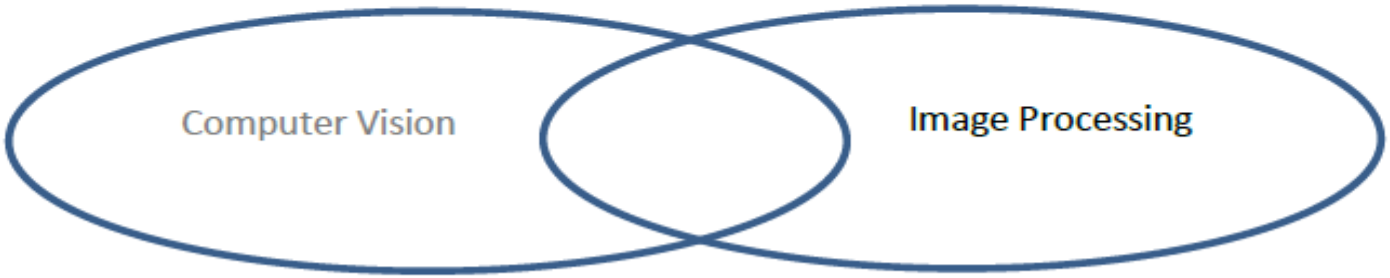
Lec. 1
Introduction to Computer Vision

Assist. Prof. Dr. Saad Albawi

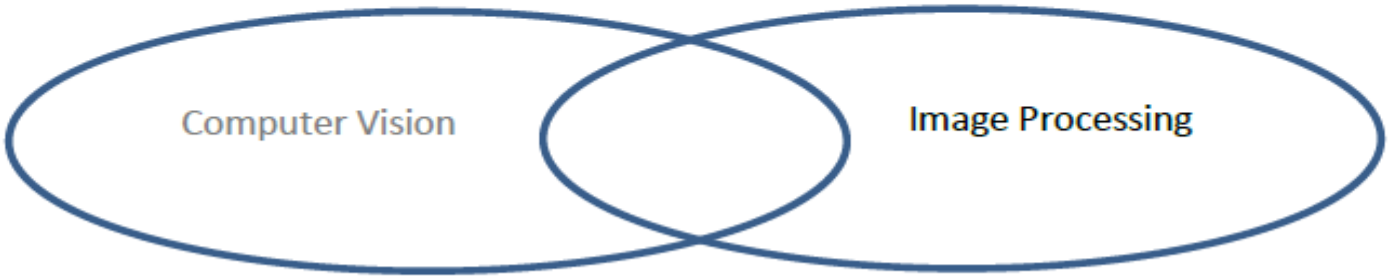
Computer Imaging



Computer vision has been around since the 1960s. Recent developments:

- Increasing availability of cheap, powerful cameras (e.g. digital cameras, webcams) and other sensors.
- Increasing availability of massive amounts of image and multimedia content on the web (e.g. face databases, streaming video or image-based communication).
- Increasing availability of cheap, powerful computers (processor speed and memory capacity).
- Introduction of techniques from machine learning and statistics (complex, data-driven models and algorithms).

Computer Imaging



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What is Computer Vision?

The goal of computer vision is to develop algorithms that allow computer to “see”.

Also called

- Image Understanding
- Image Analysis
- Machine Vision

Is a computer imaging where the application does not involve a human being in the visual loop. In other word, the image are examined and acted upon by a computer. Although people are involved in the devvelopment of the system, the final application requires a computer to use the visual information directly. One of the major topics within the filed of computer vision is image analysis.

What is Computer Vision?

- Make computers understand images and videos.

- What kind of scene?
- Where are the cars?
- How far is the building?

What is (computer) vision?

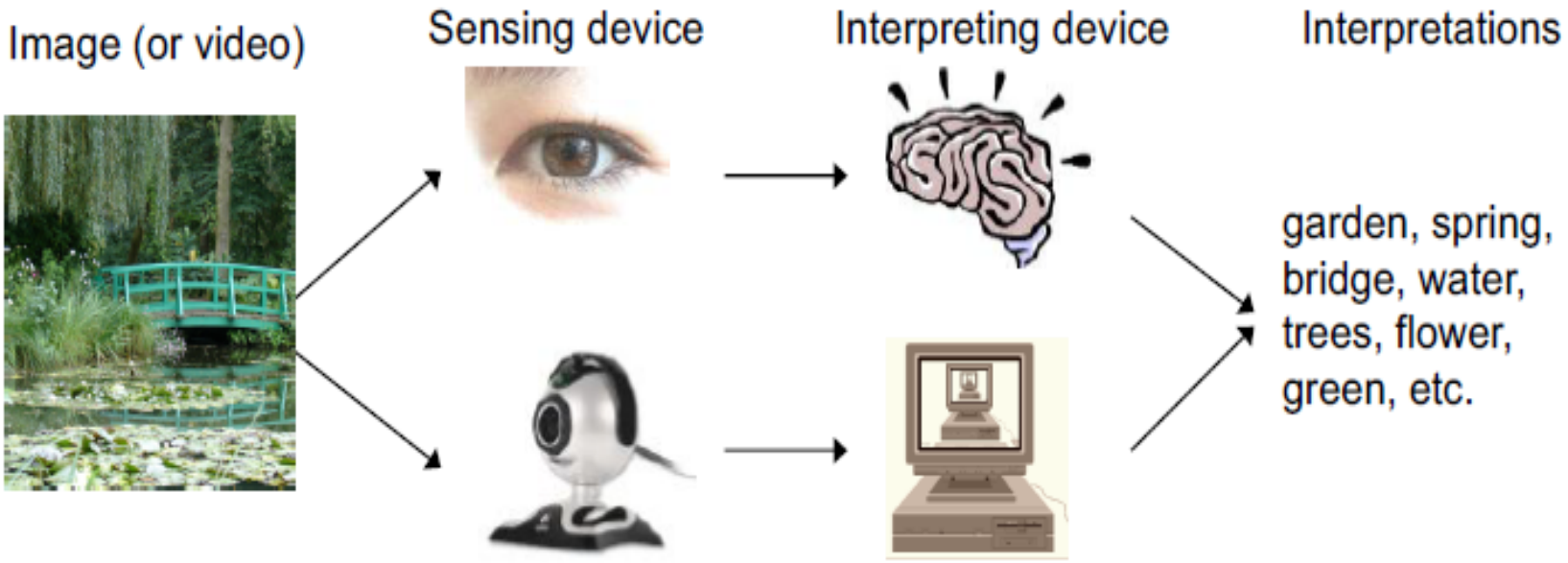

Image analysis involve the examination of the image data to facilitate solving a vision problem. The image analysis process involves two other topics: Feature extraction and pattern classification.

Features extraction is the process of acquiring higher level image information, such as shape or color information

Pattern classification is the act of taking this higher level information objects within the image.

Computer vision systems are used in many and various types of enviroments from manufacturing plants to hospital surgical suites to the surface of Mars. For example. In manufacturing systems, computer vision is often used for quality control. There, the computer vision system will scan manufactured items for defects and provide control signals to robotic manipulater to remove defective parts automatically.

General visual perception is hard

Digital Image

232	182	163	151	151	148	148	143	145	139	143	136	139	136	134	132	129	130	126	124	115	116	115	104	109	102	100	101
244	218	160	149	145	147	145	143	139	142	140	139	134	134	130	131	125	120	120	116	110	110	107	100	100	97	95	97
246	233	196	145	145	146	141	141	137	134	140	133	133	125	131	125	114	121	116	116	109	101	95	101	97	87	89	91
248	242	222	161	142	140	145	137	138	135	129	127	127	122	124	118	116	113	102	110	99	102	98	94	91	88	91	90
252	246	234	192	143	139	136	134	133	129	131	127	124	121	117	114	111	105	108	95	101	102	86	88	91	84	84	99
252	249	242	215	151	137	134	134	129	126	126	121	120	116	113	111	108	104	99	94	102	93	89	96	79	87	92	112
252	248	242	227	169	134	135	124	122	120	125	121	116	115	105	112	102	99	92	98	93	88	89	74	87	65	97	111
253	246	244	236	192	134	125	123	119	120	118	116	112	107	110	95	104	94	89	96	84	86	79	77	65	79	105	119
252	250	246	238	210	144	126	118	120	115	116	116	98	105	103	102	96	93	91	82	80	79	75	70	82	81	108	119
250	251	247	239	219	161	127	117	117	109	105	107	100	104	99	100	98	79	98	70	75	80	72	65	86	83	113	124
252	249	247	241	226	177	122	120	116	106	108	110	91	103	93	99	89	88	79	80	72	74	76	65	84	87	109	123
249	249	247	241	231	191	131	116	110	109	106	98	95	90	102	83	78	86	85	80	70	75	69	81	79	96	122	121
248	249	247	244	238	206	133	121	101	103	94	97	91	87	87	83	83	82	77	78	81	61	73	65	86	99	118	120
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212	209	200	188	177	173	174	171	169	165	173	176	180	187	191	192	195	195	201	203	207	210	208	212	201	177	147	143

The goal of computer vision

0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What we see

What a computer sees

Related fields

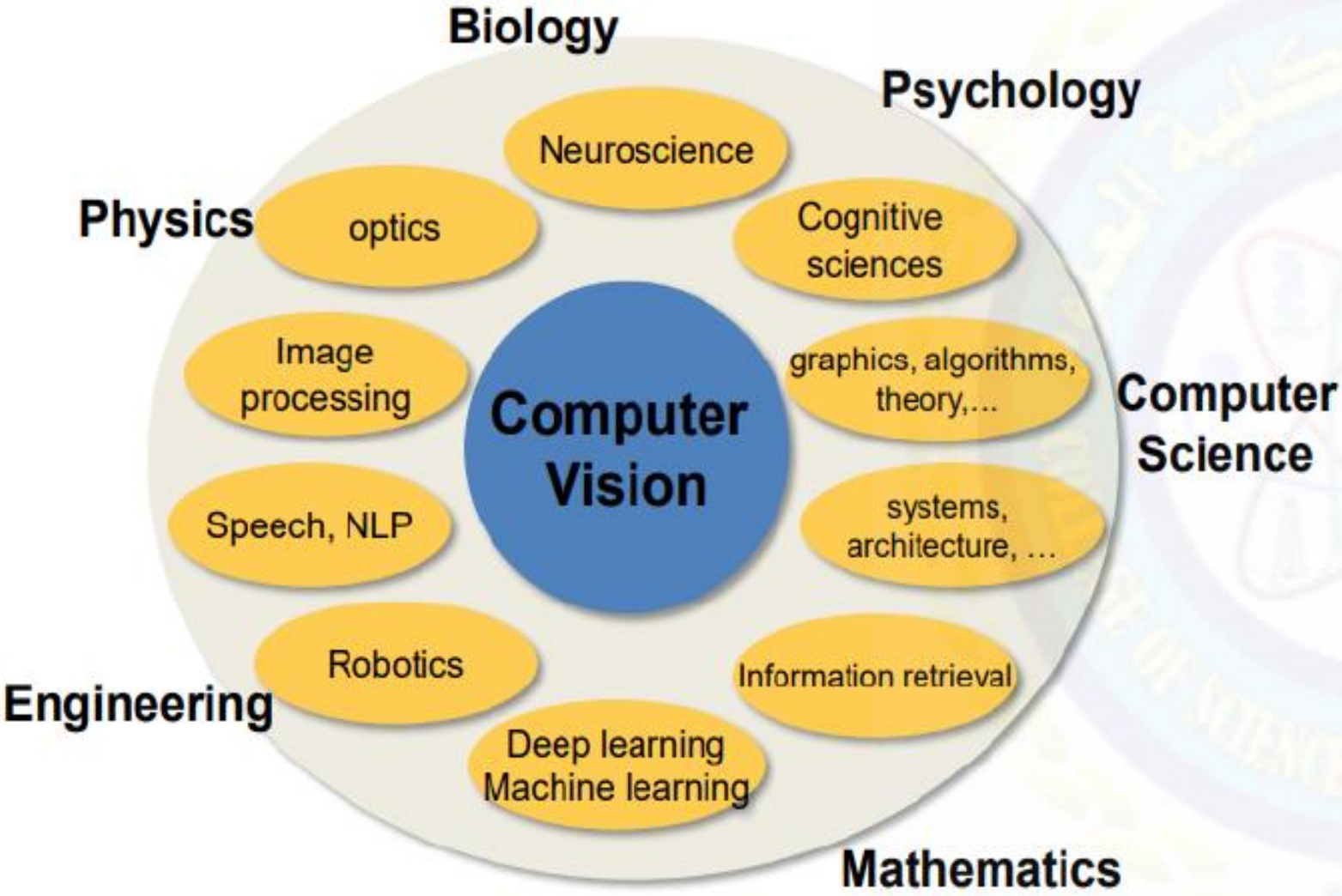
- Image Processing
- Pattern Recognition
- Photogrammetry
- Computer graphics

Our Time

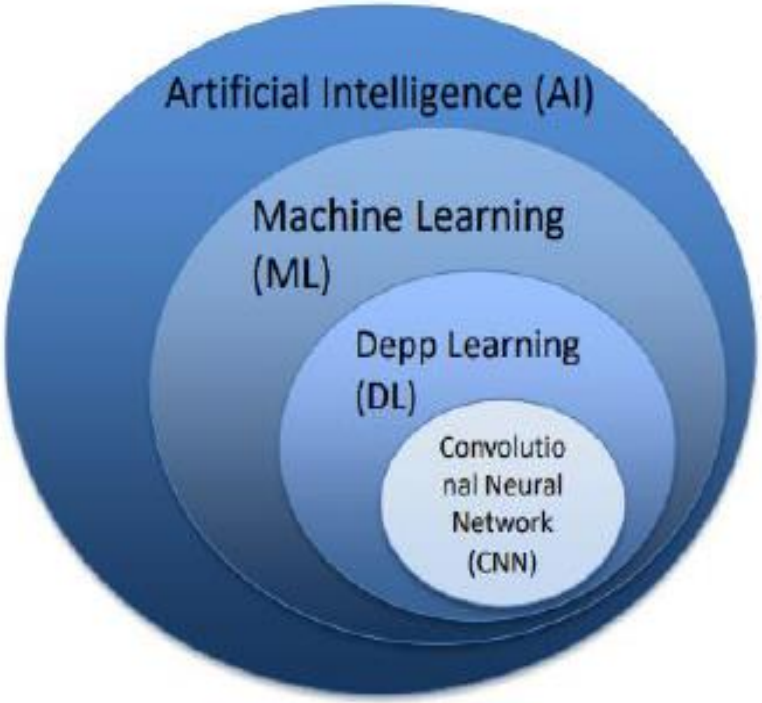
It is a good time to do computer vision now, because:

- Powerful computers
- Inexpensive cameras
- Algorithm improvements
- Understanding of vision systems

What is Computer Vision?



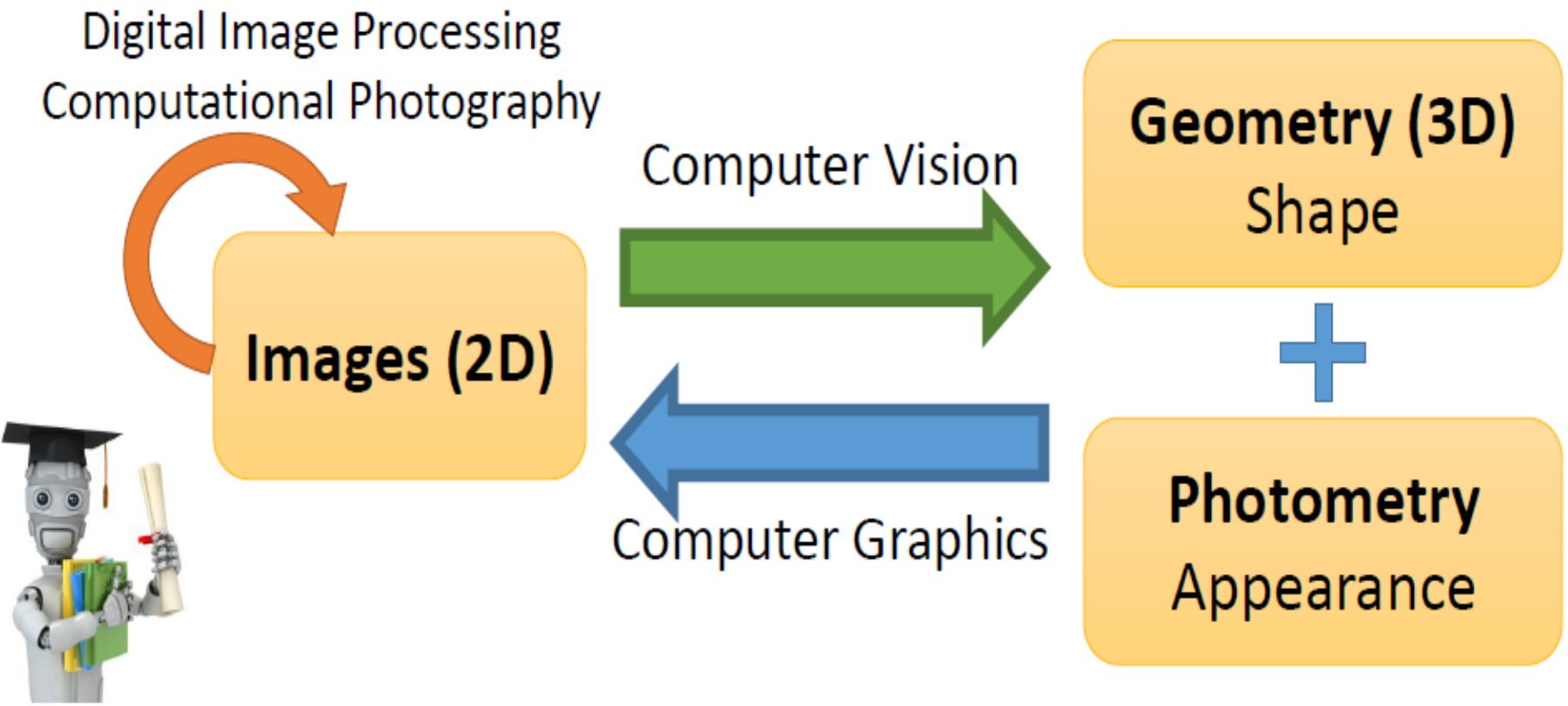
What is Computer Vision?



Computer Vision

- Object detection
- Object classification
- Scene understanding
- Semantic scene segmentation
- 3D reconstruction
- Object tracking
- Human pose estimation
- Activity recognition
- VQA
- ....

Computer Vision and Nearby Fields



Machine learning:

Vision = Machine learning applied to visual data

Where did we come from?

- Edges, segmentation, and perception

D. Lowe. *IJCV*, 1992

Low Level Topics in Computer Vision:

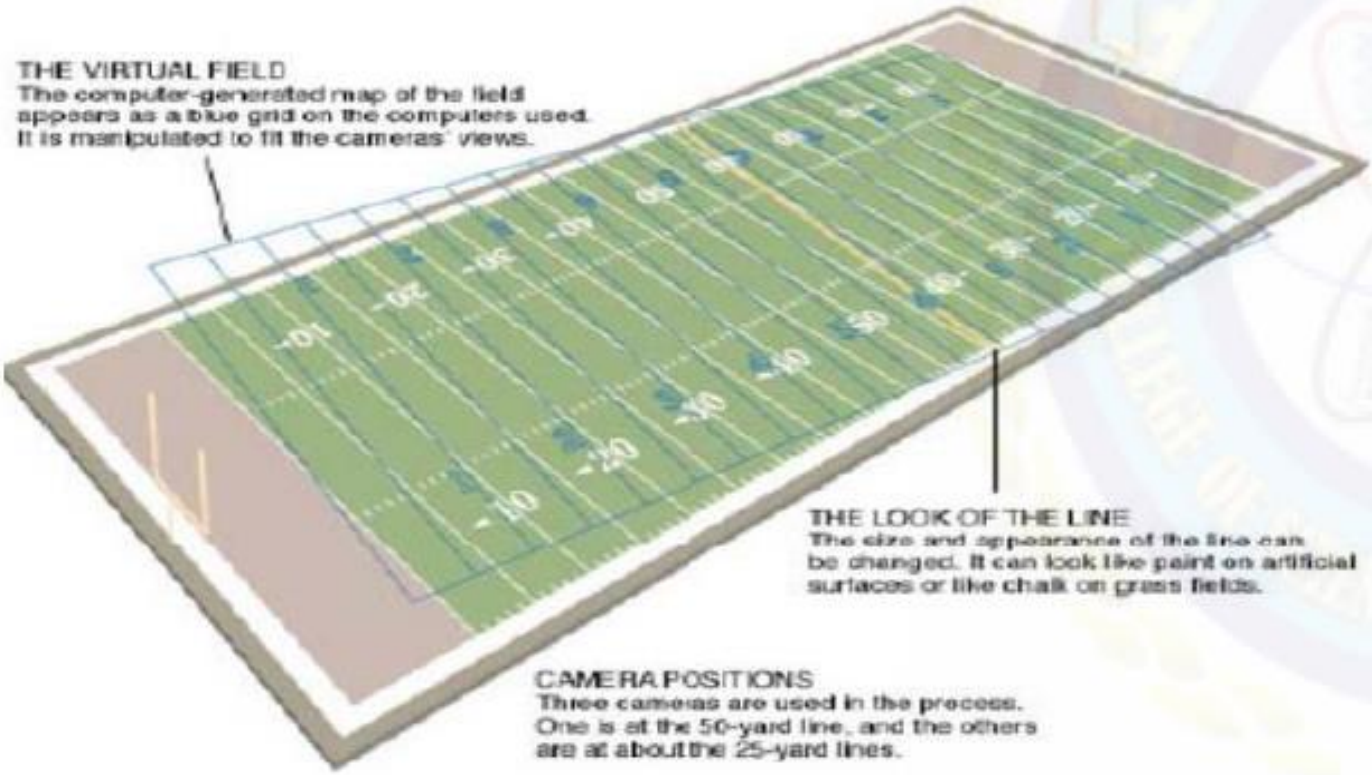
- Low level operations.
  - Image enhancement.
  - Feature detection.
  - Region segmentation.

Low Level Topics in Computer Vision:

- Low level operations.
  - Photo Stitching.

Low Level Topics in Computer Vision:

- Low level operations.
  - 3D shape reconstruction, stereopsis, structure from motion



Low Level Topics in Computer Vision:

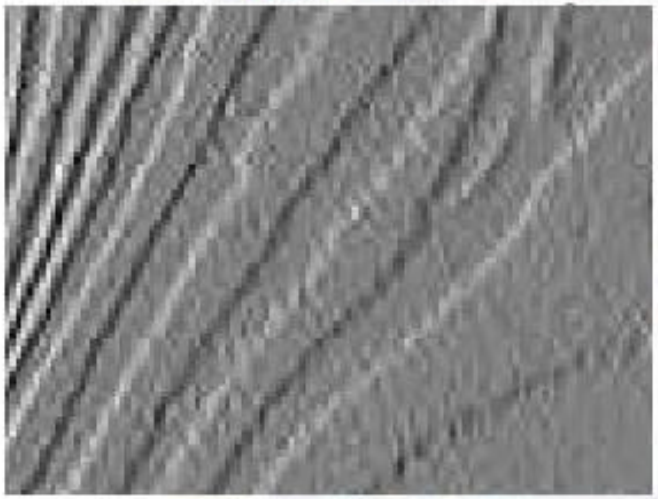
- Detecting sharp edges by convolution.

Convolve this image

With this kernel

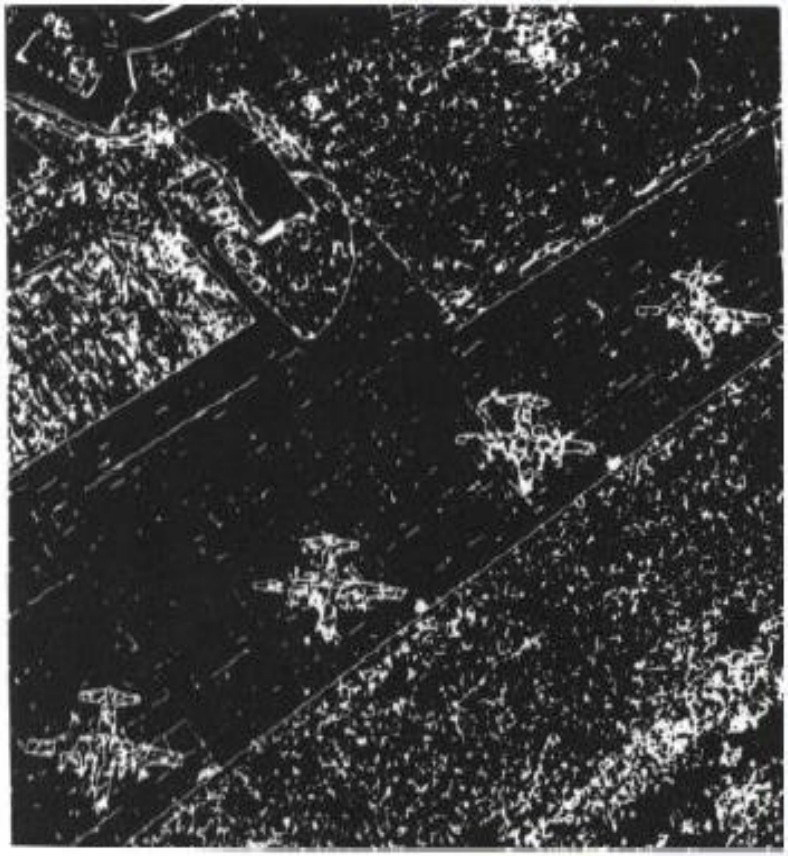
→

To get this



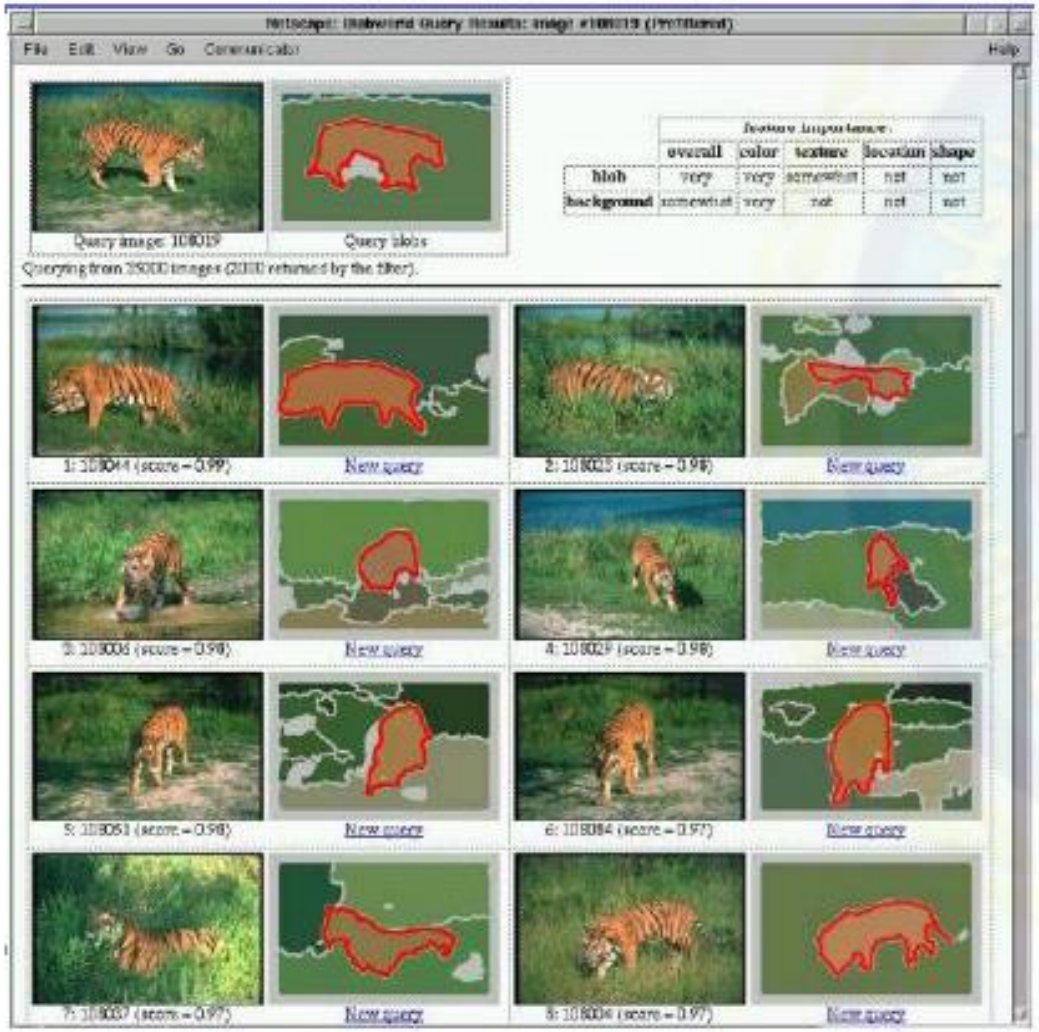
Low Level Topics in Computer Vision:

- Edge Detection Results:



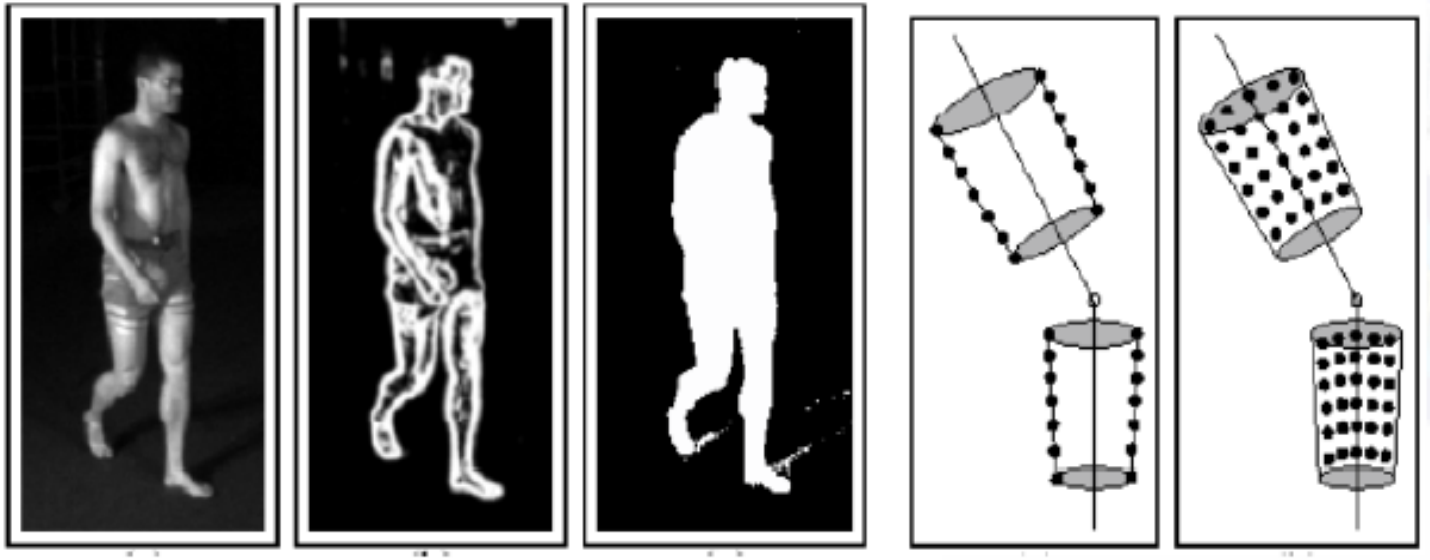
Mid Level Topic in Computer Vision:

- Segmentation:



Mid Level Topic in Computer Vision:

- Tracking:
  - Use a model to predict next position and refine using next image.
  - Model
    - Simple dynamic models (second order dynamics).
    - kinematic models.
    - etc.
  - Face tracking and eye tracking now work rather well.



Mid Level Topic in Computer Vision:

- Finding coherent structure so as to break the image or movie into big units.
  - Segmentation:
    - Breaking images and videos into useful pieces.
    - E.g., finding video sequences that correspond to one shot.
    - E.g., finding image components that are coherent in internal appearance.
  - Tracking:
    - Keeping track of a moving object through a long sequence of views

High Level Topic in Computer Vision:

- Recognition of people, places, events.

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Last Updated: Monday, 6 February 2006, 14:29 GMT

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Face-hunting cameras boost Nikon

Japanese camera maker Nikon has tripled its profits on the back of strong sales of digital cameras that automatically focus on human faces.

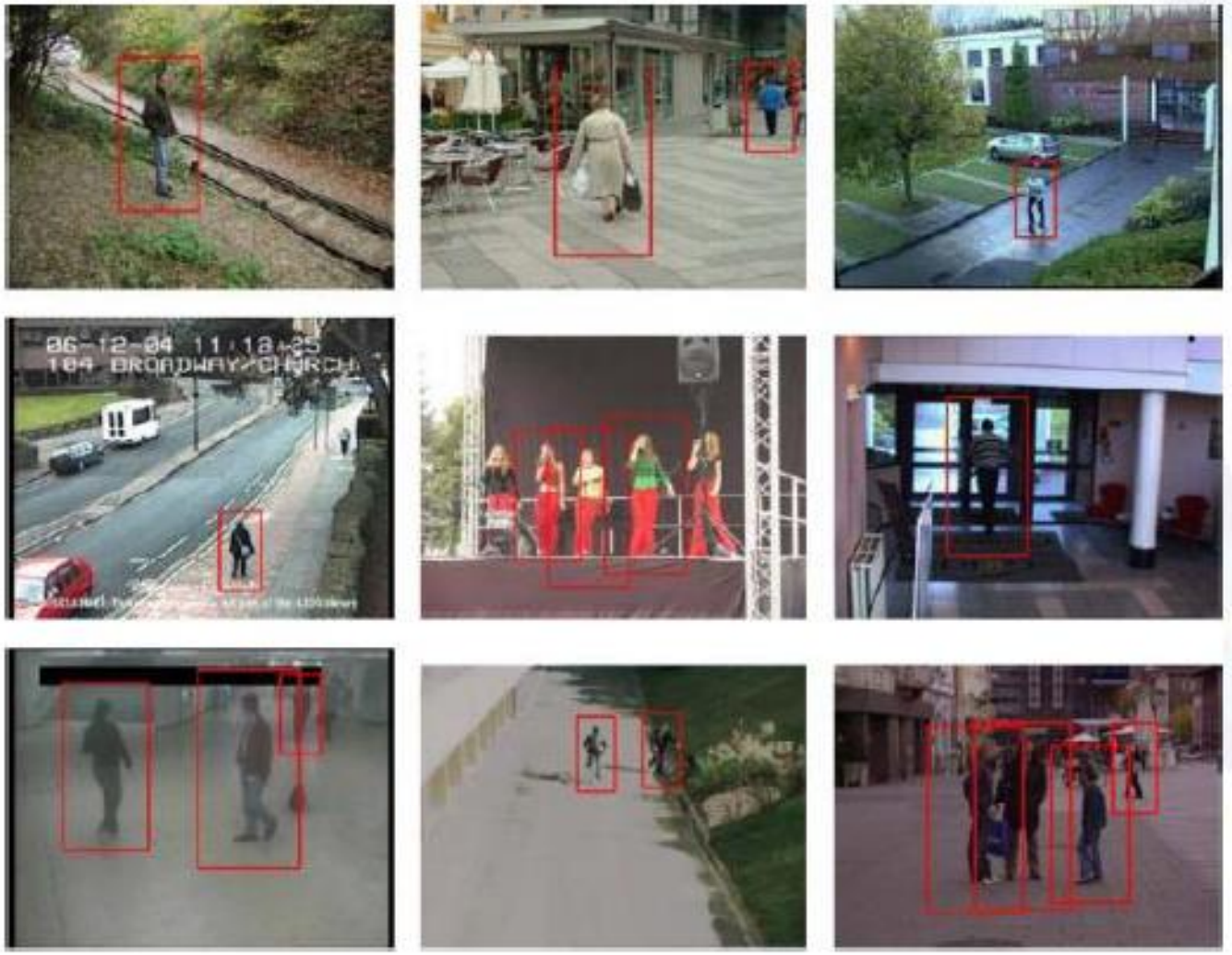
Face recognition cameras like the Coolpix L1 are popular

High Level Topic in Computer Vision:

- Face Detection.

High Level Topic in Computer Vision:

- Human Detection.



High Level Topic in Computer Vision:

- Object Recognition and Detection.
  - Object recognition:
    - Recognizing the object category.
  - Object Detection:
    - Detecting whether certain type of object presents type of object presents and where it locates.
  - Database and Challenges.
    - Pascal 2009, 2008.
    - Caltech 101, 256.

High Level Topic in Computer Vision:

- Object Recognition:

Caltech 101 images

Fei-Fei et al. 2004

Visual Object Classes Challenge 2009 (VOC2009)

PASCAL2
Pattern Analysis, Statistical Modelling and Computational Learning

[click on an image to see the annotation]

Everingham et al. 2006-2012

High Level Topic in Computer Vision:

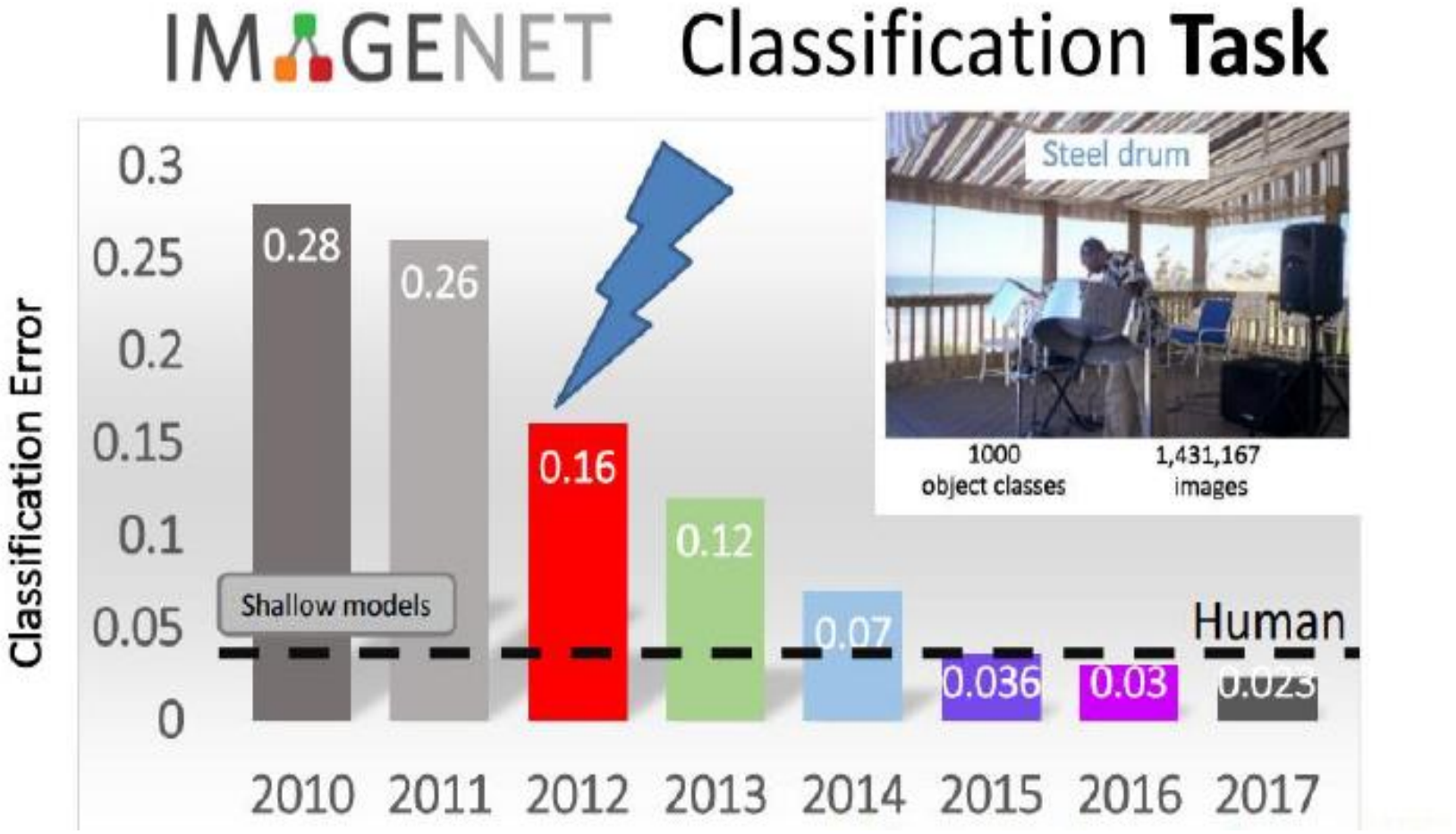
IMAGENET

22,000 categories ⋮ 15,000,000 images

J. Deng, W. Dong, R. Socher, L.-J. Li, K. Li & L. Fei-Fei. *CVPR*, 2009.

High Level Topic in Computer Vision:

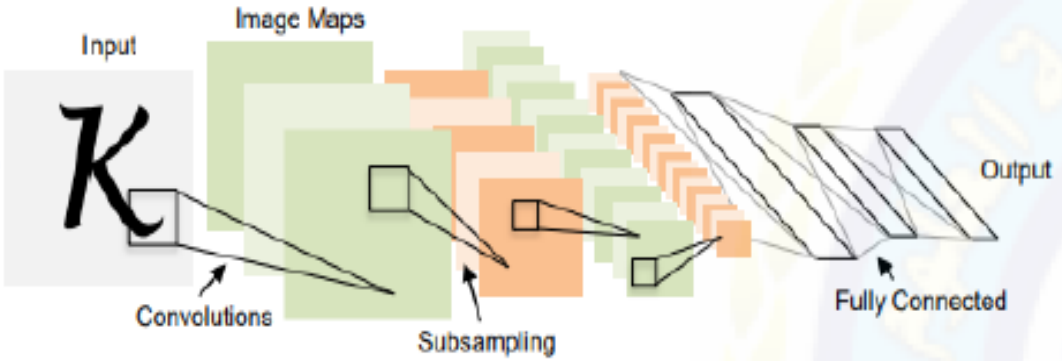
- Object Recognition:



High Level Topic in Computer Vision:

- Object Recognition:

1998
LeCun et al.



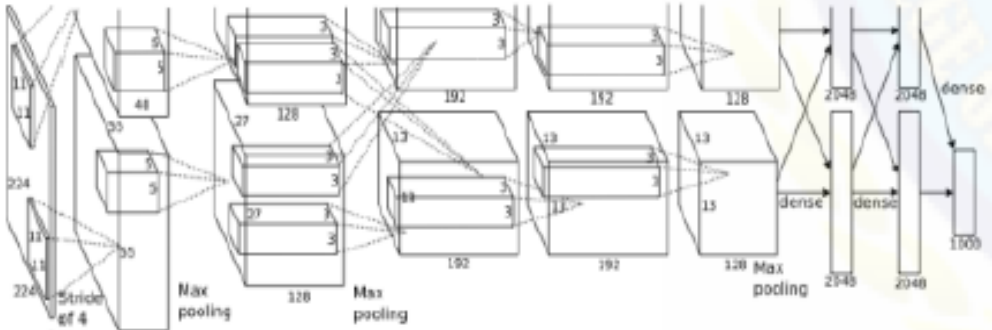
# of transistors

10^6

# of pixels used in training

10^7 NIST

2012
Krizhevsky et al.



# of transistors GPUs

# of pixels used in training

High Level Topic in Computer Vision:

- Object Recognition:

IMAGENET **Large Scale Visual Recognition Challenge**

Year 2010

NEC-UIUC

Dense descriptor grid: HOG, LBP

Coding: local coordinate, super vector

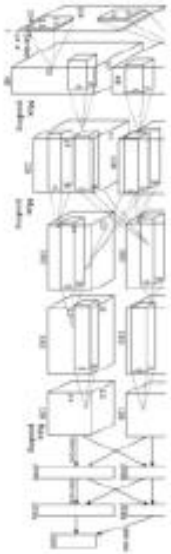
Pooling, SPM

Linear SVM

[Lin CVPR 2011]

Year 2012

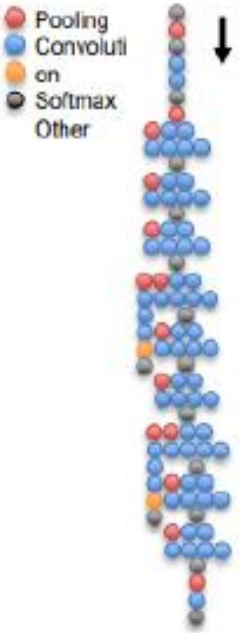
SuperVision



[Krizhevsky NIPS 2012]

Year 2014

GoogLeNet



[Szegedy arxiv 2014]

VGG

[Simonyan arxiv 2014]

Year 2015

MSRA

[He ICCV 2015]

High Level Topic in Computer Vision:

- Image Captioning: Richer Descriptions

Prior Work

Image Captioning → *A man riding a horse drawn carriage down a street*

Our Recent Work

Dense Captioning → JKF, CVPR 2016

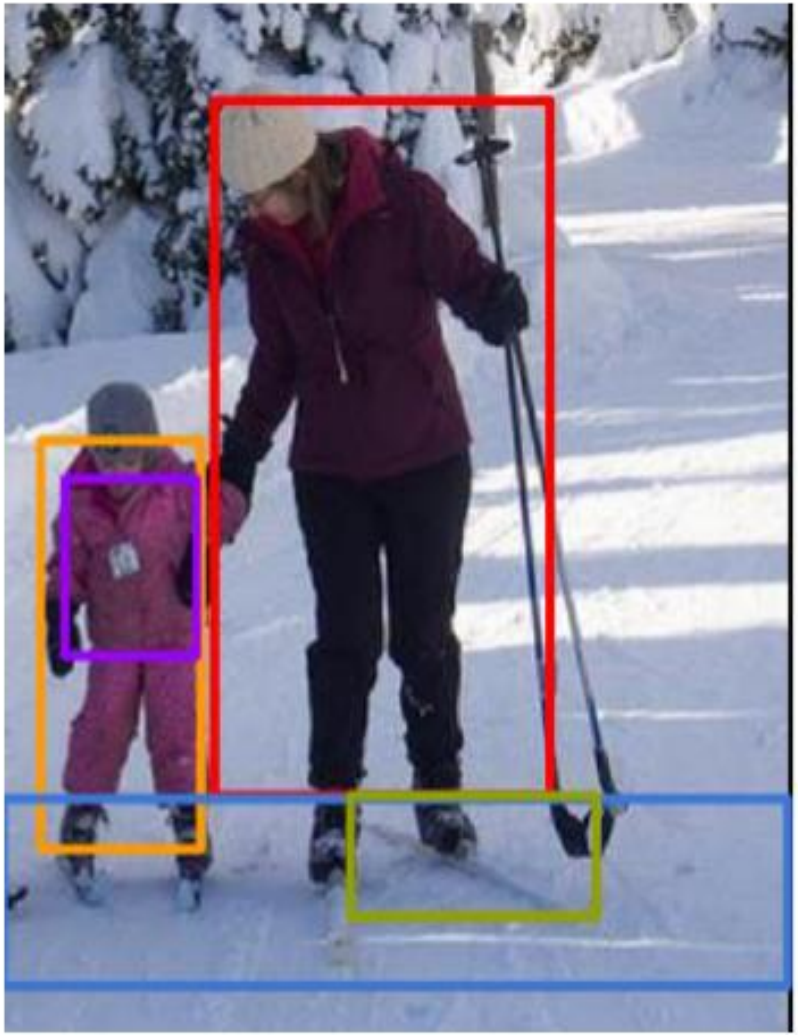
Horse pulling a cart. A wheel on a cart. A window on a building. A horse in a picture. A large white umbrella. A woman sitting on a bench. Man sitting on a motorcycle. A cart with a cart.

Paragraph Captioning → KJKF, CVPR 2017

A man is riding a carriage on a street. Two people are sitting on top of the horses. The carriage is made of wood. The carriage is black. The carriage has a white stripe down the side. The building in the background is a tan color.

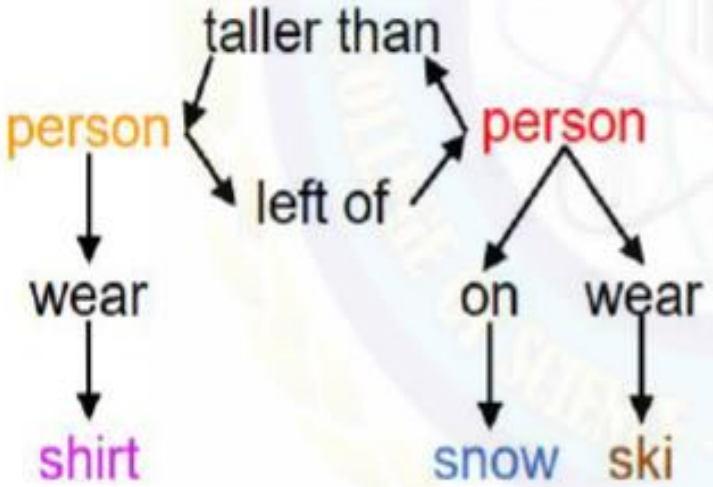
High Level Topic in Computer Vision:

- Image Captioning: Richer Descriptions



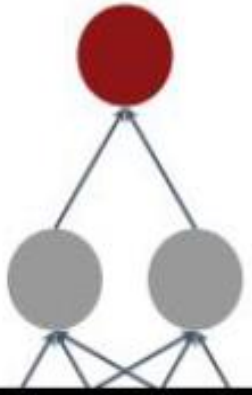
Results:

spatial, comparative, asymmetrical, verb, prepositional

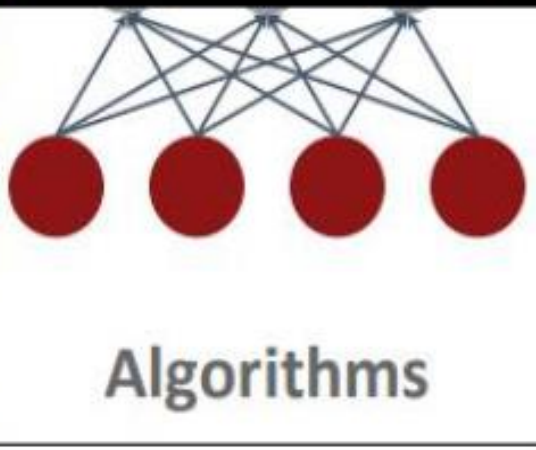


Krishna*, Lu*, Bernstein, Fei-Fei, *ECCV* 2016

High Level Topic in Computer Vision:



The Deep Learning Revolution



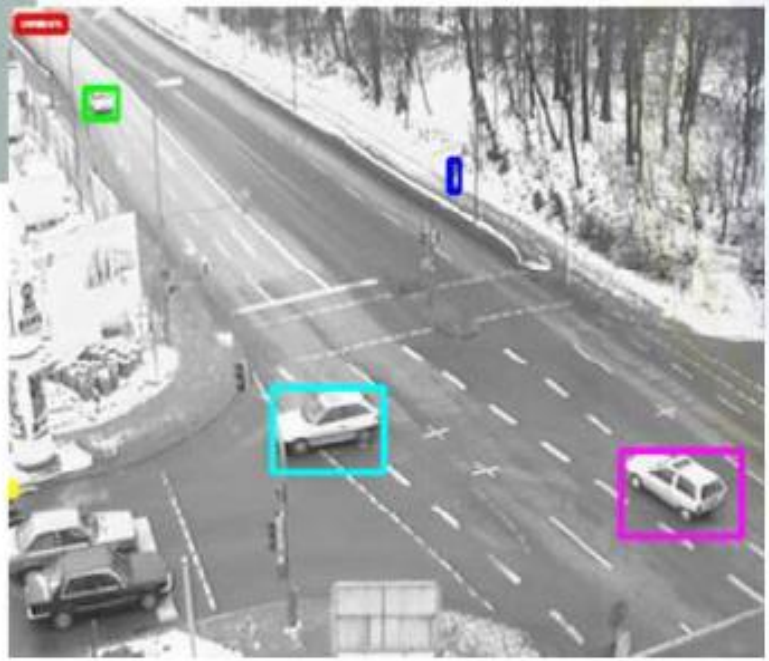
High Level Topic in Computer Vision:

- Action Recognition and Activity Anal
  - Action recognition:
    - Recognizing the action of a subject.
  - Activity Analysis:
    - Composition of several actions.
    - Multiple people involved.
  - Database and Challenge.
    - Trecvid 2009, 2008.
    - KTH, Weizmann

High Level Topic in Computer Vision:

- What is Video Surveillance?

Warn me if there is a mugging in the grove



High Level Topic in Computer Vision:

- Background Subtraction, Human Detection and Tracking in a Video and Tracking in a Video.

High Level Topic in Computer Vision:

- Real Surveillance video for an accident.

High Level Topic in Computer Vision:

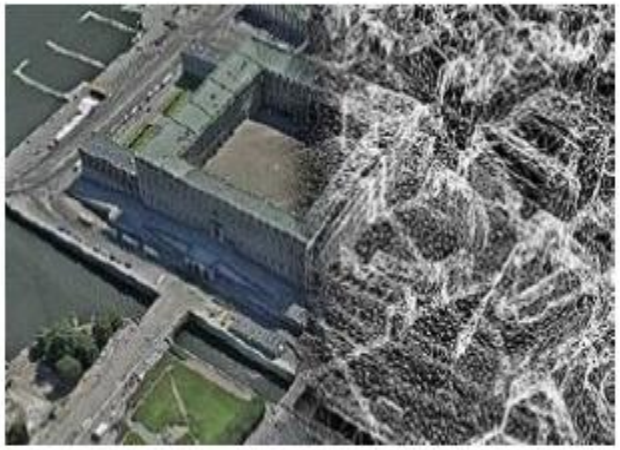
- Face Detection
  - Almost all digital cameras detect faces.
  - Snapchat face filters.

High Level Topic in Computer Vision:

- Smile Detection:

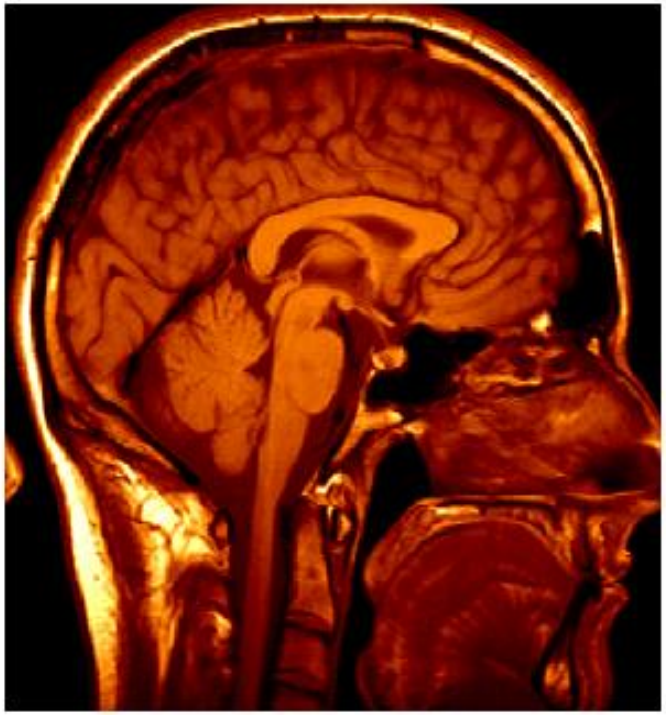
High Level Topic in Computer Vision:

- 3D from Images



High Level Topic in Computer Vision:

- Medical Imaging:



3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

High Level Topic in Computer Vision:

- AutoCars - Uber bought CMU's lab:

High Level Topic in Computer Vision:

- Mobile robots

NASA's Mars Spirit Rover
http://en.wikipedia.org/wiki/Spirit_rover

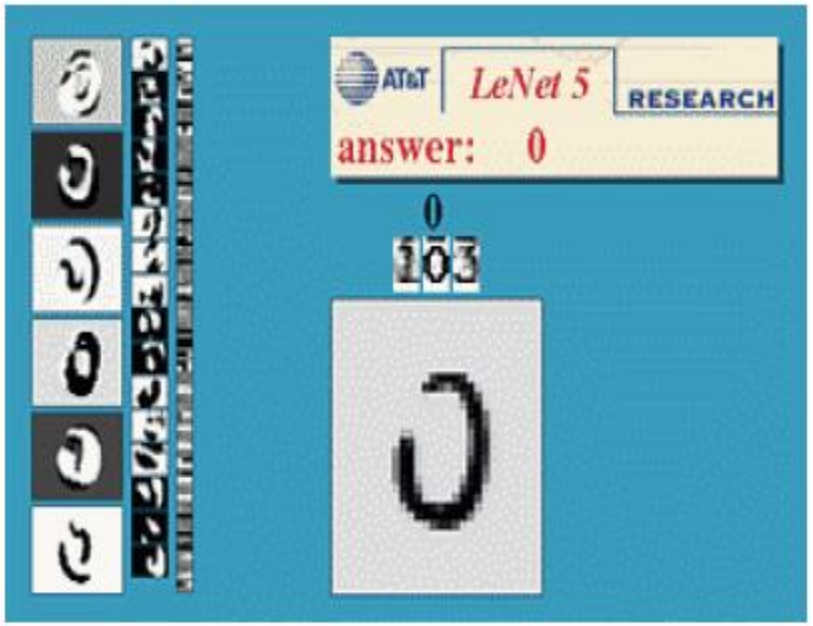
http://www.robocup.org/

amazon Prime Air

2020's: autonomous vehicles

Optical Character Recognition (OCR)

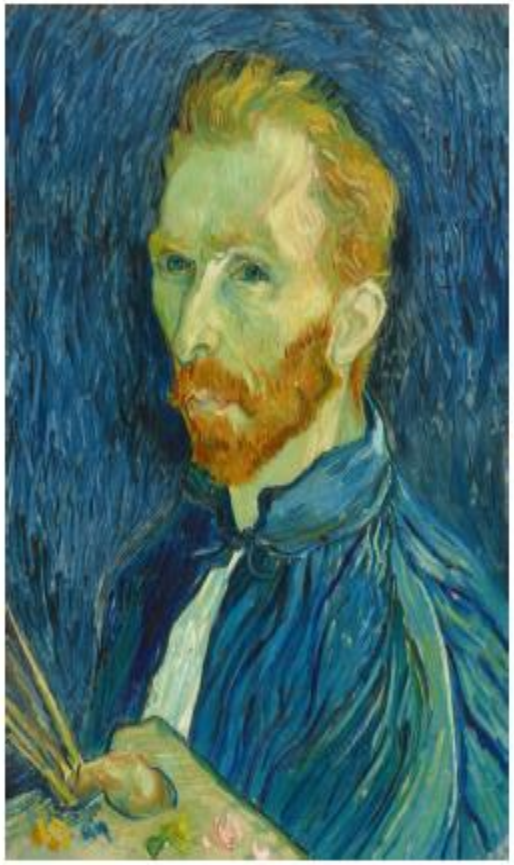
- Technology to convert scanned docs to text
  - If you have a scanner, it probably came with OCR software



Digit recognition, AT&T labs
http://www.research.att.com/~yann/

License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

Style transfer



Source image (**Style**)

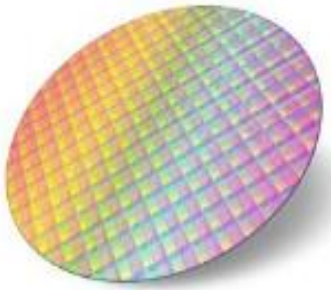
Target image (**Content**)

Output (deepart)

Panoramic Mosaics

Machine vision

Automated visual inspection



Deep Face