# COMPUTER VISION

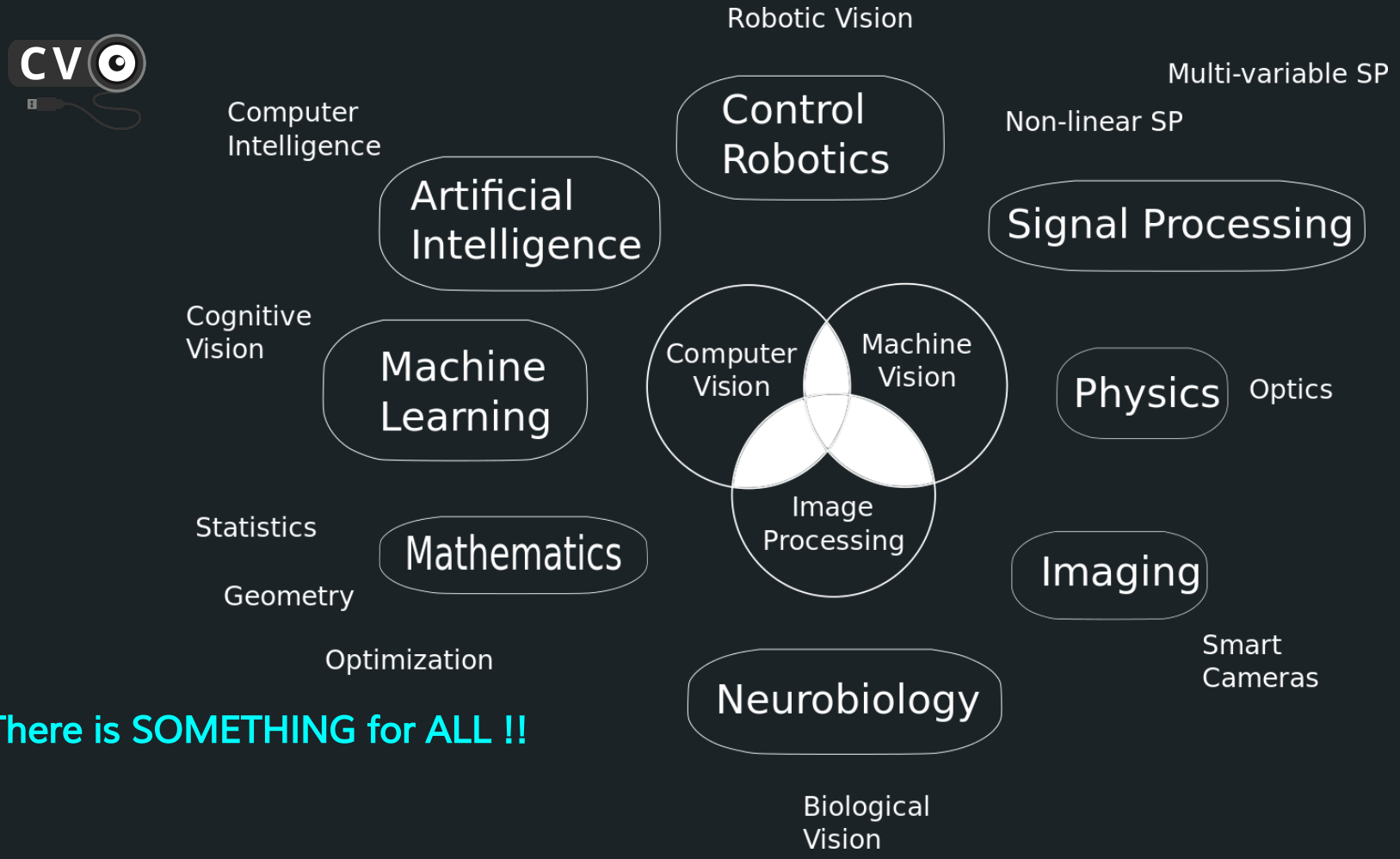
Session - 1, Winter School ‘16
Introduction and Basic Operations

# Some Fun Facts

- 40% of all nerve fibers connected to the brain are linked to the retina.
- More of our neurons are dedicated to vision than the other four senses *combined*.
- 2/3rds of the brain is used for processing visual data

# So What is CV?

Teaching computers how to make sense of images

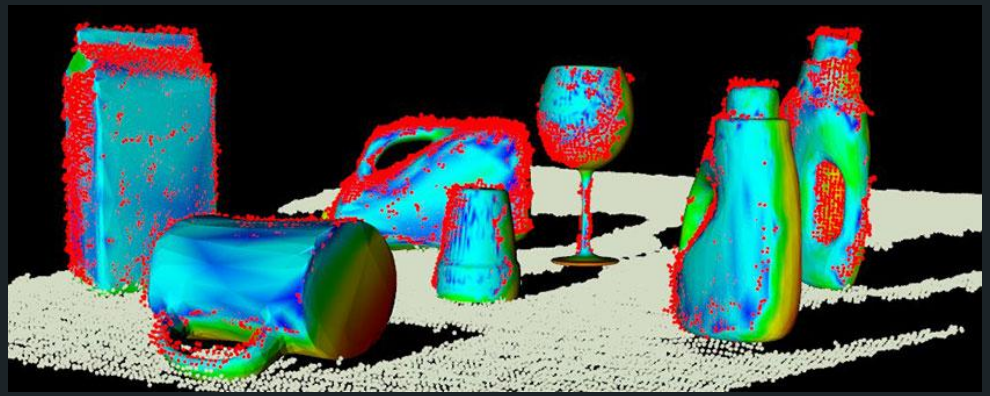



There is SOMETHING for ALL !!

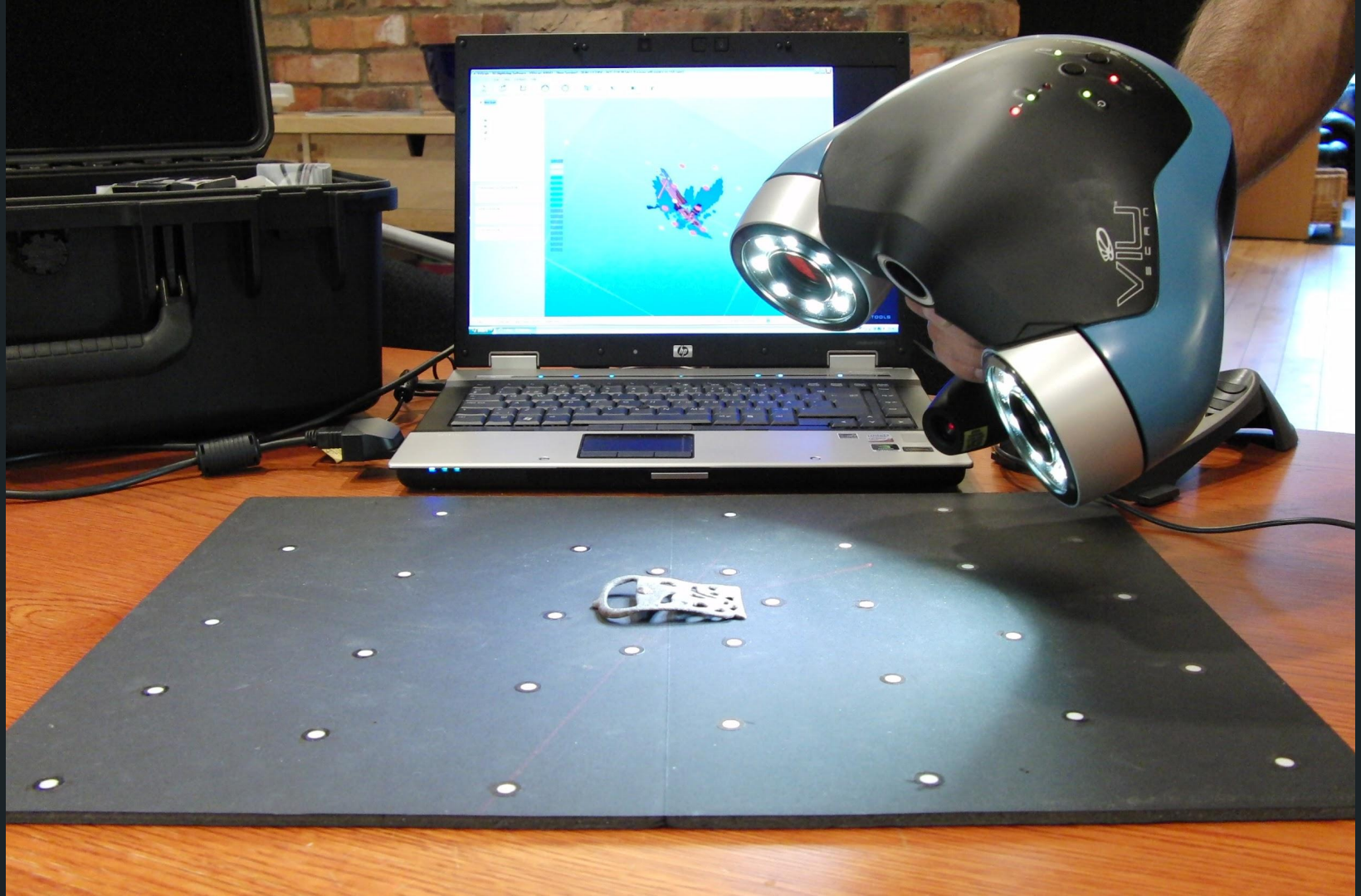
# Where is CV used?

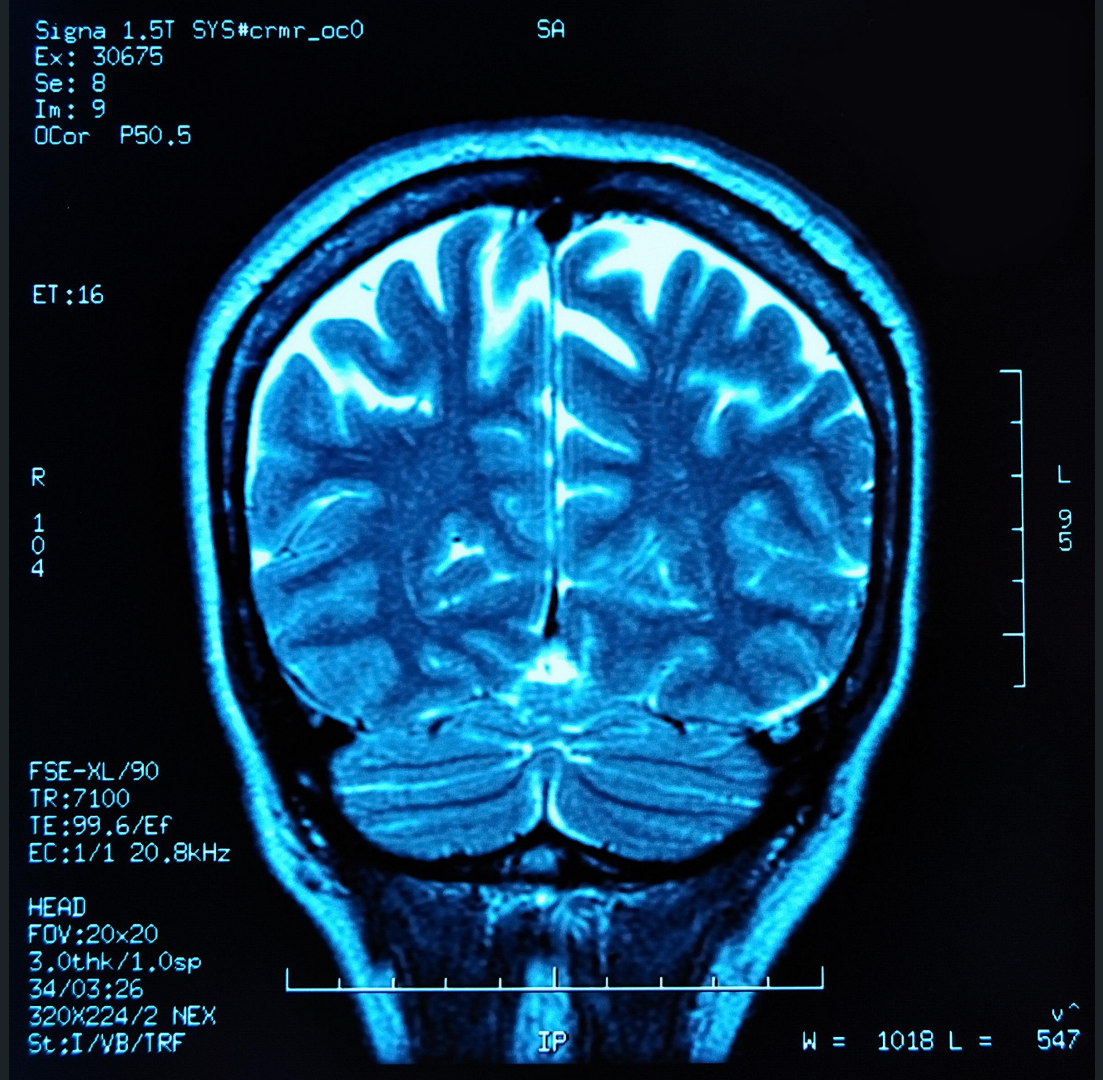
- In Robotics
- Autonomous Cars
- In cameras
- In face recognition
- Image search
- Gesture Recognition,etc
- Cam Scanner


UBER
UBER




No Service
5:28 PM
CAMERA
Horsea
CP 197


VILU


Signa 1.5T SYS#crmr_oc0
SA
Ex: 30675
Se: 8
Im: 9
OCor P50.5
ET:16
R
1
0
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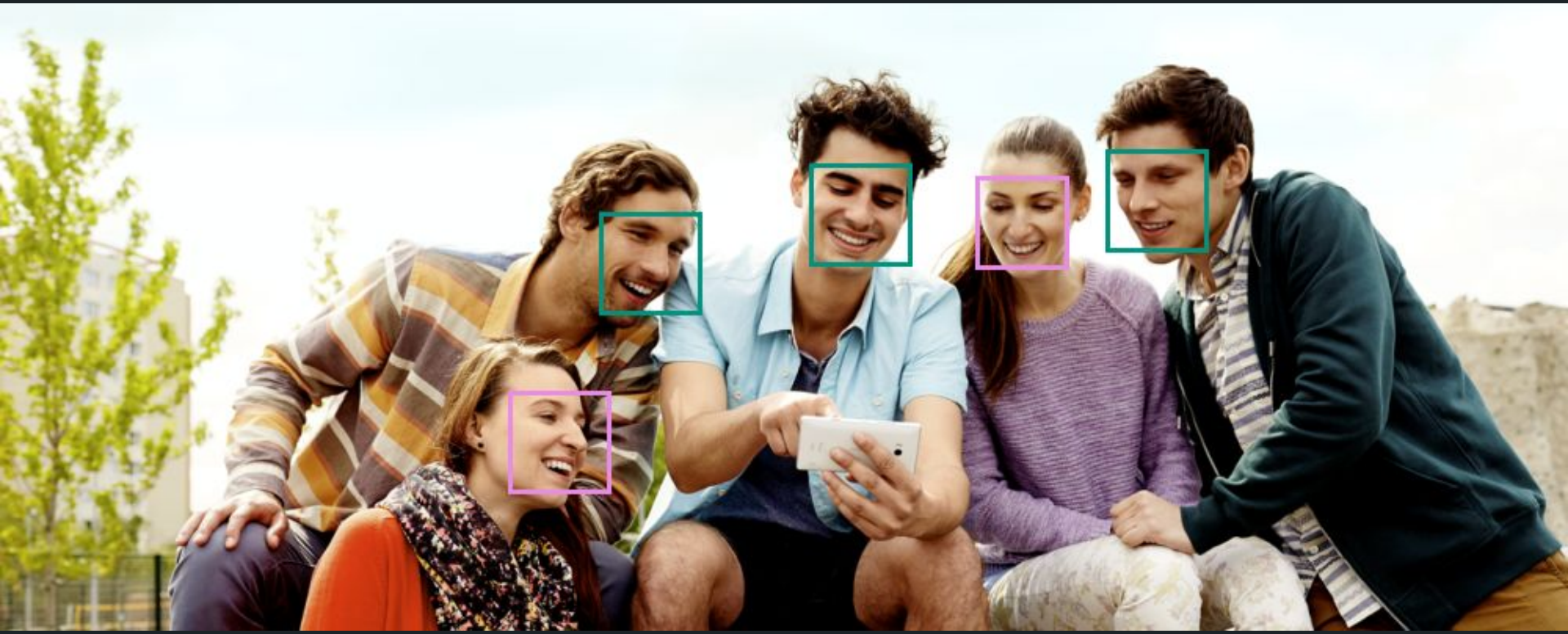
FSE-XL/90
TR:7100
TE:99.6/Ef
EC:1/1 20.8kHz
HEAD
FOV:20x20
3.0thk/1.0sp
34/03:26
320X224/2 NEX
St:I/VB/TRF
IP
W = 1018 L = 547


TGT DIST
N 41°19'20"
W 34°25'34"
RNG 269 M
ELV 76 M
WEAP
RS 60 %
MI 49
CR 39 %
Santa Monica Ferriswheel
PUSH


Microsoft
재활병원과 함께
KINECT



# autoCaption

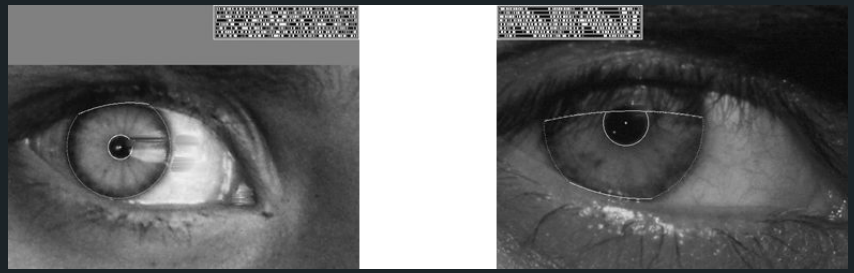
The "perfect" caption. Every time.

She became a lifeguard at the beach and kept the buoys in line.

Try another image!

# Vision based biometrics

"*How the Afghan Girl was Identified by Her Iris Patterns*" Read the story wikipedia



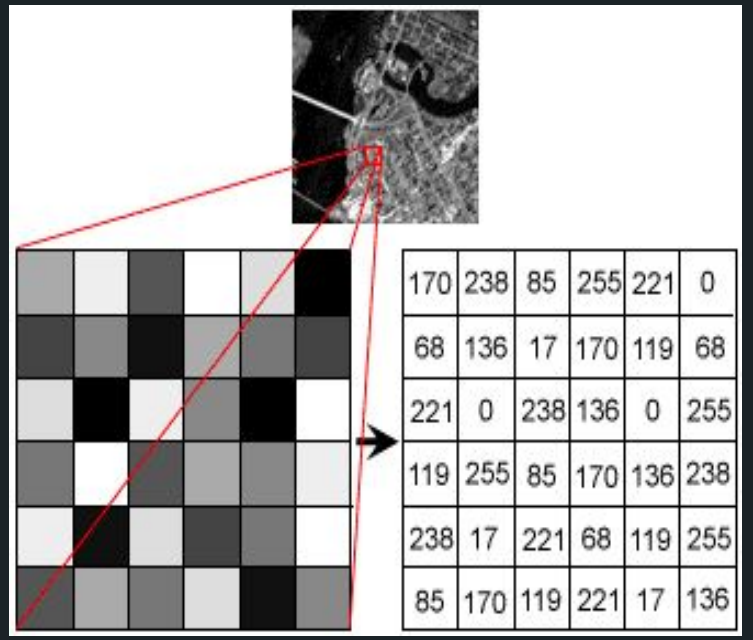
# Login without a password…


Fingerprint scanners on many new laptops, other devices


Face recognition systems now beginning to appear more widely
http://www.sensiblevision.com/

# Composition of an Image

- Images are a matrix of pixels, and pixels are numbers
- Black and white images contain pixels, which hold only one value, while RGB images have pixels that contain values for Red, Green and Blue composition.
- 1080p is actually 1920x1080 pixels (Full HD) (aspect ratio = 16:9, widescreen))



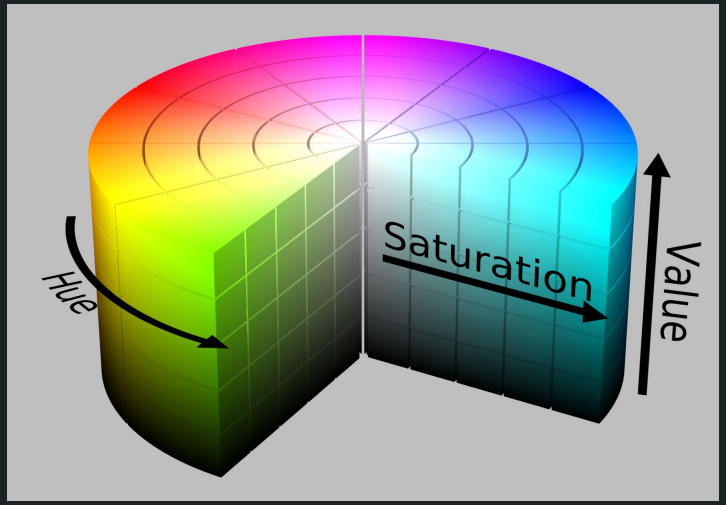
# GrayScale

- Each pixel is a 8 bit number
- It can take values from 0-255
- Each value corresponds to a shade between black
  and white( 0 -black,255-white)
- Number of channels for a grayscale image is 1
- Depth of a grayscale image is 8(bits)

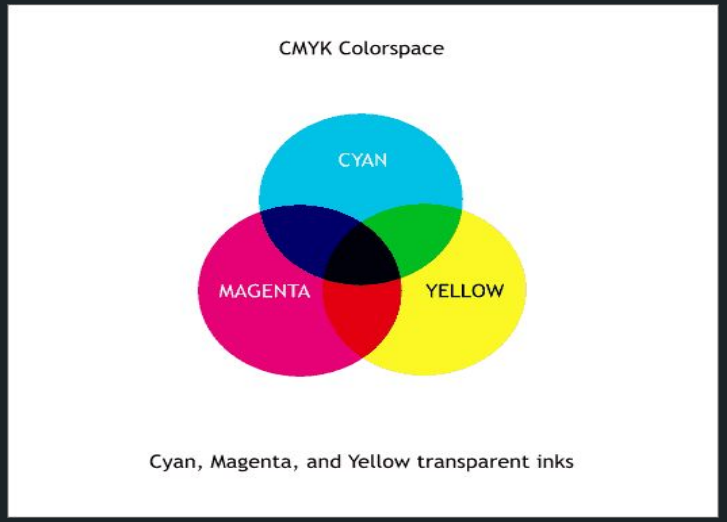
# RGB

- Each pixel stores three values:
    1. R : 0-255
    2. G : 0-255
    3. B : 0-255
- Each number between 0-255 corresponds to a shade of corresponding color
- Depth of a RGB image is 8(bits)
- Number of channels for a RGB image is 3

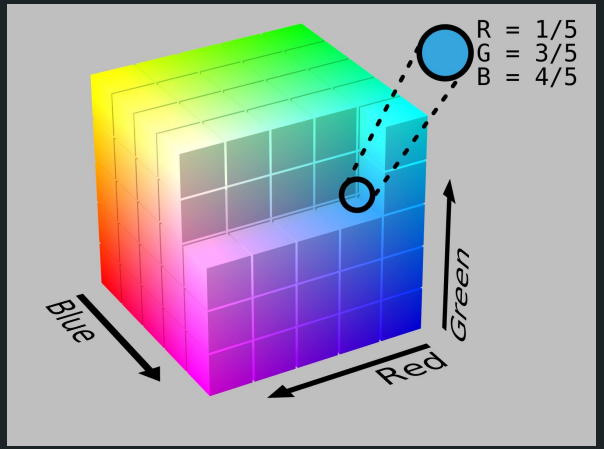
- HSV (Hue, Saturation and value)




- CMYK (Cyan Yellow Magenta Key) is a subtractive model (printing)



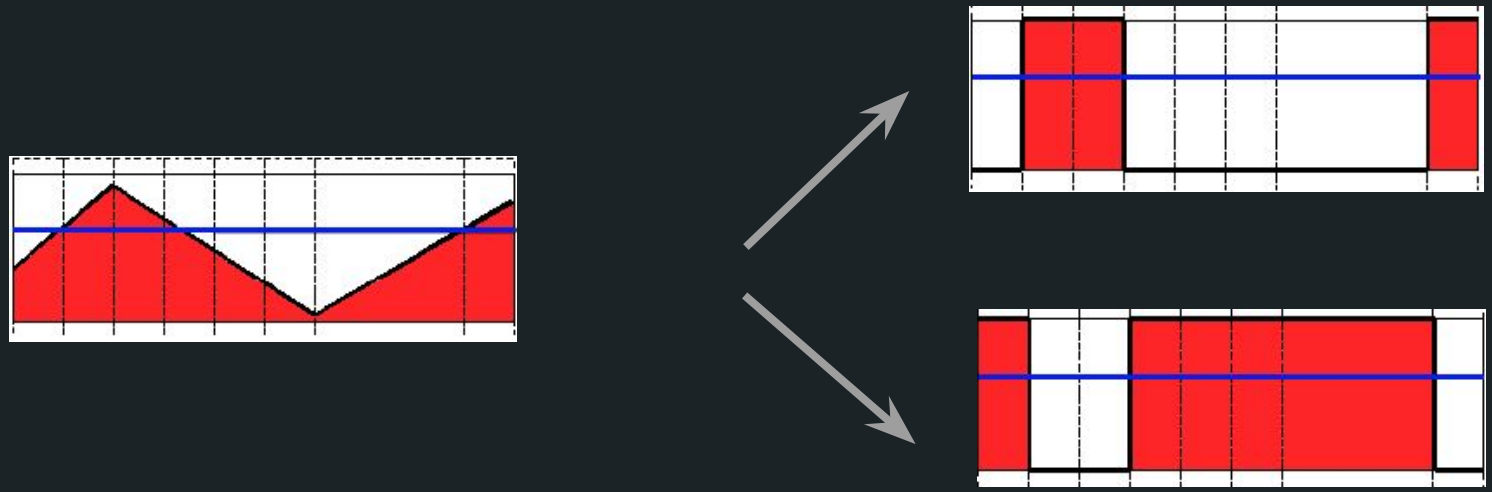

- RGB (Red, Green and Blue), is an additive color model.



# THRESHOLDING

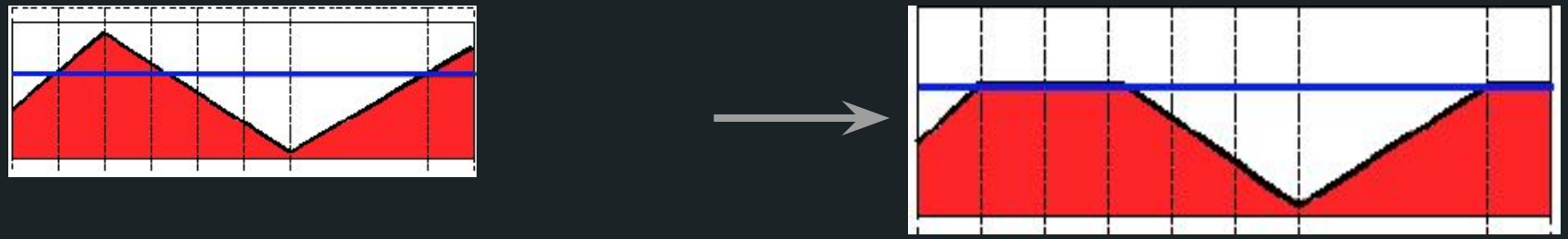
# Simple Thresholding

## Binary Threshold



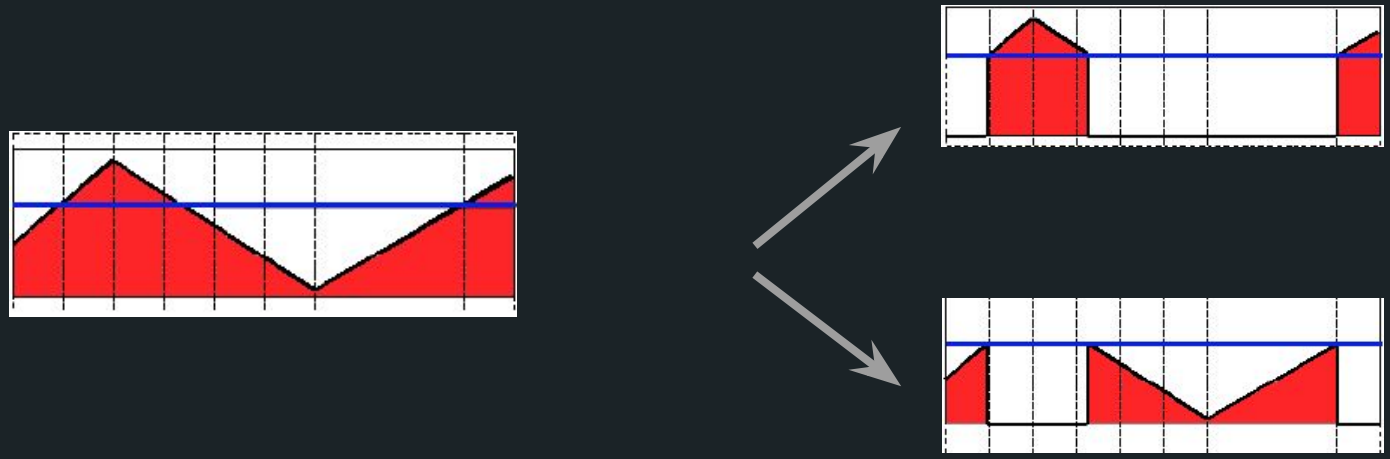
# Simple Thresholding

Truncate



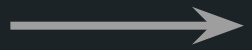
# Simple Thresholding

Truncate to zero or invert



# Non Uniform Illumination

Global Thresholding for non uniformly illuminated image



Give me My Image back!! :-(

# ADAPTIVE THRESHOLDING

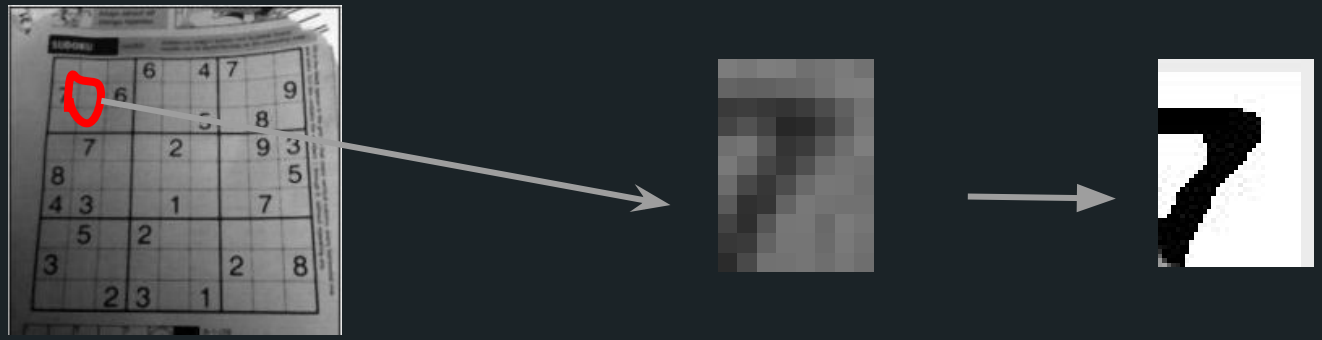
# Why Adaptive Thresholding??

There was a single threshold for all pixels of the image in the previous case.

In this, the algorithm calculate the threshold for a small regions of the image.

In this way we get threshold for a neighbourhood.

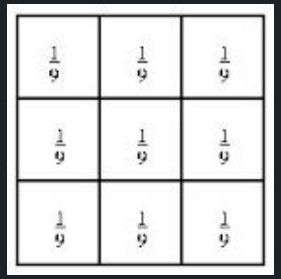
# Global Thresholding for the rounded part gives almost a clear 7.



Adaptive Mean

Adaptive Gaussian

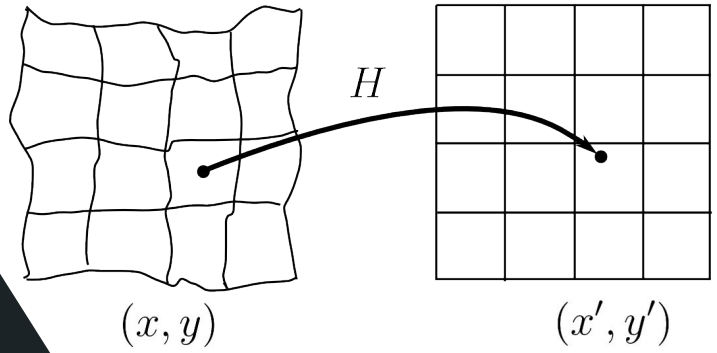
In Adaptive mean thresholding, arithmetic mean of the neighbourhood is taken as the threshold for that neighbourhood.




$$\frac{1}{273}\begin{bmatrix} 1 & 4 & 7 & 4 & 1 \\ 4 & 16 & 26 & 16 & 4 \\ 7 & 26 & 41 & 26 & 7 \\ 4 & 16 & 26 & 16 & 4 \\ 1 & 4 & 7 & 4 & 1 \end{bmatrix}$$

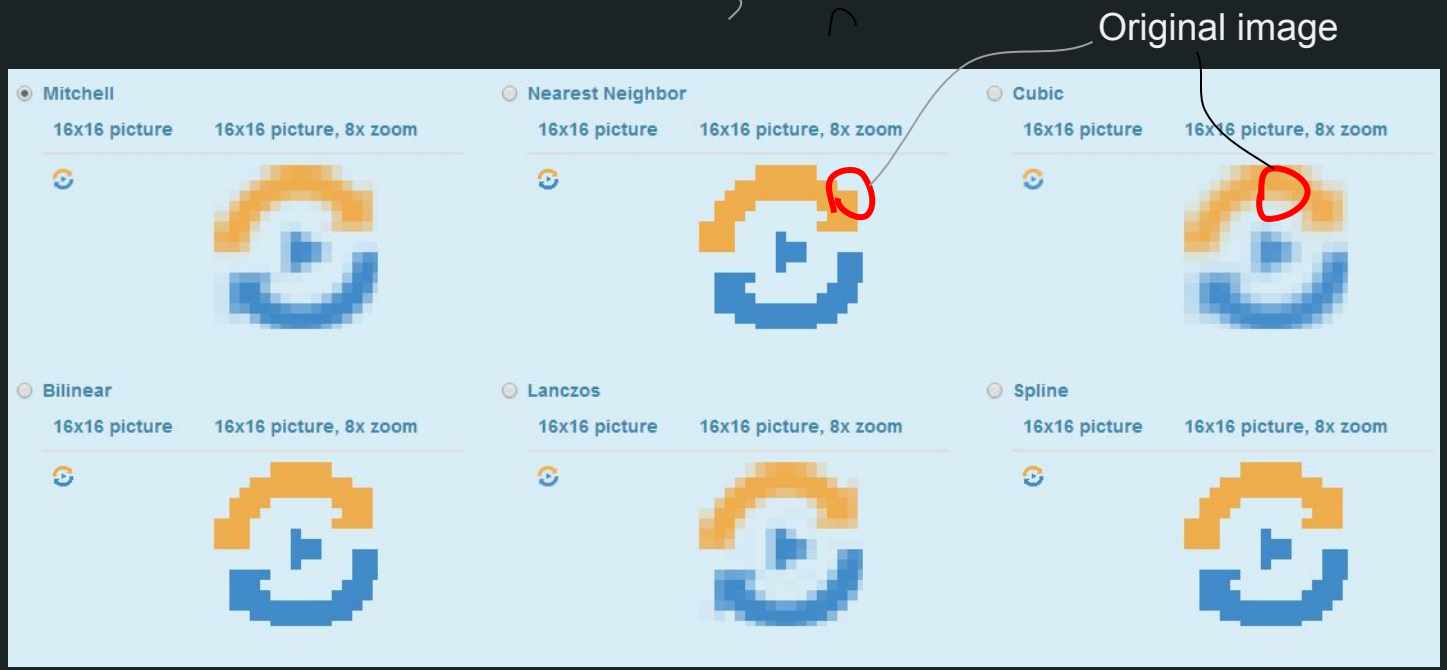
In Gaussian Thresholding, the mean of the neighbourhood is taken with Gaussian matrix as weight.

# GEOMETRIC TRANSFORMATIONS

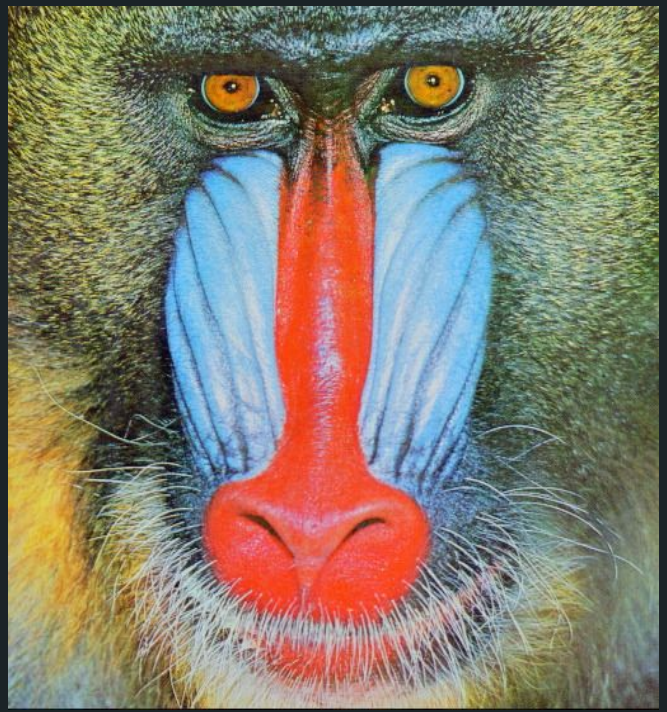


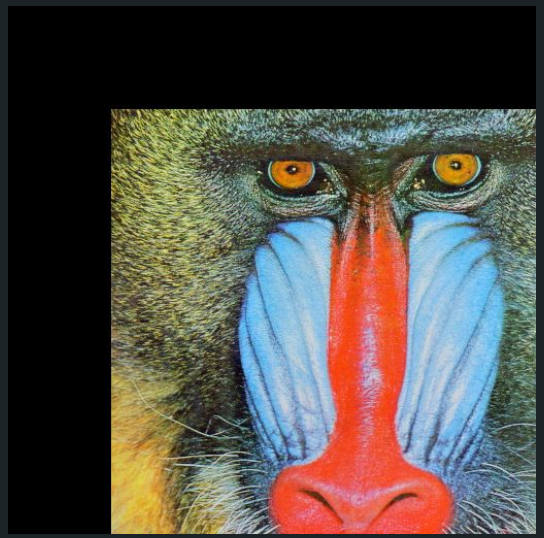
# Image Scaling

How are images resized??

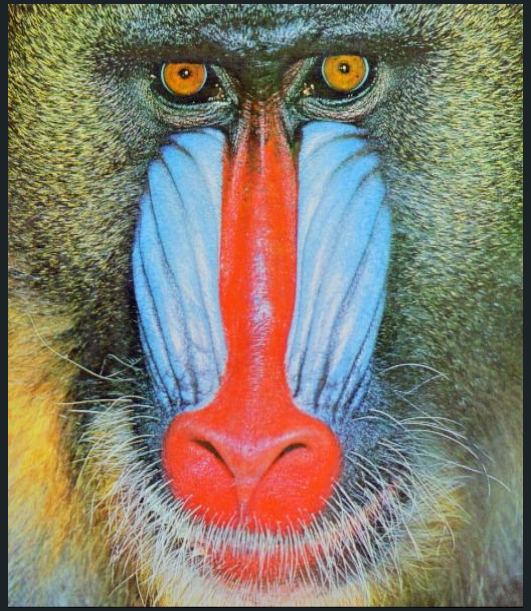


# Image Translation





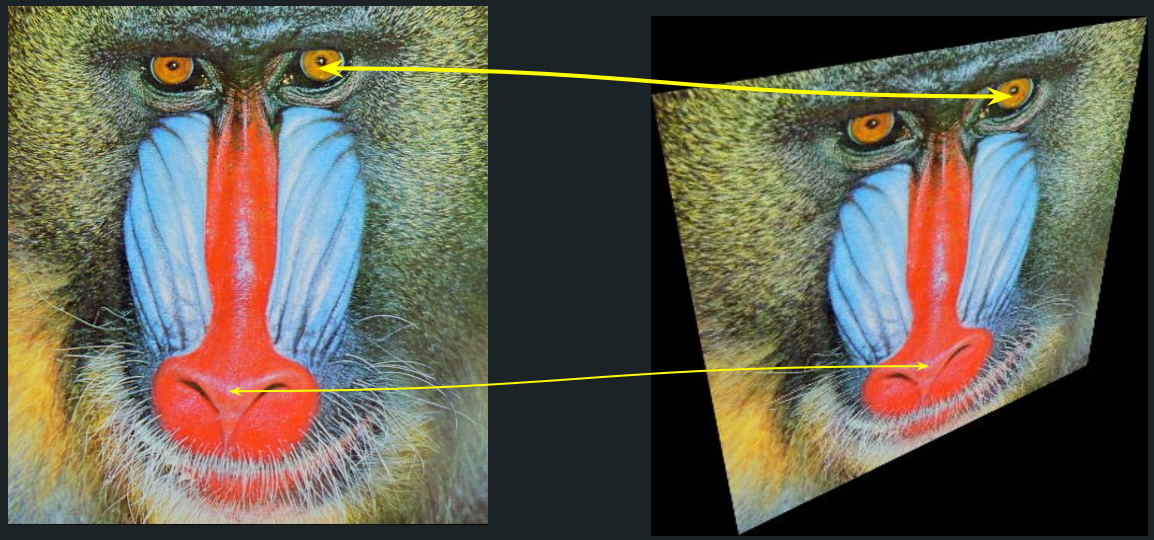
# Image Rotation



# Image Warping

Pure warping means that points are mapped to points without changing the colors.

Example



# TRY

## How can you match the two images?

# CONVOLUTION

# Making your own linear filters!

- Effects like the ones you might find in Photoshop or Gimp
- Ex: blurring, sharpening, outlining or embossing

# Convolution: Trick of Image Filtering

- Convolution: general purpose filter effect for images.
- A mathematical operation between every part of an image and an operator (kernel)
- The output is a new modified filtered image

# The process of image convolution

- Done by adding the weighted values of all its neighbors together
- Kernel:
  - Small matrix of numbers, say a 3x3, or 5x5 matrix (Why small?, Why odd size?)
  - The 2D filter matrix used to apply effects like blurring, sharpening, outlining
  - Example of a kernel:

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

# Let’s Convolve with this Kernel

| | | |
|---|---|---|
| 2 | 3 | -2 |
| 4 | 5 | -4 |
| -4 | -4 | 2 |

$$g(i,j) = \sum_{k,l} f(i+k, j+l)h(k,l)$$

# Let's Convolve the Kernel with this

| | | | | |
|---|---|---|---|---|
| 5 | 4 | 25 | 35 | 20 |
| 60 | 45 | 40 | 30 | 10 |
| 11 | 60 | 80 | 15 | 5 |
| 80 | 22 | 20 | 10 | 1 |
| 200 | 140 | 50 | 0 | 8 |

# Let's Convolve the Kernel with this

| | | | | |
|---|---|---|---|---|
| 2 5 | 3 4 | -2 25 | 35 | 20 |
| 4 60 | 5 45 | -4 40 | 30 | 10 |
| -4 11 | -4 60 | 2 80 | 15 | 5 |
| 80 | 22 | 20 | 10 | 1 |
| 200 | 140 | 50 | 0 | 8 |

45 is replaced with 2*5 + 3*4 + (-2)*25 + 4*60 + 5*45 + (-4)*40 + (-4)*11 + (-5)*60 + 2*80

# Ensuring Values are within range

What if values exceed 255 or drop below 0?

Truncation: Output more than 255 is taken as 255, and output with negative value is taken as 0 or as its absolute value

Normalization:

Dividing each element in the kernel by the sum of all elements

Normalized kernel gives output image with same brightness as input image

# What to do with edge pixels?

- Use “zeros” as the neighbour pixels that aren’t there, i.e. pad with zeros
- Wrap around the image to the other side
- Extend the nearest border pixels as far as necessary
- Crop, i.e. don’t consider edge pixels. Output image is slightly smaller

# Try it Out!

What happens on convolving with this kernel?

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 0 | 0 |
| 0 | 0 | 0 |

# Try it Out!

What happens on convolving with this kernel?

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 0 | 0 |
| 0 | 0 | 0 |

Displaces the image

# Try it Out!

What happens on convolving with this kernel?

| | | |
|---|---|---|
| 0 | -1 | 0 |
| -1 | 5 | -1 |
| 0 | -1 | 0 |

# Try it Out!

What happens on convolving with this kernel?

| | | |
|---|---|---|
| 0 | -1 | 0 |
| -1 | 5 | -1 |
| 0 | -1 | 0 |

Creates a sharpened image. (Convince yourself)

# Try it Out!

What happens on convolving with this kernel?

$$\frac{1}{9}$$

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 1 | 1 | 1 |

# Try it Out!

What happens on convolving with this kernel?

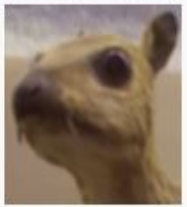
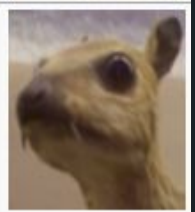
$$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

This causes Blurring.
The above kernel is normalized Box Filter

# Blurring

- Also called *Smoothing*
- Important in image processing
- The different kinds of filters for blurring:
  - Simple Blur (Normalized box filter) : Mean of kernel neighbors
  - Gaussian Blur: Uses Gaussian kernel
  - Median Blur: Median of neighbor pixels in kernel
  - Bilateral Filter : Gaussian function of space and intensity (preserves edges)

| | | |
|---|---|---|
| **Identity** | $\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ |  |

| | | |
|---|---|---|
| **Sharpen** | $\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$ |  |
| **Box blur** (normalized) | $\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ |  |
| **Gaussian blur** (approximation) | $\frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$ |  |
| **Edge detection** | $\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$ |  |
| | $\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$ |  |
| | $\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$ |  |