Introduction

(Digital Image Processing)

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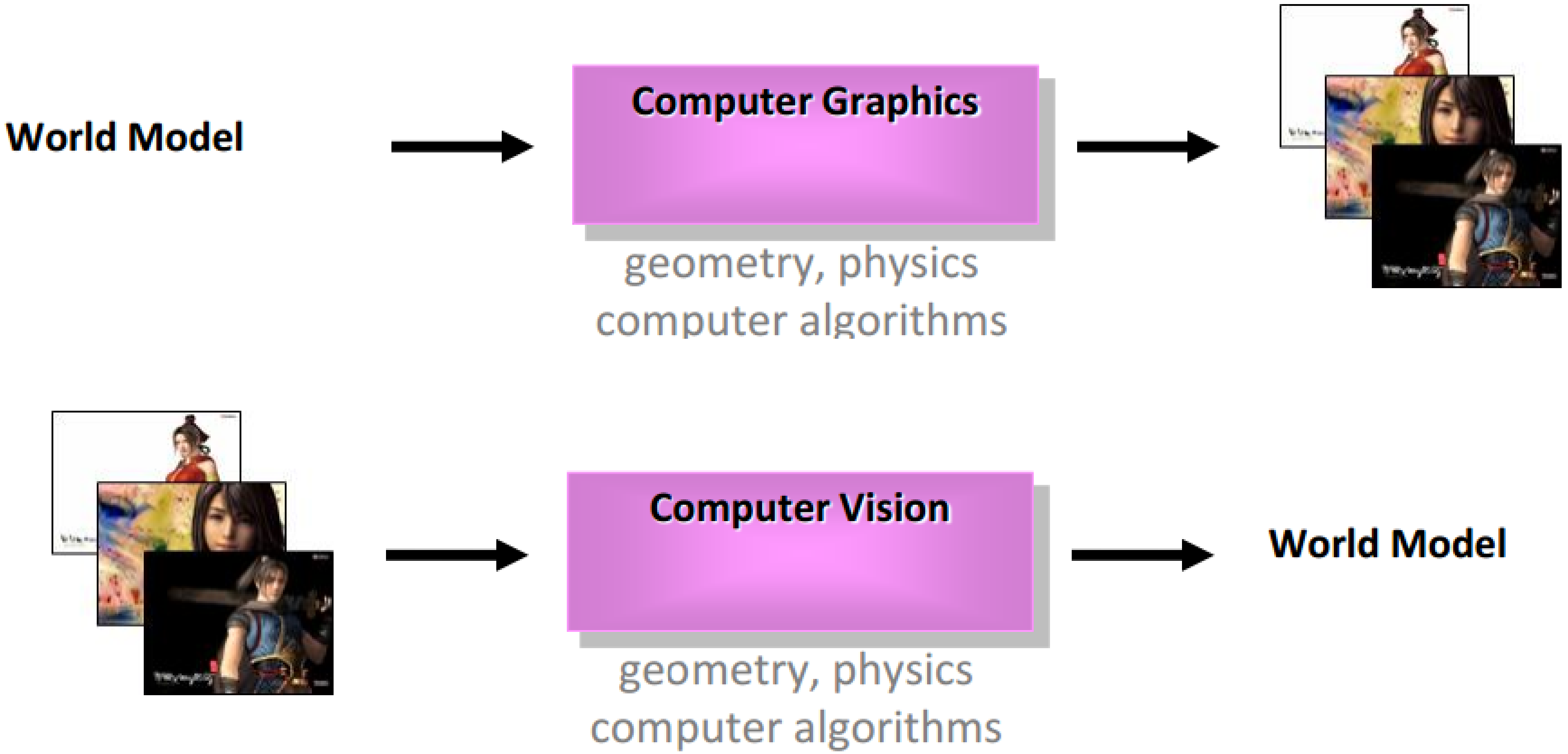
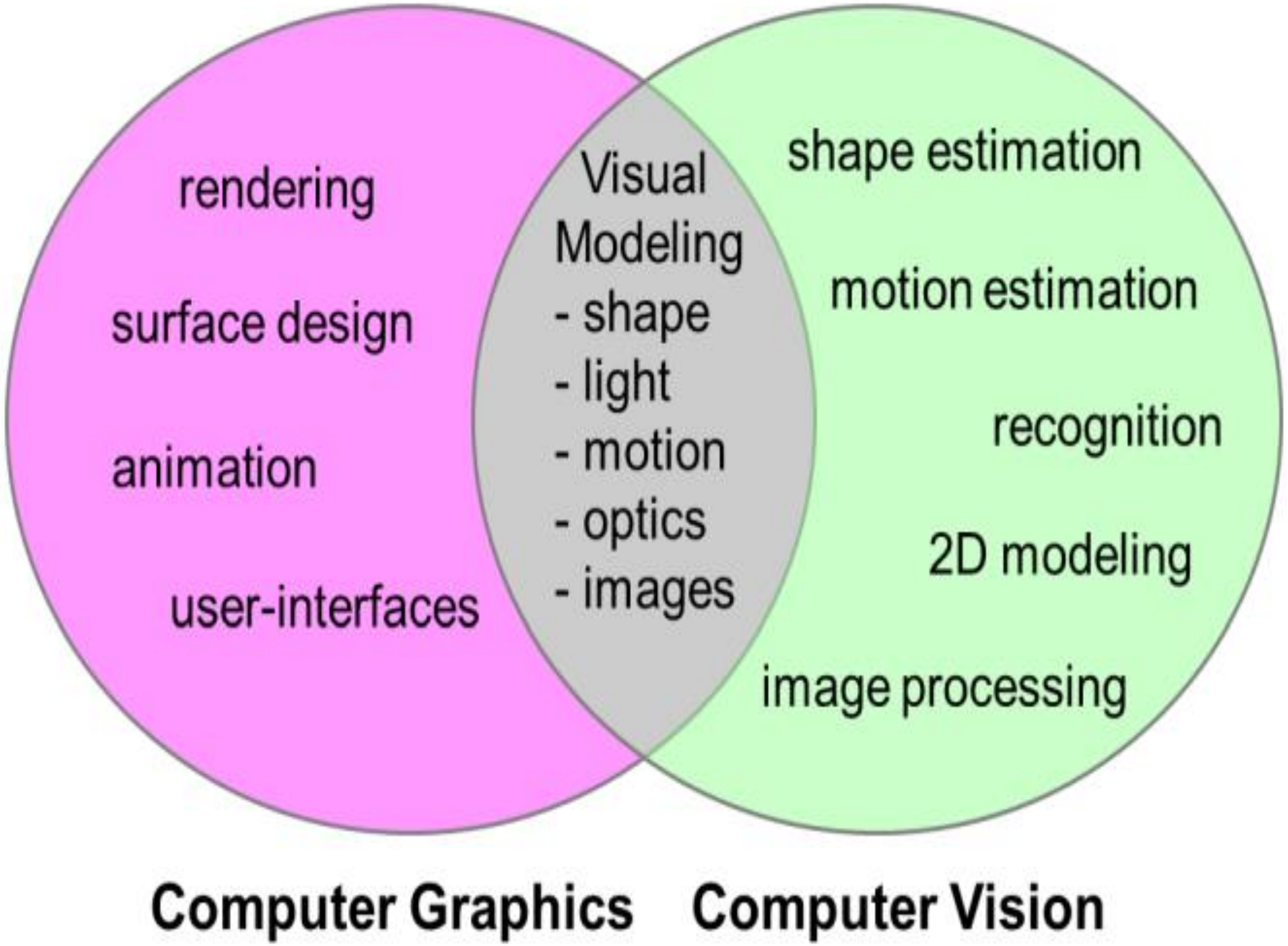
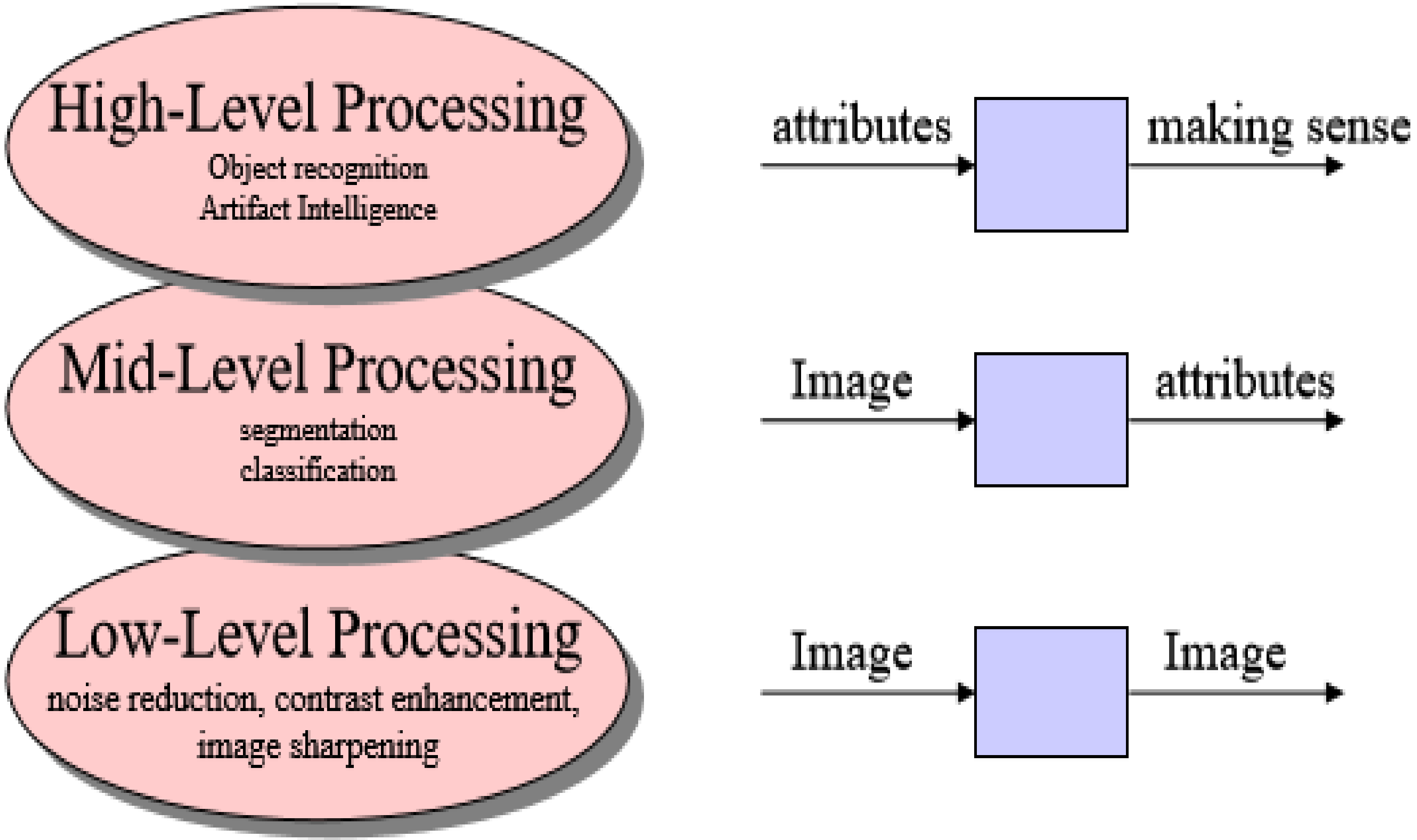
Compare

- Digital image processing
- Computer graphics
- Computer Vision


World Model
Computer Graphics
geometry, physics
computer algorithms
Computer Vision
geometry, physics
computer algorithms
World Model


rendering
surface design
animation
user-interfaces
Visual
Modeling
- shape
- light
- motion
- optics
- images
shape estimation
motion estimation
recognition
2D modeling
image processing
Computer Graphics
Computer Vision

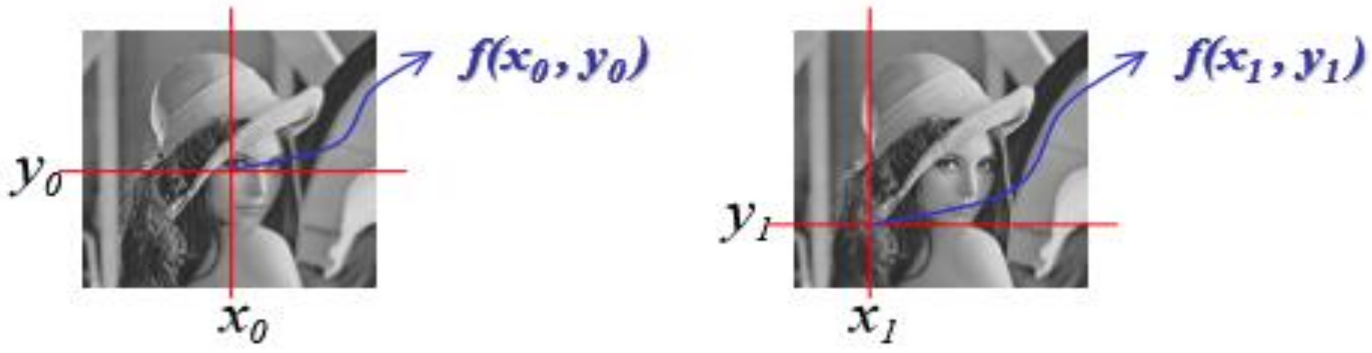
- *Image processing to computer vision*



Digital image processing

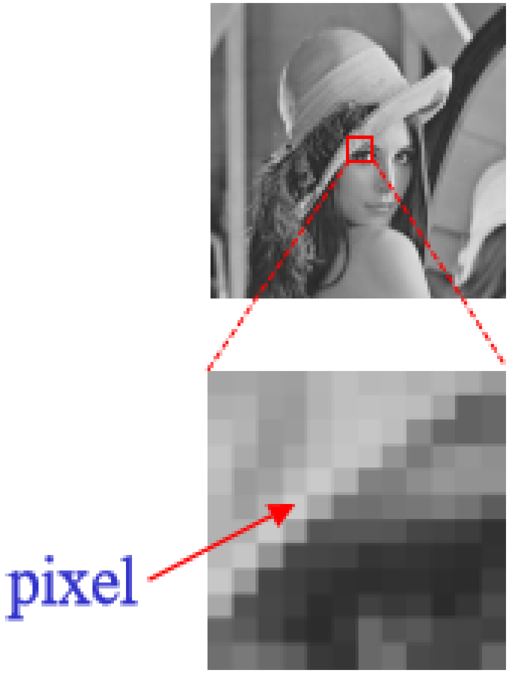
1.1 What is digital image processing?

- ***Image***
  - A 2D function, ***f(x, y)*** Intensity = Độ sáng
  - ***x*** and ***y*** are spatial coordinates
  - Amplitude of ***f*** is called the **intensity** or **gray level**



Digital image processing

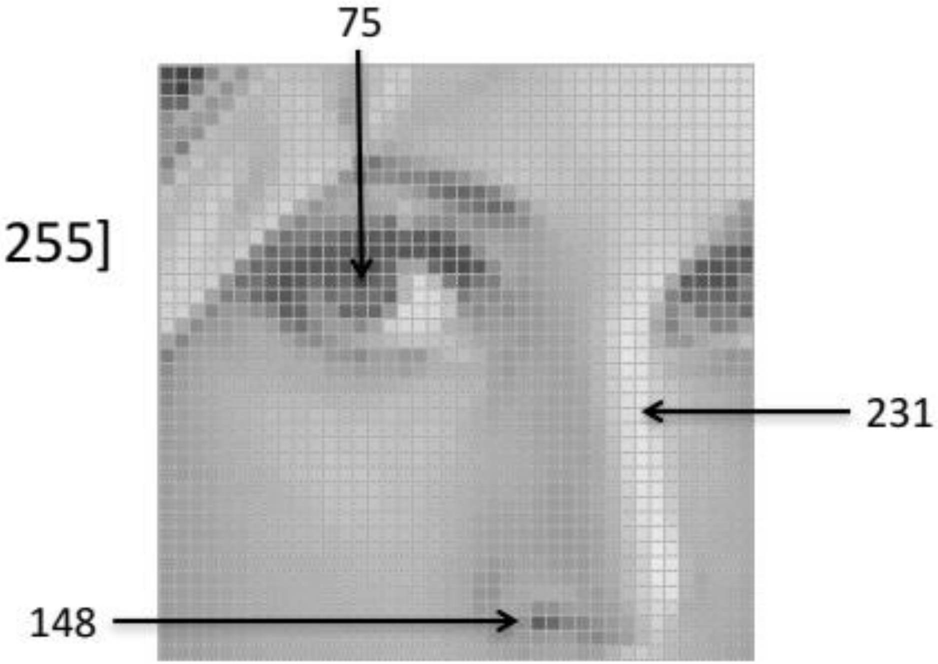
- ***Digital image***
  - *x*, *y*, *f*(*x*, *y*) are all finite and discrete
  - is composed of ***a finite number of elements***
  - These elements are referred to as
    - picture elements
    - image elements
    - pels
    - pixels - most widely used



Images as functions

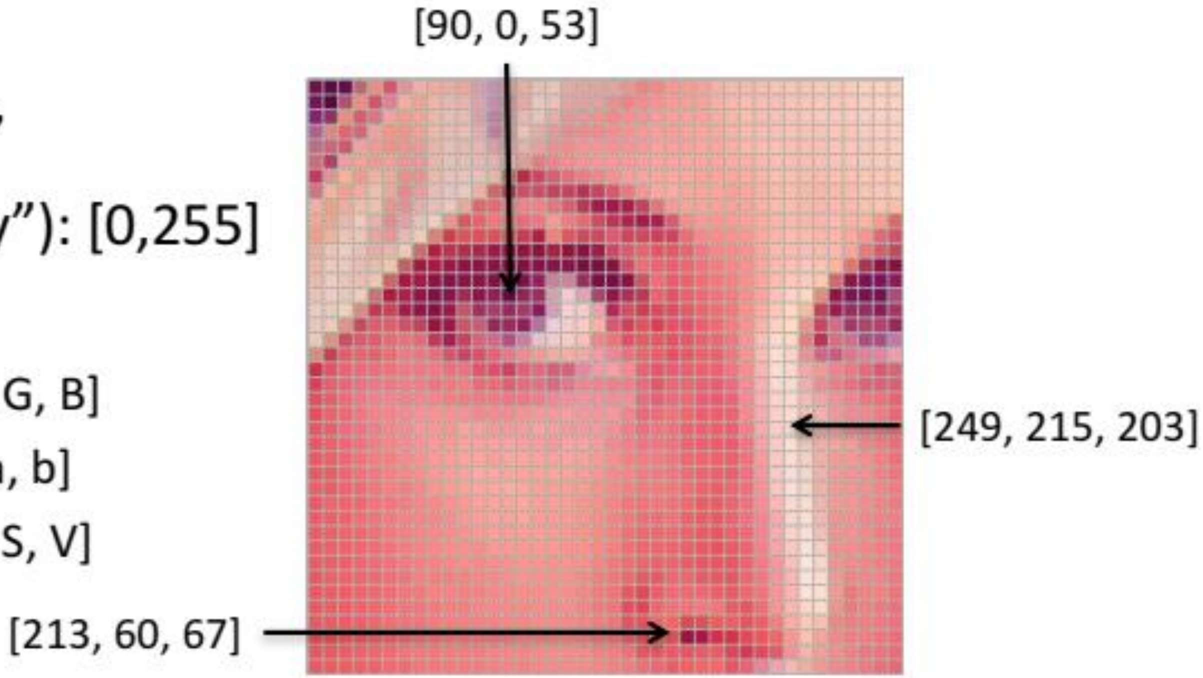
- An image contains discrete number of pixels
  - A simple example
  - Pixel value:
    - "grayscale"

    (or "intensity"): [0,255]



Images as functions

- An image contains discrete number of pixels
  - A simple example
  - Pixel value:
    - "grayscale"
    (or "intensity"): [0,255]
    - "color"
      - RGB: [R, G, B]
      - Lab: [L, a, b]
      - HSV: [H, S, V]



Images as discrete functions

- Images are usually **digital (discrete)**:
  - **Sample** the 2D space on a regular grid

- Represented as a matrix of integer values

pixel

j

i

62	79	23	119	120	05	4	0
10	10	9	62	12	78	34	0
10	58	197	46	46	0	0	48
176	135	5	188	191	68	0	49
2	1	1	29	26	37	0	77
0	89	144	147	187	102	62	208
255	252	0	166	123	62	0	31
166	63	127	17	1	0	99	30

Image formation

- What the computer "sees" is just a grid of numbers.
- this grid of numbers is all the computer "sees".
- Our task then becomes to turn this noisy grid of numbers into the perception: "side mirror".

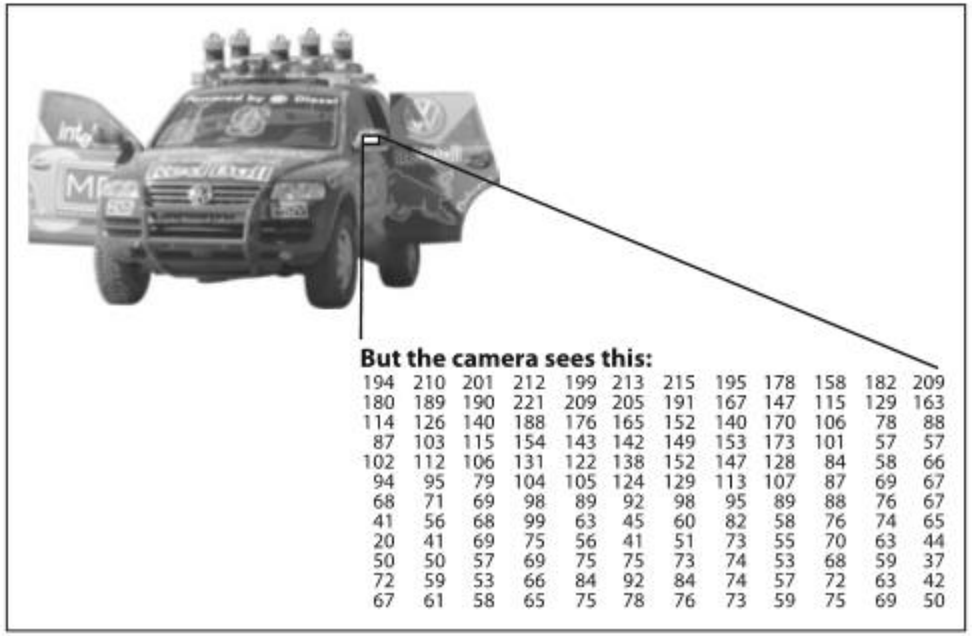
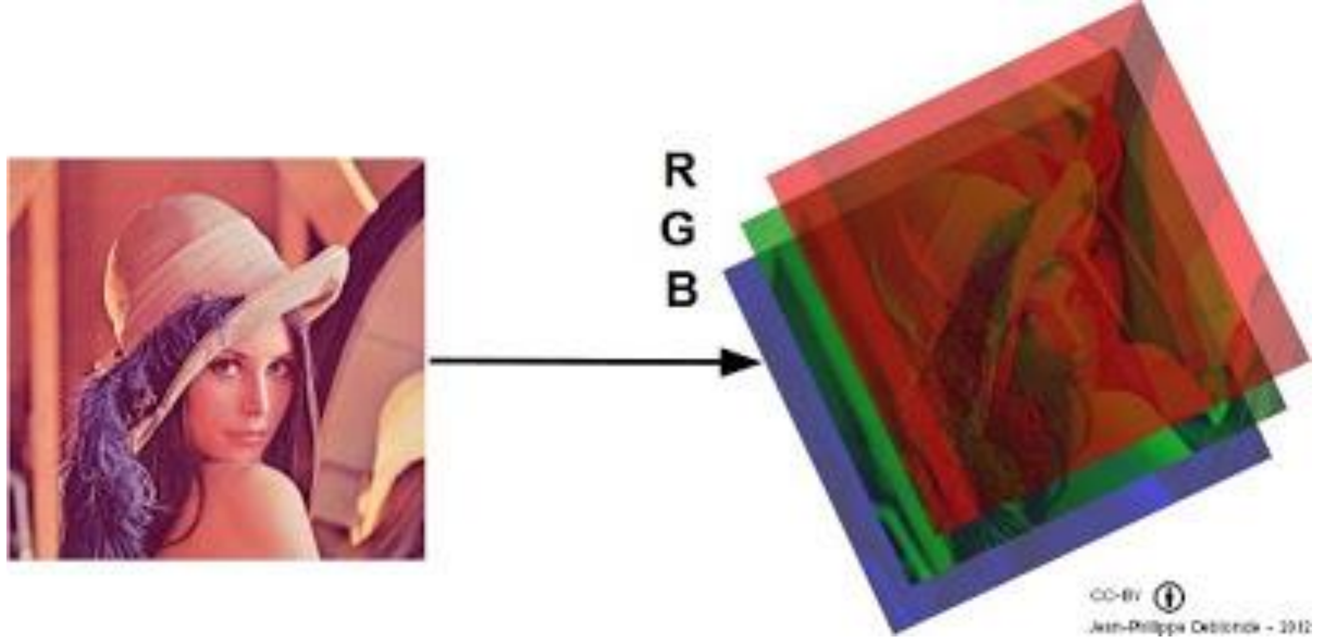
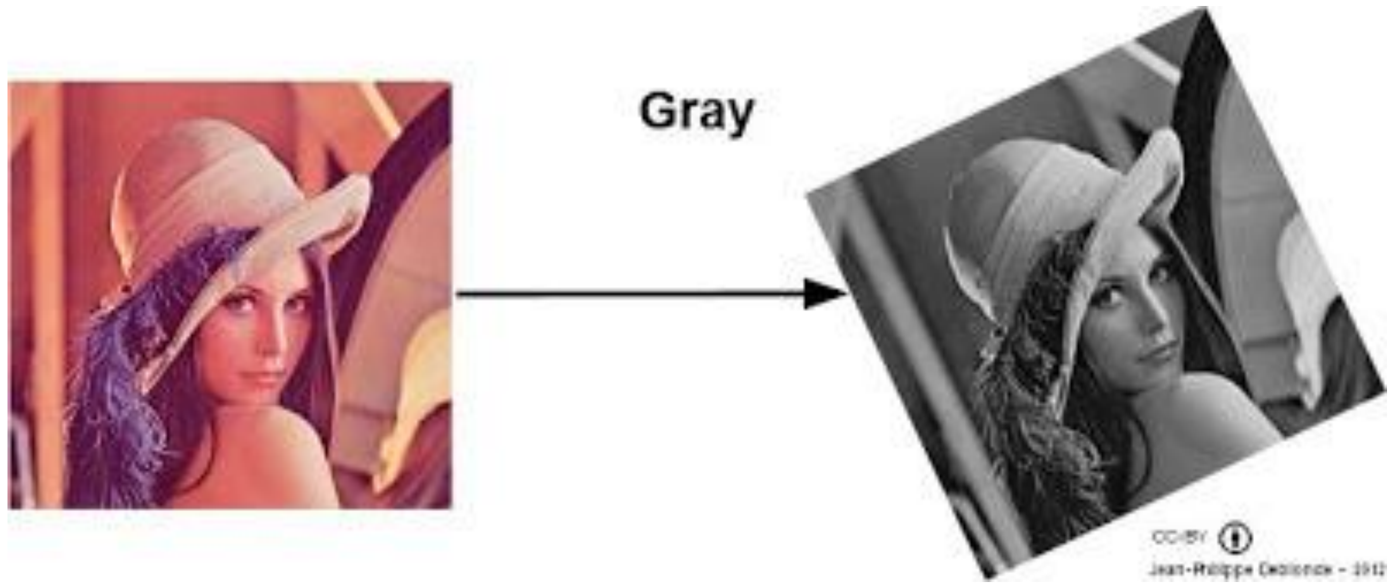


Figure 1-1. To a computer, the car's side mirror is just a grid of numbers

Grayscale & Color image





RGB to Grayscale

- The **lightness** method

I = (**max**(R, G, B) + **min**(R, G, B)) / 2.

- The **average** method

I = **(R + G + B) / 3**.

- The **luminosity** method

I = 0.21 R + 0.72 G + 0.07 B.

https://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/

Tools to learn DIP

- **OPENCV** Library
  - **OpenCV** for **C++**
  - **Emgu** for **C#**
  - **OpenCV** for **Java/Python**

Good for programmers

Fast and efficent

OPEN SOURCE

- **MATLAB**

Very easy to program

Less efficient

NOT FREE

Using OpenCV & Matlab

- OpenCV

Example 2-1. A simple OpenCV program that loads an image from disk and displays it on the screen

```
#include "highgui.h"

int main( int argc, char** argv ) {
    IplImage* img = cvLoadImage( argv[1] );
    cvNamedWindow( "Example1", CV_WINDOW_AUTOSIZE );
    cvShowImage( "Example1", img );
    cvWaitKey(0);
    cvReleaseImage( &img );
    cvDestroyWindow( "Example1" );
}
```

```
#include <opencv2/opencv.hpp> //Include file for every supported OpenCV function

int main( int argc, char** argv ) {
  cv::Mat img = cv::imread(argv[1],-1);
  if( img.empty() ) return -1;
  cv::namedWindow( "Example1", cv::WINDOW_AUTOSIZE );
  cv::imshow( "Example1", img );
  cv::waitKey( 0 );
  cv::destroyWindow( "Example1" );
}
```

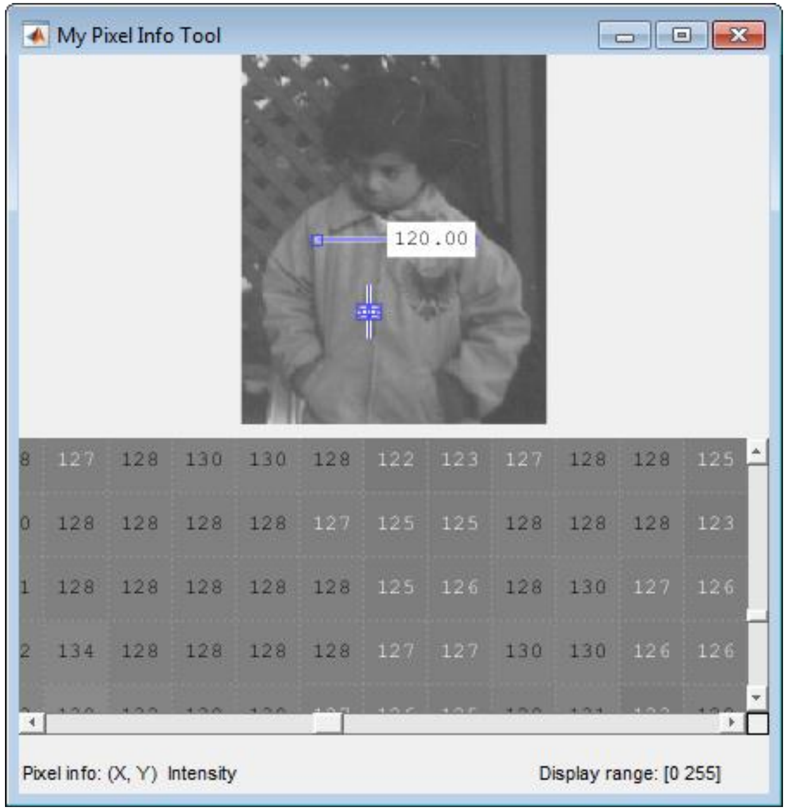
- Matlab

```
I = imread('cameraman.tif');
imshow(I)
```

Build App To Display Pixel Information

- https://www.mathworks.com/help/images/build-app-to-display-pixel-information.html

```
function my_pixinfotool(im)
% Create figure, setting up properties
fig = figure('Toolbar','none',...
              'Menubar', 'none',...
              'Name','My Pixel Info Tool',...
              'NumberTitle','off',...
              'IntegerHandle','off');

% Create axes and reposition the axes
% to accommodate the Pixel Region tool panel
ax = axes('Units','normalized',...
           'Position',[0 .5 1 .5]);

% Display image in the axes
img = imshow(im);

% Add Distance tool, specifying axes as parent
distool = imdistline(ax);

% Add Pixel Information tool, specifying image as parent
pixinfo = impixelinfo(img);

% Add Display Range tool, specifying image as parent
drange = imdisplayrange(img);

% Add Pixel Region tool panel, specifying figure as parent
% and image as target
pixreg = impixelregionpanel(fig,img);

% Reposition the Pixel Region tool to fit in the figure
% window, leaving room for the Pixel Information and
% Display Range tools.
set(pixreg, 'units','normalized','position',[0 .08 1 .4])
```



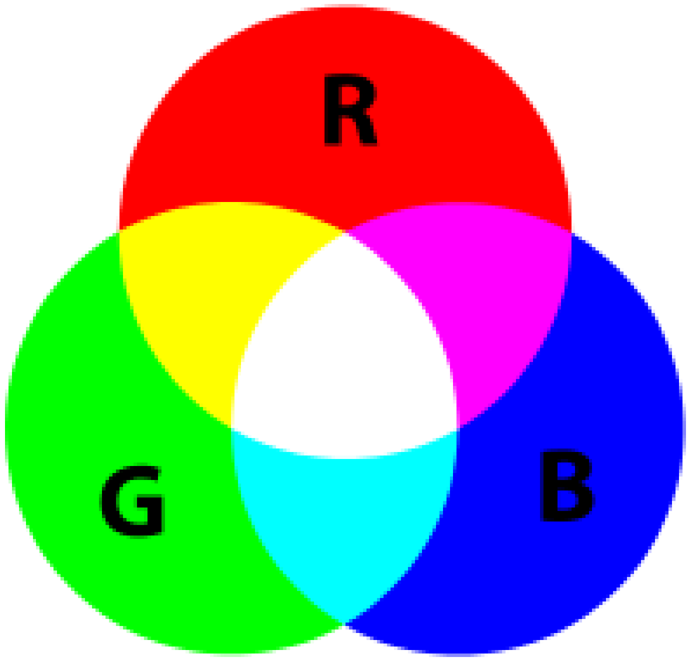
Color spaces

- Many color spaces? Why?

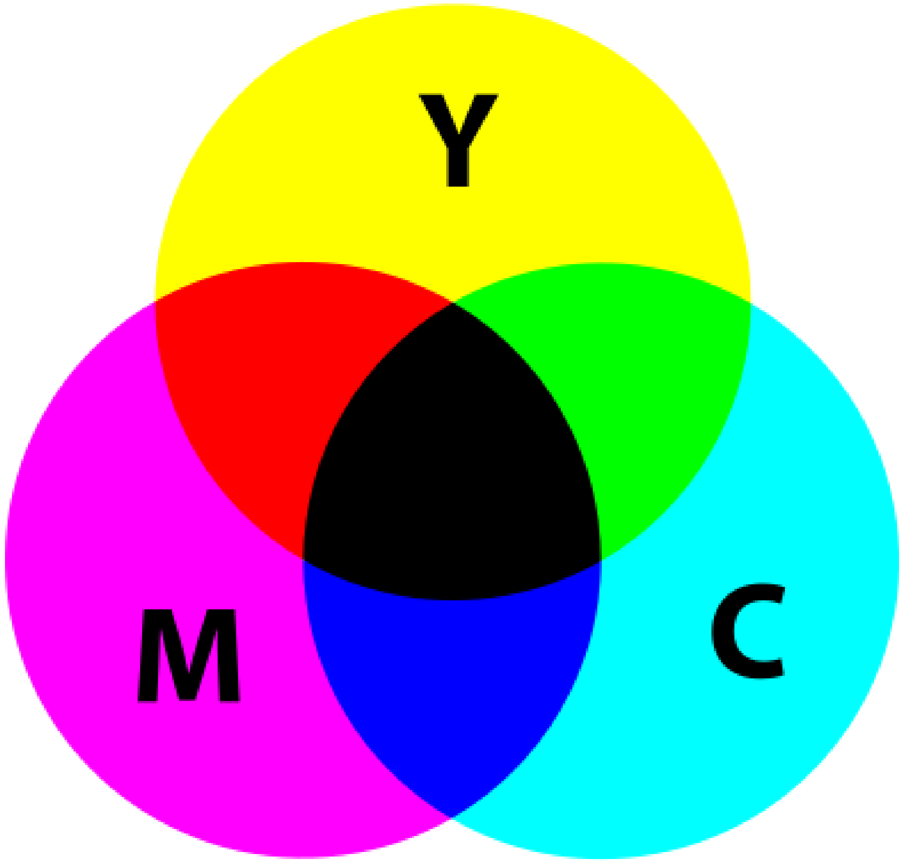
https://en.wikipedia.org/wiki/Color_space

Color spaces

- RGB uses additive color mixing, because it describes what kind of light needs to be emitted to produce a given color. RGB stores individual values for red, green and blue.
- RGBA is RGB with an additional channel, alpha, to indicate transparency.



Color spaces



- CMYK uses subtractive color mixing used in the printing process
- HSV (hue, saturation, value), also known as HSB (hue, saturation, brightness) is often used by artists because it is often more natural to think
- HSL (hue, saturation, lightness/luminance), also known as HLS or HSI (hue, saturation, intensity) is quite similar to HSV, with "lightness" replacing "brightness".

Color spaces

- **ABSOLUTE** color space
  - A color space in which the perceptual **difference between colors** is directly related to **distances between** colors as represented by **points** in the color space
  - CIEXYZ and sRGB are examples of absolute color spaces
  - The L*a*b* is sometimes referred to as absolute, though it also needs a white point specification to make it so

Color space	**Color mixing**	**Primary parameters**	**Used for**	**Pros and cons**
RGB	*Additive*	Red, Green, Blue		Easy but wasting bandwidth
CMYK	*Subtractive*	Cyan, Magenta, Yellow, Black	Printer	Works in pigment mixing
YCbCr YPbPr	*additive*	Y(luminance), Cb(blue chroma), Cr(red chroma)	Video encoding, digital camera	Bandwidth efficient
YUV	*additive*	Y(luminance), U(blue chroma), V(red chroma)	Video encoding for NTSC, PAL, SECAM	Bandwidth efficient
YIQ	*additive*	Y(luminance), I(rotated from U), Q(rotated from V)	Video encoding for NTSC	Bandwidth efficient

Color Space conversion

http://www.equasys.de/colorconversion.html

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 1]
Y [0 ... 1]
U [-0.436 ... +0.436]
V [-0.615 ... +0.615]

RGB to YUV color conversion for analog TV

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.140 \\ 1.000 & -0.395 & -0.581 \\ 1.000 & 2.032 & 0.000 \end{bmatrix} \cdot \begin{bmatrix} Y \\ U \\ V \end{bmatrix}$$

Ranges:
Y [0 ... 1]
U [-0.436 ... +0.436]
V [-0.615 ... +0.615]
R/G/B [0 ... 1]

YUV to RGB color conversion for analog TV

A Theory Based on Conversion of RGB image to Gray image

Grey image

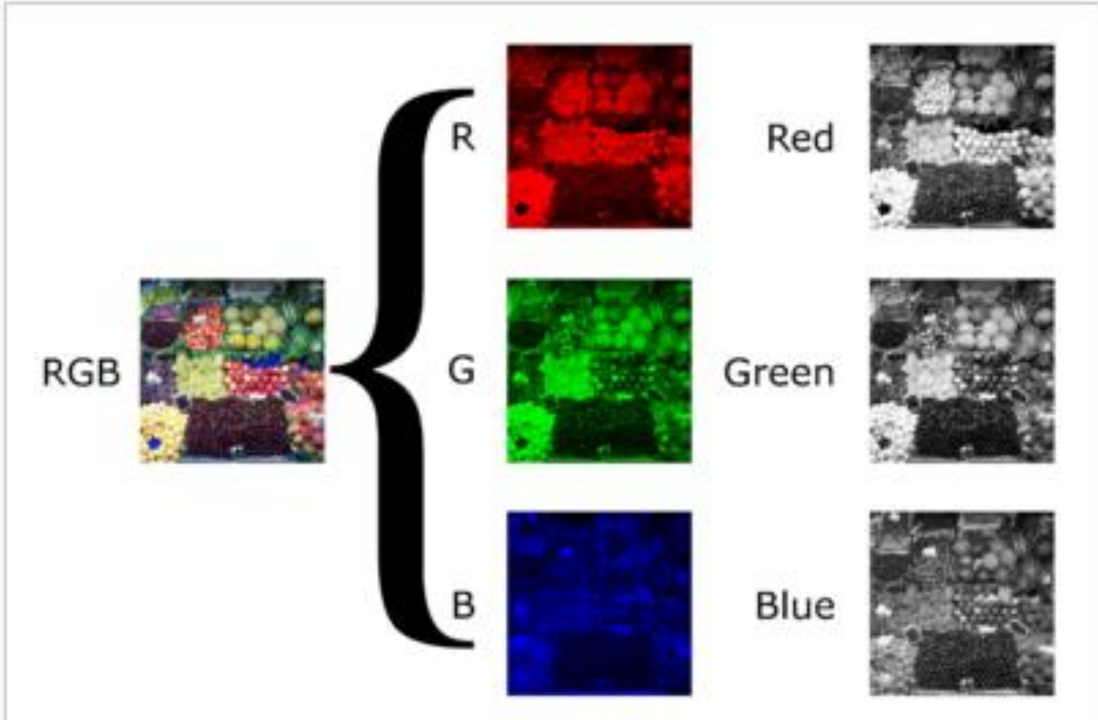
Grey color codes chart

Color	HTML / CSS Color Name	Hex Code #RRGGBB	Decimal Code (R,G,B)
	gainsboro	#DCDCDC	rgb(220,220,220)
	lightgray / lightgrey	#D3D3D3	rgb(211,211,211)
	silver	#C0C0C0	rgb(192,192,192)
	darkgray / darkgrey	#A9A9A9	rgb(169,169,169)
	gray / grey	#808080	rgb(128,128,128)
	dimgray / dimgrey	#696969	rgb(105,105,105)
	lightslategray / lightslategrey	#778899	rgb(119,136,153)
	slategray / slategrey	#708090	rgb(112,128,144)
	darkslategray / darkslategrey	#2F4F4F	rgb(47,79,79)
	black	#000000	rgb(0,0,0)

- http://www.rapidtables.com/web/color/gray-color.htm

Grayscale as single channels of multichannel color images

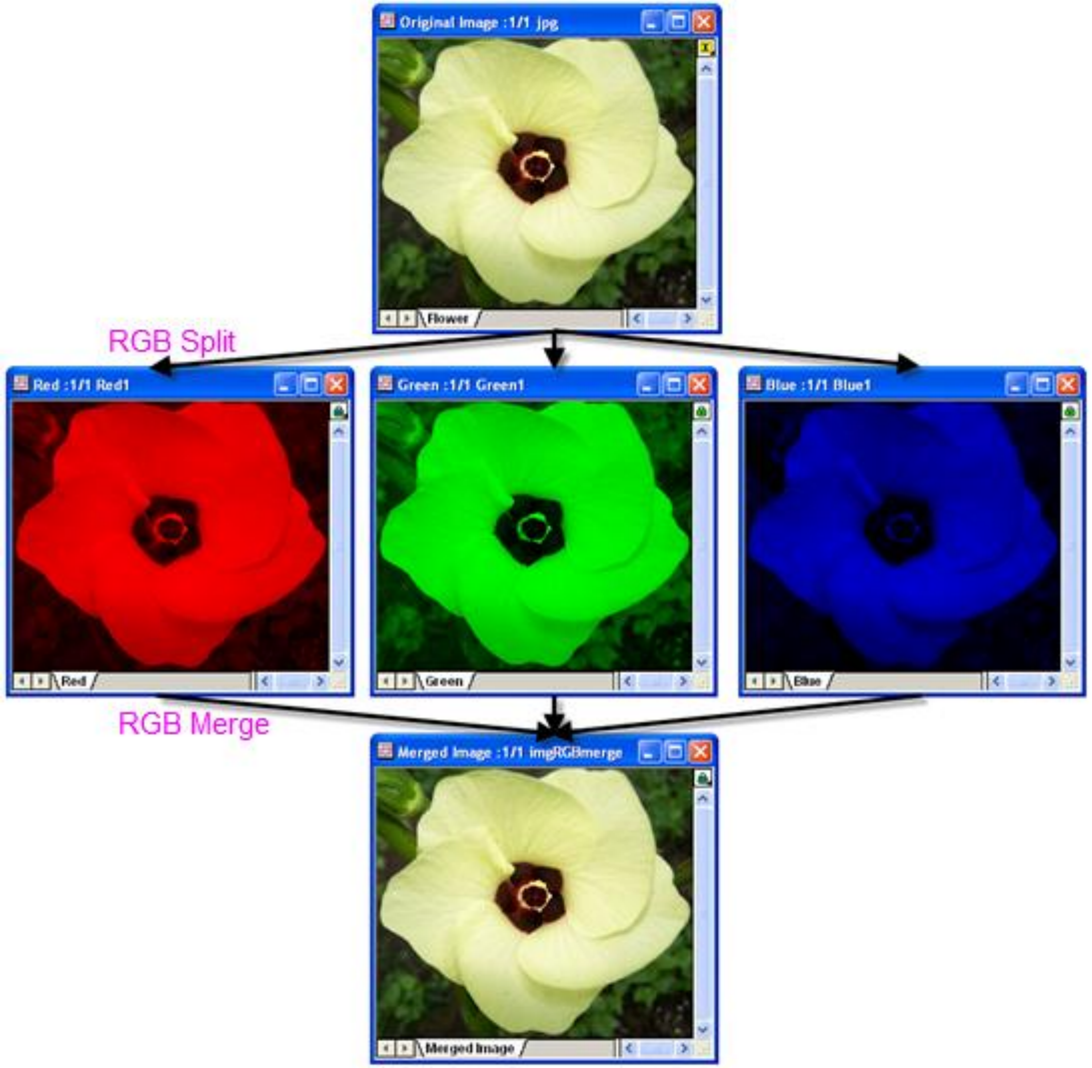
- Color images are often built of several stacked color channels,
- each of them representing value levels of the given channel.
- For example, RGB images are composed of three independent channels for red, green and blue primary color components;



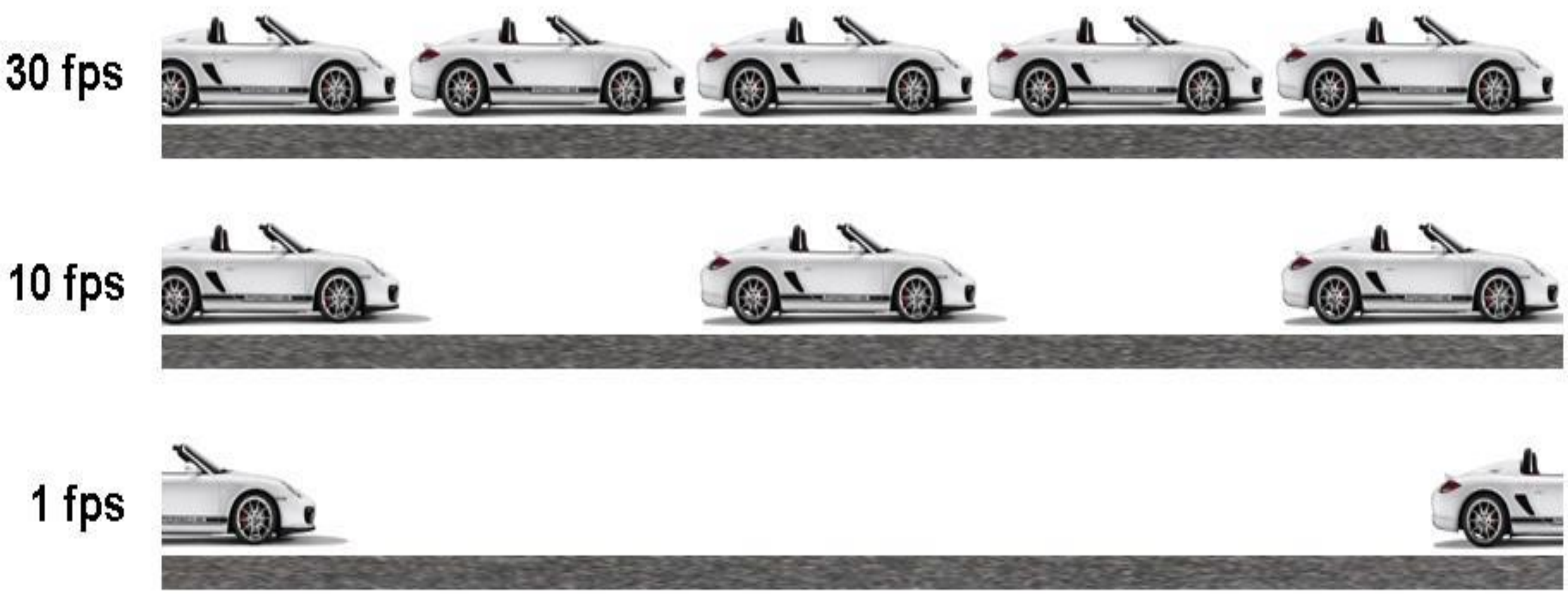
Composition of RGB from 3 Grayscale images

https://en.wikipedia.org/wiki/Grayscale

```
img = imread('filename.png'); % Read image
red = img(:,:,1); % Red channel
green = img(:,:,2); % Green channel
blue = img(:,:,3); % Blue channel
```

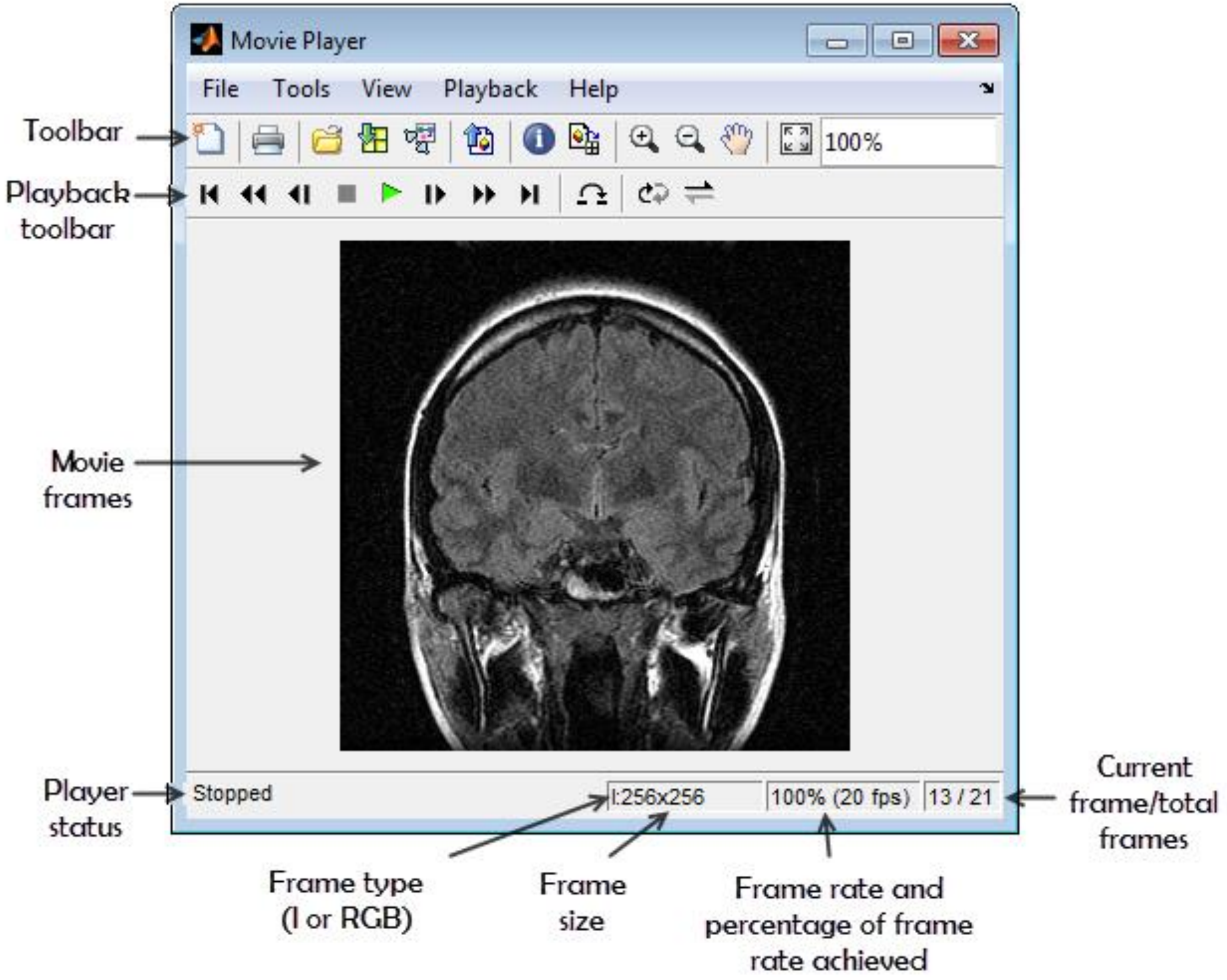


Video processing



Play video in Matlab

```
implay('rhinos.avi');
```



OpenCV

- From video file
  - VideoCapture frameSource(“file name”);

- Webcam
  - VideoCapture frameSource(0) ;

Homework topics

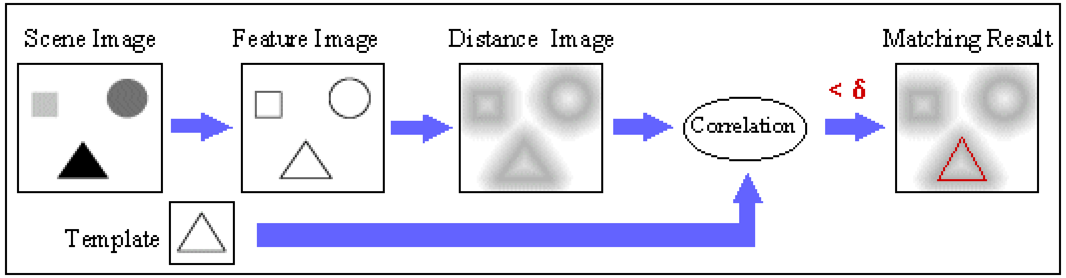
Topics

1. Mean-shift segmentation
2. K-means clustering
3. Graph based segmentation
4. Motion detection
5. Watershed segmentation
6. Corner detection
7. Template matching
8. Distance transform
   & Chamfer matching
9. Hough transform
   & Line detection

Edge detection

- Gradient
- Edge detection
  - Sobel
- Canny algorithm

Chamfer matching



- Distance transform
- Chamfer matching
  - The Chamfer Matching Algorithm basically calculates the distance (dis-similarity) between two images. The basic idea is to:
    - Extract the edge/contours of a query image as well as target image.
    - Take one point/pixel of contour in query image and
      find the distance of a closest point/pixel of contour in target image.
    - Sum the distances for all edge points/pixels of query image.
  - This gives the Chamfer Distance i.e. a value of dis-similarity between two images. The lower the value better the result.
    take care of scaling, and sliding windows)

Segmentation

- Thresholding
- Otsu method
- K-means clustering
- Graph-based segmentation

Contact

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