Introduction to Robotics for cognitive science

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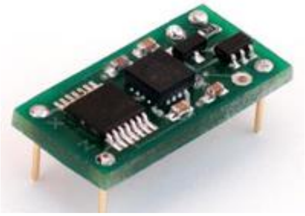
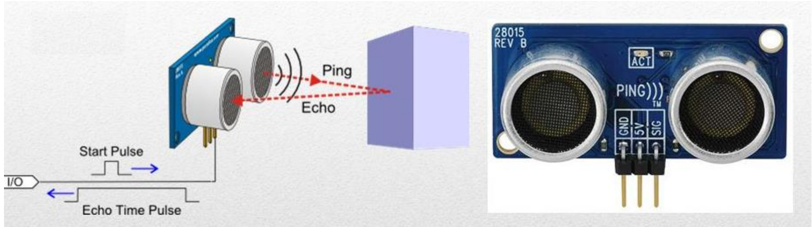
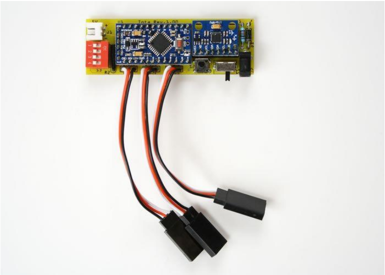
Web page of the subject

www.agentspace.org/kv

Sensors




Ping
Echo
Start Pulse
I/O
Echo Time Pulse
28015
REV B
ACT
PING)))
GND
5V
SIG




Velodyne


Microphone array
LED
Vision camera
Microphone array
XBOX 360
3D depth sensor cameras
Motorized tilt
KINECT
for XBOX 360.

Sensors

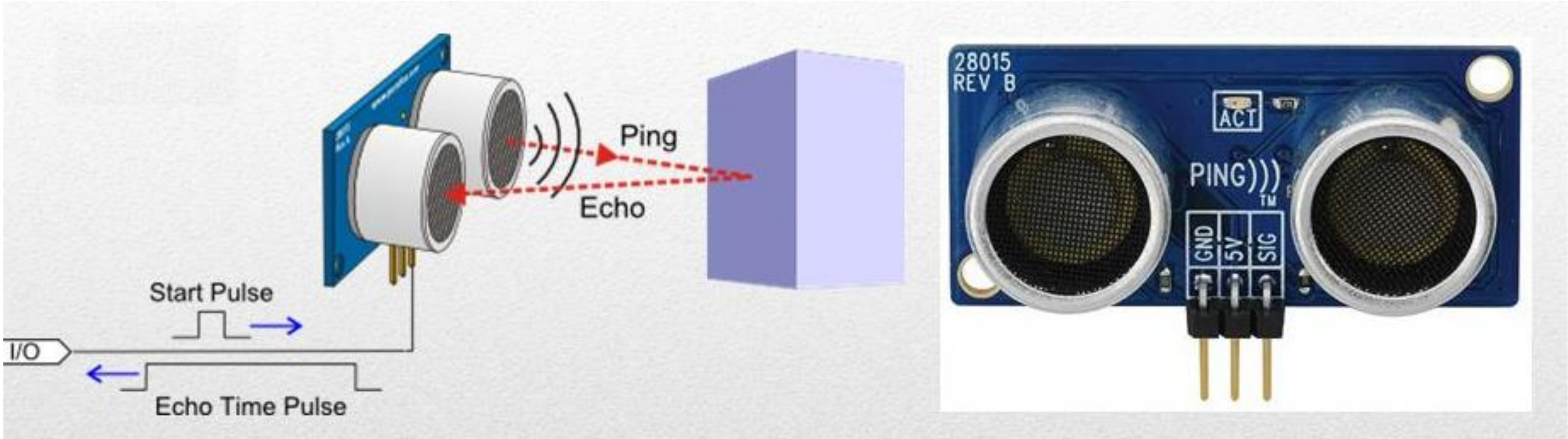
- Bumper (0/1)

Sensors

- Bumper (0/1)
- Infra red sensor (distance or color)

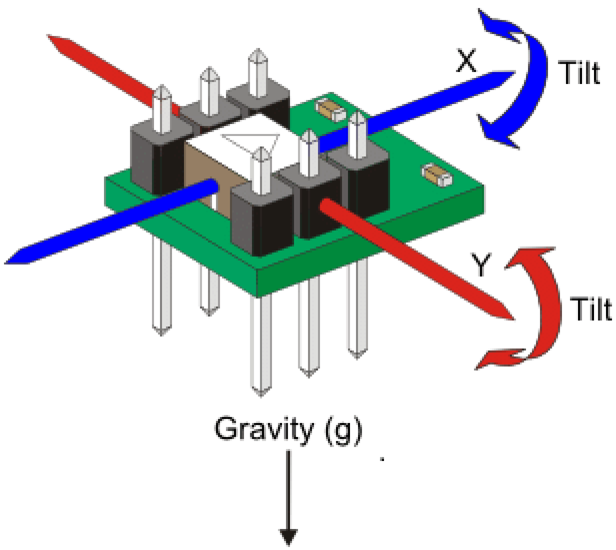
Sensors

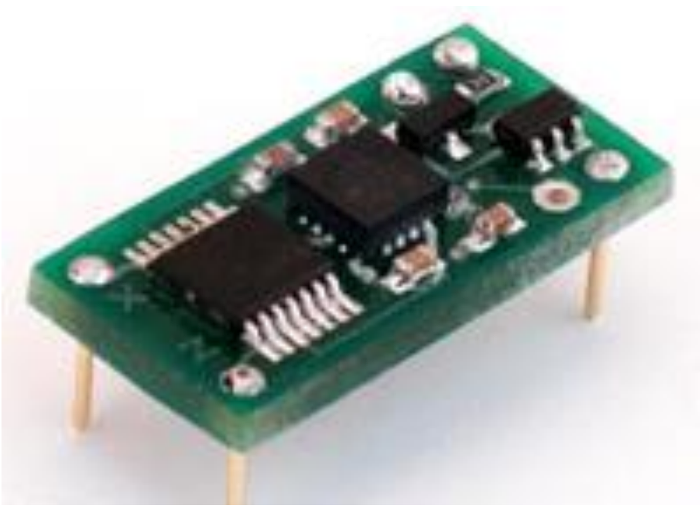
- Bumper (0/1)
- Infra red sensor (distance or color)
- Sonar (distance)



Sensors

- Bumper (0/1)
- Infra red sensor (distance or color)
- Sonar (distance)
- Accelerometer (inertia)



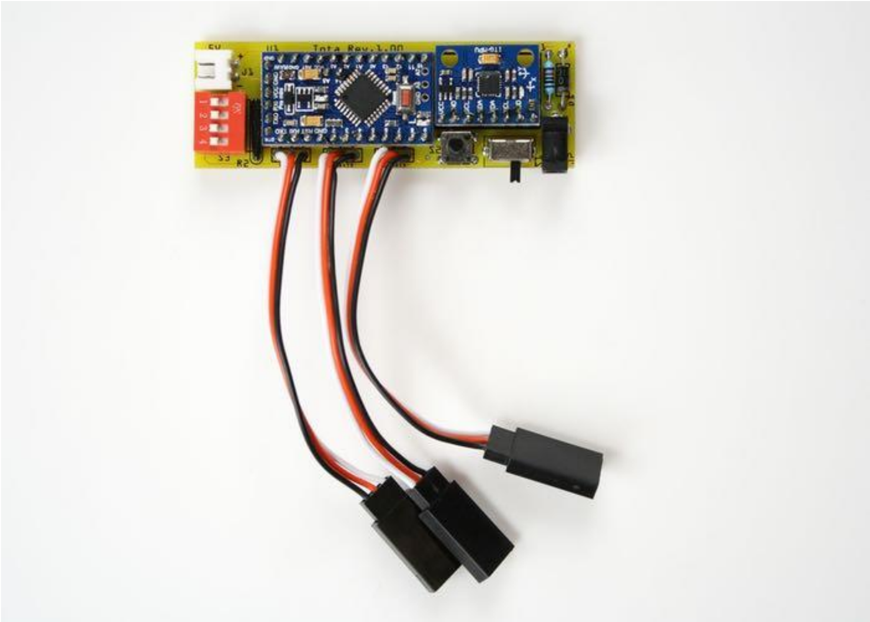


Sensors

- Bumper (0/1)
- Infra red sensor (distance or color)
- Sonar (distance)
- Accelerometer (inertia)
- Tachometer (rpm = revolutions)

Sensors

- Bumper (0/1)
- Infra red sensor (distance or color)
- Sonar (distance)
- Accelerometer (inertia)
- Tachometer (rpm = revolutions)
- Gyroscope (angular velocity)



Sensors

- Bumper (0/1)
- Infra red sensor (distance or color)
- Sonar (distance)
- Accelerometer (inertia)
- Tachometer (rpm = revolutions)
- Gyroscope (angular velocity)
- Camera (image)

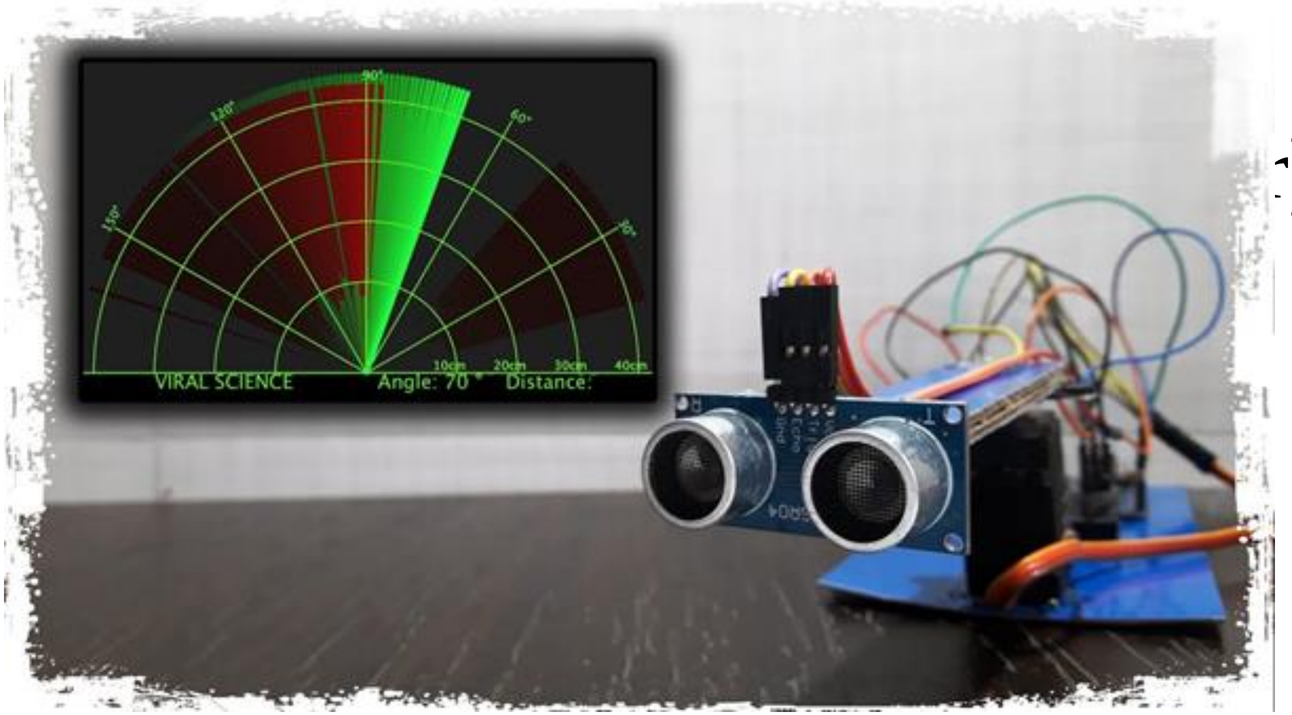
Sensors

- Bumper (0/1)
- Infra red sensor (distance or color)
- Sonar (distance)
- Accelerometer (
- Tachometer (rpı
- Gyroscope (ang
- Camera (image)
- 3D camera (image + depth)

Sensors

- Bumper (0/1)
- Infra red sensor (distance or color)
- Sonar (distance)
- Accelerometer (in
- Tachometer (rpm
- Gyroscope (angul
- Camera (image)
- 3D camera (image
- Laser profile sensor (distance 2D, 3D)

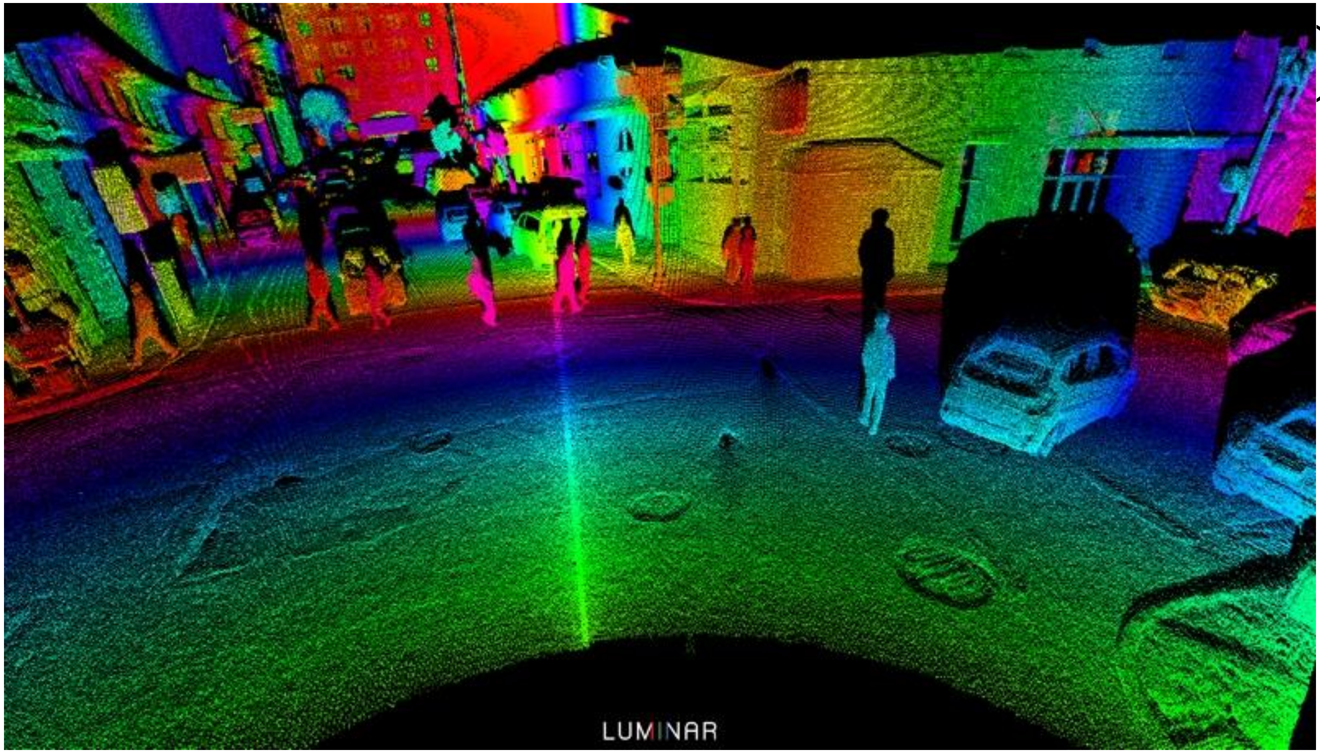
Sensors



- Camera (image)
- 3D camera (image + depth)
- Laser profile sensor (distanc
- doppler radar (depth map)

Sensors

- Bumper (0/1)



- 3D camera (image + depth)
- Laser profile sensor (distance 2D, 3
- doppler radar (depth map)
- LIDAR (depth map)

Sensors

- Bumper (0/1)
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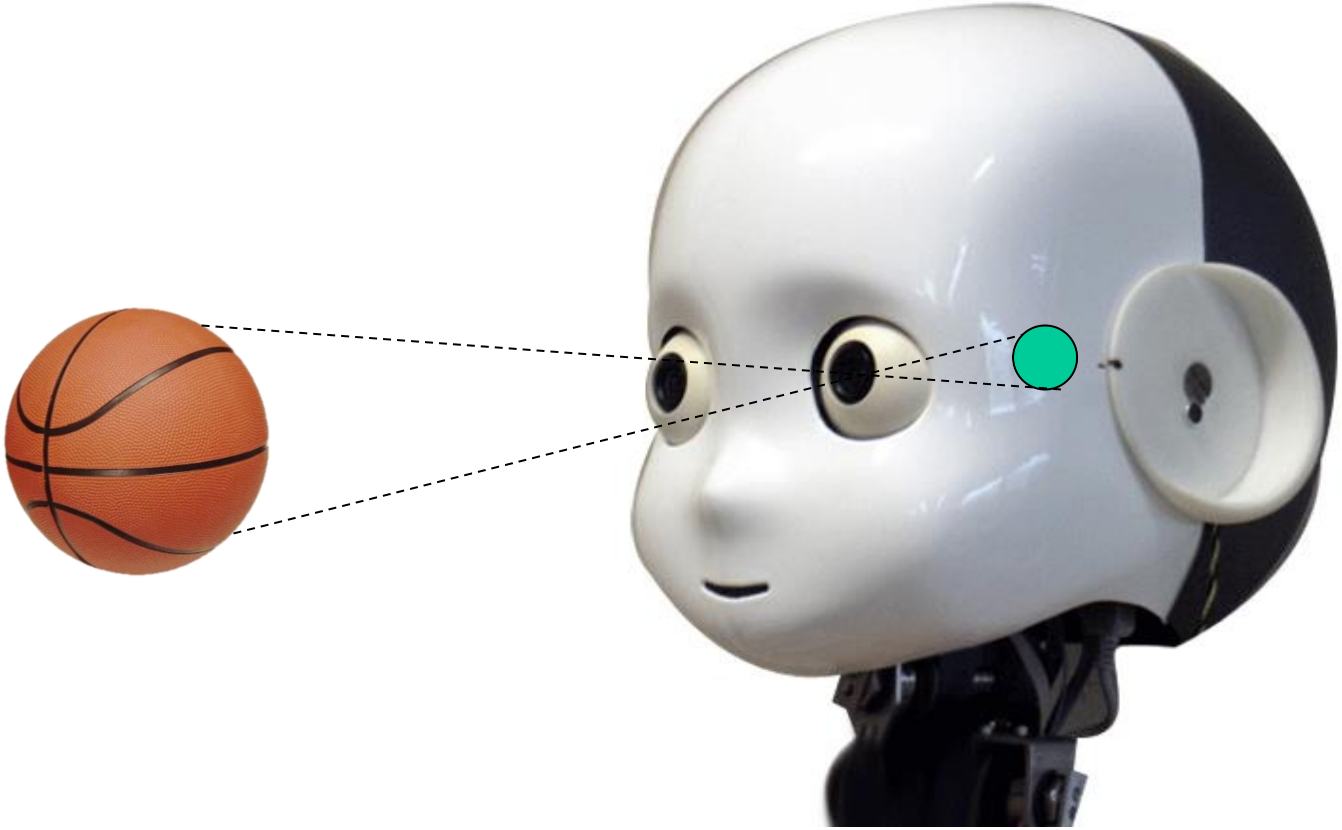
- LIDAR (depth map)

Sensor parameters

- Range
- Accuracy
- Resolution
- FOV (field of view)
- Fps
- Supply voltage
- Power consumption
- Interface (TTL, RS232, USB, Ethernet, …)

Perception



iCub 2007

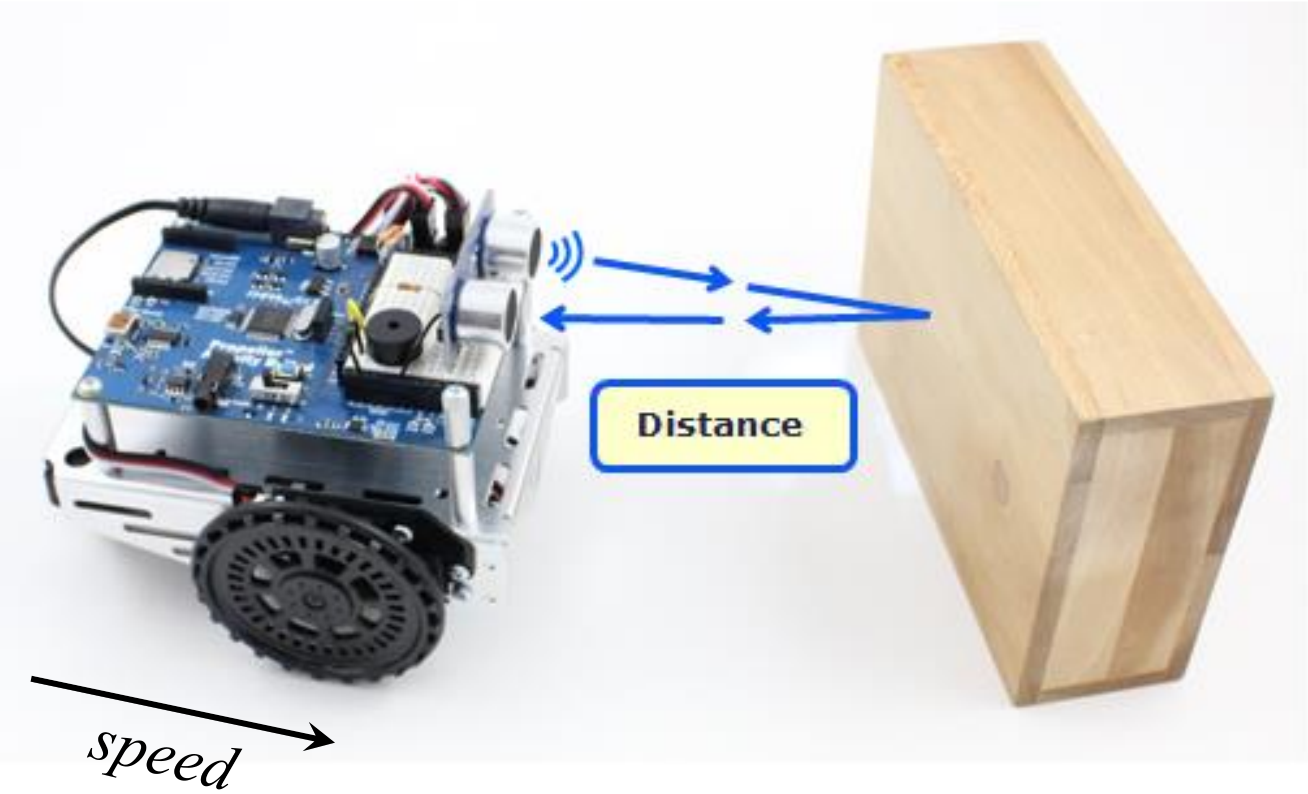
Sensorimotor approach

- usual solution: stationary perception
- sensory-motor approach: constitute actions to improve perception
- Examples:
  - strong light causes closing eyelids
  - dark causes stretch of pupils
  - when recognition fails, we move head
  - we treat convolution caused by body movement by contra movement of the extraocular muscles

Processing one value

- Processing of measured distance, speed, acceleration, … is relatively easy
- We need to concern just that any measurement has certain accuracy
- So even when the robot stops, the measured distance to close obstacle varies and oscillate
- If we know how to predict future state of our robot from the current state, the variation can be decreased by Kalman filter

Robot moving to obstacle



- When a robot measures distance to obstacle, it has inner state – speed, which we also know just with some accuracy and which can be derived from distance measurement
- from the speed we can predict what distance will be measured in the next instant of time
- In the next instant of time we have two values – measured and predicted
- Kalman filter tell us what the best estimation of the actual distance value under these uncertain circumstances and derive the best estimation for the next value of the inner state

Computer vision

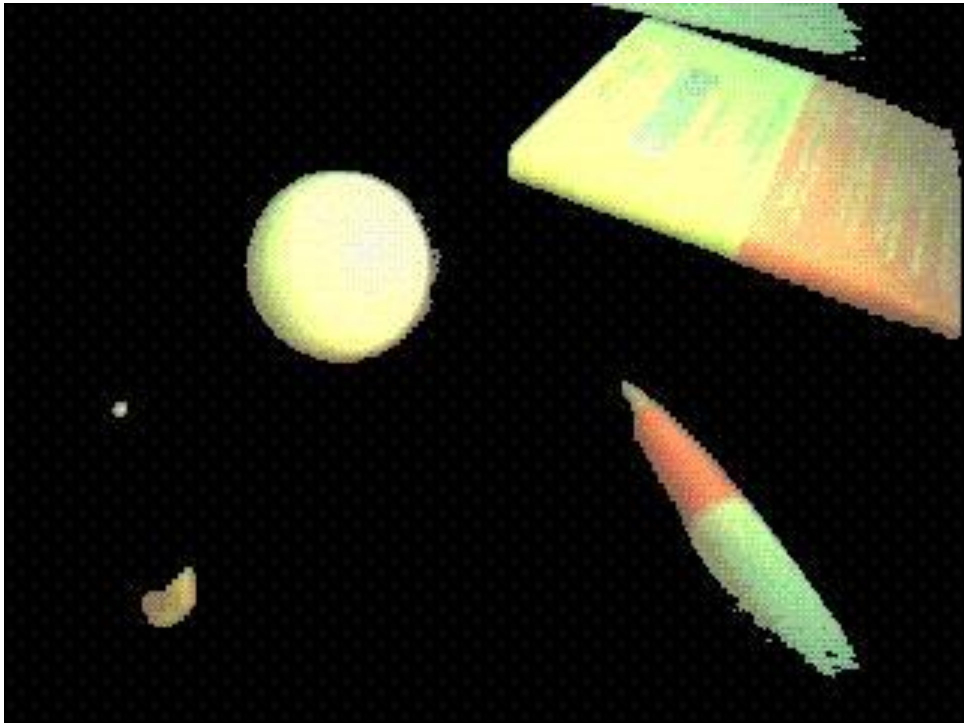
- Much more complicated is processing of image or depth map provided by camera, radar or LIDAR
- Typical processes:
  - Filtering
  - Shape detection
  - Object detection and tracking
  - Segmentation
  - Semantic segmentation

OpenCV

- Open source library for computer vision
- Intel, Itseez (Gary Bradski)
- BSD License
- > 2500 algorithms
- C++, Java, Python
- Windows, Linux, Android
- fast & reliable
- CUDA & OpenCL support

```
pip install opencv-contrib-python
```

Camera provides image

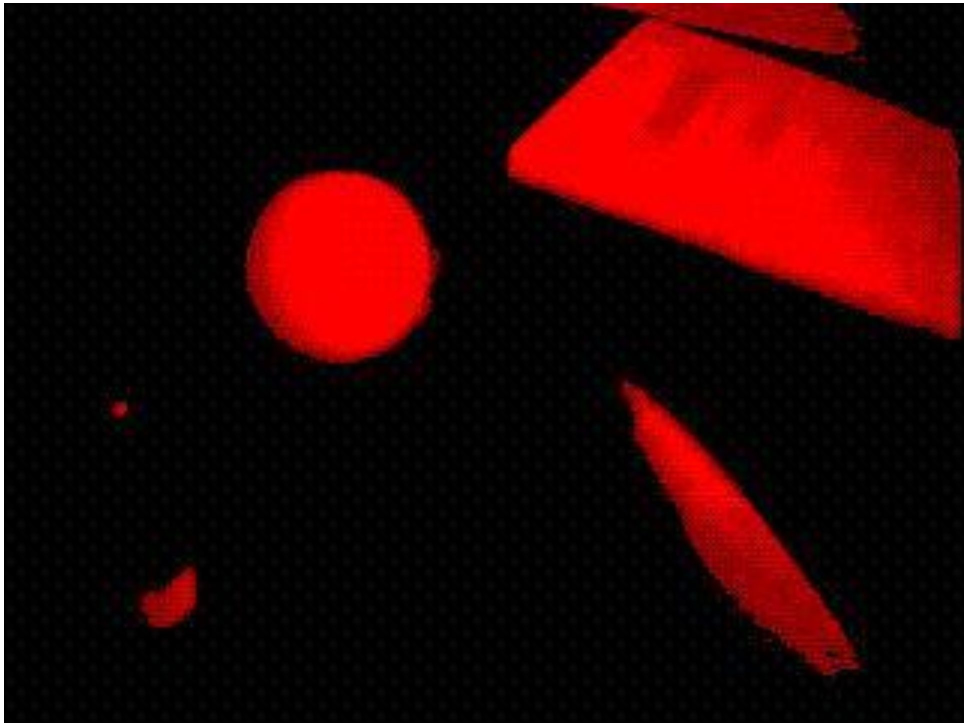


numpy array with shape (rows, columns, channels)

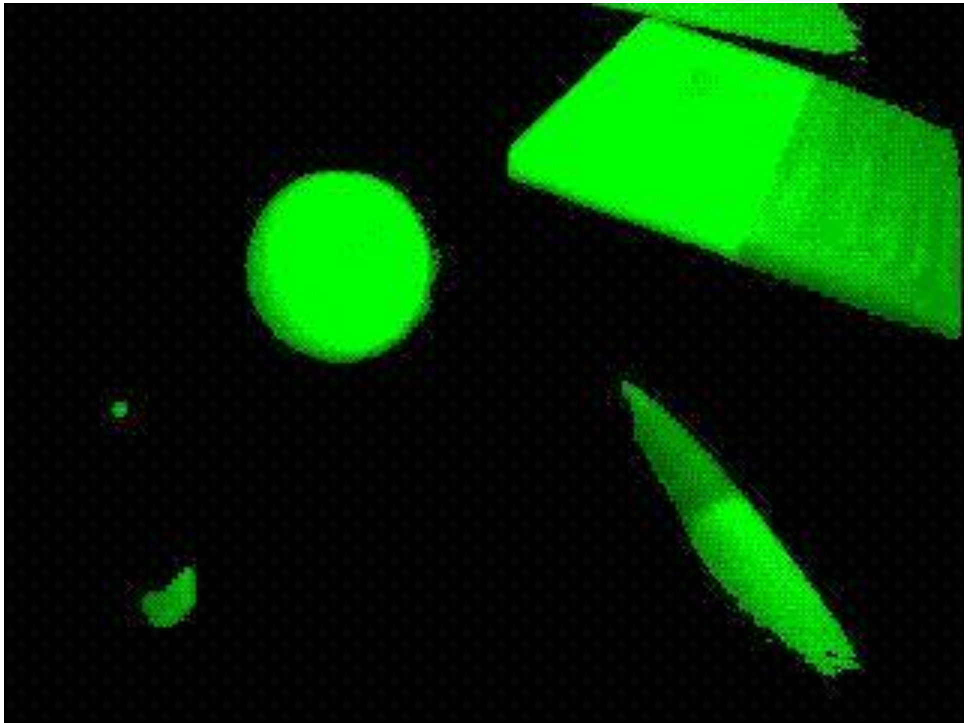
index [0,0,;] or point (0,0) is top left

NumPy

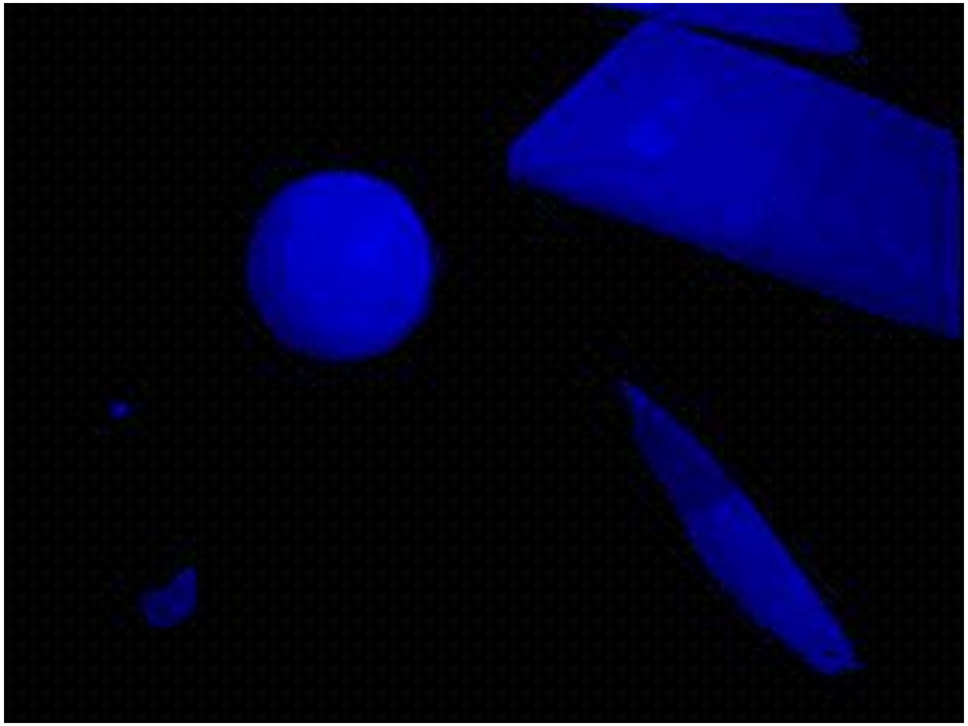
Red channel



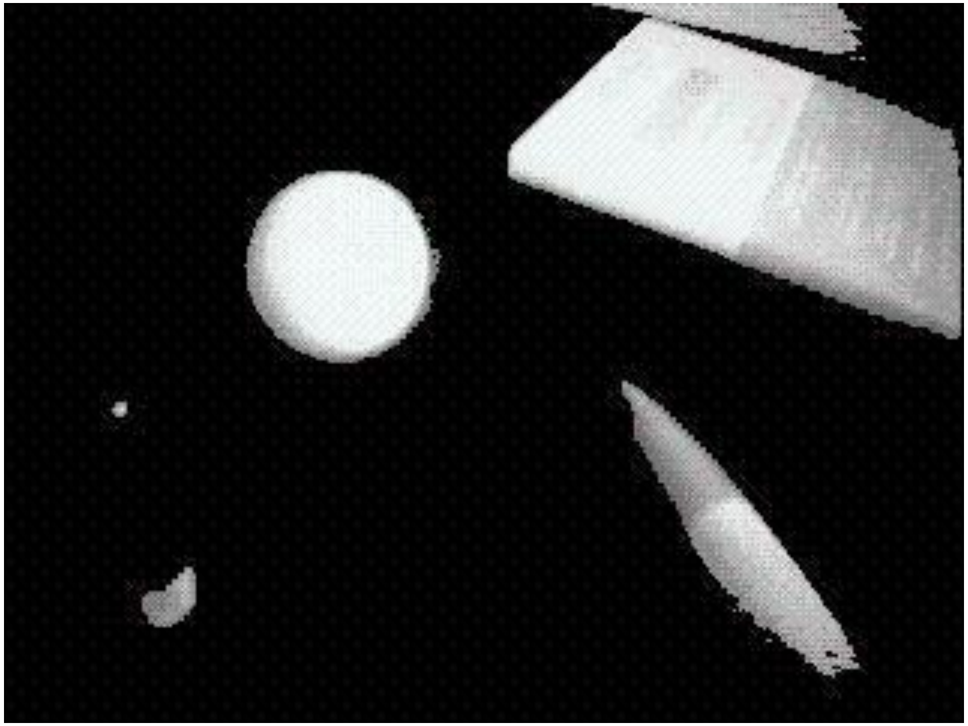
Green channel



Blue channel



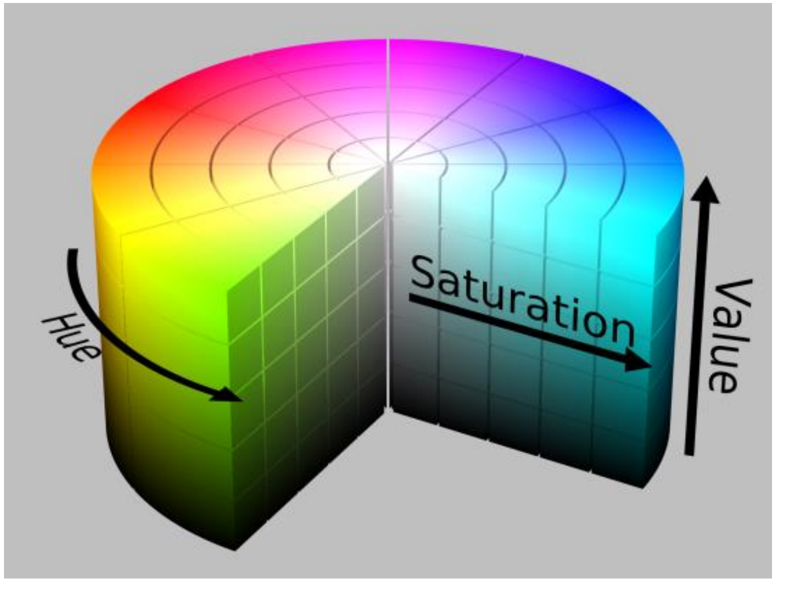
Grayscale image



grey = 0.3 × red + 0.59 × green + 0.11 × blue

Color models

- RGB used by cameras is just one of possible color model
- OpenCV employs mainly BGR model., `(255,0,0)` is blue, `Scalar(0,0,255)` is read, `Scalar(255,0,255)` is magenta, `Scalar(127,127,127)` grey, ...
- OpenCV can convert one model to other, ie. To HSV, which suitable for color filtering
- Other models: YUV, YCrCb, HLS, CIE 1976 L*a*b*



Brightness

+ bias =

Contrast

× weight =

Filtering: blur

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

```
dst = cv2.blur(src,(kx,ky))
```

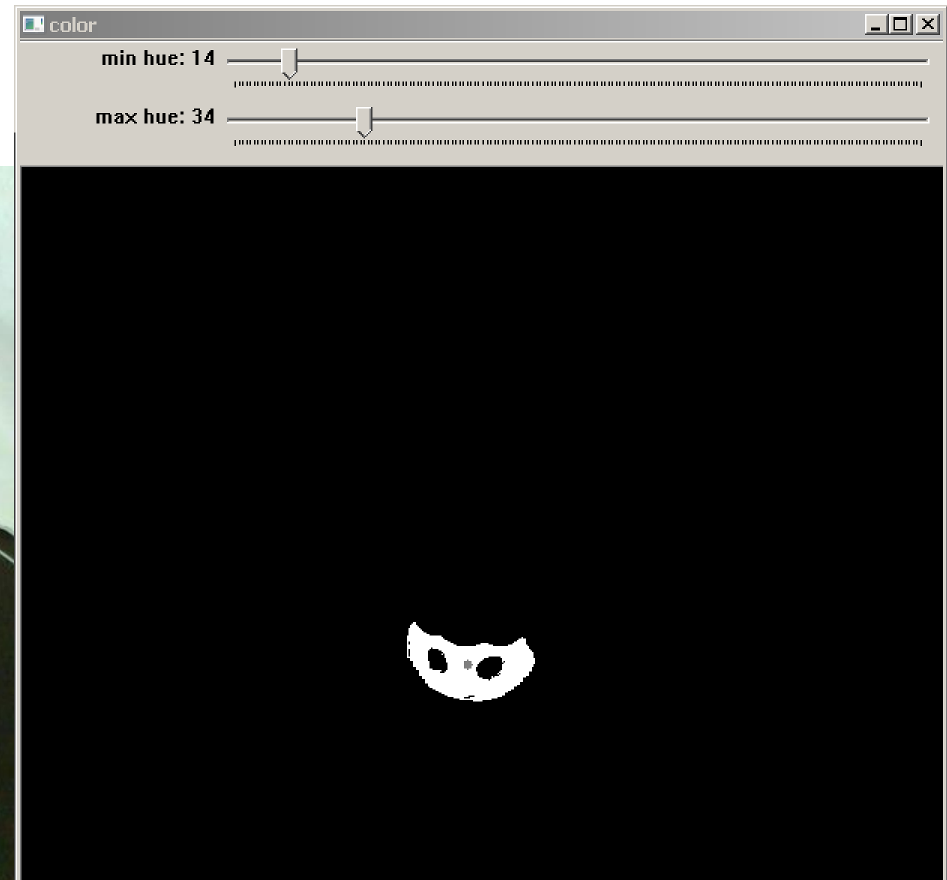
Many others: median filter, bilateral filter, anisotropic diffusion …

Filtering: meanshift

```
img_filtered = cv2.pyrMeanShiftFiltering(
                    img, spatial_radius, color_radius)
```

Filtering: color detection

yellow color in HSV

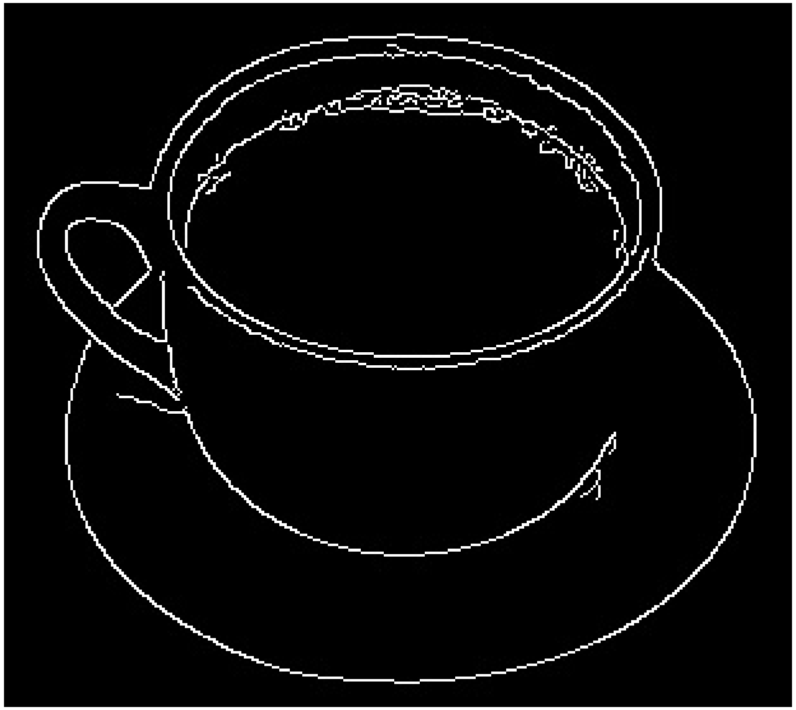


Filtering: edge detection (Sobel)

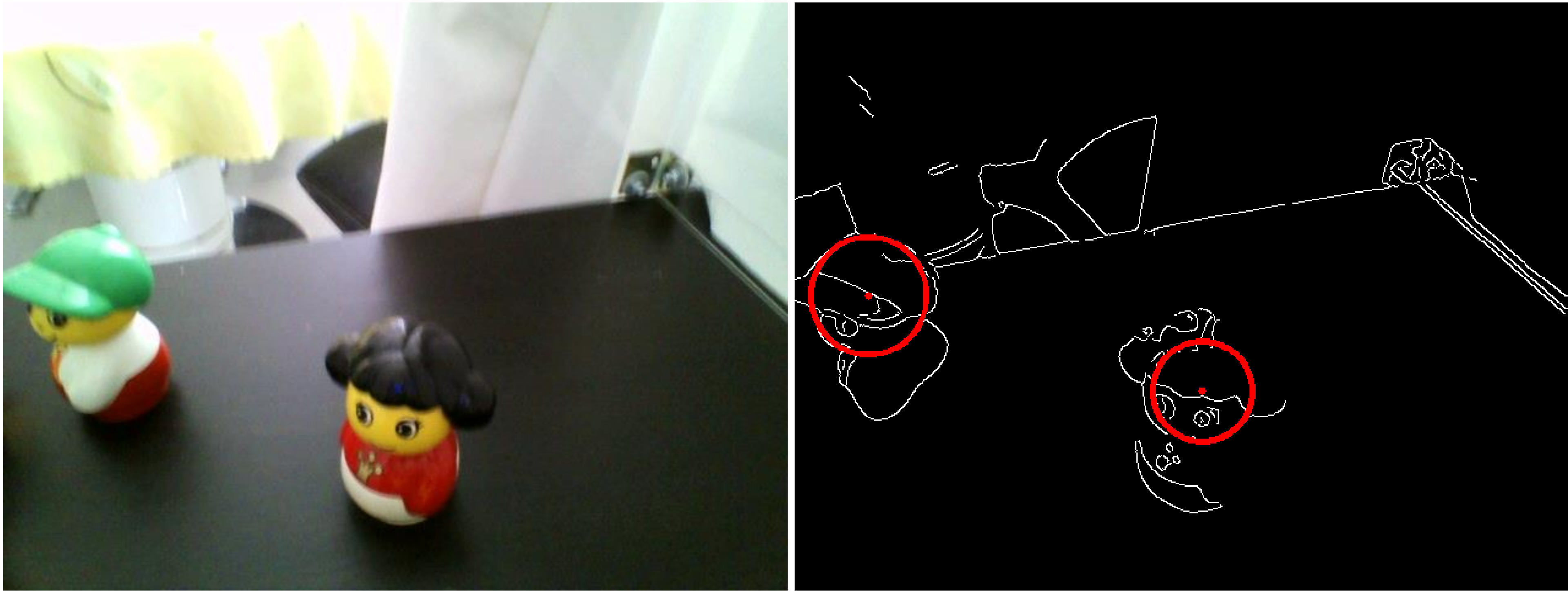
horizontal Sobel kernel:

-1	-2	-1
0	0	0
1	2	1

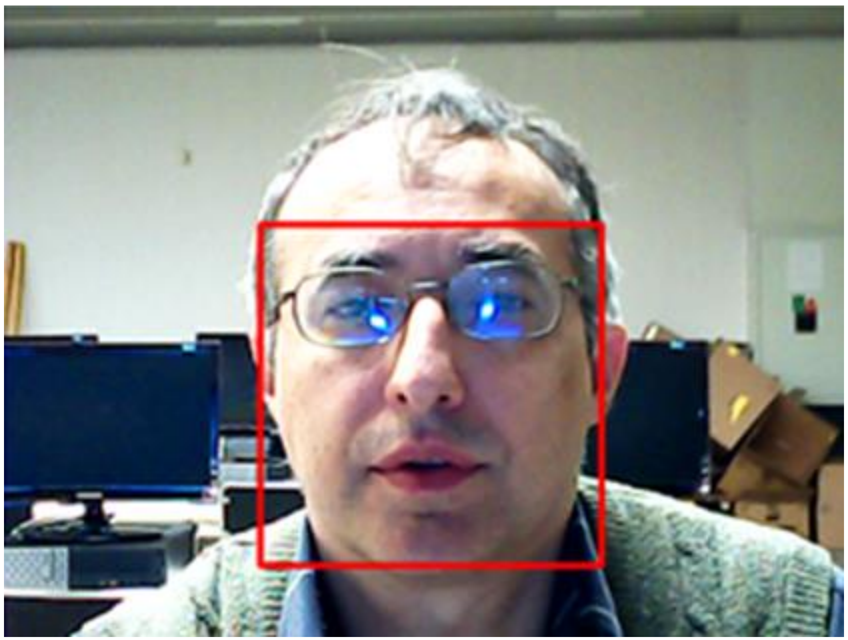
Filtering: edge detection (Canny)



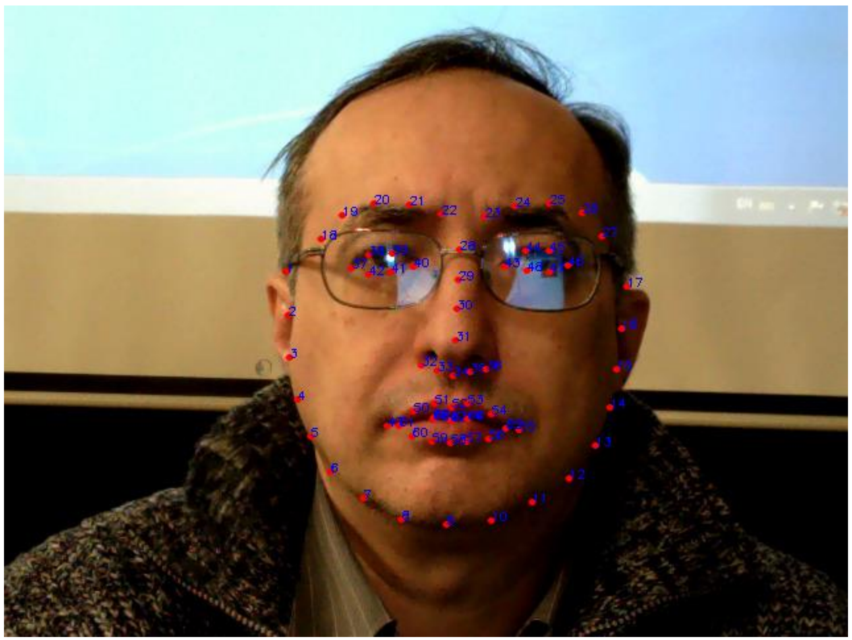
Shape detection



Face detection,
Face landmark detection

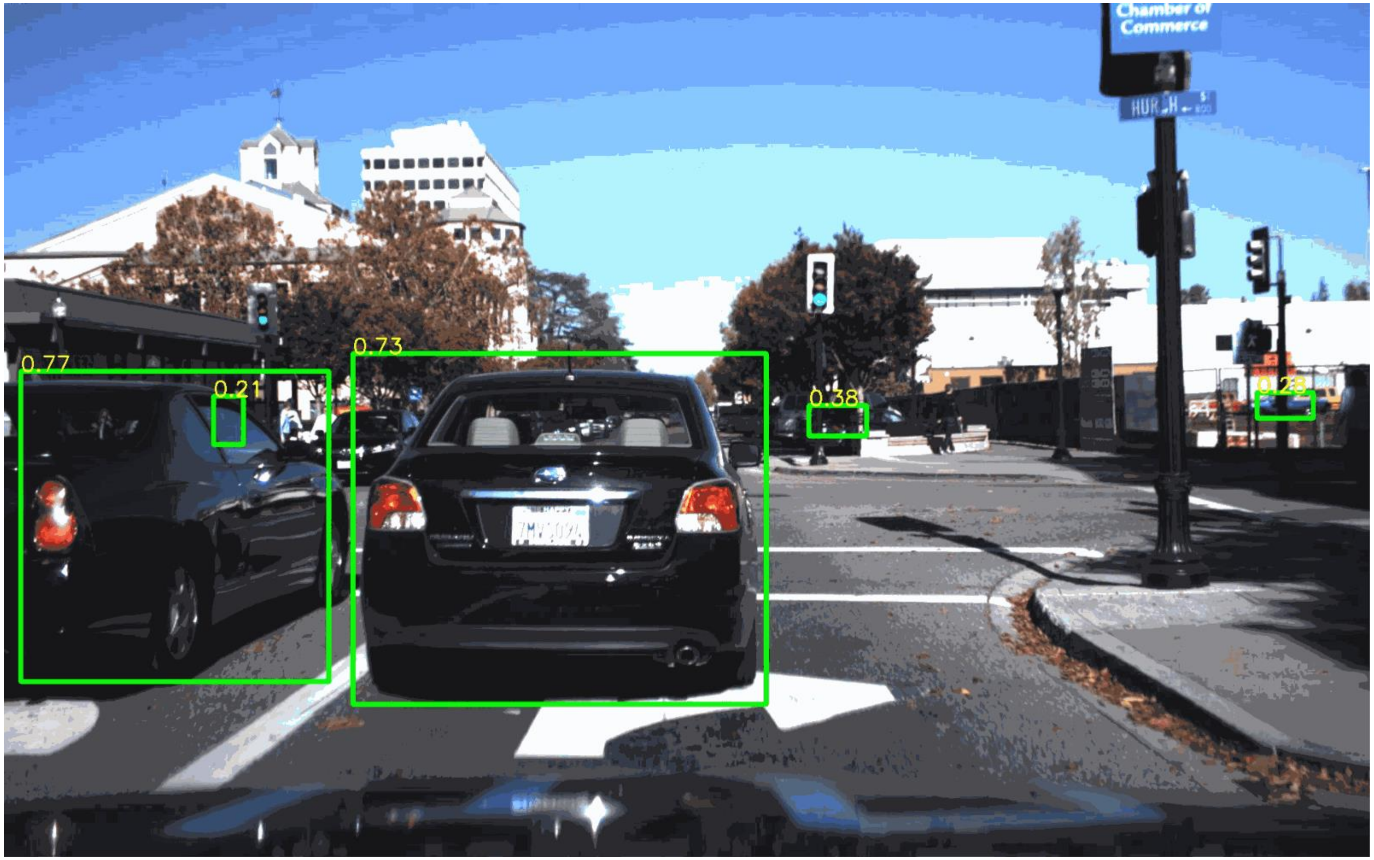


HOG detector



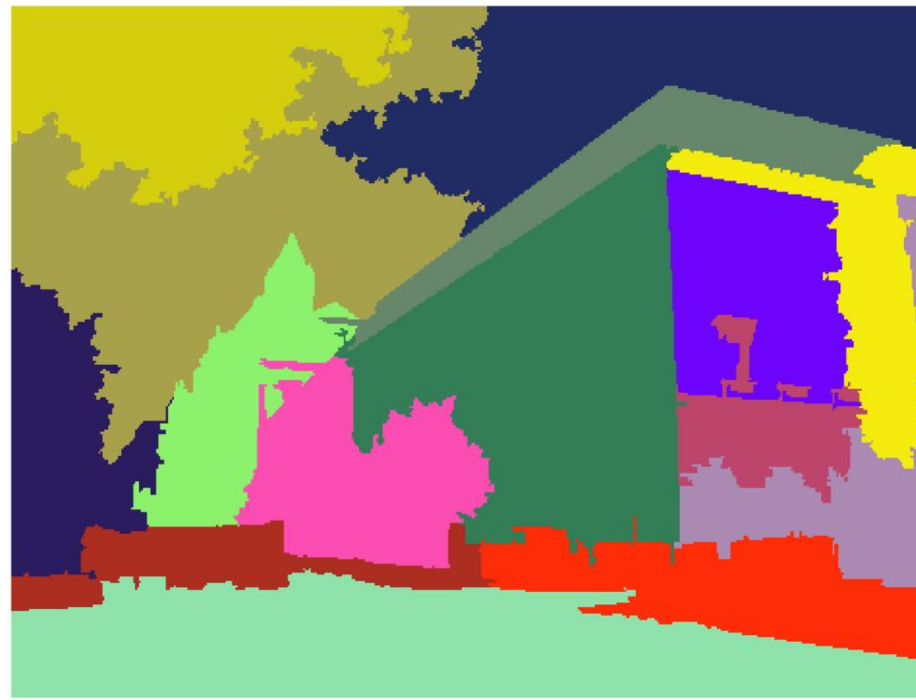
Kazemi’s cascade regressor trained by gradient boosting

Object Detection



Object tracking

Segmentation



Semantic segmentation