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Digital Image Processing Introduction

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Introduction Class

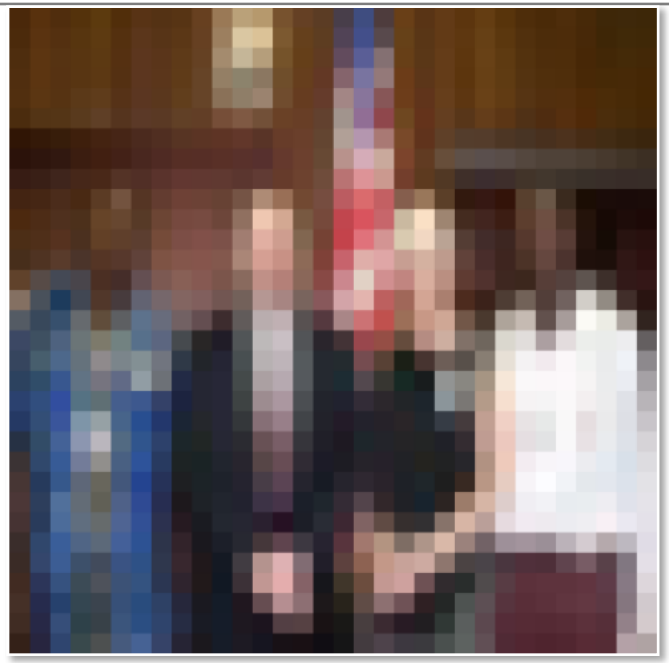
For Today….

- What is Computer vision?

For the next class….

- What is Image Processing?

What is computer vision?



Humans are remarkably good at this…or not?

What is computer vision?

What we see

What a computer sees

$$\begin{bmatrix} 3 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 2 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 2 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 3 \end{bmatrix}.$$

Main goal is to bridge the gap between pixels and meaning

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What is computer vision?

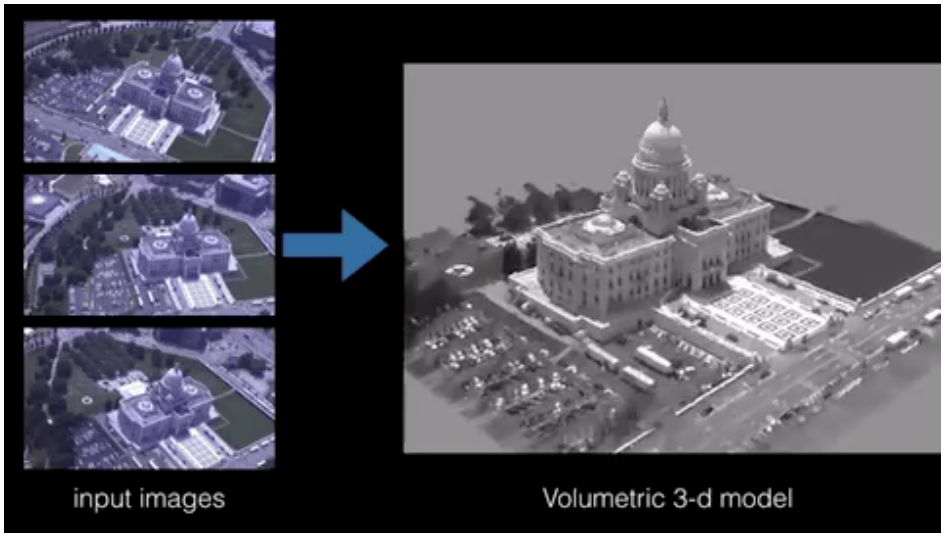
What kind of information can be extracted from an image?

1. Metric 3D information.
2. Semantic information.

What is computer vision?

What kind of information can be extracted from an image?

1. Metric 3D information.



What is computer vision?

2. Semantic information.

What is computer vision?

2. Semantic information. Object Categorization

What is computer vision?

2. Semantic information. Scene and context categorization

What is computer vision?

2. Semantic information. Qualitative spatial information

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What is computer vision?

The ability of computers to see and make analysis of some stuff.

- Image/video understanding.
- Machine Vision.
- Robot Vision.
- Image/Video analysis.

What is computer vision?

Image

Sensing device

Interpreting device

Carpet, parade, instruments, uniforms, garfield, etc.

Interpretations

What is computer vision?

Image

Sensing device

Interpreting device

Carpet, parade, instruments, uniforms, garfield, etc.

Interpretations

What is computer vision?

Image

Sensing device

Interpreting device

Carpet, parade, instruments, uniforms, garfield, etc.

Interpretations

Computer vision is a hard problem!!

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Why study computer vision?

- Vision is useful
- Vision is interesting
- Vision is difficult
  - Half of primate cerebral cortex is devoted to visual processing
  - Achieving human-level visual perception is probably “AI-complete”

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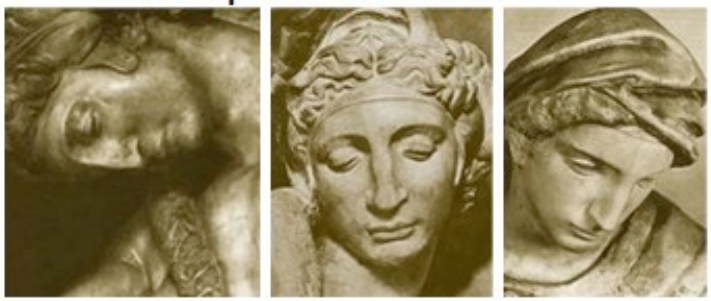
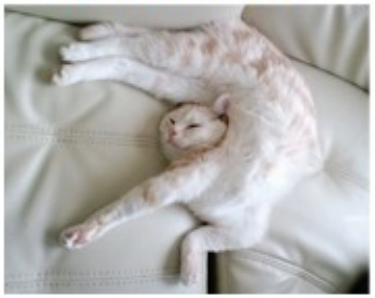
Why computer vision is difficult?

Viewpoint variation



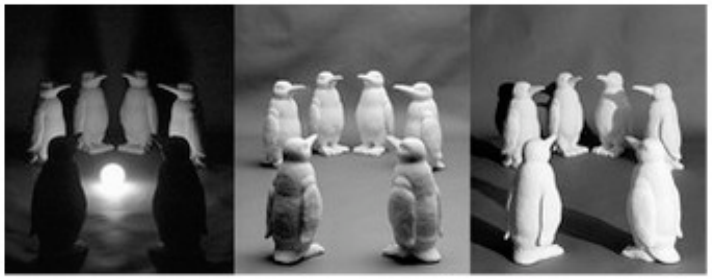
Scale variation

Deformation



Occlusion

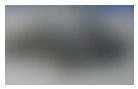
Illumination conditions

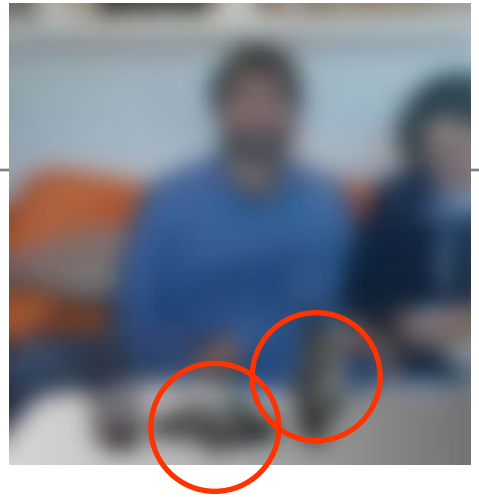


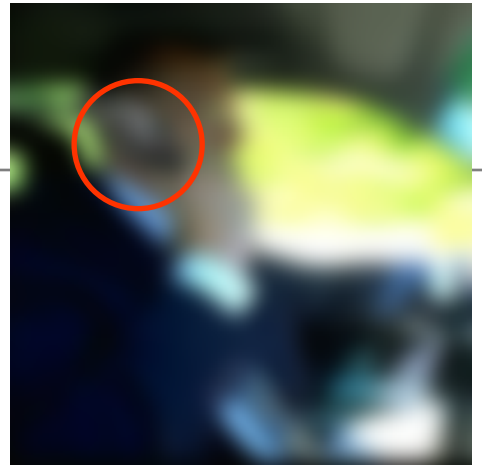
Background clutter

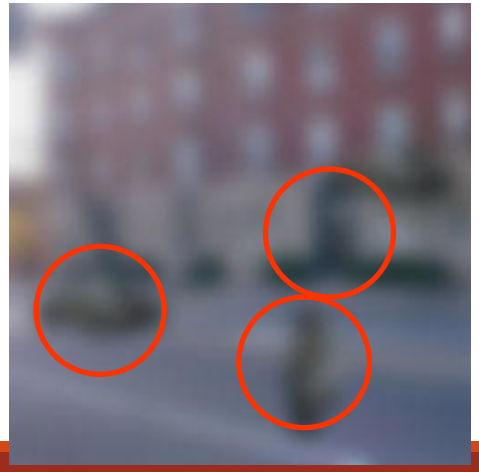
Intra-class variation

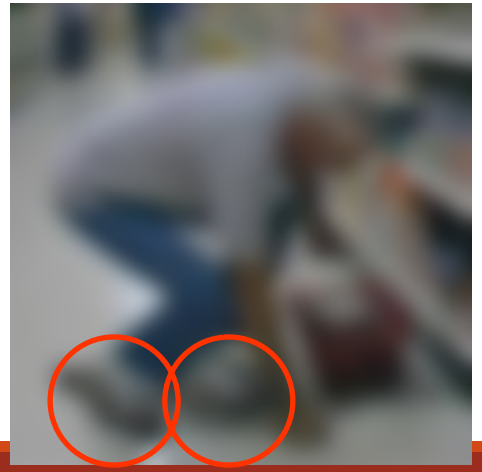
Challenges: local ambiguity





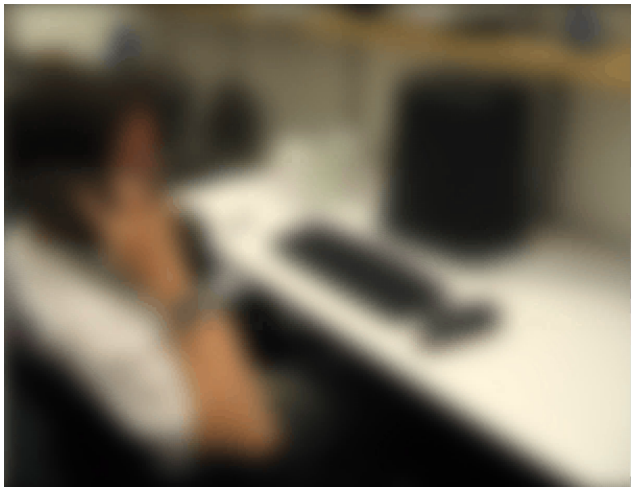






slide credit: Fei-Fei, Fergus & Torralba

Challenges: local ambiguity



Source: Rob Fergus and Antonio Torralba

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Challenges: local ambiguity

Source: Rob Fergus and Antonio Torralba

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Inherent ambiguity of the problem

Many different 3D scenes could have given rise to a particular 2D picture

Inherent ambiguity of the problem

Possible solutions

- Bring in more constraints (more images)
- Use prior knowledge about the structure of the world

Need a combination of geometric and statistical methods

Challenges or opportunities?

- Images are confusing, but they also reveal the structure of the world through numerous cues.
- Our duty is to interpretate the cues!

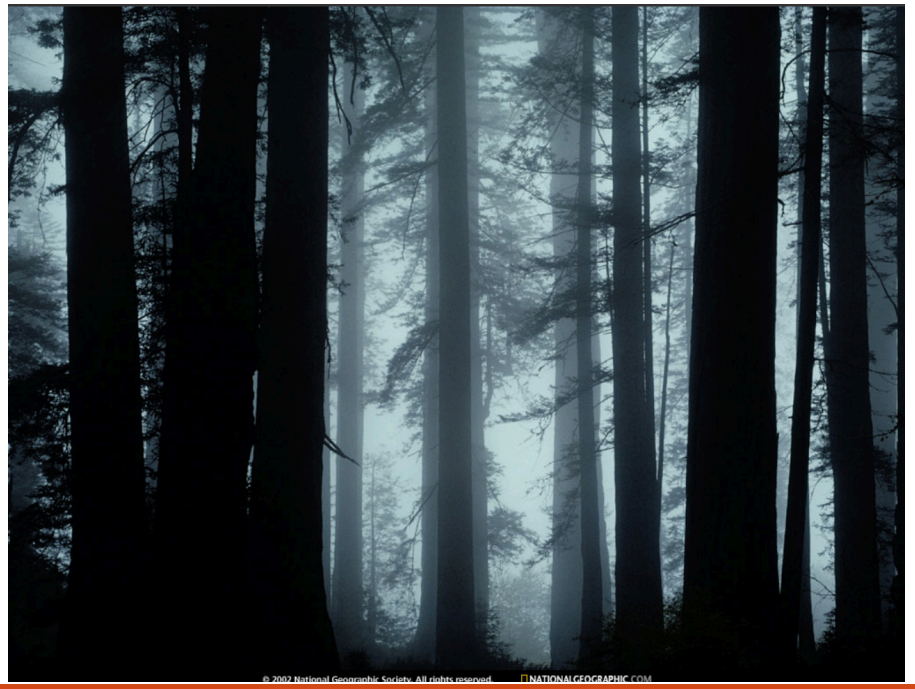
Friz Freleng. The Pink Panther (1983)

Challengers or opportunities

Depth cues: Linear Perspective

Challengers or opportunities

Depth cues: Aerial Perspective



Challengers or opportunities

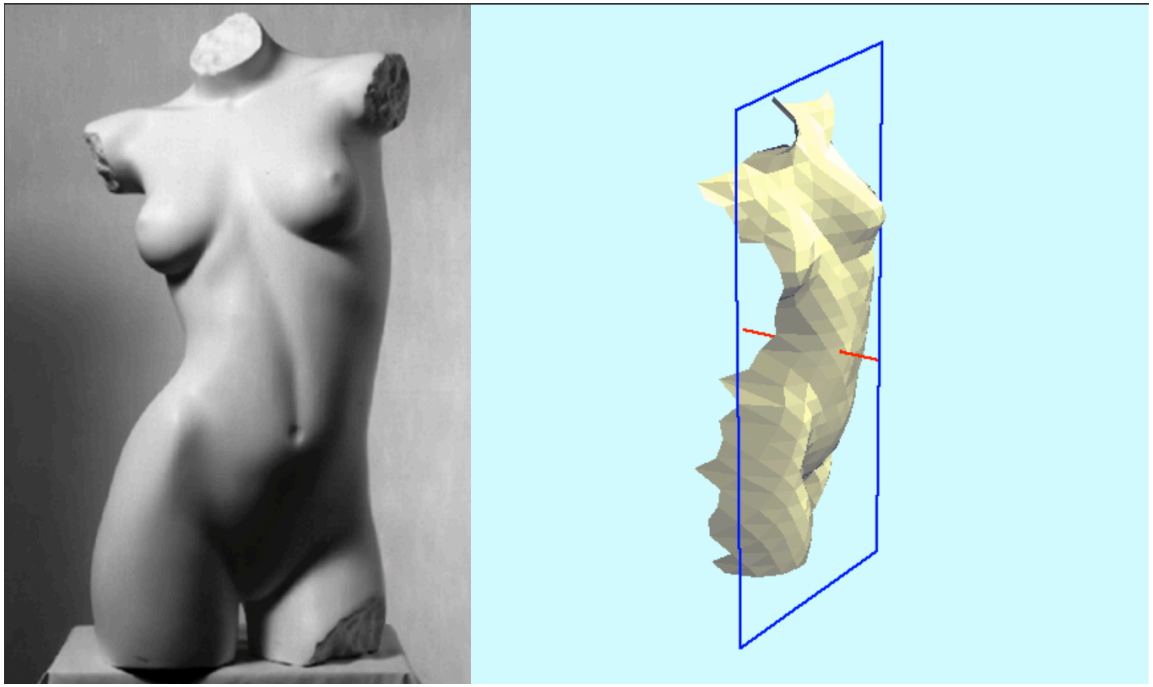
Depth ordering cues: Occlusion

Challengers or opportunities

Shape cues: Texture gradient

Challengers or opportunities

Shape and lighting cues: Shading



Challengers or opportunities

Position and lighting cues: Shadows

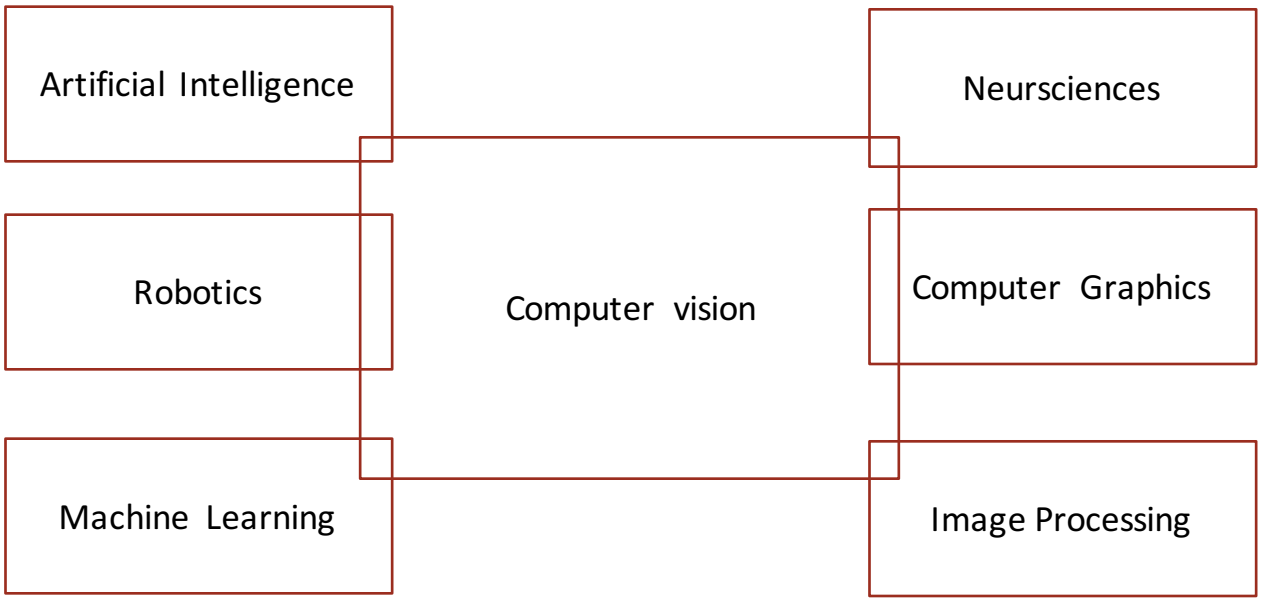
Challengers or opportunities

Grouping cues: Similarity (color, texture, proximity)

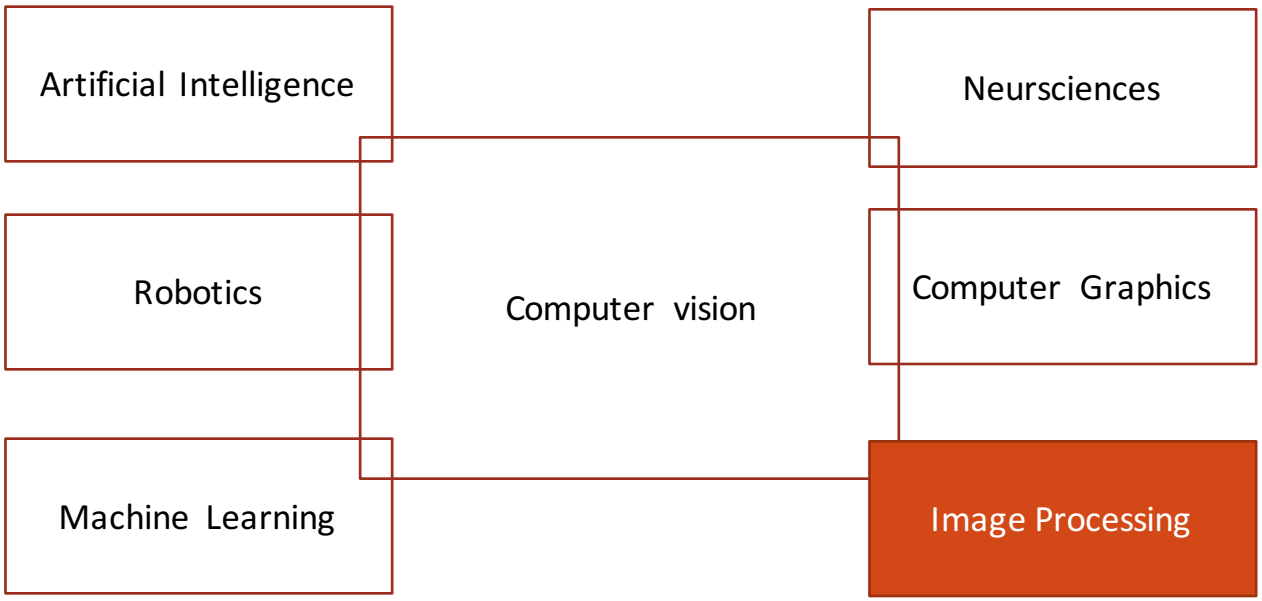
Challengers or opportunities

Grouping cues: Common fate.

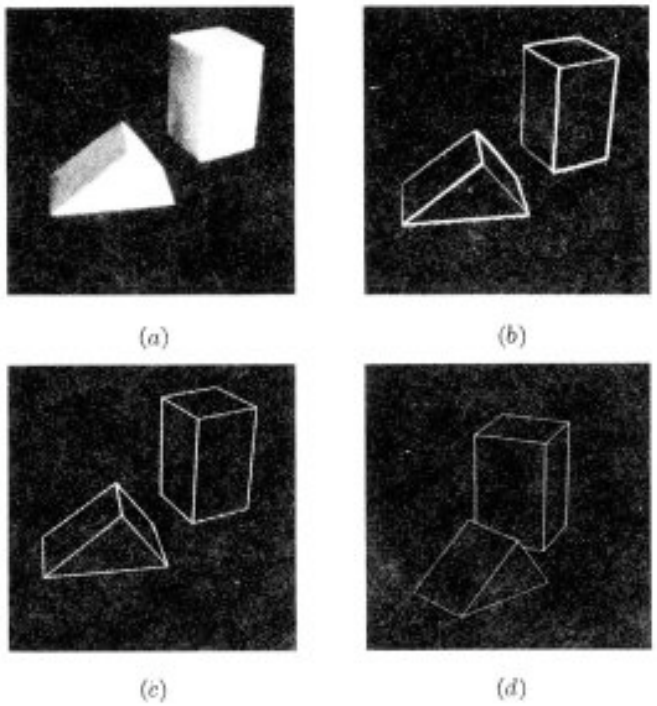
Connection to other disciplines



Connection to other disciplines

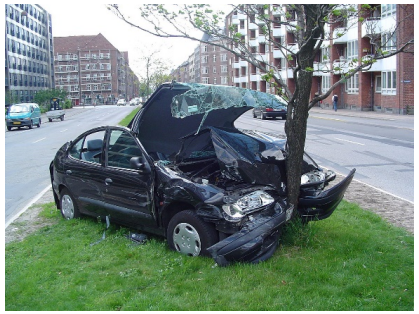


Origins of computer vision

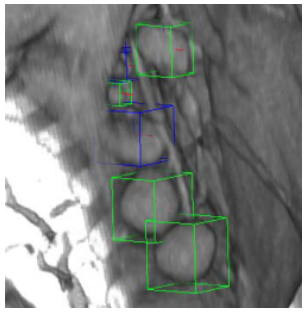


L. G. Roberts, Machine Perception of Three Dimensional Solids, Ph.D. thesis, MIT Department of Electrical Engineering, 1963.

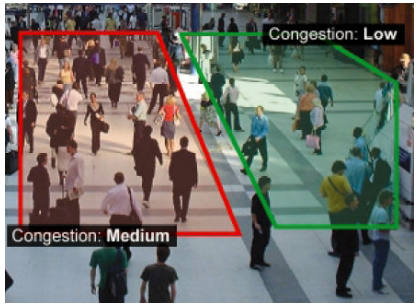
Why computer vision matters?



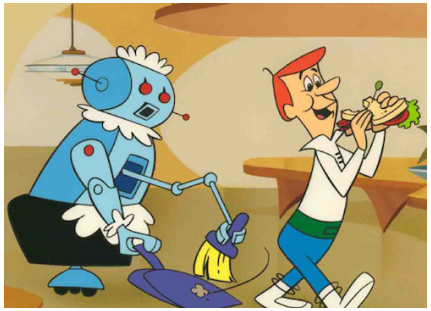
Safety



Health

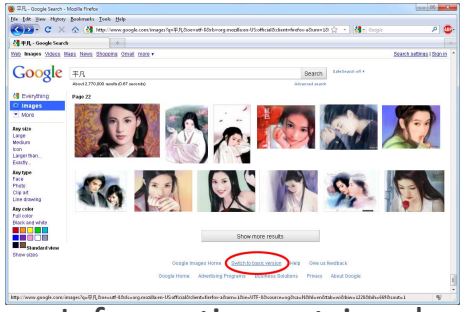


Suveillance



Comfort

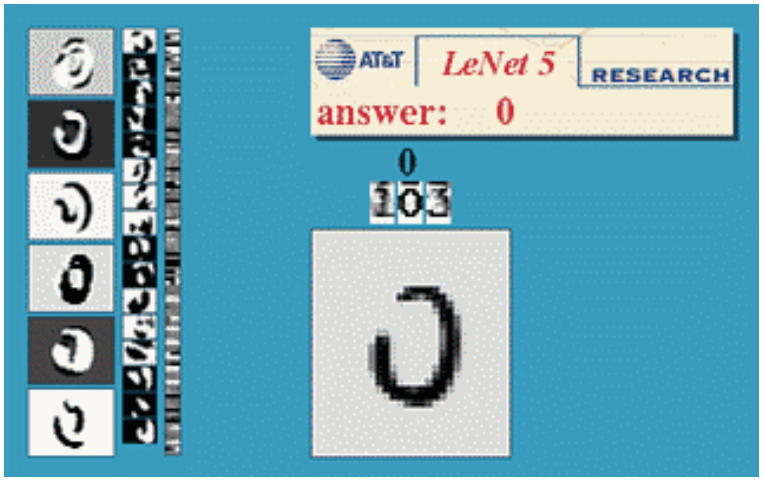
Fun



Information retrieval

Applications of computer vision

Optical character recognition (OCR)



Applications of computer vision

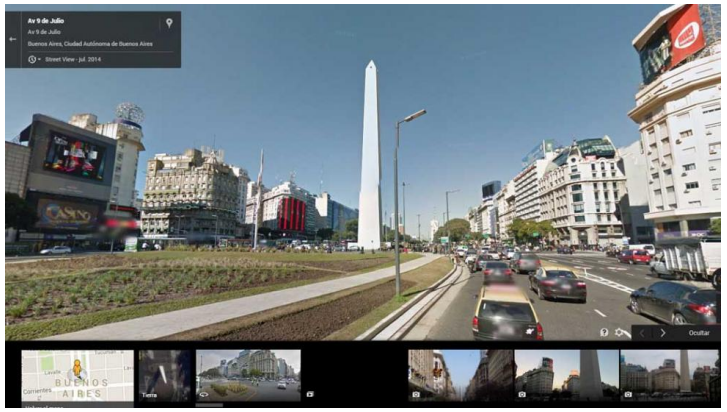
Shape and motion capture




Applications of computer vision

3D Reconstruction

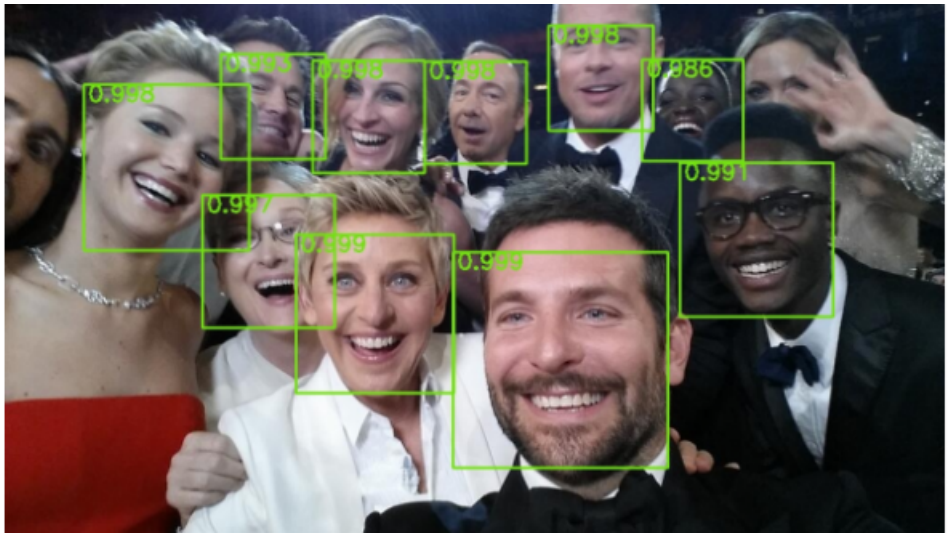
Photosynth
http://photosynth.net



Google streetview
maps.google.com

Applications of computer vision

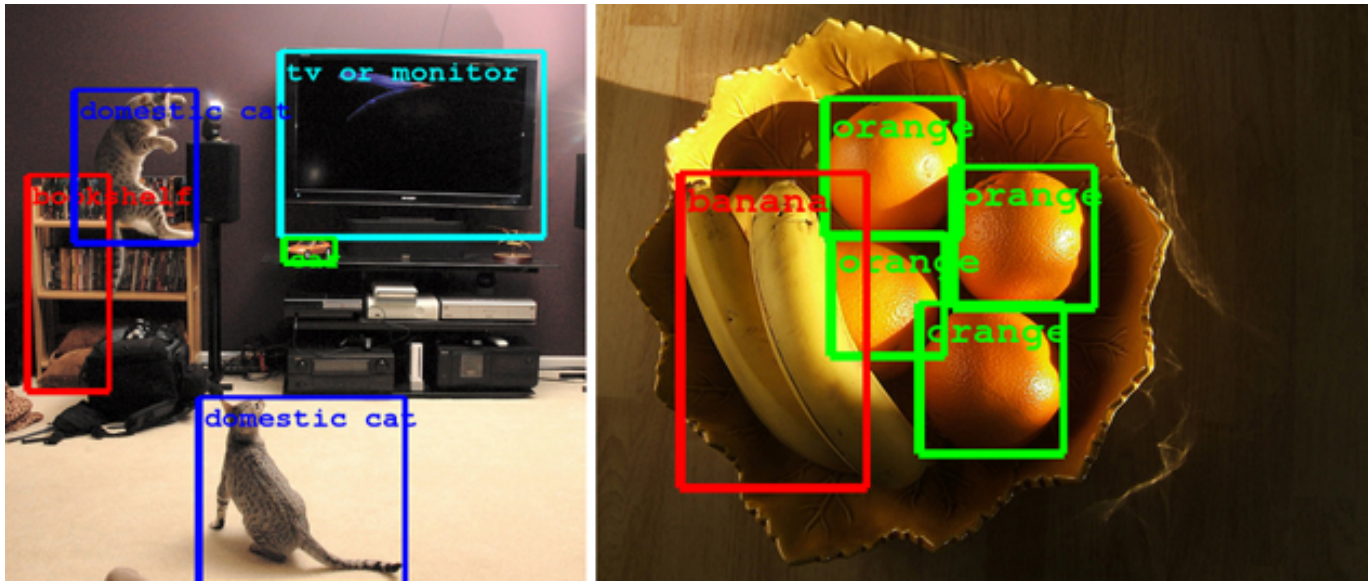
Object detection



Jones, M., & Viola, P. (2003). Fast multi-view face detection.

Applications of computer vision

Object recognition



Erhan D., Szegedy C., Toshev, A., and Anguelov, D. (2014), "Scalable Object Detection using Deep Neural Networks

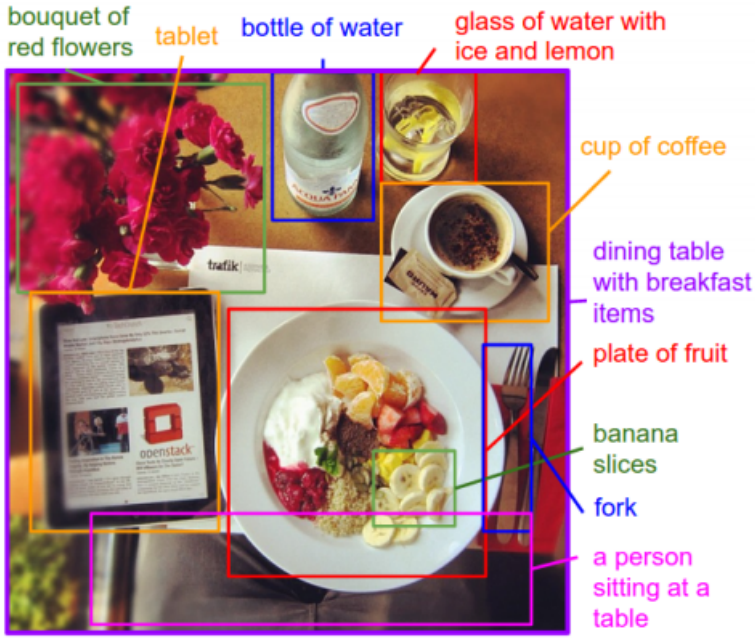
Applications of computer vision

Image colorization

https://github.com/richzhang/colorization

Applications of computer vision

Image captioning



Karpathy, A., & Fei-Fei, L. (2015). Deep visual-semantic alignments for generating image descriptions.

Applications of computer vision

Neural style

Style image

Content image

CNN

Network output

Gatys, L. A., Ecker, A. S., & Bethge, M. (2015). A neural algorithm of artistic style.
Code: https://github.com/jcjohnson/neural-style