenVX 1.1 API
- Pre-built and fully-validated community OpenCV 3.3 binaries
- Vision Algorithm Designer (VAD)
- Deep Learning Model Optimizer tool
- Deep Learning Inference Engine

# KHRONOS GROUP

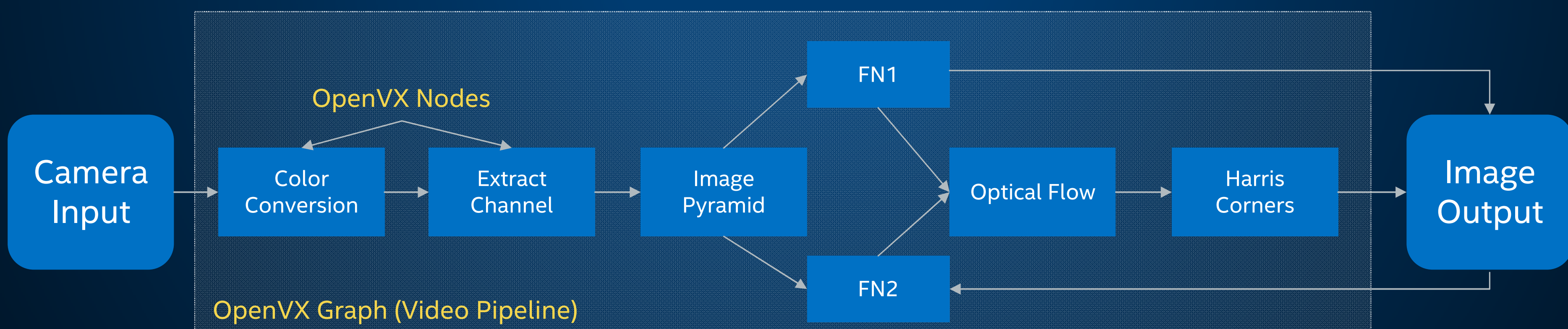
## Active Standards

COLLADA
DataFormat
EGL
glTF
NNEF
OpenCL
OpenGL ES
OpenGL
OpenGL SC
OpenVG
OpenXR
OpenVX
SPIR
SYCL
Vulkan
WebGL

# WHAT IS OPENVX*?

OpenVX* is about standardized, portable, power-efficient vision processing.

- Faster development of computer vision applications
- Better optimization via directed graph scheduling of image kernels/algorithms. Each graph node can run on a separate piece of hardware.
- OpenVX chooses which hardware to run each step of your computer vision graph (e.g. CPU, GPU, VPU).
- Smaller number of algorithms than OpenCV. However, Khronos maintains a conformance test suite that can validate a vendors OpenVX implementation.



# ALGORITHMS IN OPENVX* 1.1

- Absolute Difference
- Accumulate
- Accumulate Squared
- Accumulate Weighted
- Arithmetic Addition
- Arithmetic Subtraction
- Bitwise And
- Bitwise OR
- Box Filter
- Canny Edge Detector
- Channel Combine
- Channel Extract
- Color Covert
- Convert bit depth
- Custom Convolution
- Dilate Image
- Equalize Histogram
- Erode Image
- Fast Corners
- Gaussian Filter
- Harris Corners
- Histogram
- Image Pyramid
- Integral Image
- Magnitude
- Mean and Standard Deviation
- Media Filter
- Min Location
- Max Location
- Optical Flow Pyramid
- Phase
- Pixel-wise Mulitplication
- Remap
- Scale Image
- Sobel 3x3
- TableLookup
- Thresholding
- Warp Affine
- Warp Perspective

# OPENVX* VS. OPENCV*

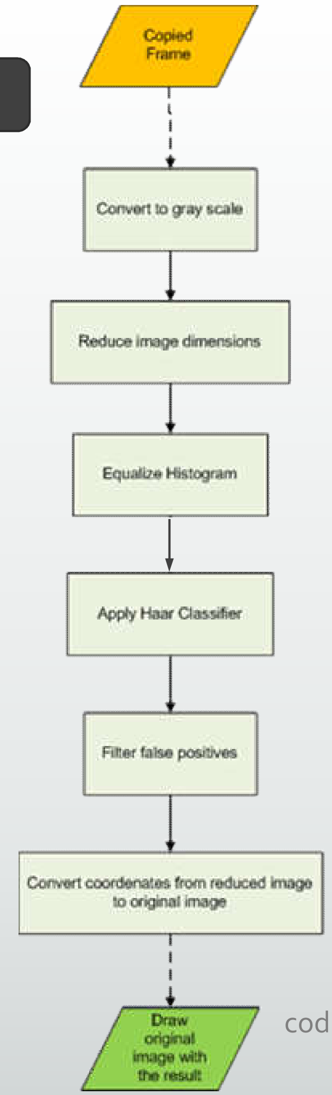
| | *OpenCV** | *OpenVX** |
|---|---|---|
| ***Implementation*** | Community driven open source library | Open standard API designed to be implemented by hardware vendors |
| ***Conformance*** | Extensive OpenCV Test Suite but no formal Adopters program | Implementations must pass defined conformance test suite to use trademark |
| ***Consistency*** | Available functions can vary depending on implementation / platform | All core functions must be available in all conformant implementations |
| ***Scope*** | Very wide 1000s of imaging and vision functions Multiple camera APIs/interfaces | Tight focus on core hardware accelerated functions for mobile vision – but extensible Uses external/native camera API |
| ***Efficiency*** | Memory-based architecture Each operation reads and writes to memory | Graph-based execution Optimizable computation and data transfer |
| ***Typical Use Case*** | Rapid experimentation and prototyping - especially on desktop | Production development & deployment on mobile and embedded devices |
| ***Embedded Deployment*** | Re-usable code | Callable library |

# OpenCV*

```
# python code snippets go here
```

- Open Source library for computer vision
- Written in C++
  - Bindings for most popular languages
- Block-like programming structure
  - Image data is sequentially passed through functions
  - Fundamental concepts allow for powerful image processing tools

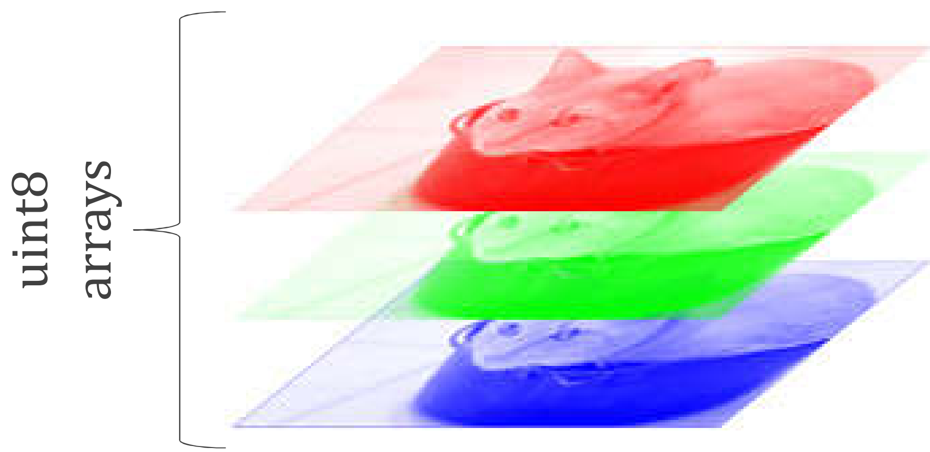
```
import cv2
import numpy as np
```




codingbox.com


# COMPUTER VISION ALGORITHMS

# Image Binary Representation




=

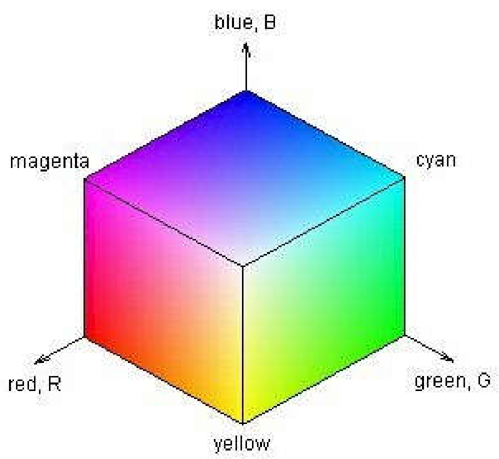
Cadin Batrack

```
img = cv2.imread( 'image.jpg') # open image
cv2.imshow( 'Title', img ) # show image
cv2.imwrite( 'image2.jpg', img ) # write image file
```

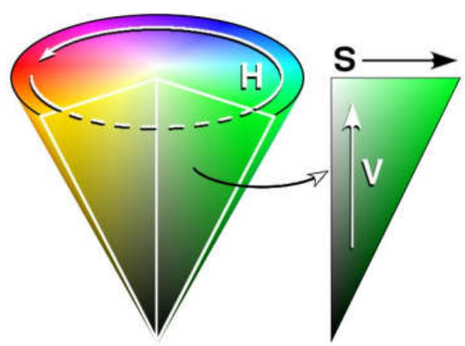
# Colorspaces

$$(Blue, Red, Green) \leftrightarrow (Hue, Saturation, Value) \rightarrow (Intensity)$$

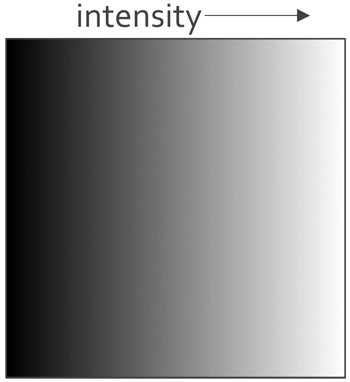
BGR




HSV




Grayscale

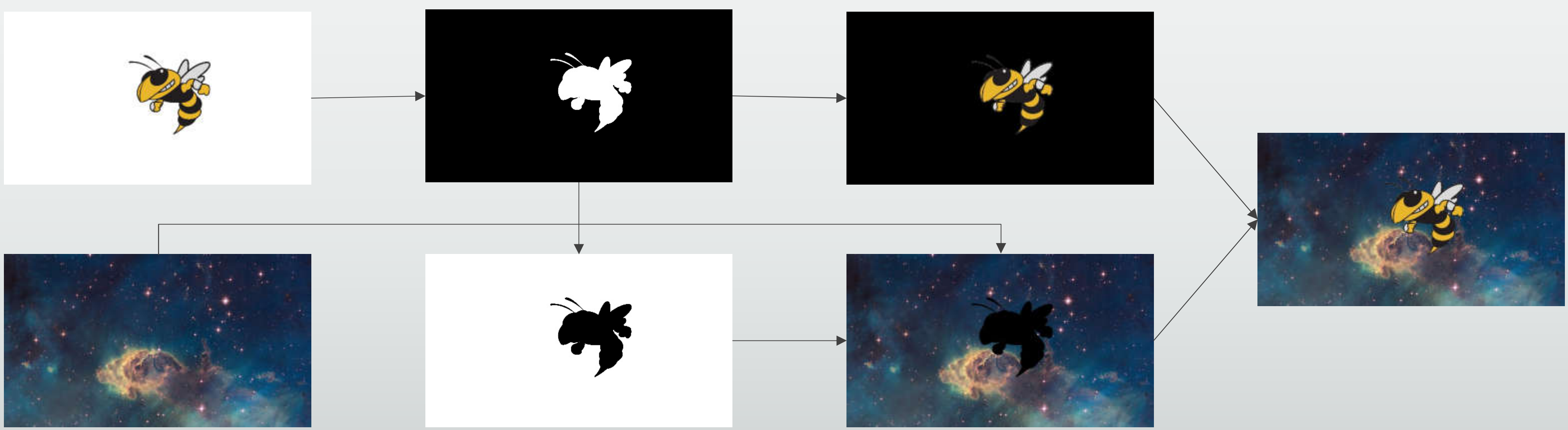



```
img2 = cv2.cvtColor( img, cv2.COLOR_BGR2HSV )
```

# Masking

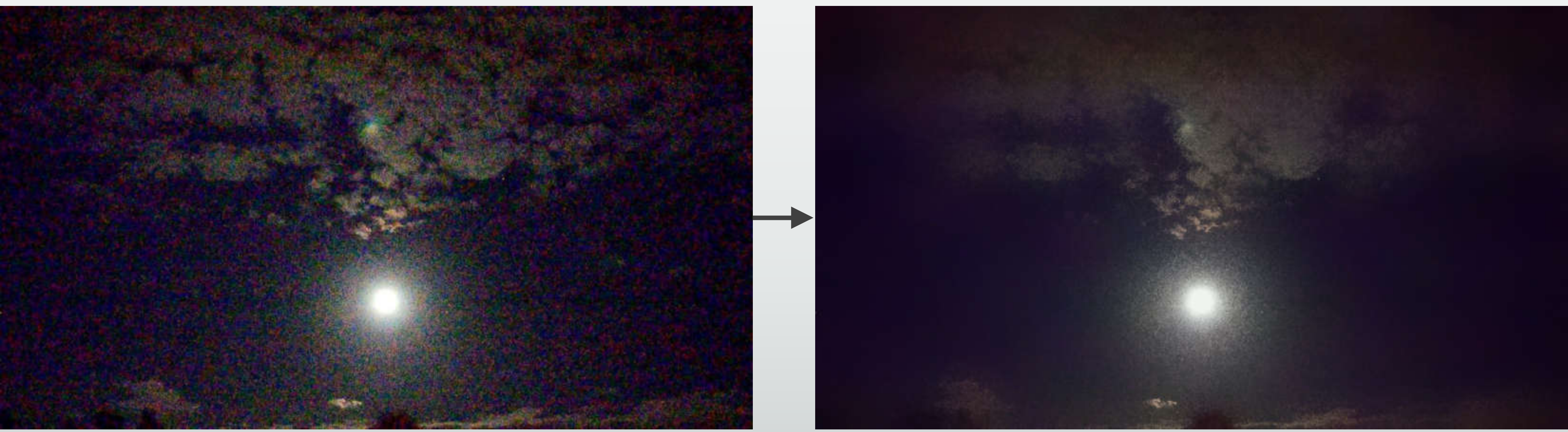
```
ret, thresh = cv2.threshold( single_channel, min_value , set_value_to, cv2.THRESH_BINARY )
mask = cv2.inRange( hsv_img, lower_color , higher_color )
cv2.bitwise_and( img, img, mask = mask )
```

inRange / threshold → Image Mask → Binary operations → Combine Image + Mask



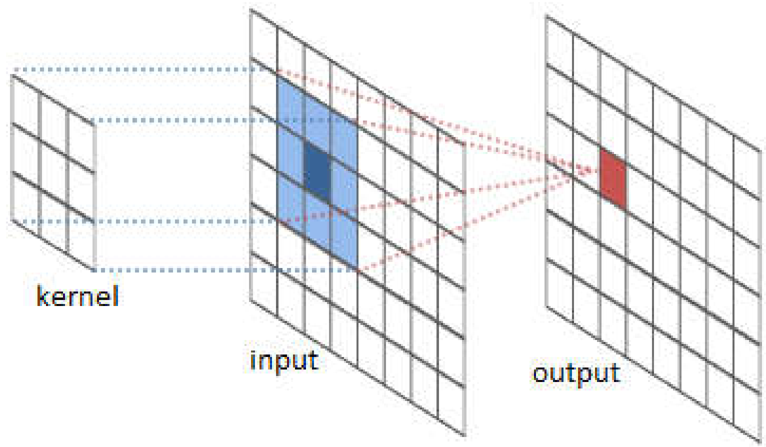
# Filtering

- Noise Removal (LPF)
- Sharpness increase (HPF)
- Operate on Kernel



# Filtering: Smoothing

- Uses 2D Convolution
- Blurring removes noise
- Kernel size determines blur amount
- Types:
  - Mean - *average*
  - Median – *less prone to outliers*
  - Gaussian – *applies Gaussian curve*
  - Bilateral – *blurs & preserves edges*

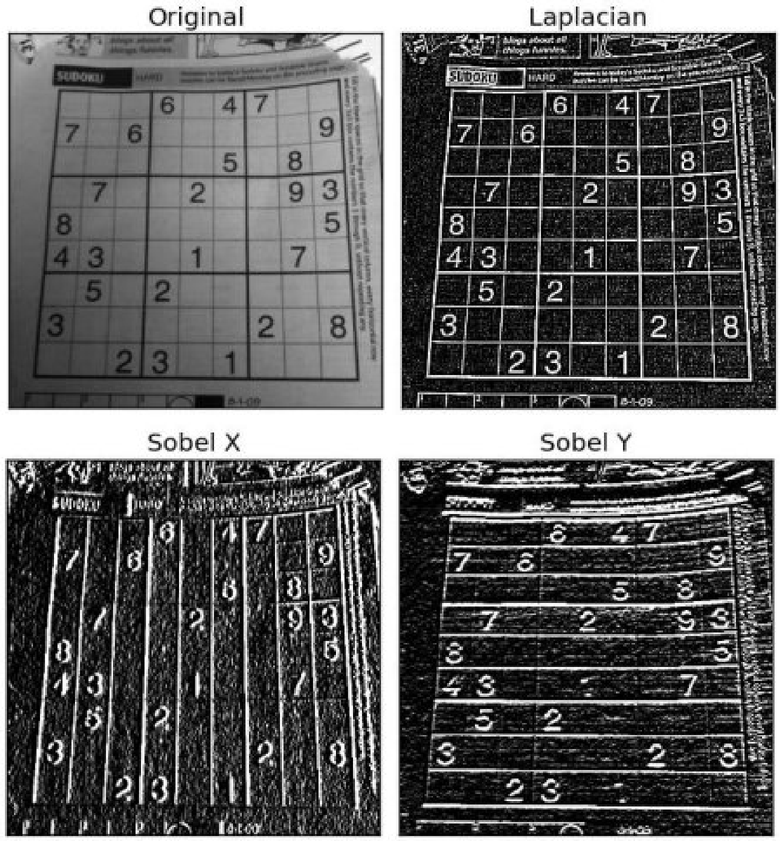



```
# 5x5 mean filter
kernel = np.ones( ( 5, 5 ) , np.float32 ) / 25
res = cv2.filter2D( img, -1, kernel )
```

# Filtering: Gradients

- High Pass Filters
- Used to find edges in an image
- Specify Kernel size
- Types:
  - Sobel – *directional derivatives*
  - Scharr – *better for smaller kernel*
  - Laplacian – *relation on Sobel derivatives*

```
laplace = cv2.Laplacian( img,  cv2.CV_64F )
sobelX = cv2.Sobel( img, cv2.CV_64F, 0, 1, ksize = 5 )
```




OpenCV Documentation

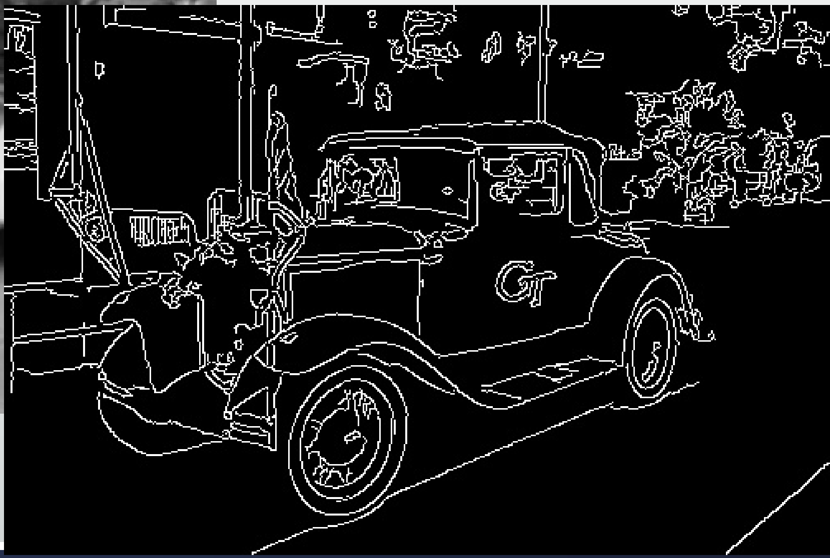
# Gradients for Canny Edge Detection

```
# 4x4 mean filter
kernel = np.ones( ( 4, 4 ) , np.float32 ) / 16
wreck= cv2.filter2D( img, -1, kernel )

# apply canny edge detection
edges = cv2.Canny( wreck, 0, 200 )
```

Original

Smoothed

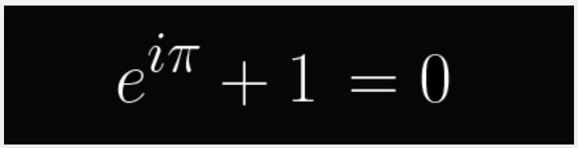
Canny

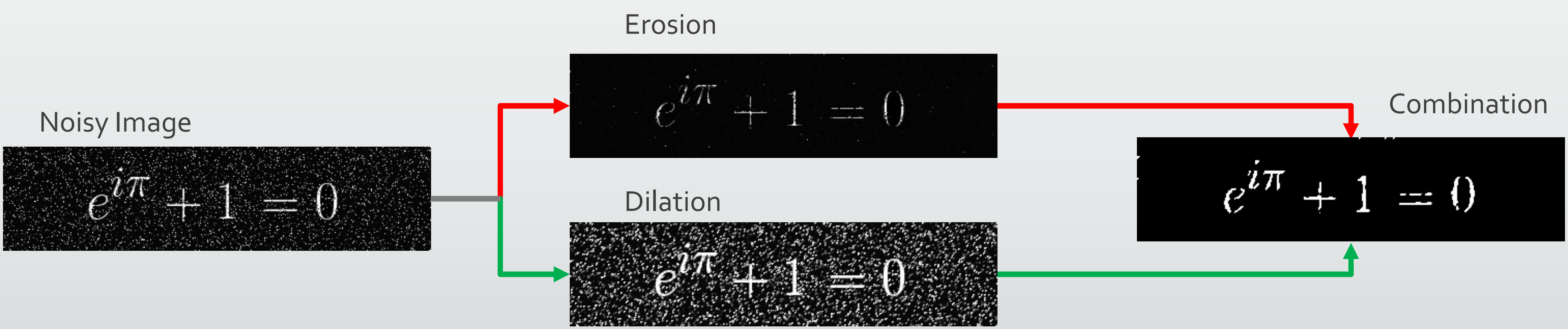


# Filtering: Morphological Transformations

```
kernel = np.ones( ( 5, 5 ) , np.float32 ) / 25
erosion = cv2.erode( img, kernel,  iterations = 1 )
dilation = cv2.dilate( img, kernel,  iterations = 1 )
opening = cv2.morphologyEx( img, cv2.MORPH_OPEN, kernel )
closing = cv2.morphologyEx( img, cv2.MORPH_CLOSE, kernel )
```

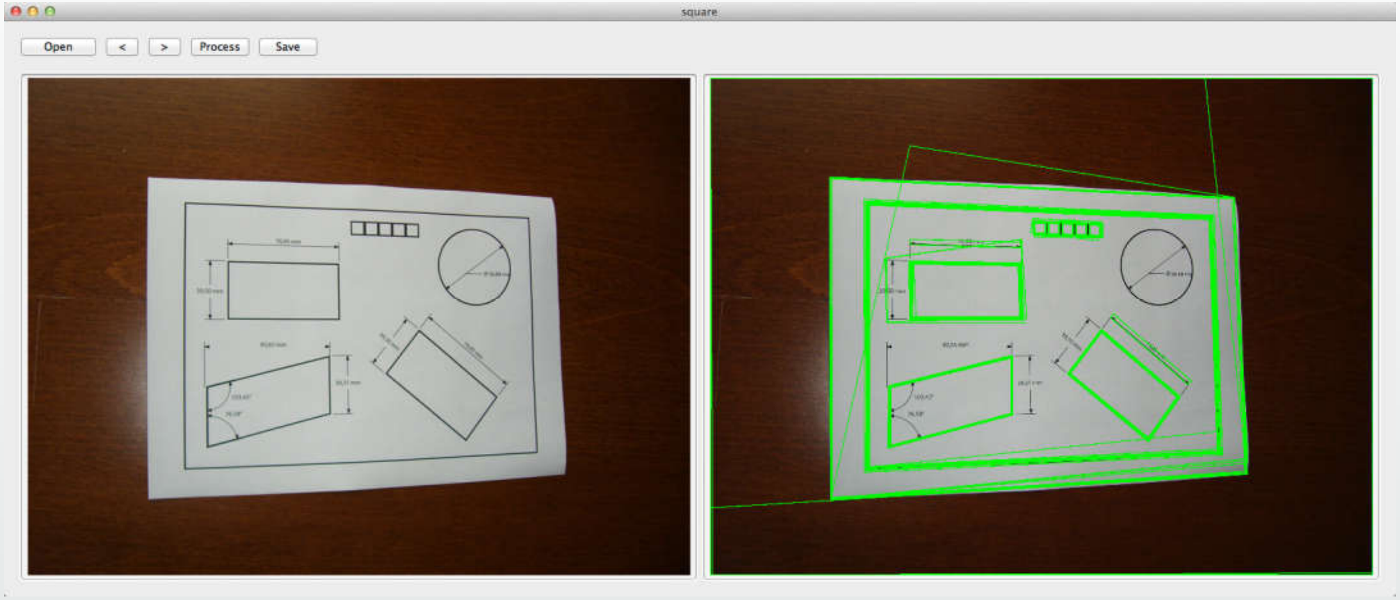
Original



# Contours

- Join all continuous points along boundary
- Detect from logical mask
- Contour hierarchies allow selection of a contour based on its relation to others



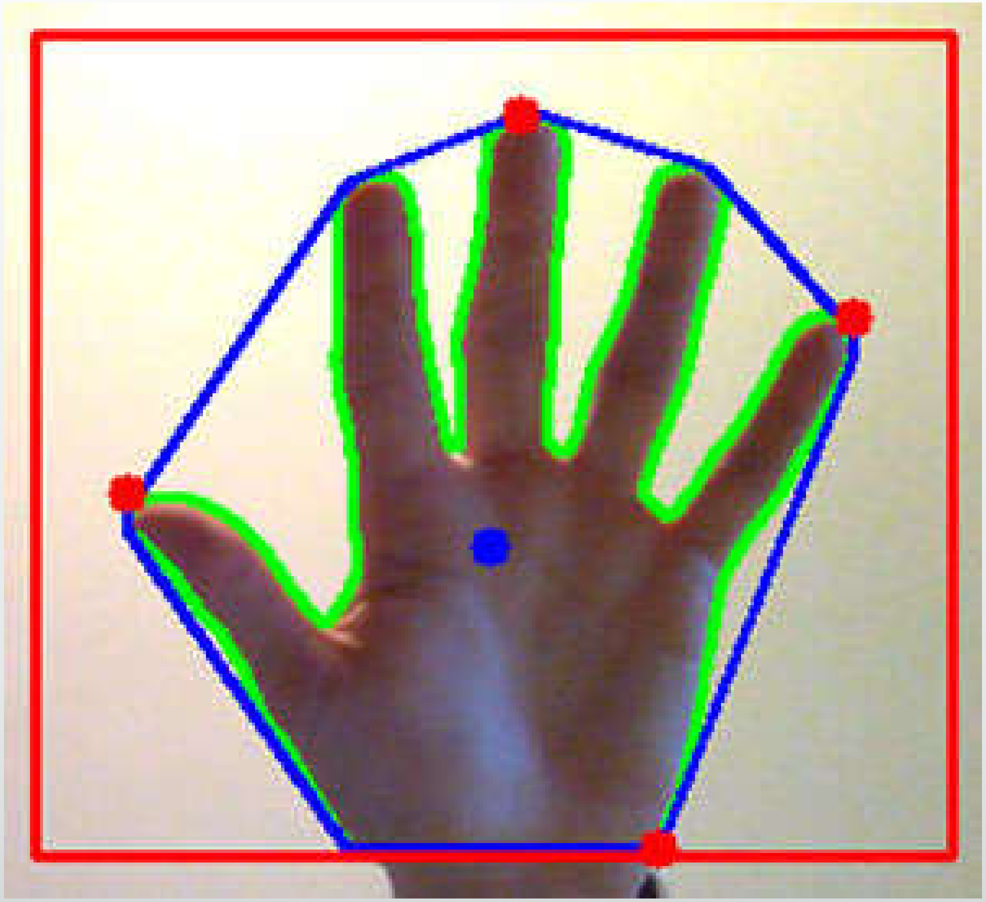

```
img2, contours, hierarchy = cv2.findContours( mask, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE )
cv2.drawContours( img, contours, contour_number, ( 0, 255, 0 ), thickness )
```

# Contour Functions

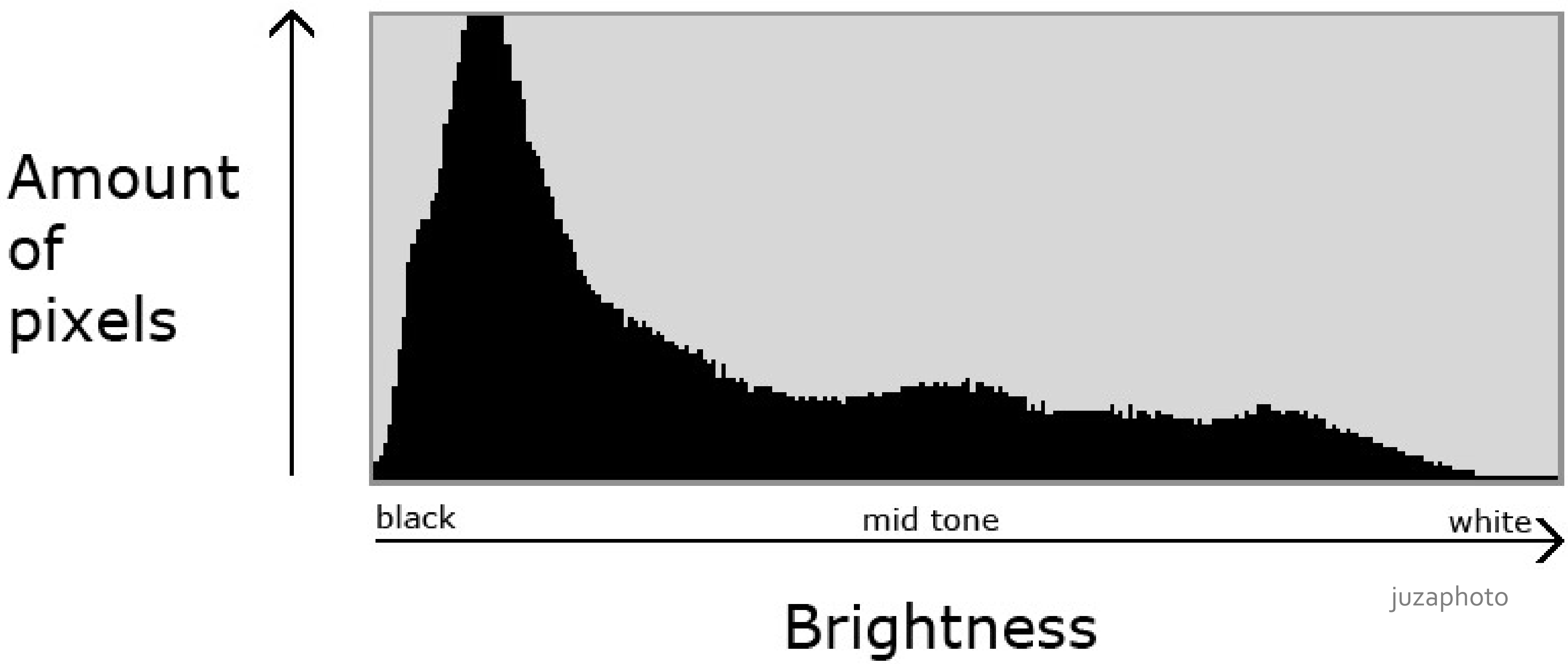
Contours can be mathematically analyzed

OpenCV functions give:

- Moments & Centroids
- Area & Perimeter
- Convex hulls
- Bounding Rectangles
- Fit curves & shapes
- Outermost points
- Shape Matching

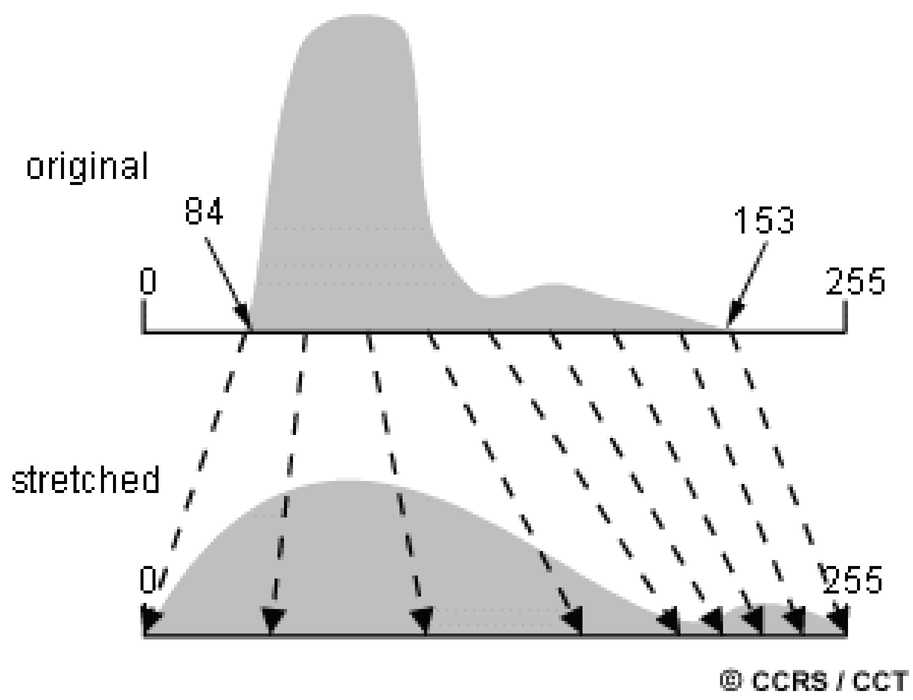


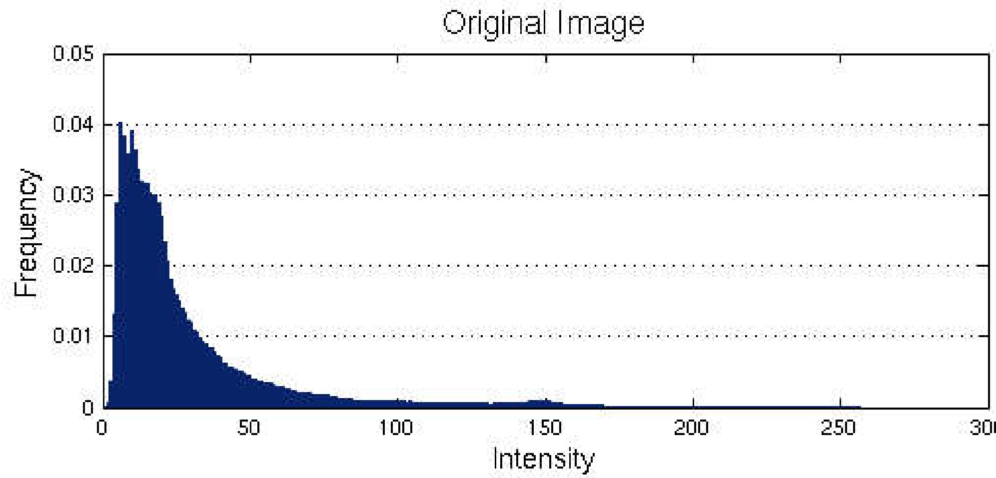
# Histogram: $intensity \rightarrow frequency$

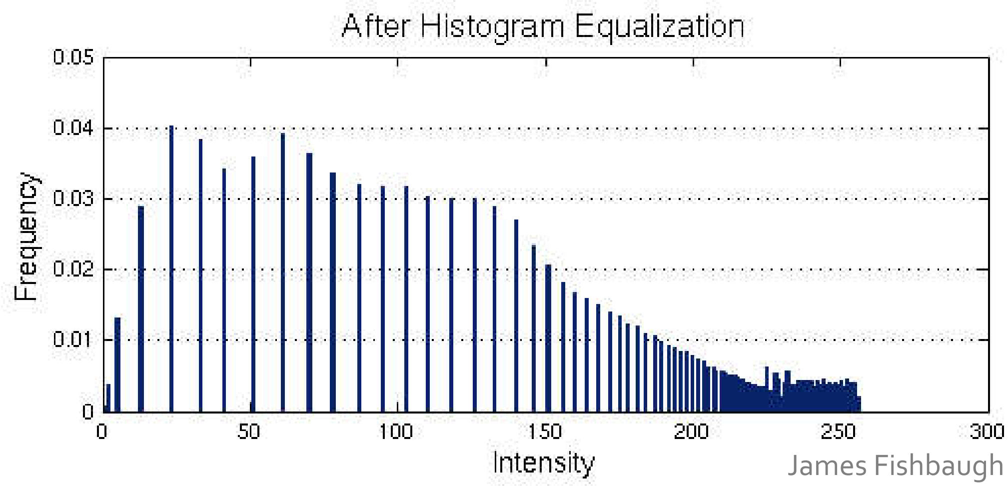



```
hist = cv2.calcHist( [img], [channel], mask, [number_bins], [min_val, max_val] )
```

# Histogram Equalization



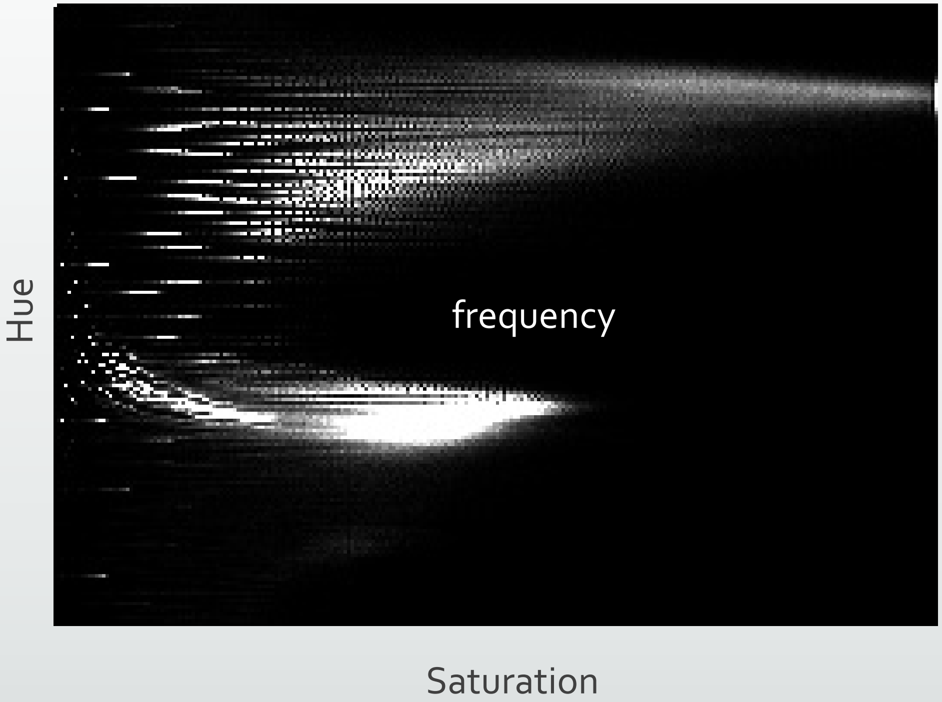



James Fishbaugh

```
eq = cv2.equalizeHist( img )
```

# 2D Histogram: $(hue, saturation) \rightarrow frequency$

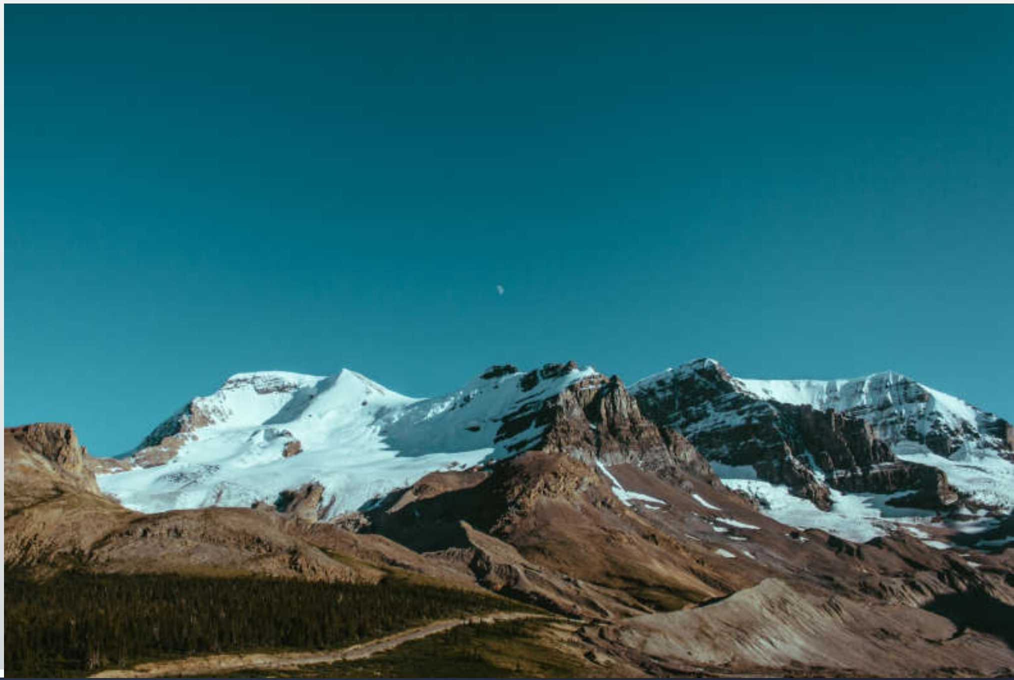



```
hist = cv2.calcHist( [img], [0, 1], mask, [180, 256], [0, 180, 0, 256] )
```

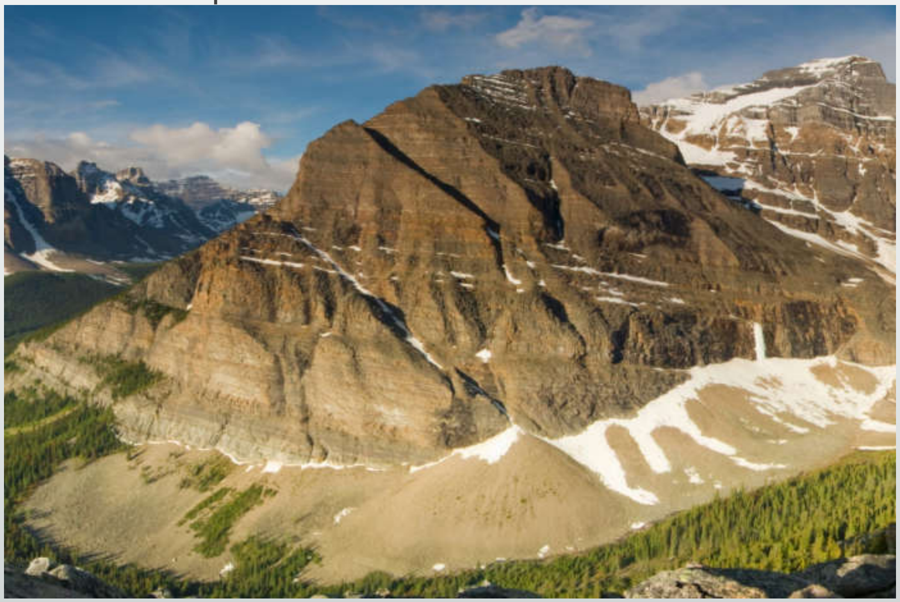
# Histogram Backprojection

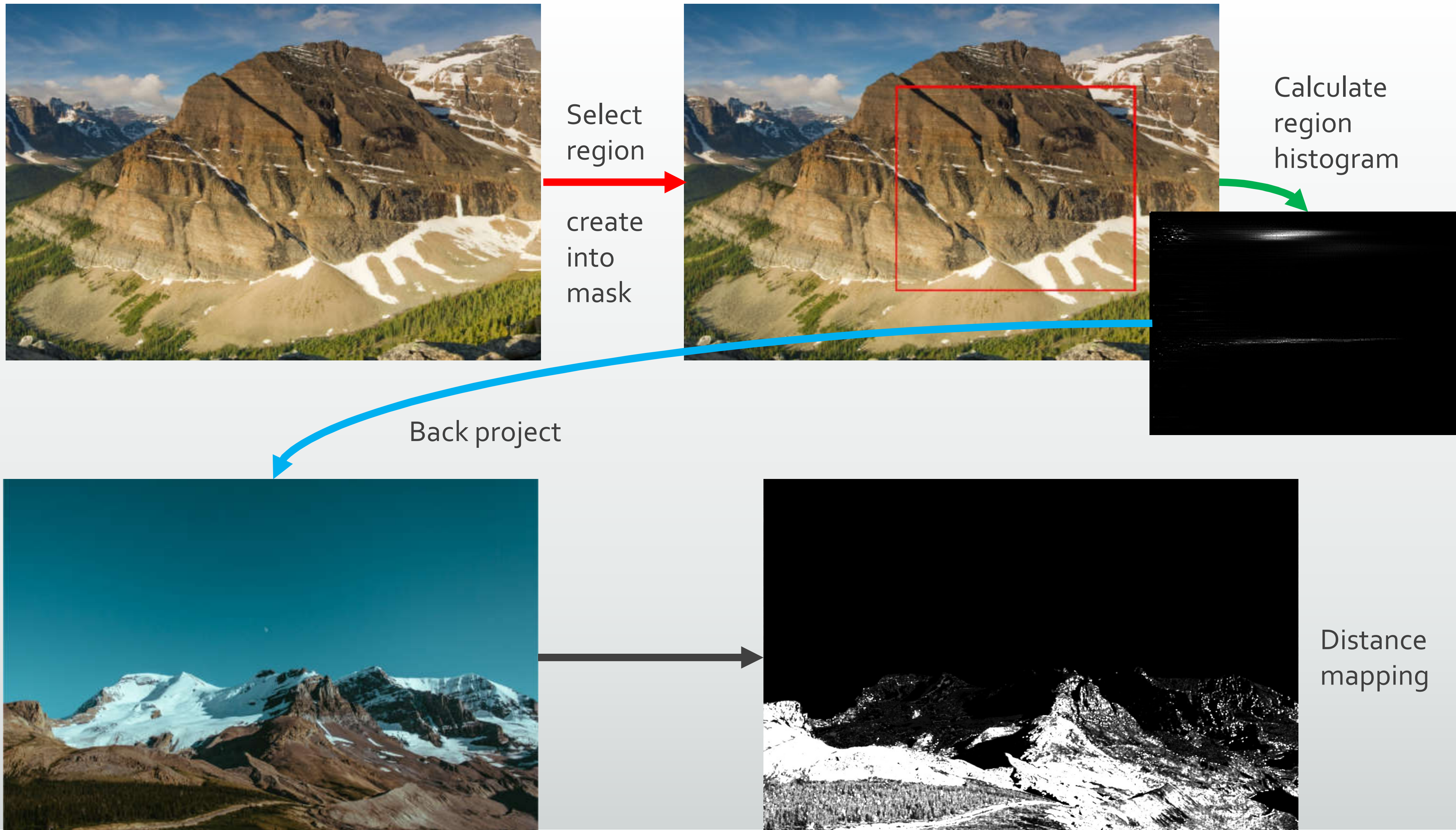
- Returns similarity of pixels in image region to the histogram
- Useful for object detection

Find similar mountains

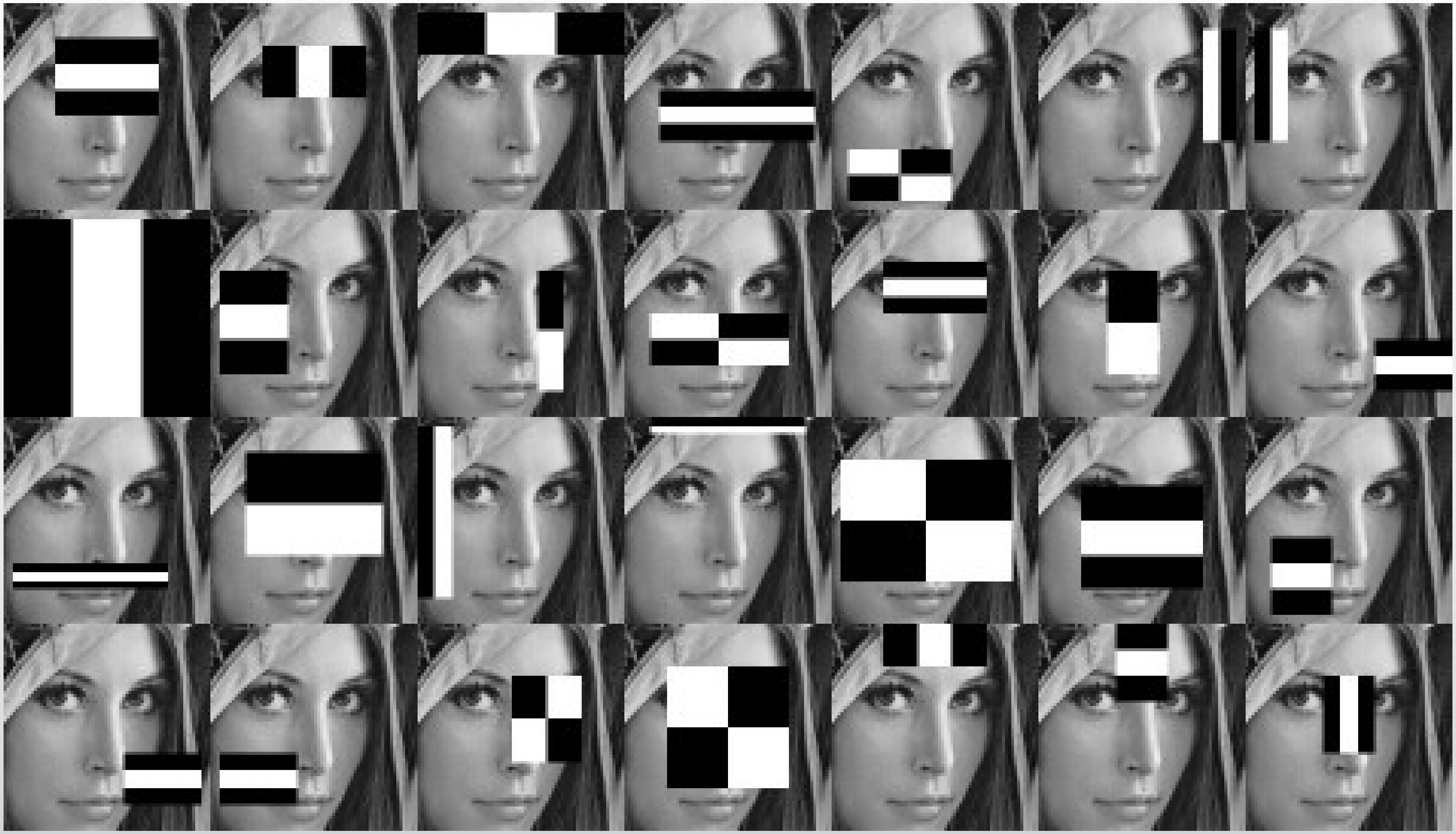


Example of a mountain

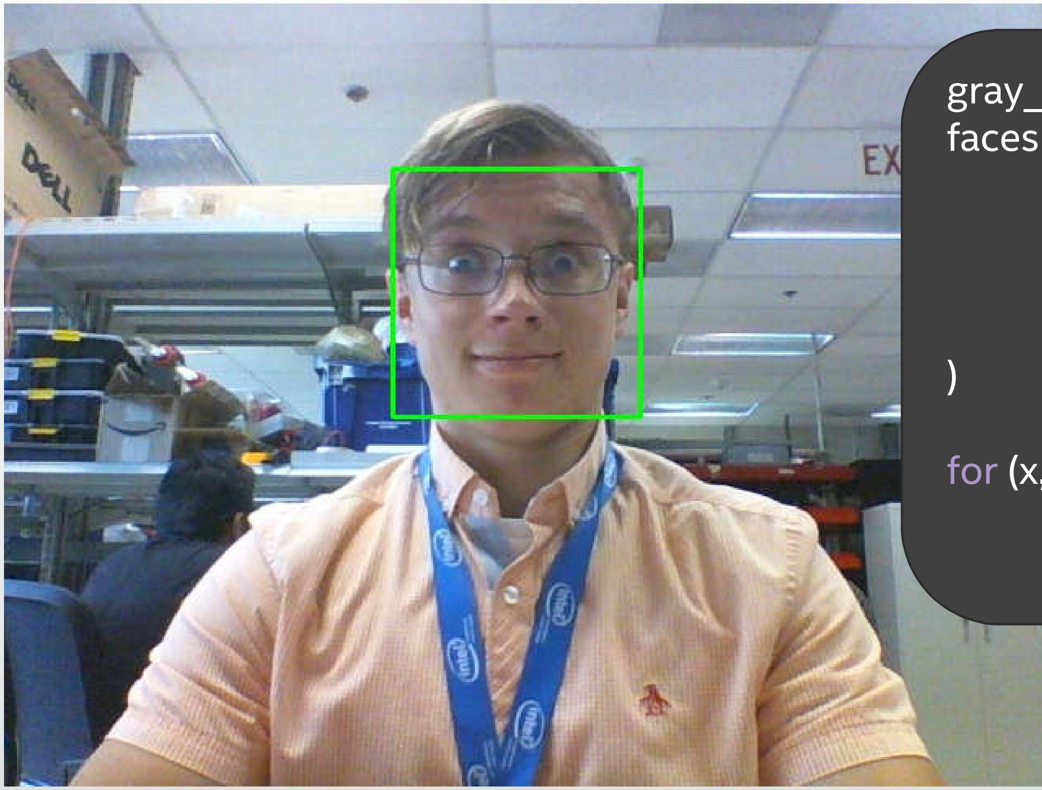



Select region
create into mask
Calculate region histogram
Back project
Distance mapping

# Haar Cascades & Classifiers



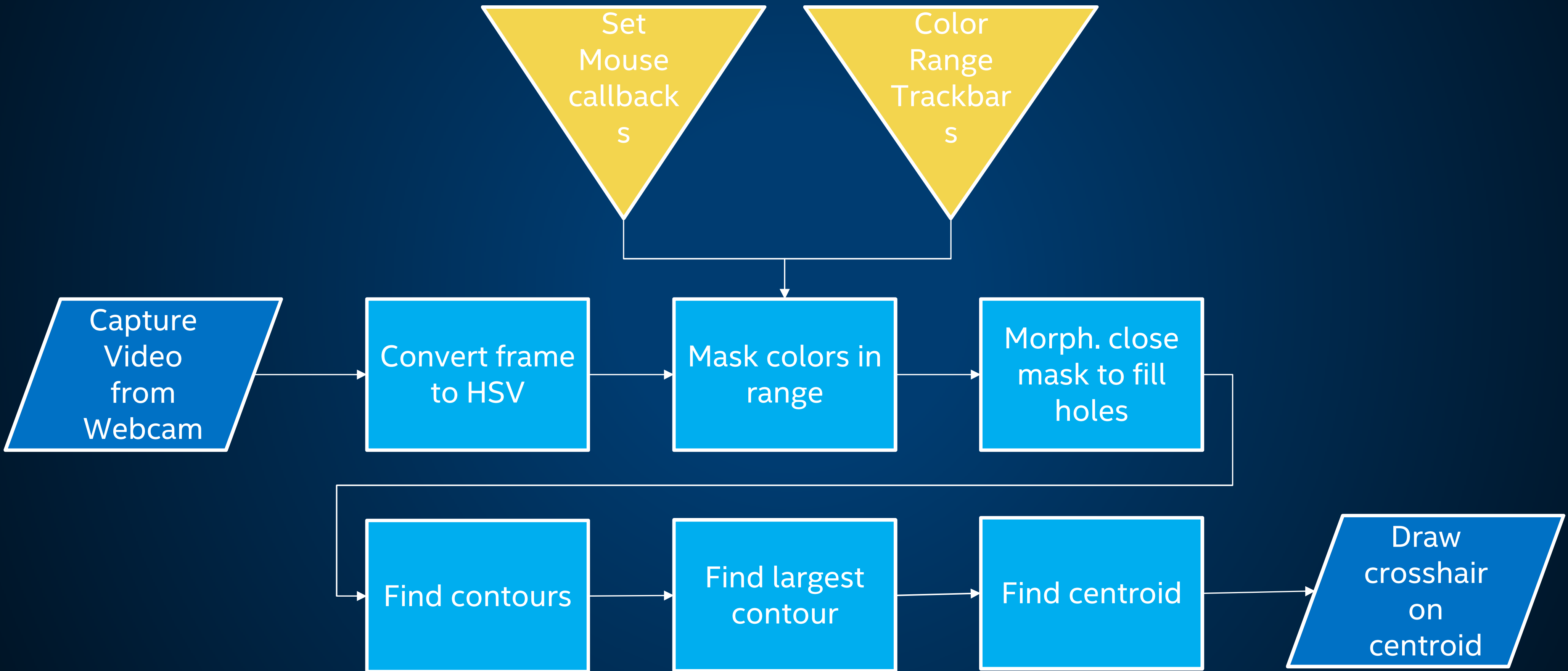
```
cascade = cv2.CascadeClassifier( 'haarcascade_frontalface_default.xml' )
```



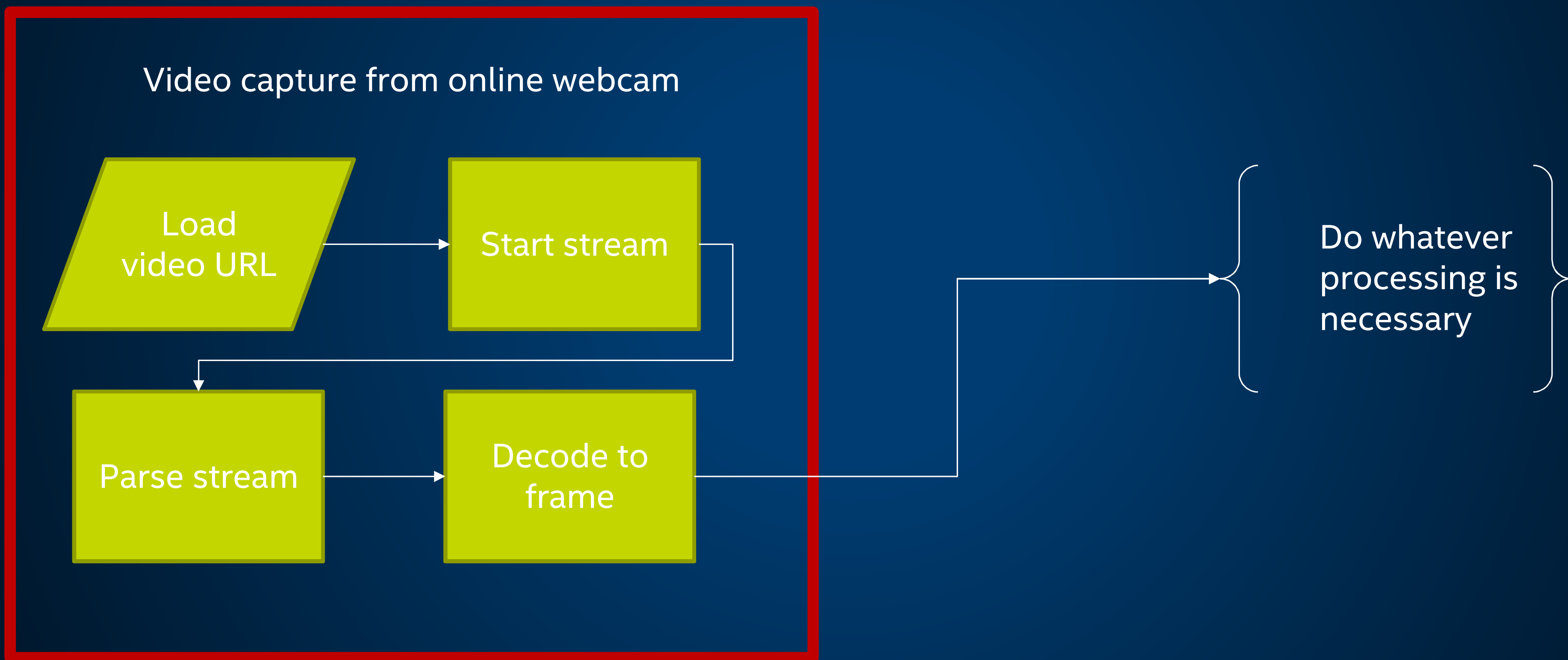
```
gray_img = cv2.cvtColor( img, cv2.COLOR_BGR2GRAY )
faces = cascade.detectMultiScale(
        gray_img,
        scaleFactor = 1.25,
        minNeighbors = 5,
        minSize = ( 30, 30 ),
)

for (x, y, w, h) in faces:
        cv2.rectangle( img, x, y, (x+w, y+h), (0, 255, 0), 2)
```

# COMPUTER VISION GRAPH EXAMPLES

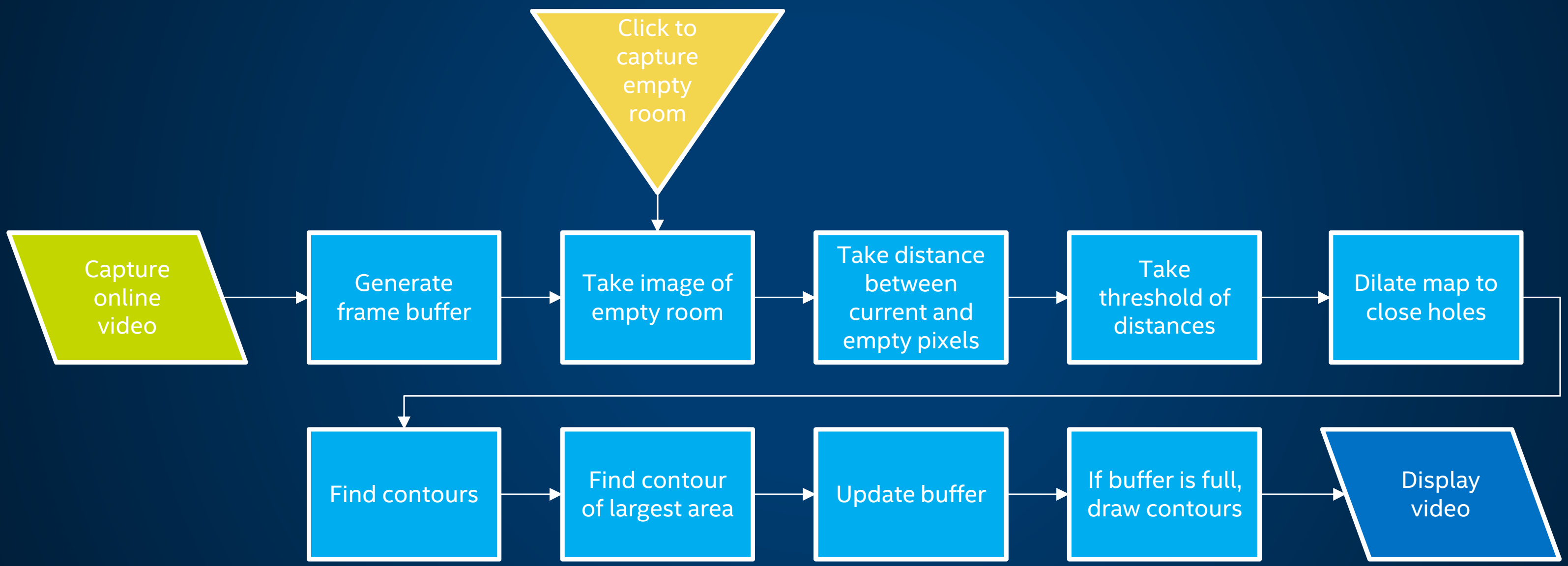
# CROSSHAIR FOLLOWS OBJECT OF DISTINCT COLOR



# MODULARITY: USING AN ONLINE VIDEO STREAM



# PRESENCE DETECTION FROM AN ONLINE CAMERA



# STORING VIDEO UPON FACE DETECTION