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COMPUTER VISION SYSTEMS

- Professor: Rubén Alvarez

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- Why I'm tacking this course?
- From which career am I?
- In which programming languages I know to program?
- Something good that happened in online classes?
- Something bad that happened in online classes? (without names)

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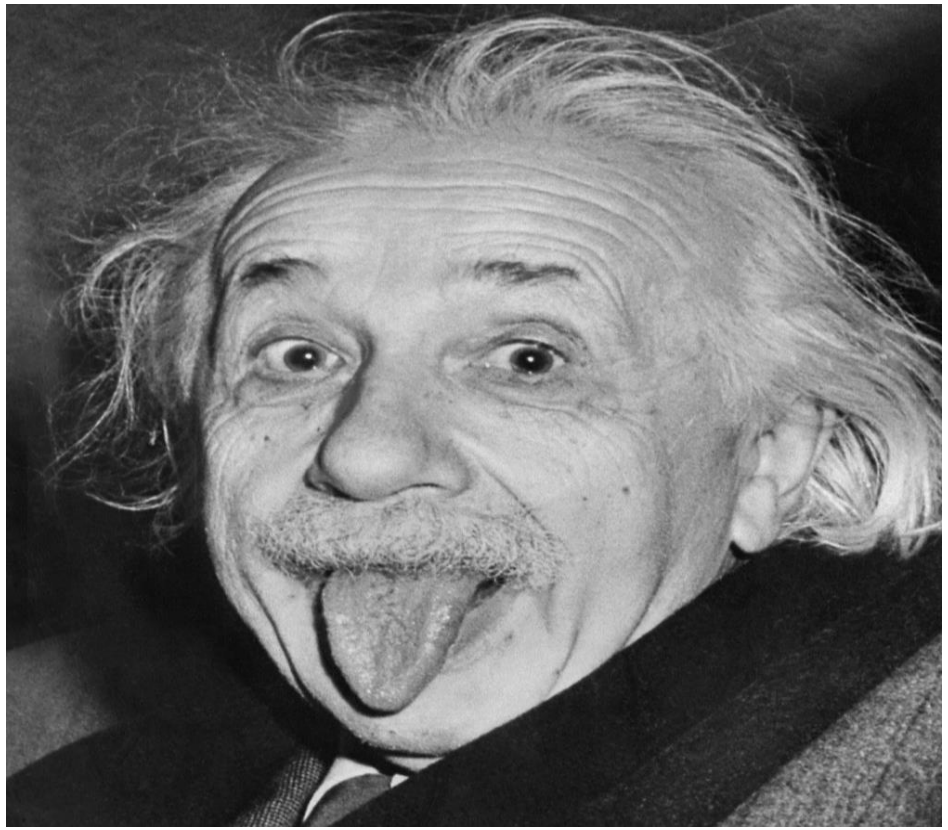
INTRODUCTION TO COMPUTER VISION

COMPUTER VISION

CONTENT

- History of Computer Vision
- What is Computer Vision?
- Areas in Computer Vision
- Optics
- Mathematics necessary

- *"Everything human beings can imagine; nature has already created…"*
  - -Albert Einstein.



WHAT IS COMPUTER VISION?

- Humans use our eyes and our brains to see and visually perceive the world around us. Computer Vision is the science that aims to provide a similar, if not better, capability to a machine or computer.

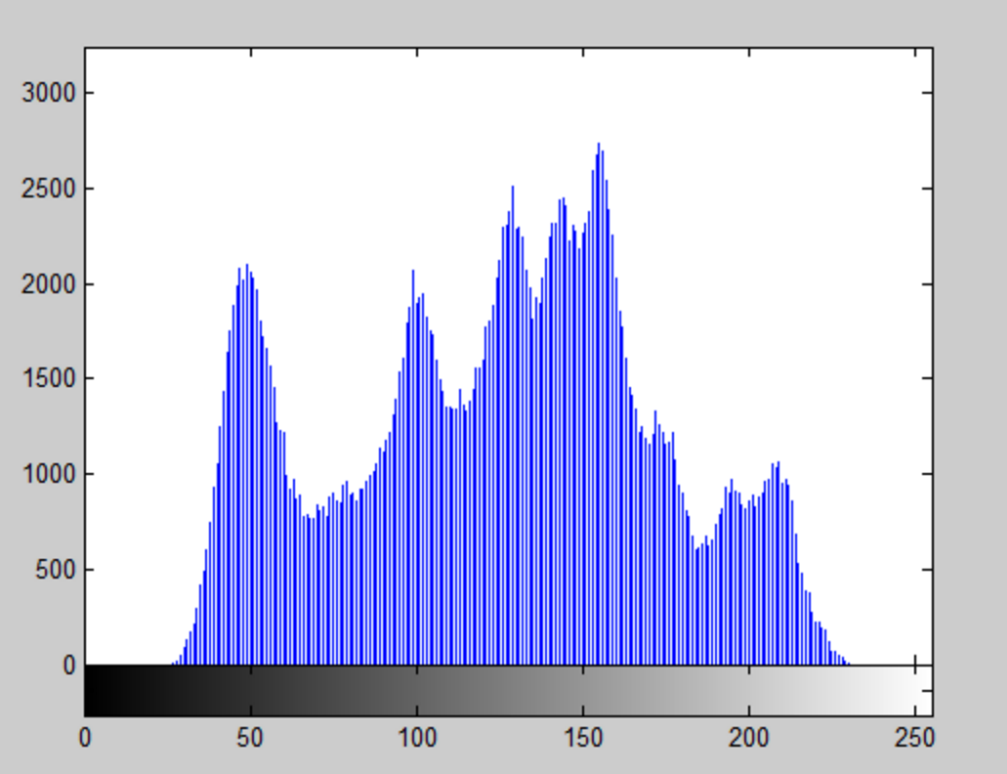
WHO IS THIS GUY?

Alexander Sawchuk 1973

WHO IS SHE?

November 1972

HISTOGRAM



WHAT DO I NEED TO KNOW?

- Image Processing
- Geometric Optics
- Electromagnetic Optics
- Data Science
  - Data Engineering, Data Analysis, Data Visualization
- Signal Processing
- …

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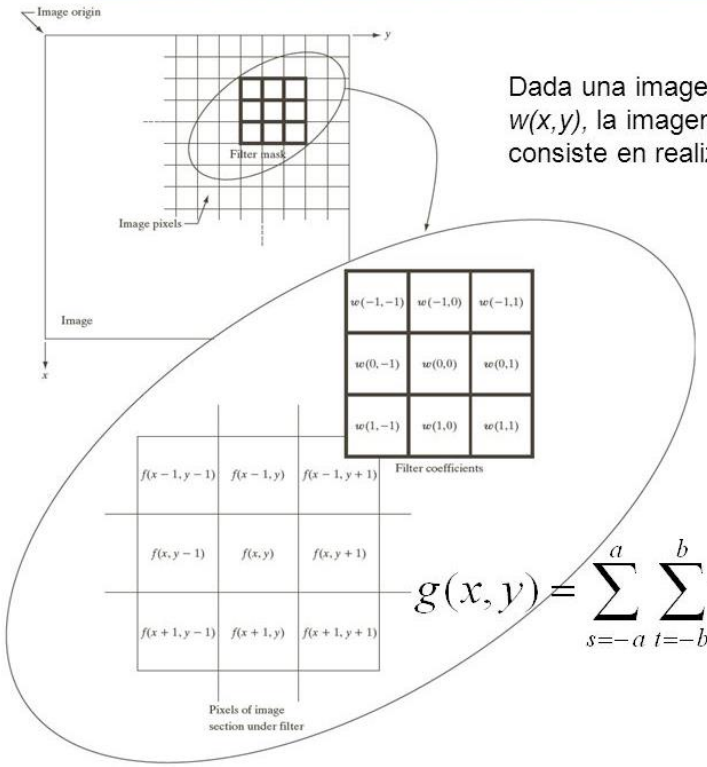
LINEAR FILTERS



Dada una imagen *f(x,y)* y una máscara *w(x,y)*, la imagen resultante *g(x,y)* consiste en realizar la operación:

$$g(x,y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)$$

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GAUSSIAN FILTER

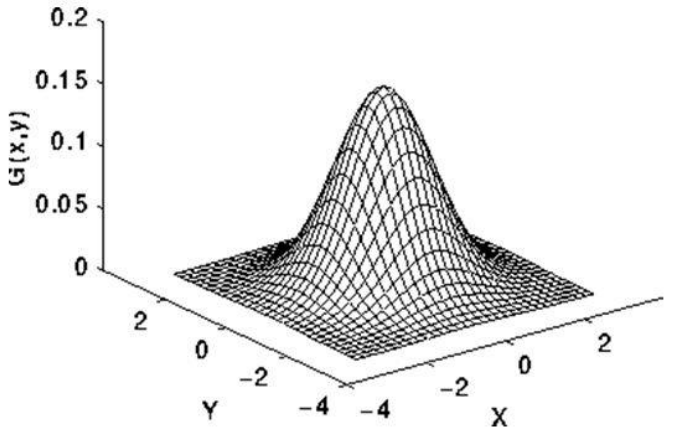
Aproximación discreta de un filtro 2D Gaussiano :

Suma ponderada, los pixels centrales son más importantes que los pixels de los bordes

$$G(x,y)=\frac{1}{2\pi\sigma_x\sigma_y}e^{-\frac{1}{2}\left(\frac{x^2}{\sigma_x}+\frac{y^2}{\sigma_y}\right)}$$

$$g_3=\frac{1}{16}\begin{bmatrix}1&2&1\\2&4&2\\1&2&1\end{bmatrix}$$

$$g_5=\frac{1}{246}\begin{bmatrix}1&4&6&4&1\\4&16&24&16&4\\6&24&36&24&6\\4&16&24&16&4\\1&4&6&4&1\end{bmatrix}$$



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MEAN FILTER

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

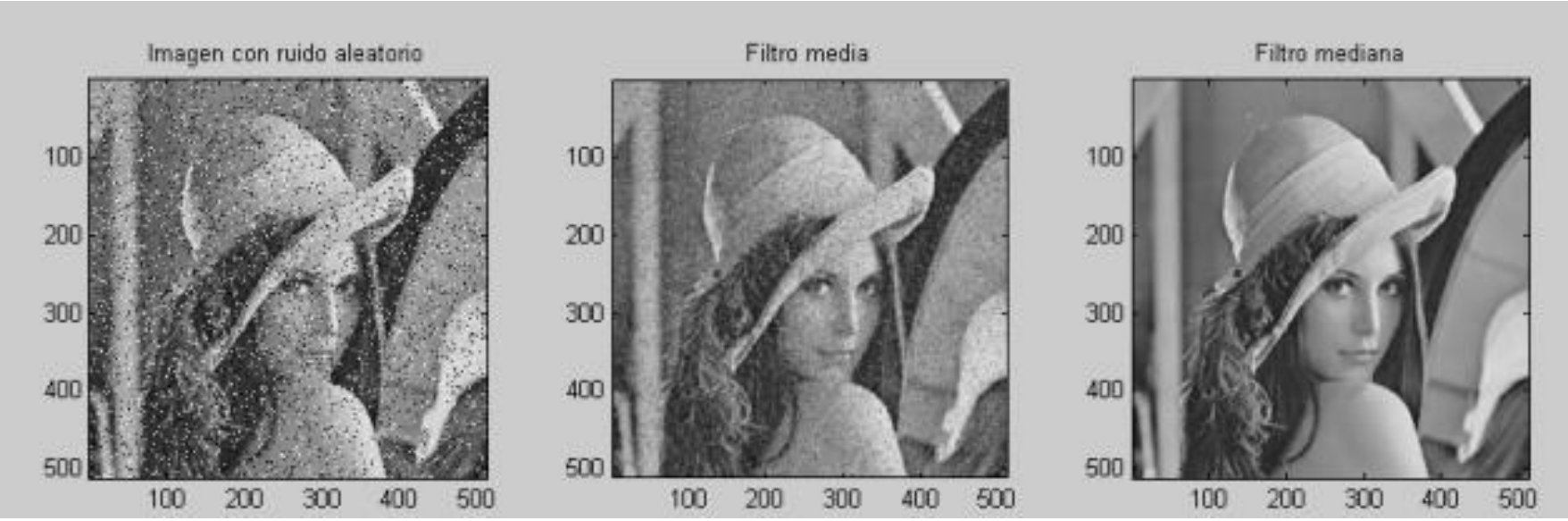
Imagen con ruido aleatorio
Filtro media
Filtro mediana
100
200
300
400
500

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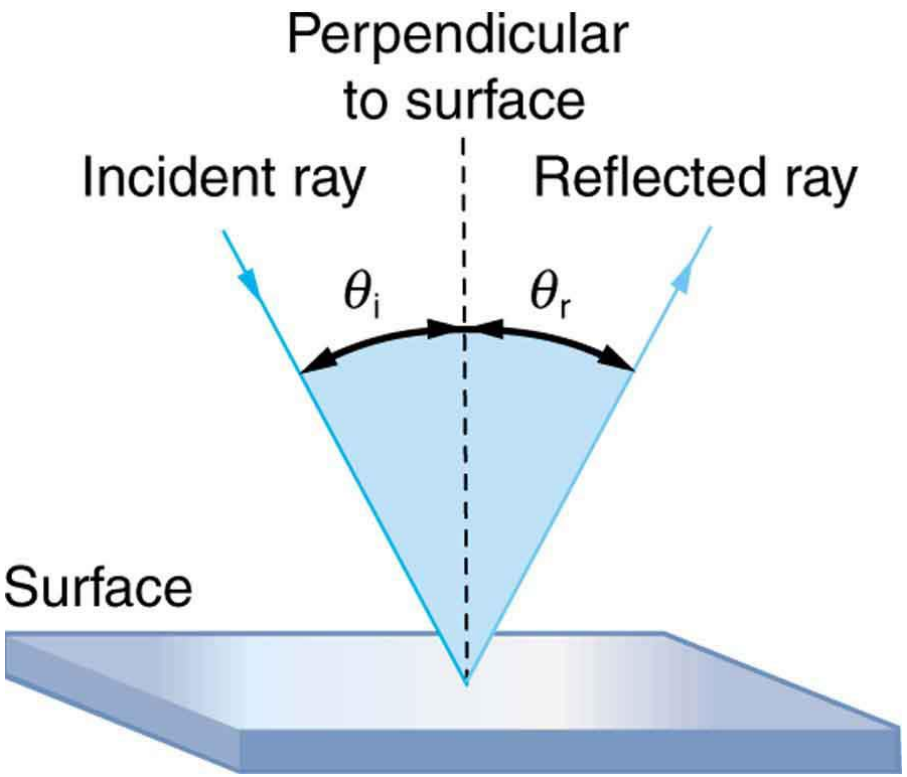
FERMAT PRINCIPLE

- The light travels between two points P_0 and P_1 following the path that takes the shortest time.

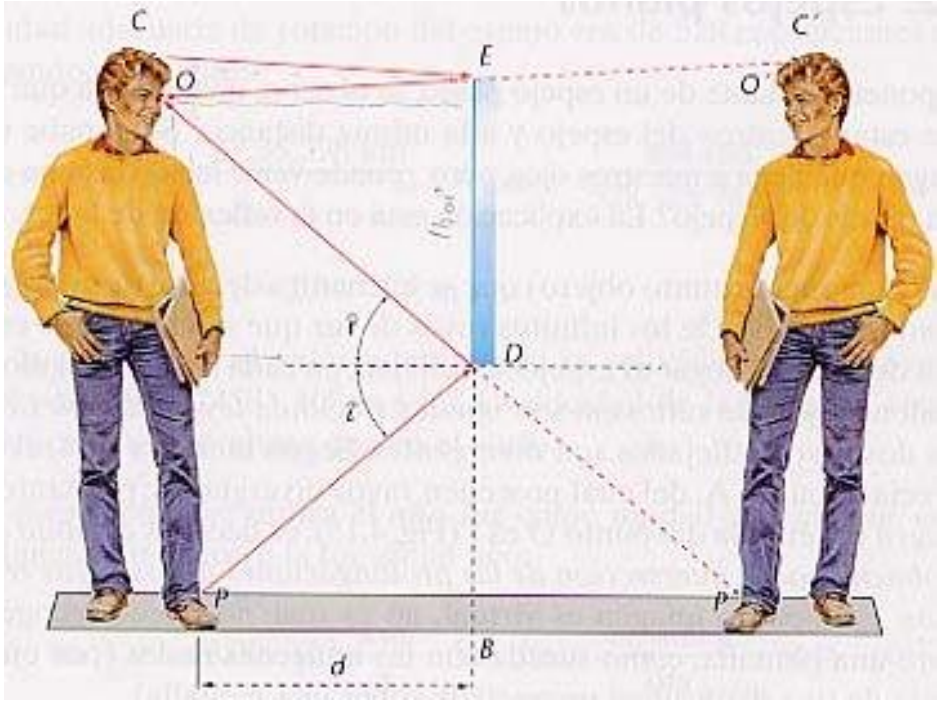
REFLECTION LAW

$$\theta_i = \theta_r$$

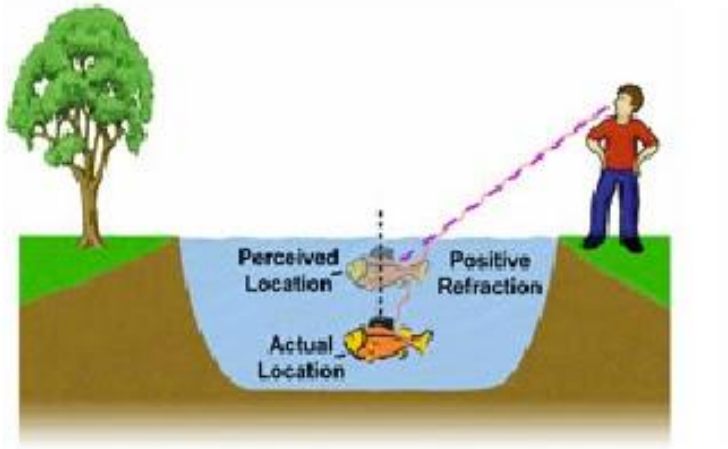


REFLECTION LAW EXAMPLE

- What is the length of the smaller vertical flat mirror in which a full-body person can be seen and where should it be located?



SNELL'S LAW OR REFRACTION

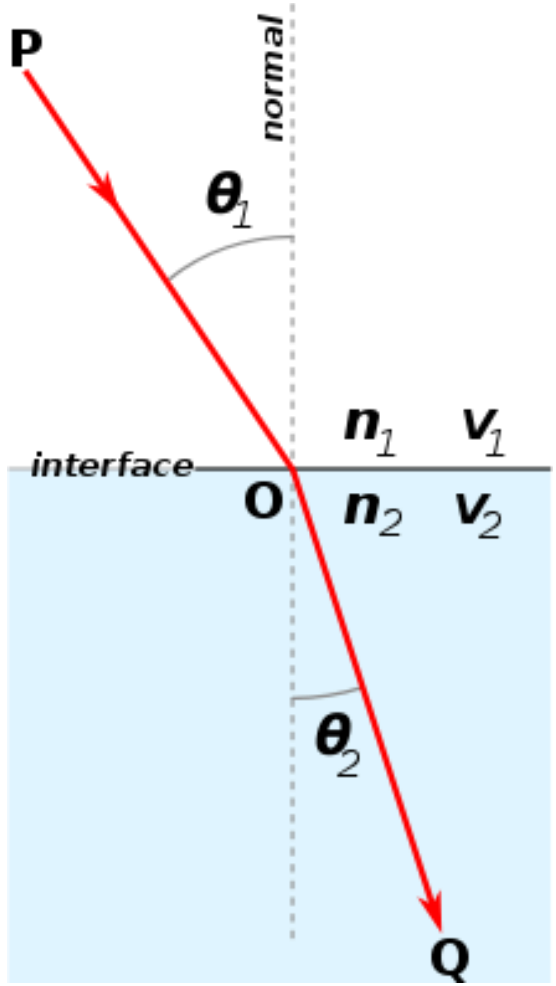


REFRACTIVE INDEXES

Material	Index of Refraction (n)
Vacuum	1.000
Air	1.000277
Water	1.333333
Ice	1.31
Glass	About 1.5
Diamond	2.417

SNELL'S LAW OR REFRACTION

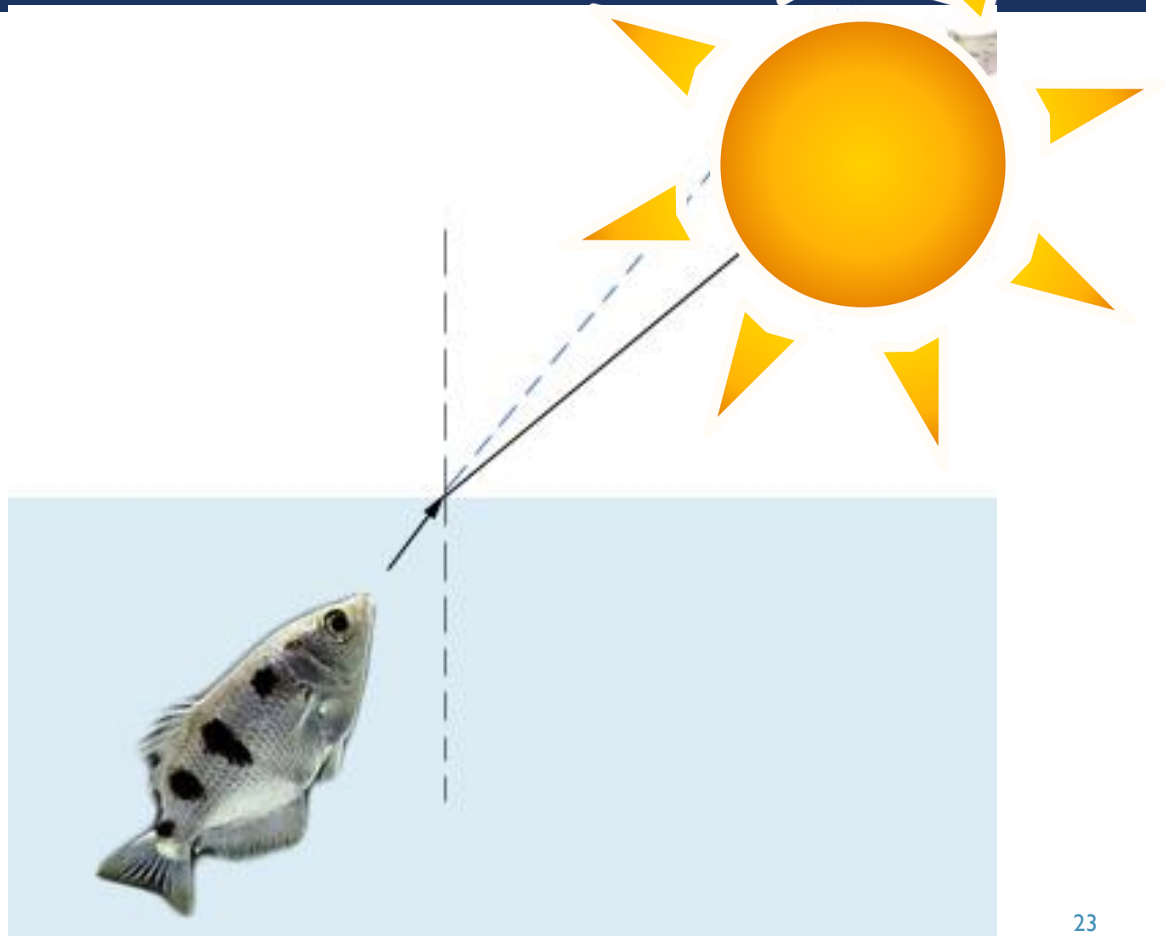
$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$



EXERCISE

- A fish sees the sun at an angle of 60 degrees to the surface of the water. What is the actual angle of the sun over the horizon?

- The water refractive index is no. 1.33



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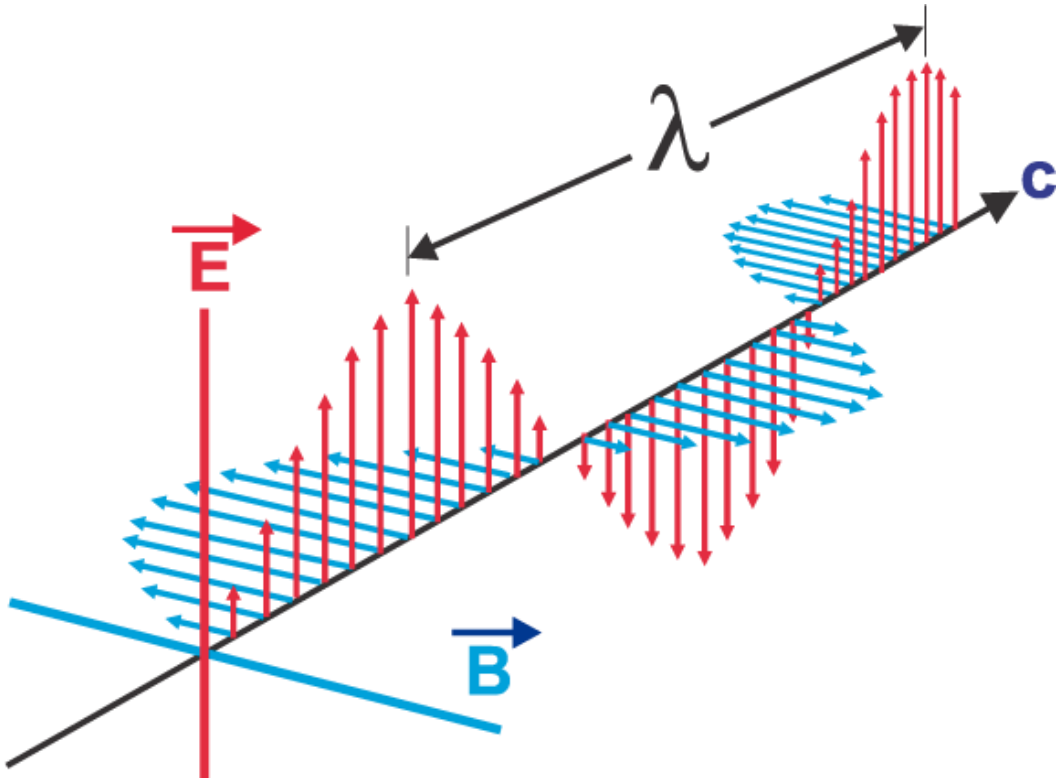
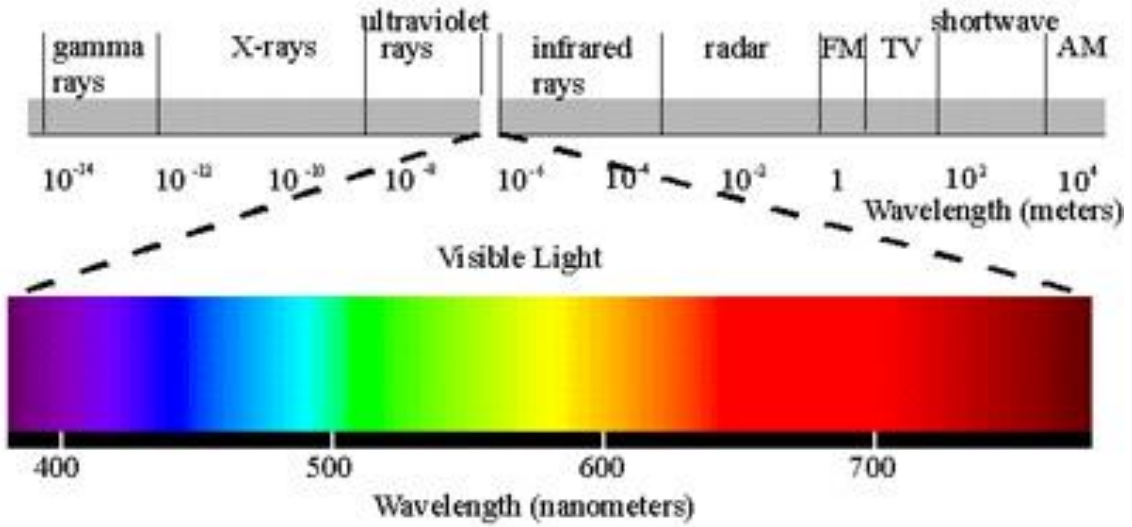
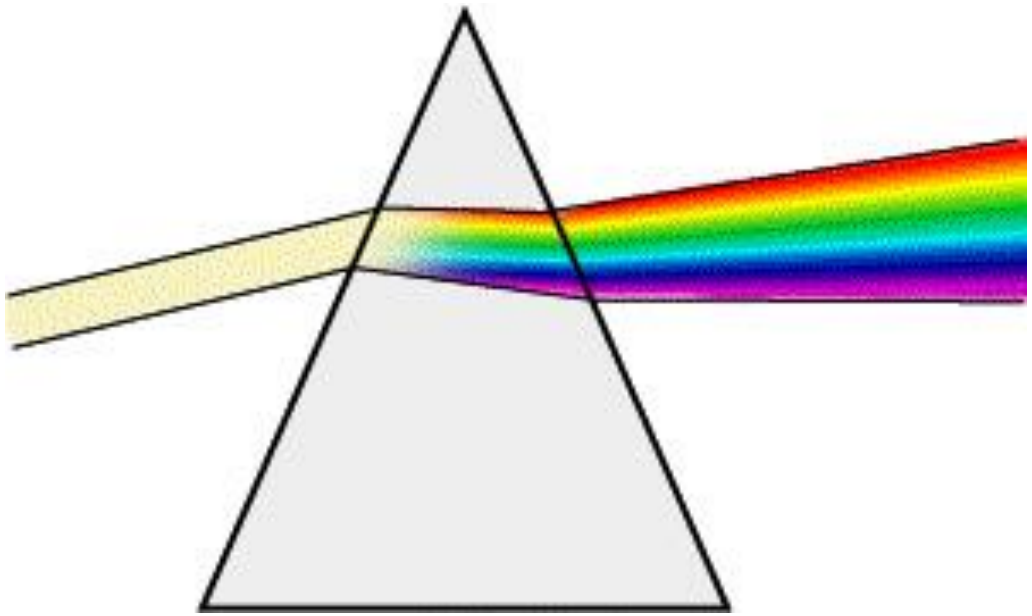
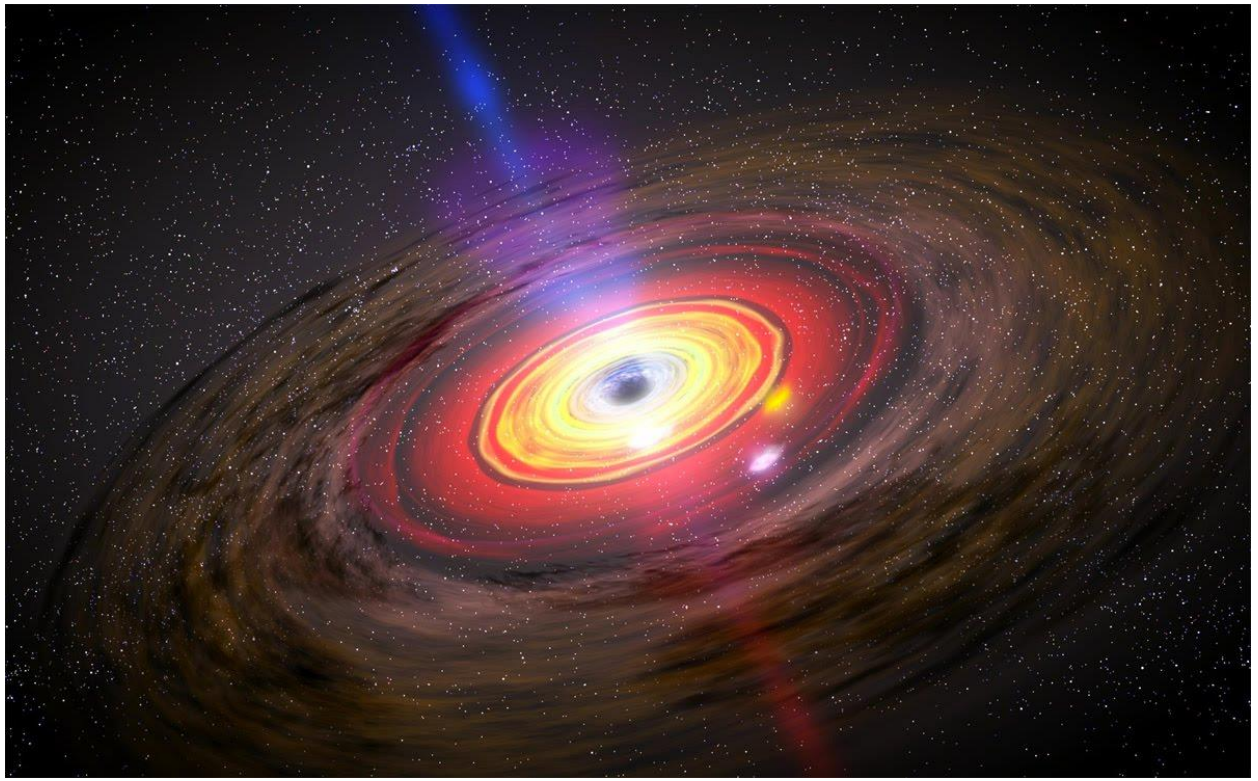
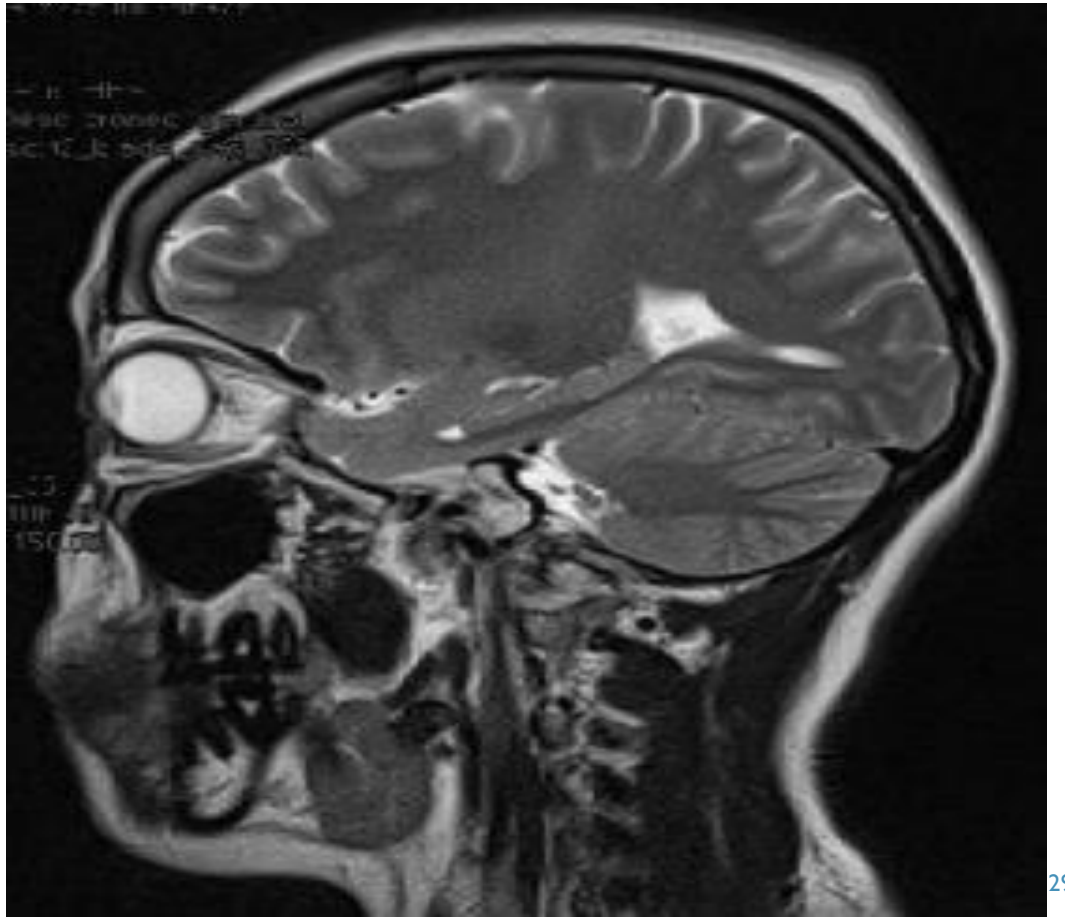
MECHANICAL WAVE VS ELECTROMAGNETIC WAVE




gamma rays
X-rays
ultraviolet rays
infrared rays
radar
FM
TV
shortwave
AM
10^{-14}
10^{-12}
10^{-10}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
1
10^{2}
10^{4}
Wavelength (meters)
Visible Light
400
500
600
700
Wavelength (nanometers)







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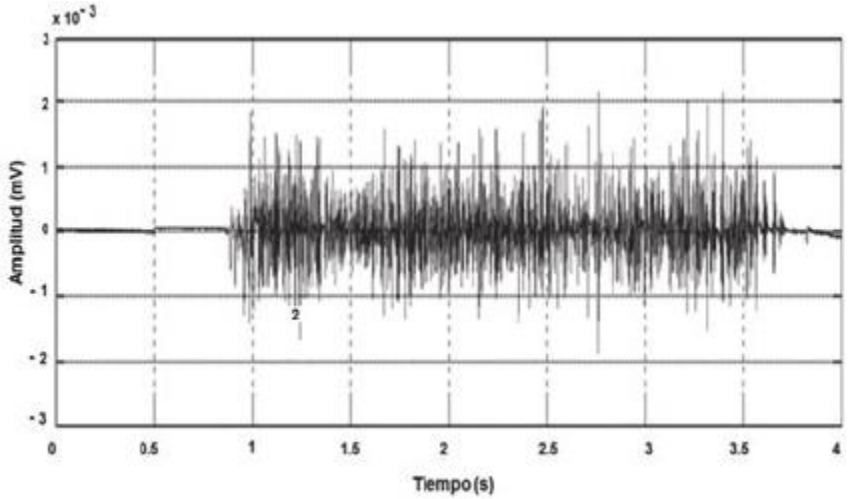
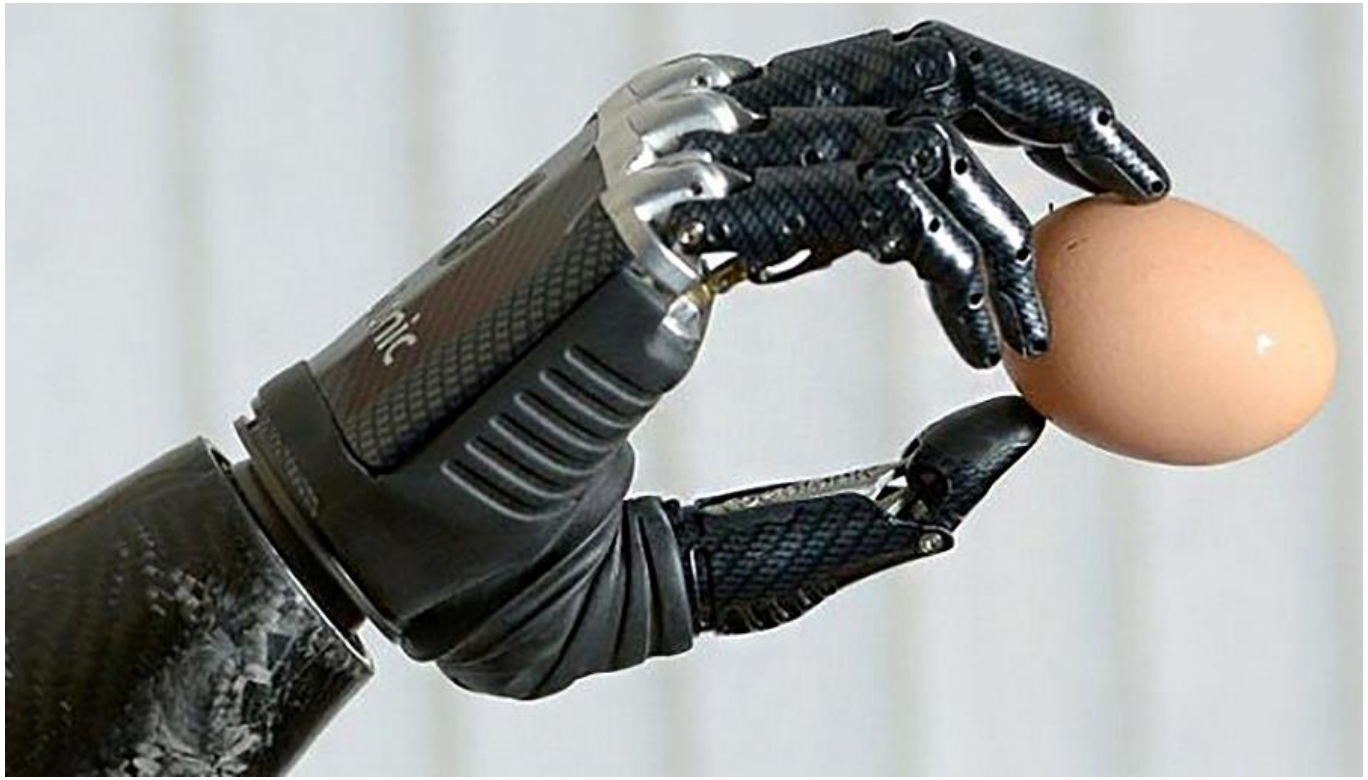
MACHINE LEARNING IS IMPORTANT?

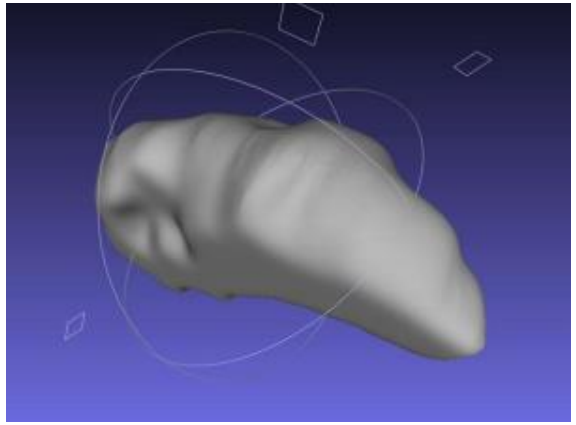
IN COMPUTER VISION?

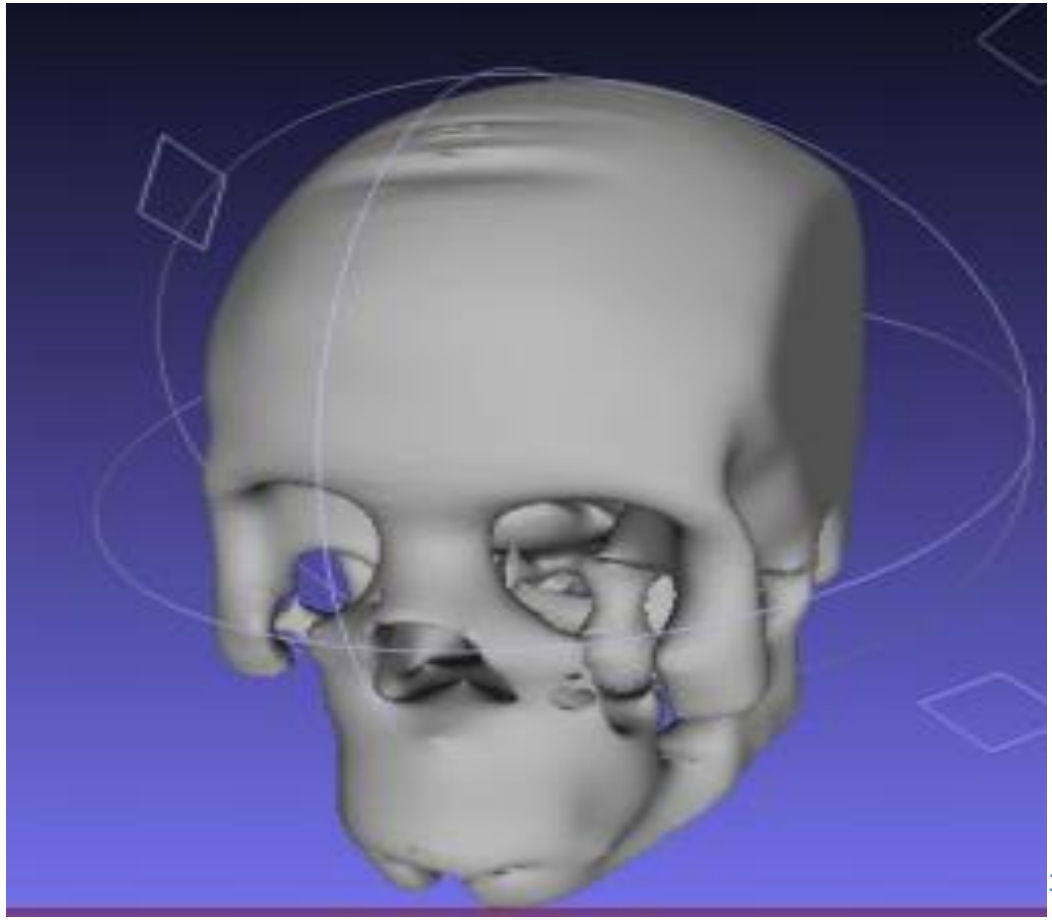
WHAT KIND OF SIGNAL DO YOU THINK IT IS?





HUG HERR





MACHINE LEARNING AND COMPUTER VISION

[Courtesy of Dean Pomerleau]


Fp1-F3
F3-C3
C3-P3
P3-O1
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
14 µV/mm

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Presented clip

Clip reconstructed from brain activity

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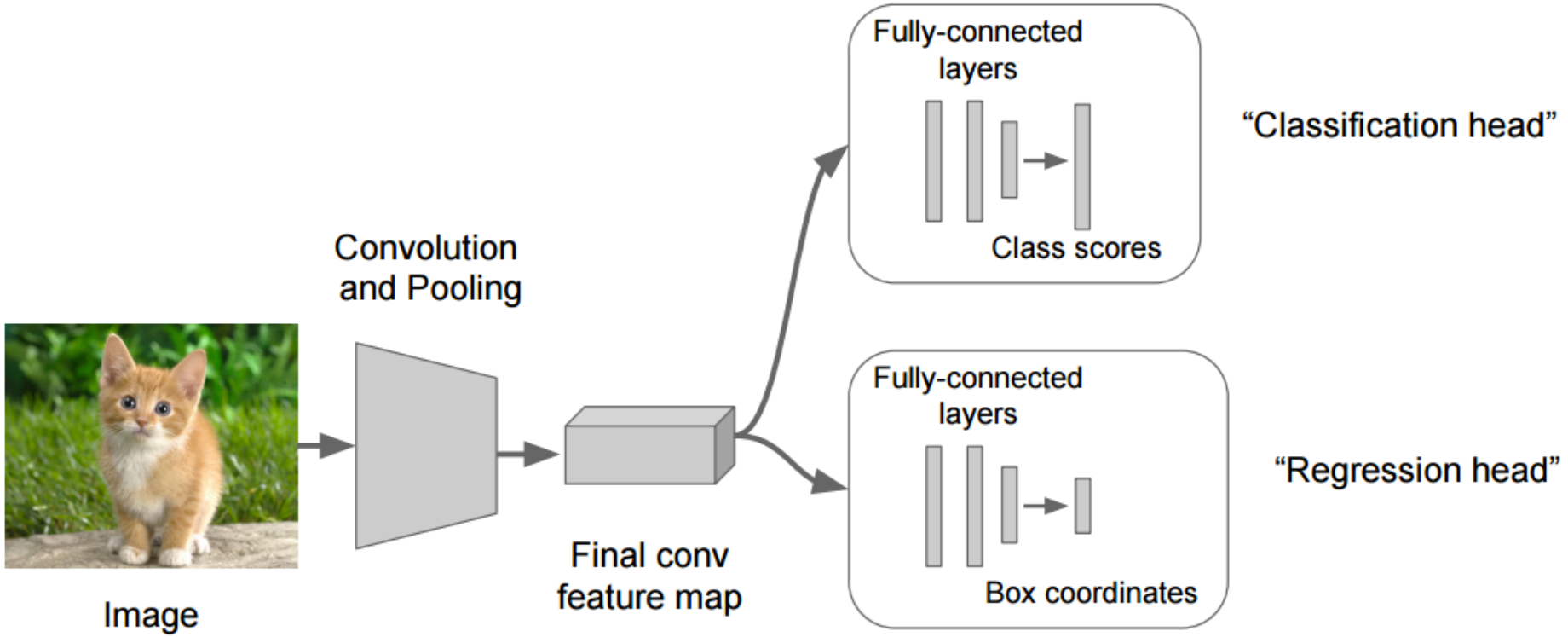
WHAT IS A CNN?

CONVOLUTIONAL NEURAL NETWORK


Fully-connected layers
Class scores
"Classification head"
Convolution and Pooling
Fully-connected layers
Box coordinates
"Regression head"
Image
Final conv feature map

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WE CAN USE CNN ONLY IN IMAGES?

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WE CAN USE CNN ONLY IN IMAGES?

AN IMAGE IS A 2D SIGNAL

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HOW MANY AREAS COMPUTER VISION HAS?

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COMPUTER VISION AREAS

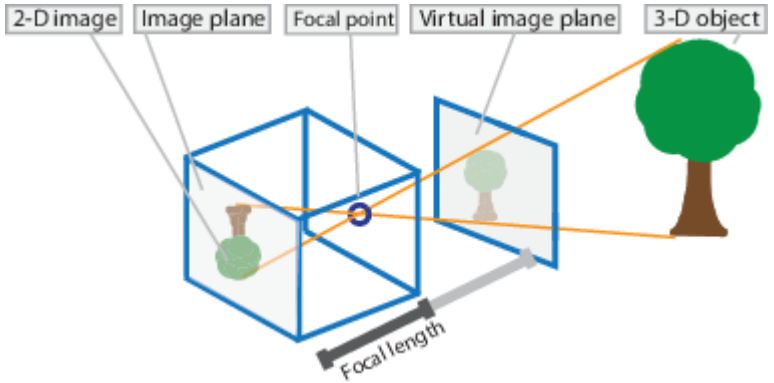
COMPUTER VISION

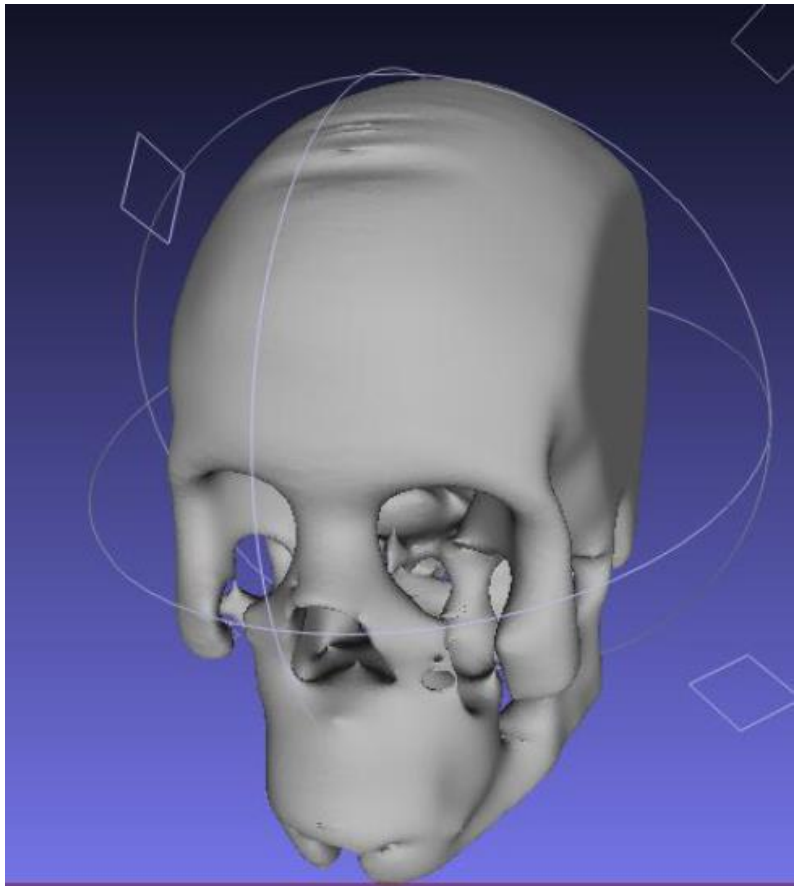
1. Optics and 3D Reconstruction
2. Image Processing
3. Object Recognition (ML/DL)

COMPUTER VISION

1. **Optics and 3D Reconstruction**
2. Image Processing
3. Object Recognition (ML/DL)

OPTICS AND 3D RECONSTRUCTION





COMPUTER VISION

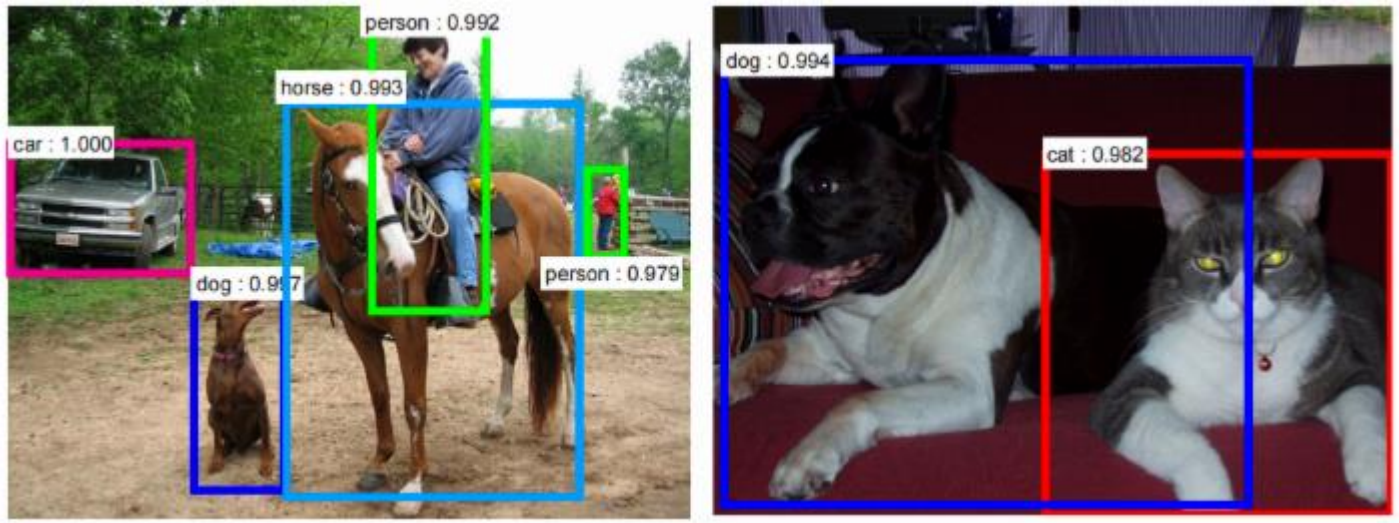
1. Optics and 3D Reconstruction
2. **Image Processing**
3. Object Recognition (ML/DL)

IMAGE PROCESSING

COMPUTER VISION

1. Optics and 3D Reconstruction
2. Image Processing
3. **Object Recognition (ML/DL)**

OBJECT RECOGNITION



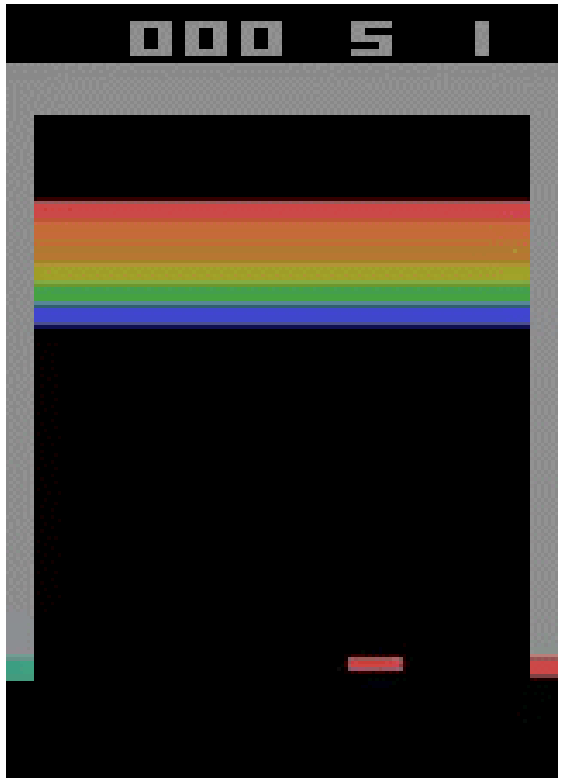
SEGMENTATION

(c) Semantic segmentation

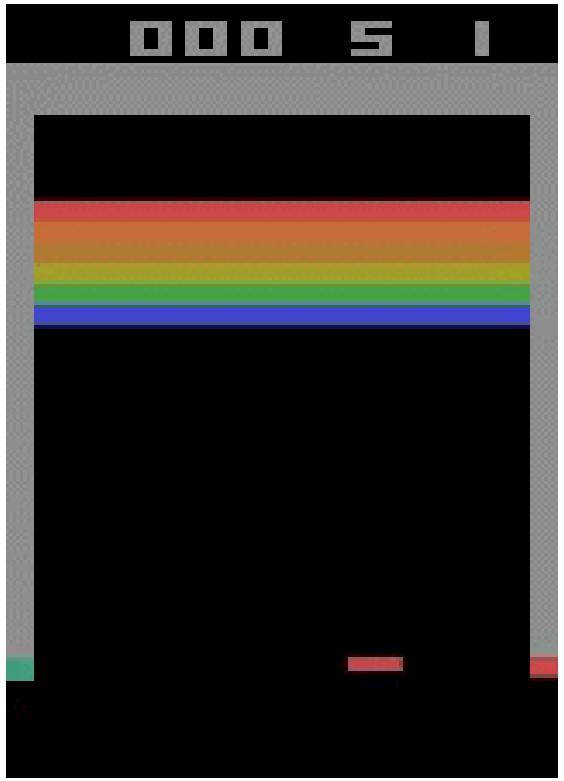
(d) Instance segmentation

STYLE TRANSFER

VIDEO GAMES

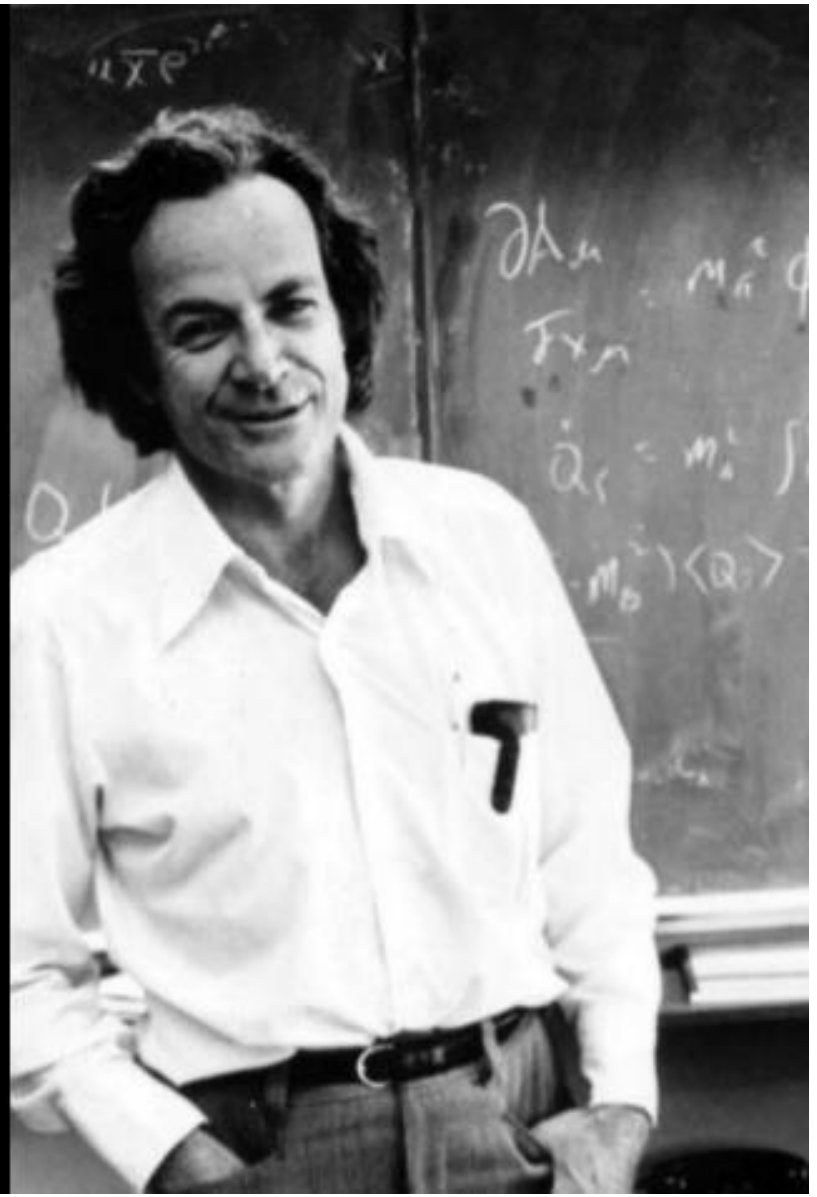


VIDEO GAMES



What I cannot build, I do not understand.

– Richard Feynmann



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Questions?