PROJECT fLEXABLE

European Research Council
Established by the European Commission

A Brief Introduction to Computer Vision

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EnCoV Institut Pascal

cnrs

UNIVERSITÉ Clermont Auvergne

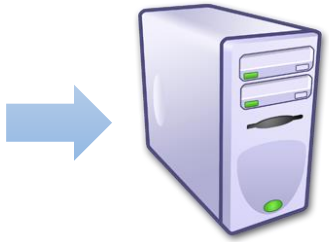
CHU

CICE Centre International de Chirurgie Endoscopique

What is it?

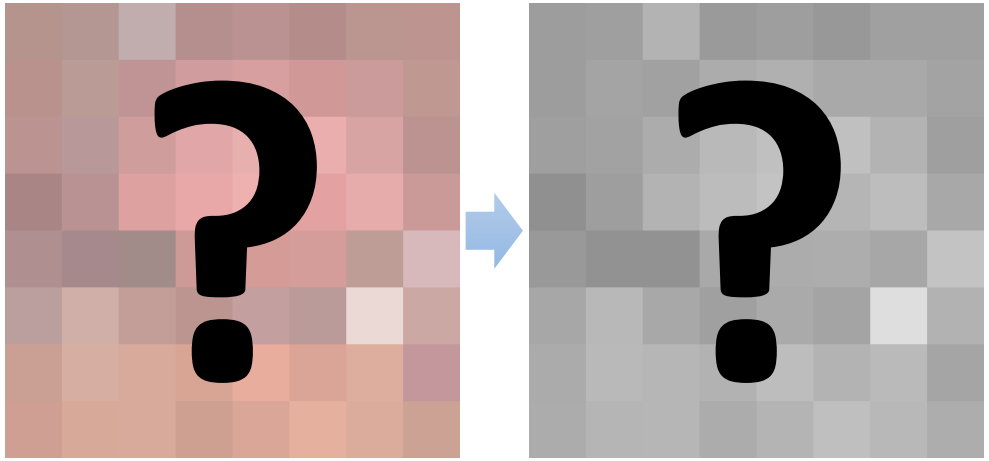
Computer Vision

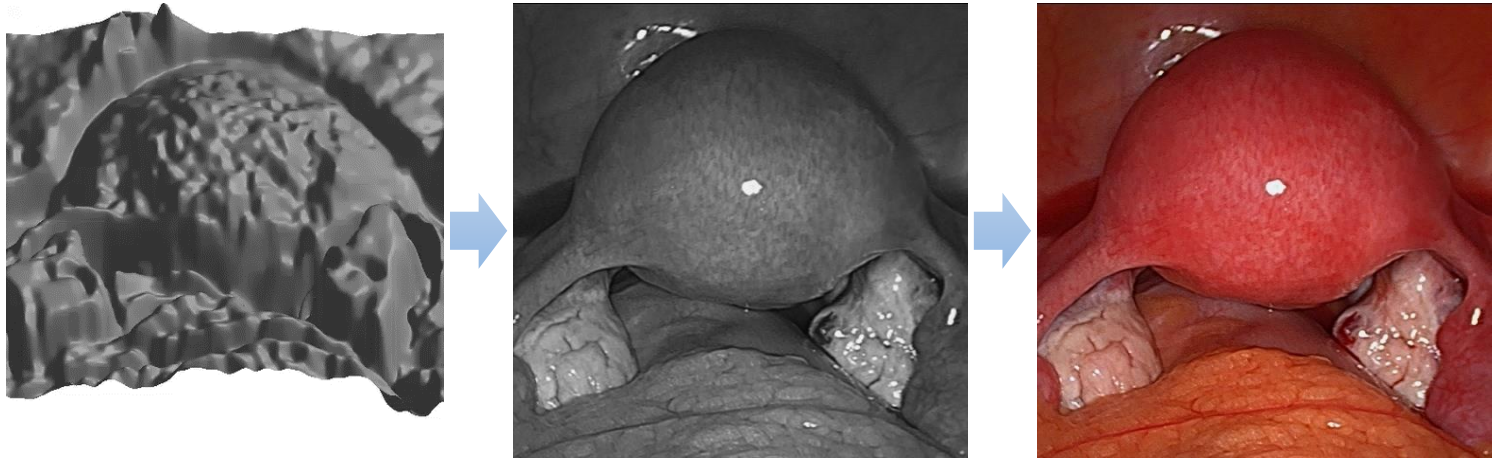
20	17	42	01	72	33	94	55	89	65	58	60
74	49	04	27	56	49	11	63	77	79	90	31
94	70	49	49	05	74	64	00	26	07	23	00
22	15	78	49	74	26	50	94	13	90	08	14
93	29	12	20	26	87	66	98	37	53	82	62
45	04	77	48	87	72	66	91	42	98	17	26
44	91	99	08	72	97	33	58	12	08	91	12
16	23	91	95	97	87	52	49	40	37	21	46
04	50	65	37	99	98	74	98	93	99	78	30
32	70	17	05	79	63	50	26	54	30	01	88
03	64	59	55	85	96	49	46	61	89	33	79
62	49	00	67	28	94	19	65	13	44	78	39
61	00	95	85	86	60	64	17	47	67	87	59
89	03	90	40	10	05	18	43	97	37	68	97



LANDSCAPE

Image classification

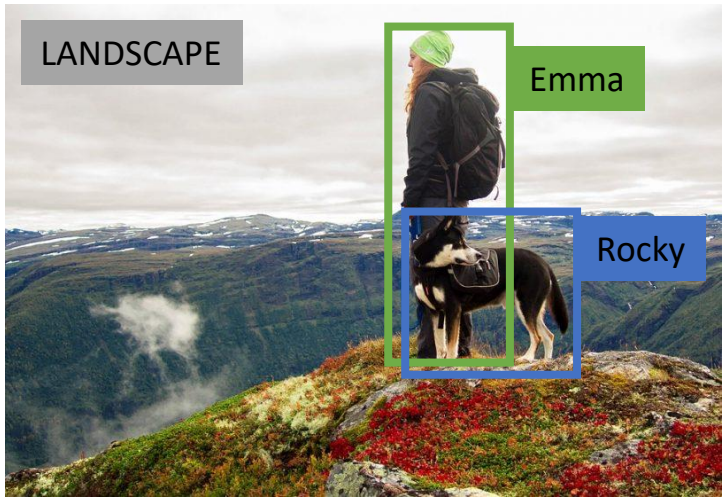




Computer Vision

Image classification

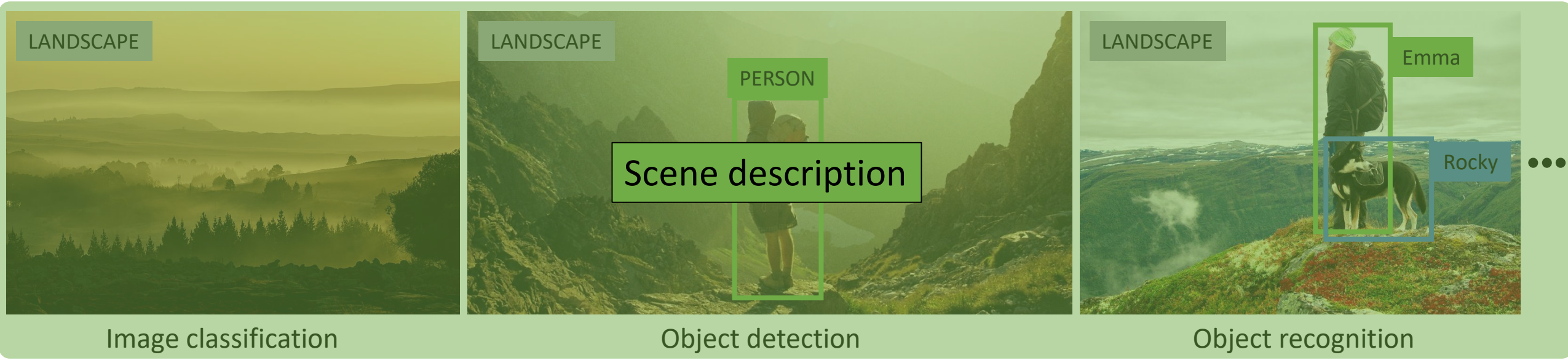
Object detection



Object recognition

●●●

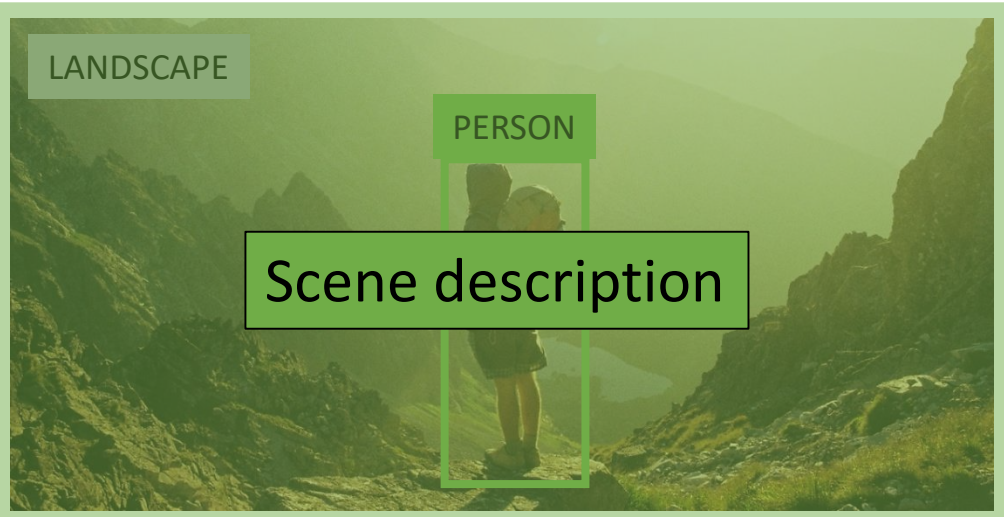
Computer Vision



How Far is the Tower?

Computer Vision

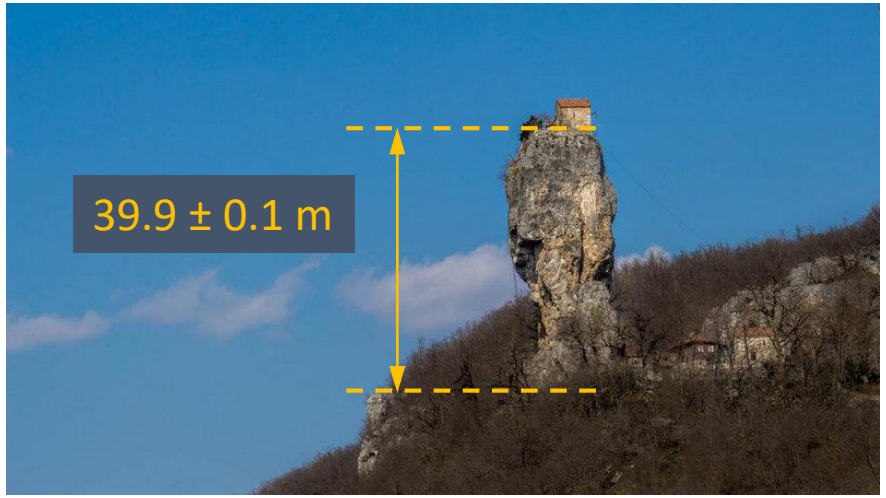
Image classification



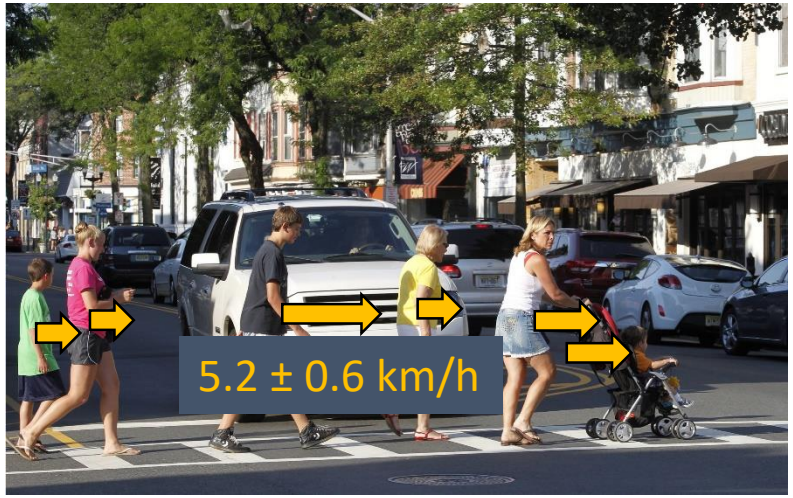
Object detection

Object recognition

Depth measurement



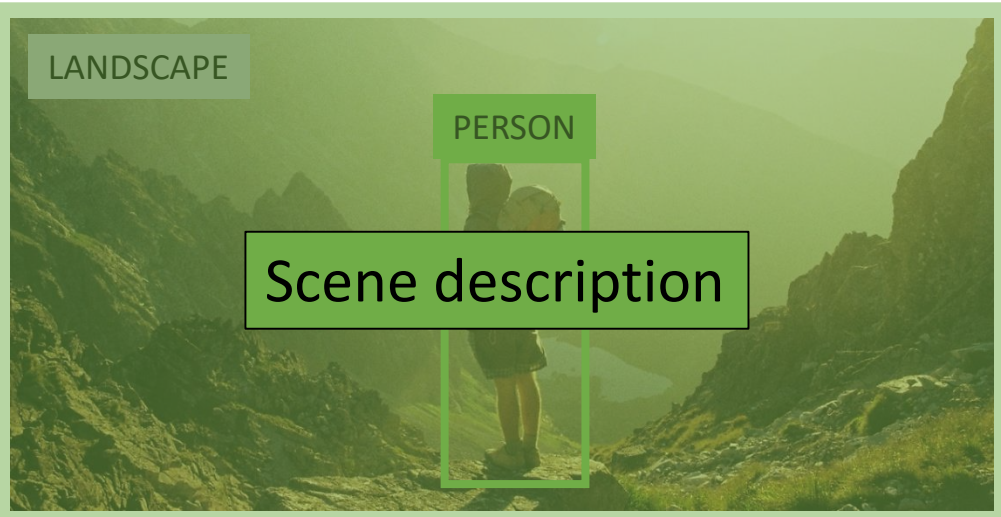
Size measurement



Dynamics measurement

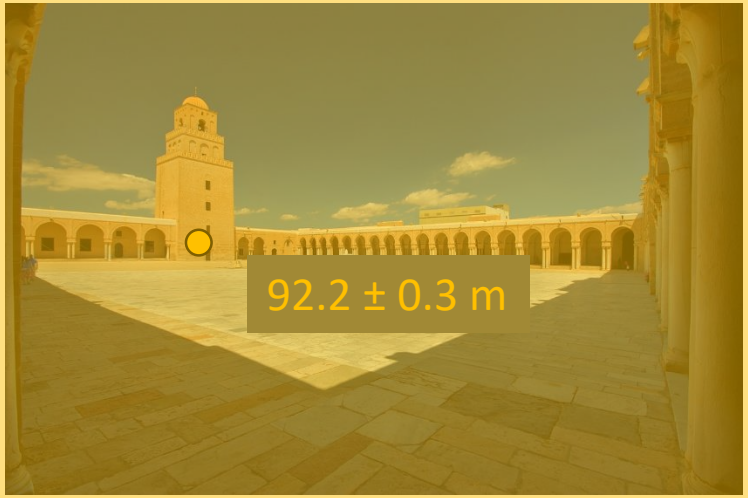
Computer Vision

Image classification

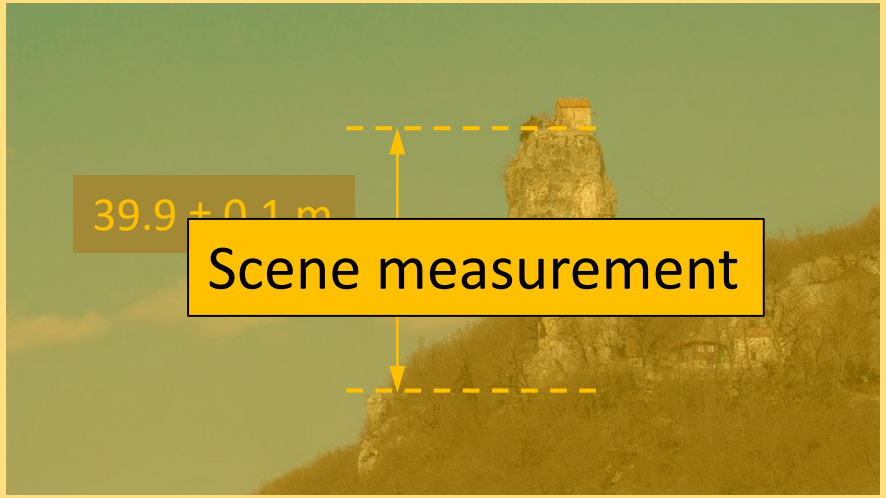


Object detection

Object recognition



Depth measurement



Size measurement

Dynamics measurement

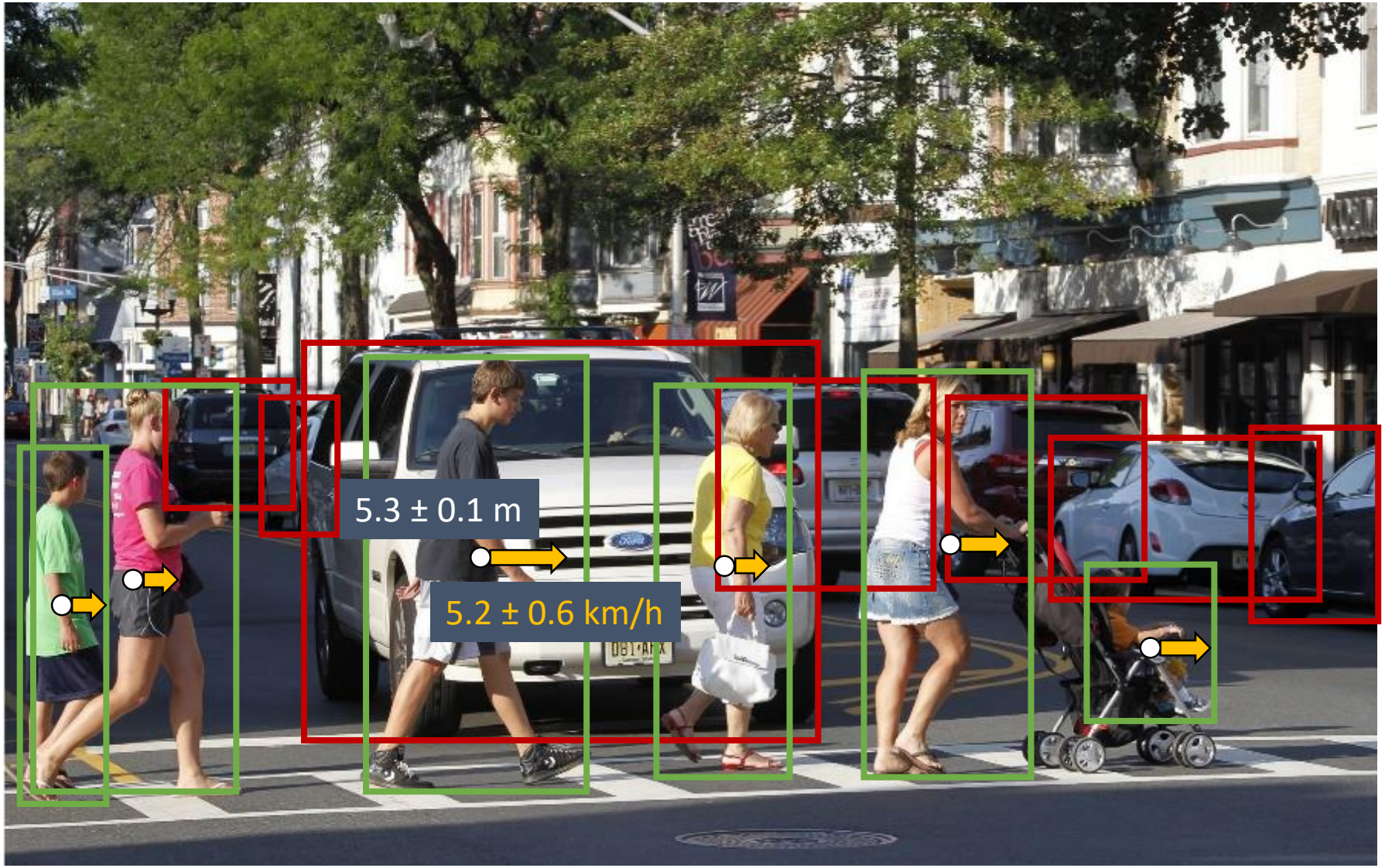
Computer Vision

PERSON

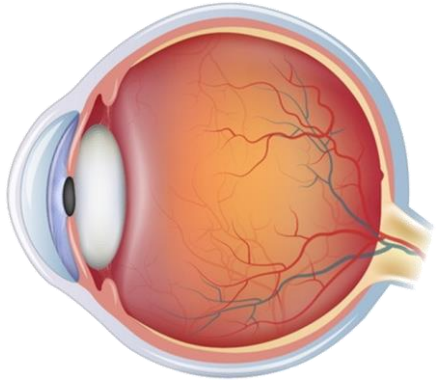
CAR

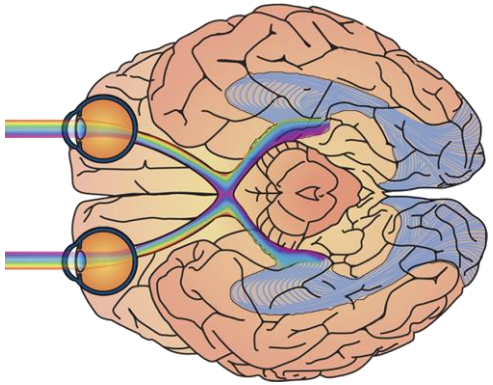
○ distance

⇨ dynamics

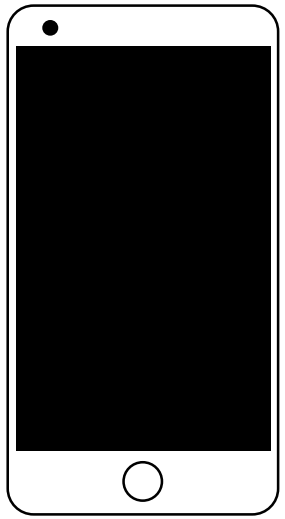


Analogies between Computer Vision and Biological Vision



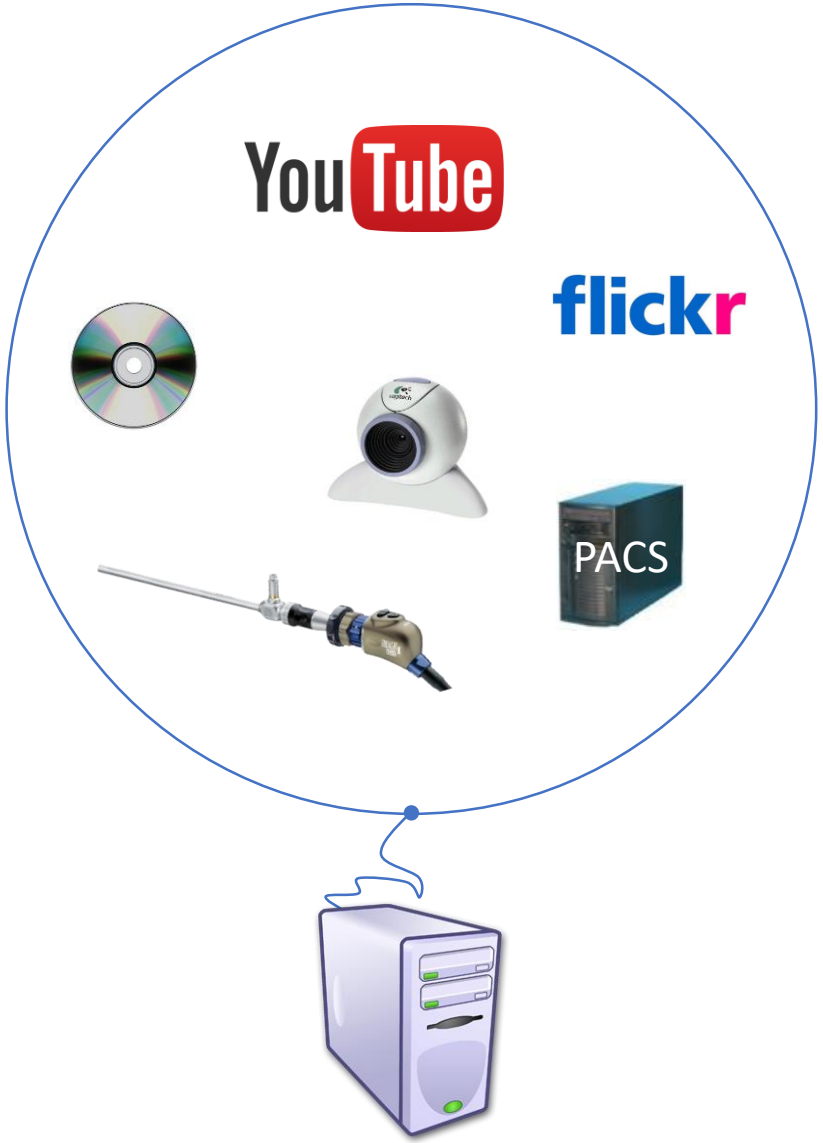


camera



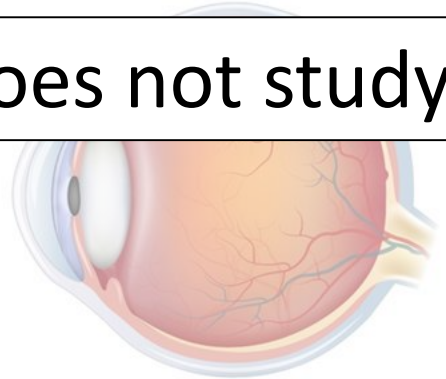
memory

processor

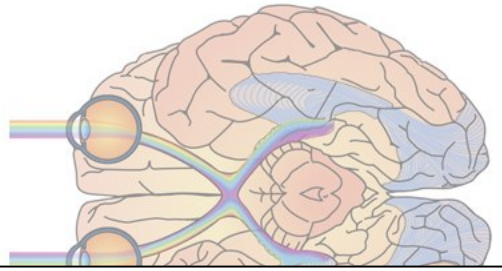


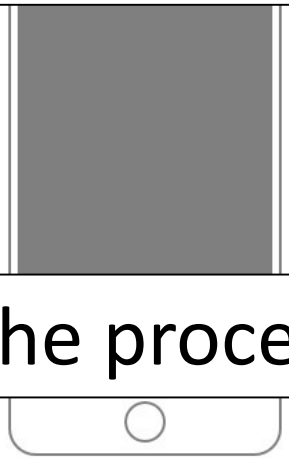
Computer Vision

… does not study biological vision



… attempts to replicate some capabilities of human vision, but not only





… is more concerned with the processing than with the physical camera

Related Fields, Application Examples

Mathematics **Artificial Intelligence** **Computer Science**

Computer Vision

Medical Imaging

Computer Graphics

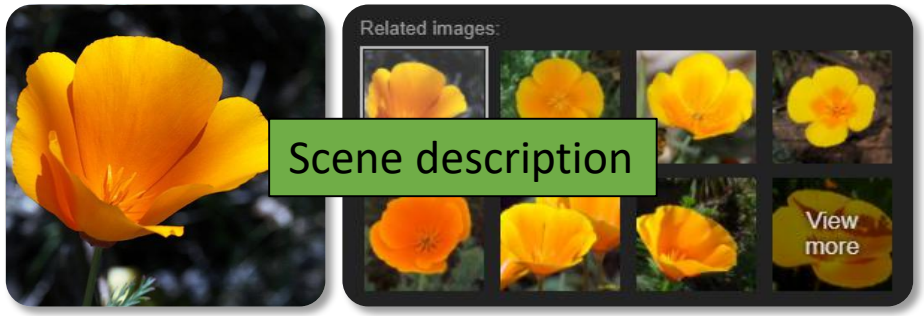
Computational Geometry

Physics

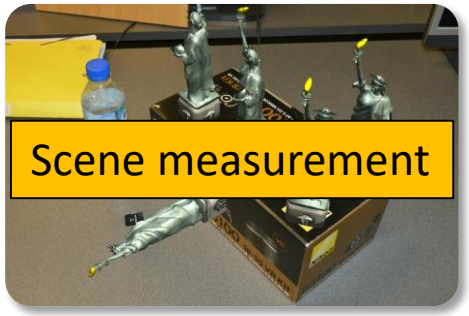
...

...

Image retrieval

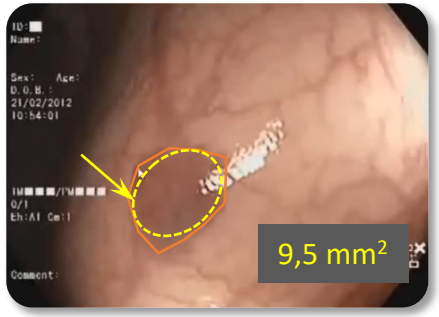


Augmented Reality



Self-driving cars

- adenoma
- serrated adenoma
- hyperplastic



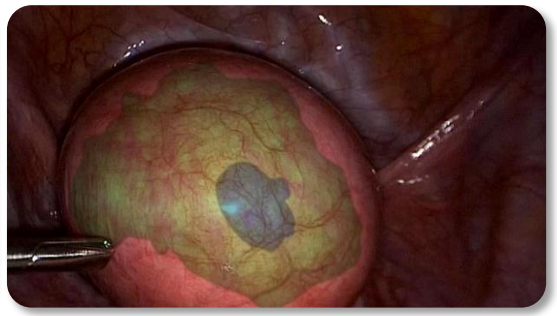
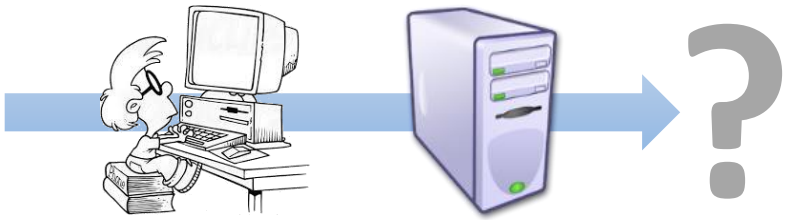


Image Retrieval





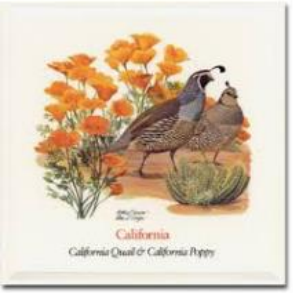










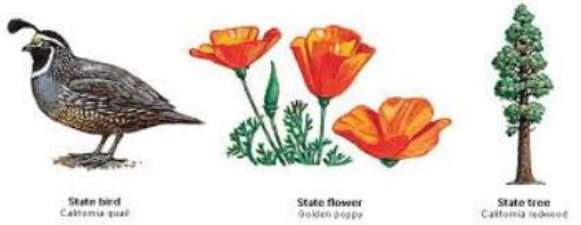
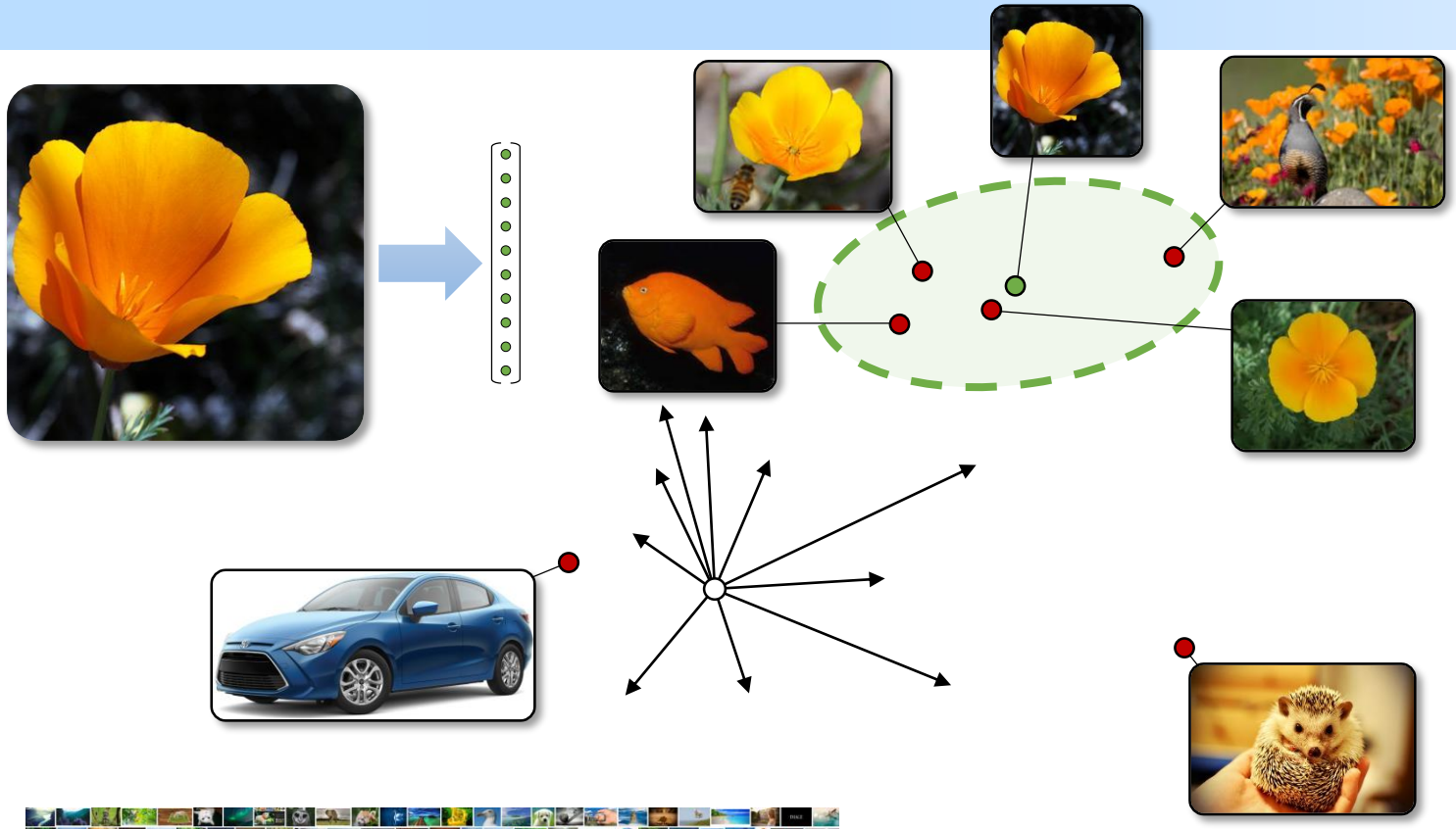
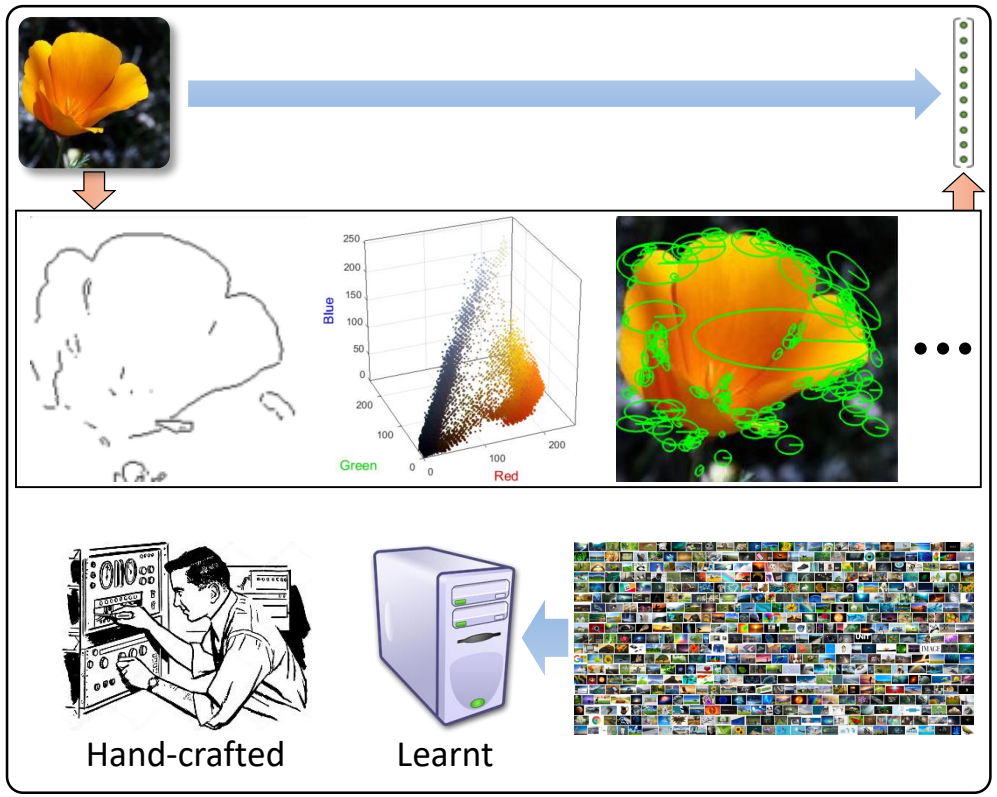
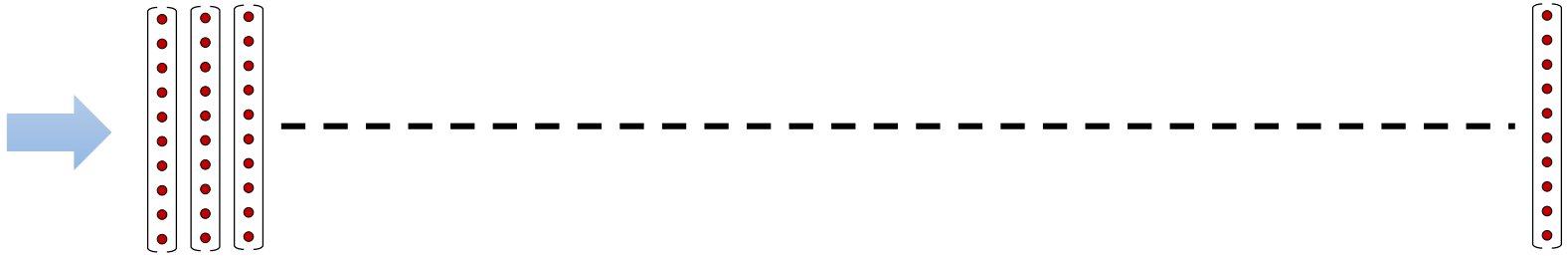




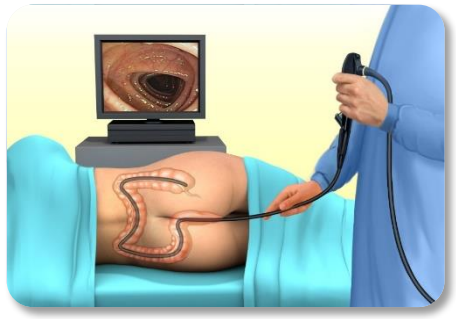
Image Retrieval from Descriptors



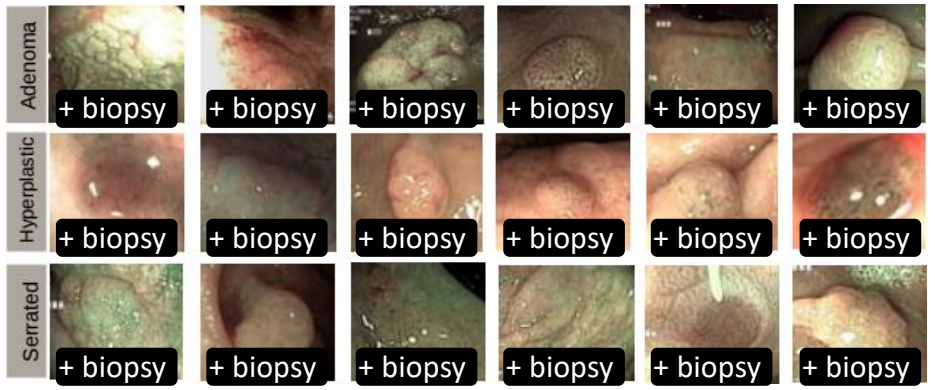




Computer-Aided Colonoscopy: Polyp Type Recognition

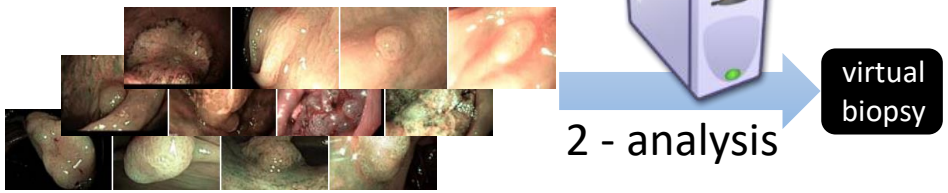


- adenoma
- serrated adenoma
- hyperplastic

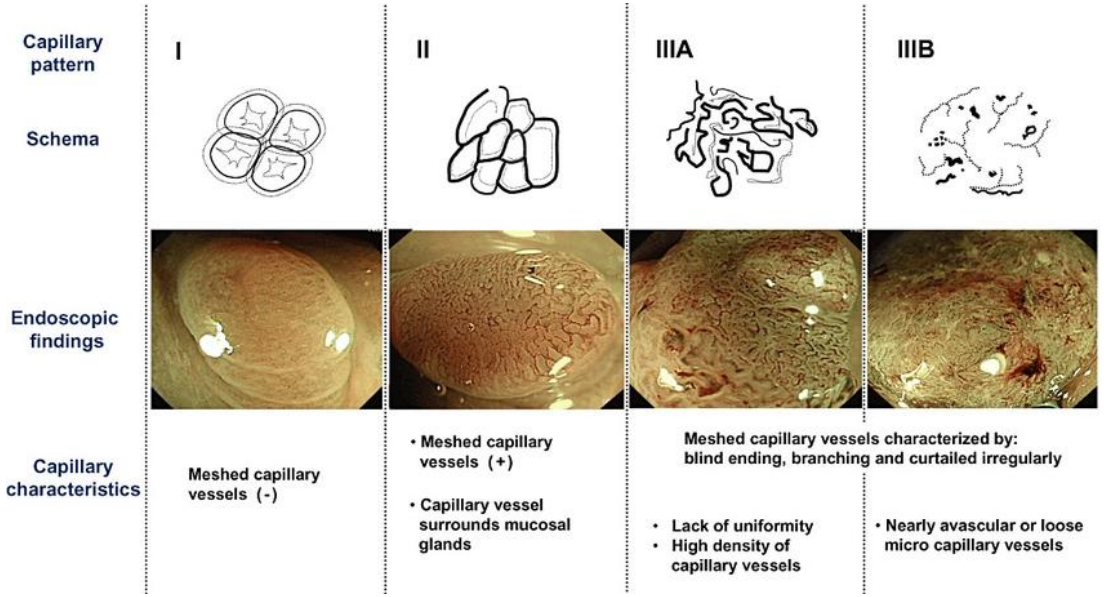


76 polyps

1 - learning

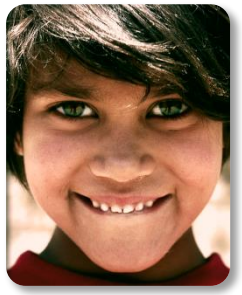


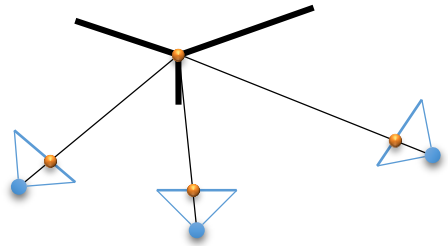
Classifications: Paris, Kudo, Sano, Hiroshima, *etc*

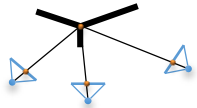


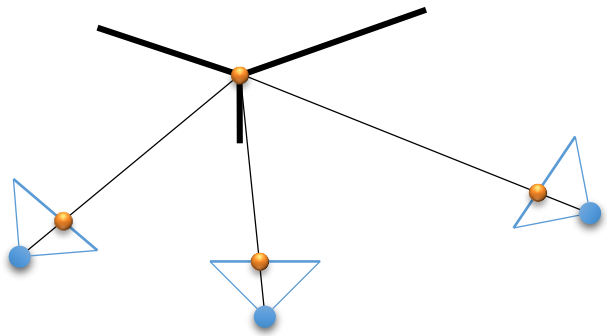
Juniors (between 0 and 4 years practice):	72.2%
Seniors (more than 8 years practice):	76.5%
Machine:	82.4%

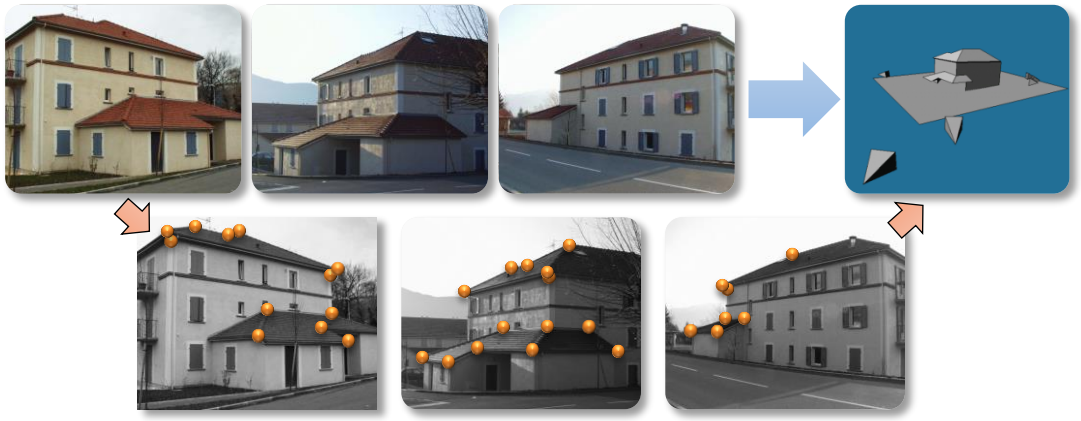
Scene Measurement

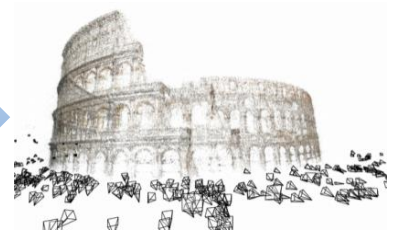








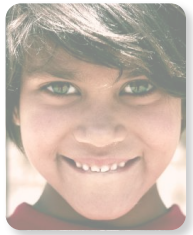




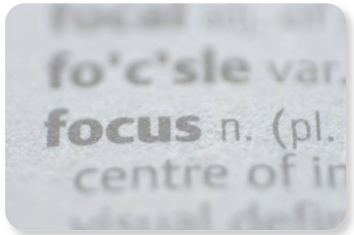
Agarwal et al, University of Washington

Visual Cues

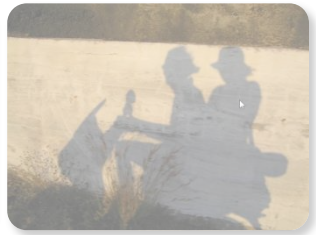
Escaping Criticism
by del Caso, 1874



Stereo

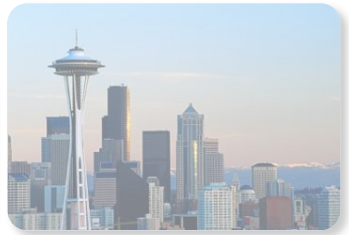


Blur



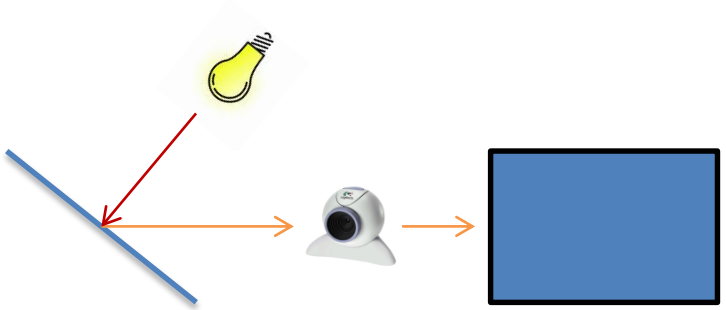
Shadow

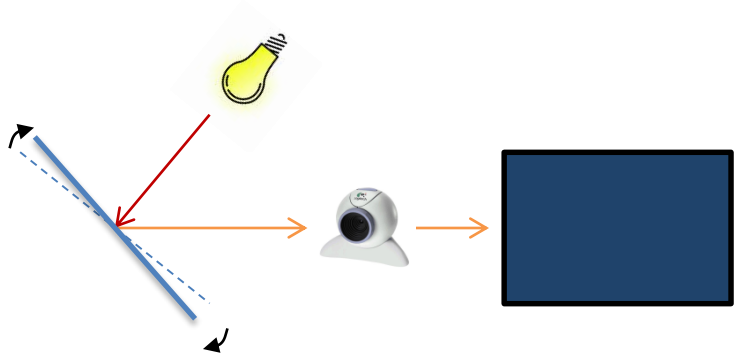
Silhouette

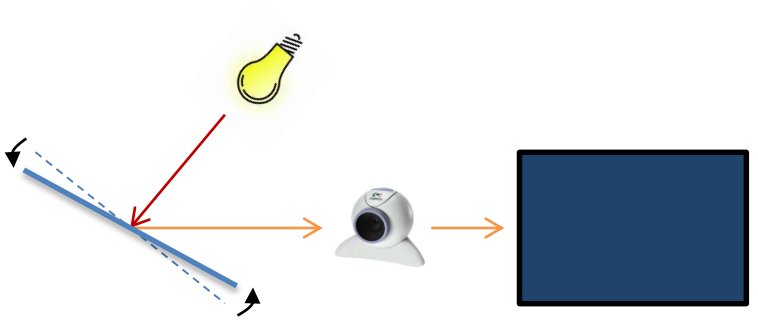


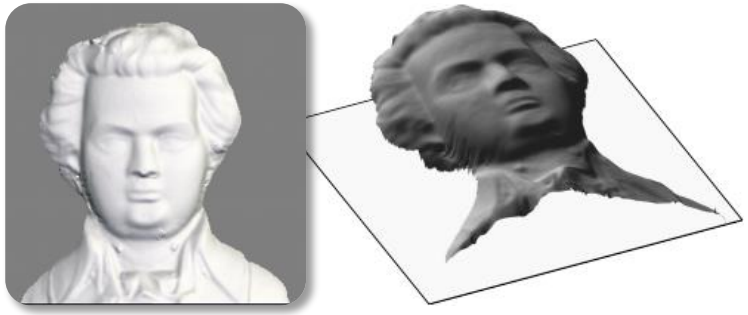
Occlusions

Shading



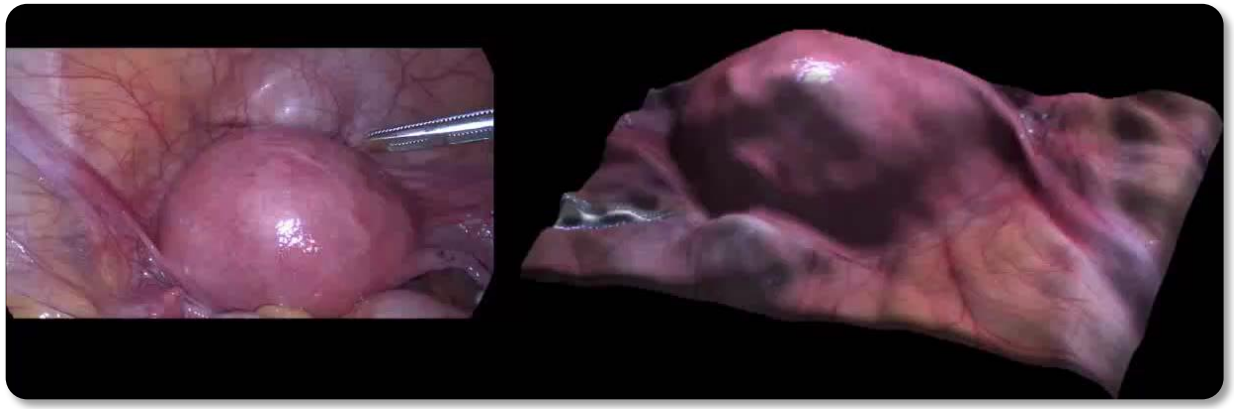






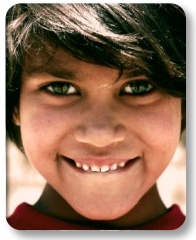
Johnson et al, MIT

Cate et al, Virginia Tech

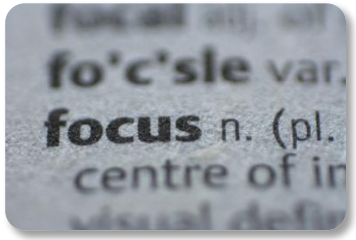


Computer-Aided Colonoscopy: Polyp Measurement

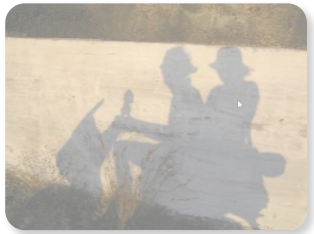
Escaping Criticism
by del Caso, 1874



Stereo

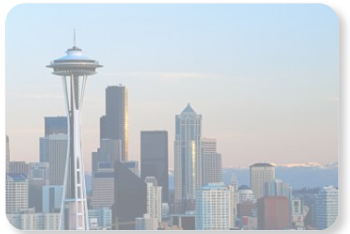


Blur

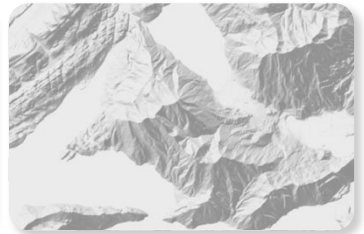


Shadow

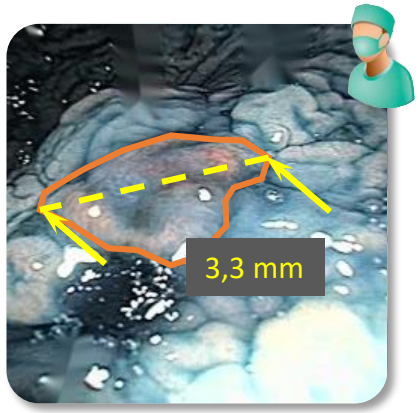
Silhouette



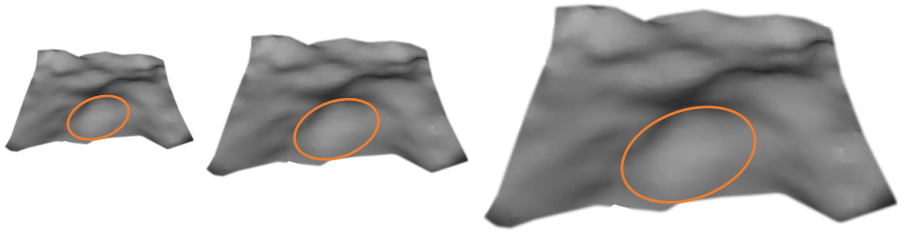
Occlusions



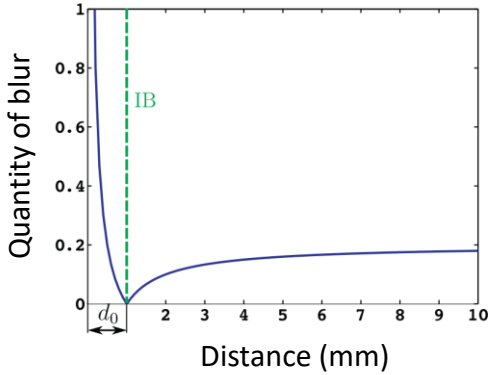
Shading

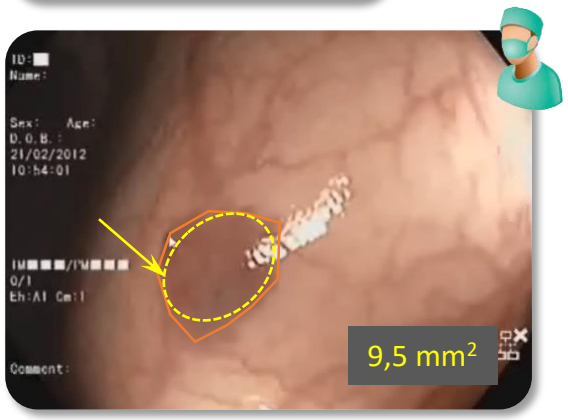


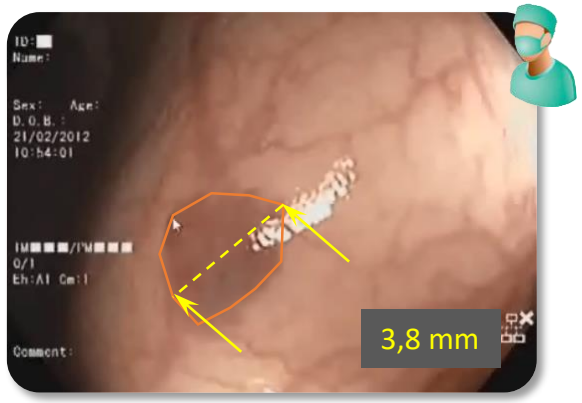
1 - estimate 3D shape from multiple images

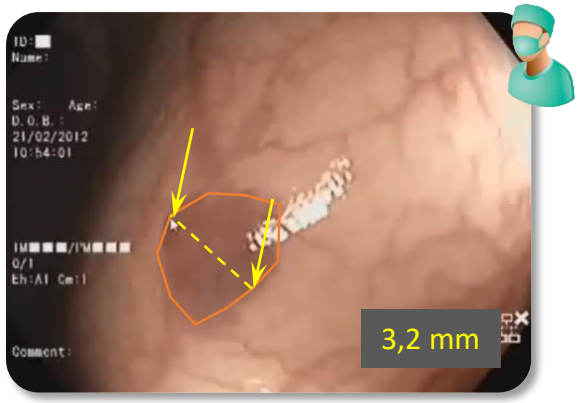


2 - estimate scale
from focus blur





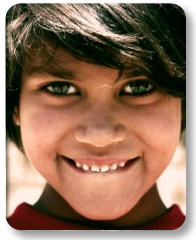




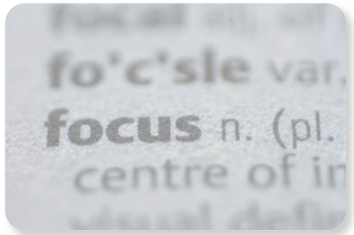
Precision: about 0.3 mm
(evaluated on a porcine model)

Computer-Aided Laparoscopy: Augmented Reality

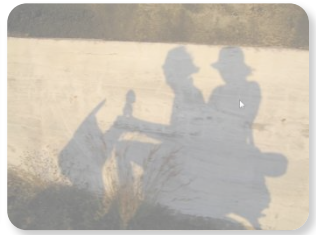
Escaping Criticism
by del Caso, 1874



Stereo

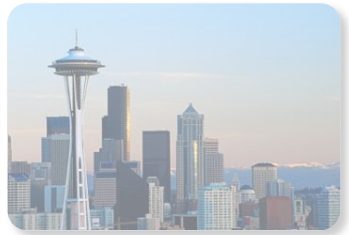


Blur



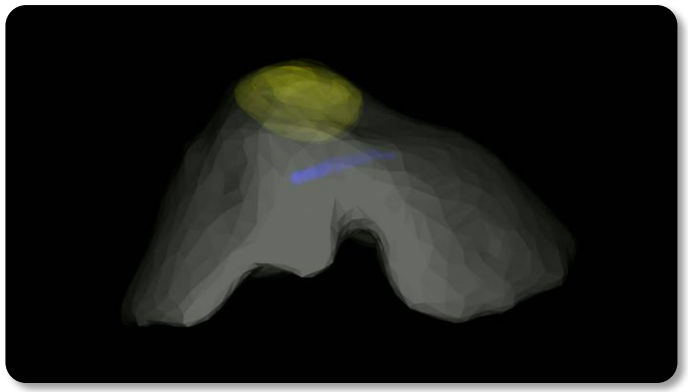
Shadow

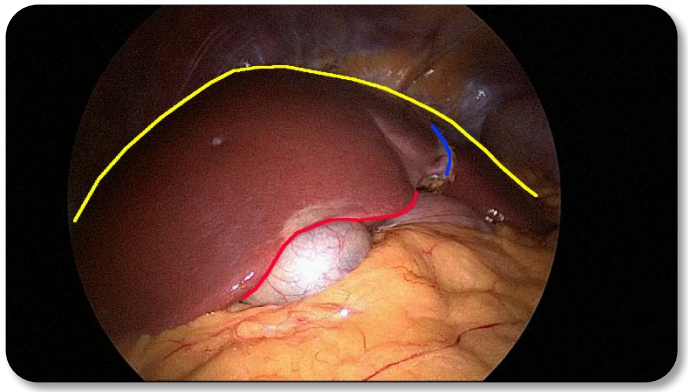
Silhouette

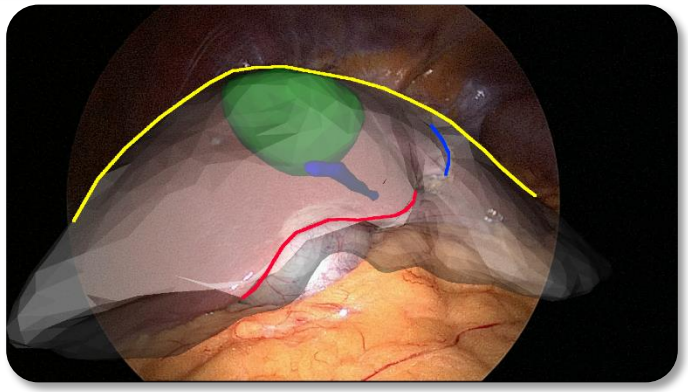


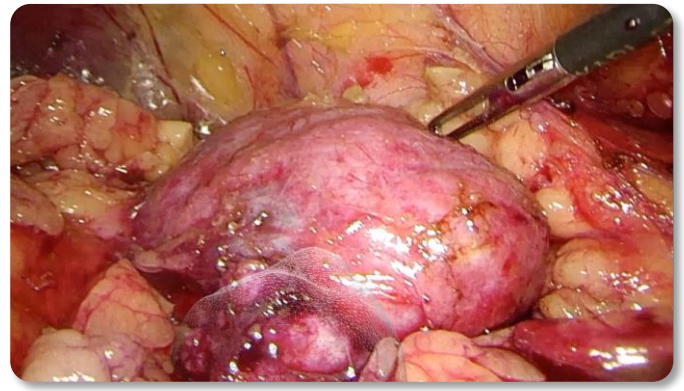
Occlusions

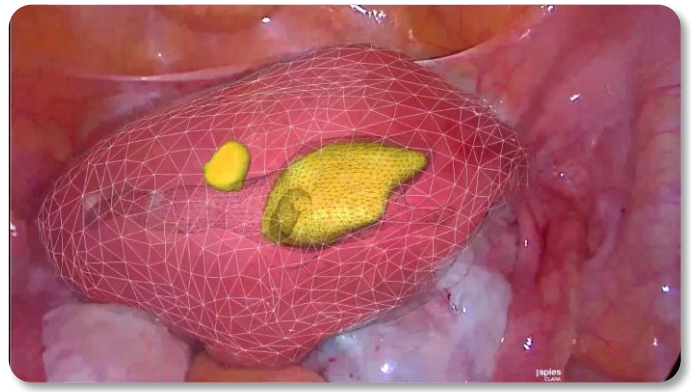
Shading







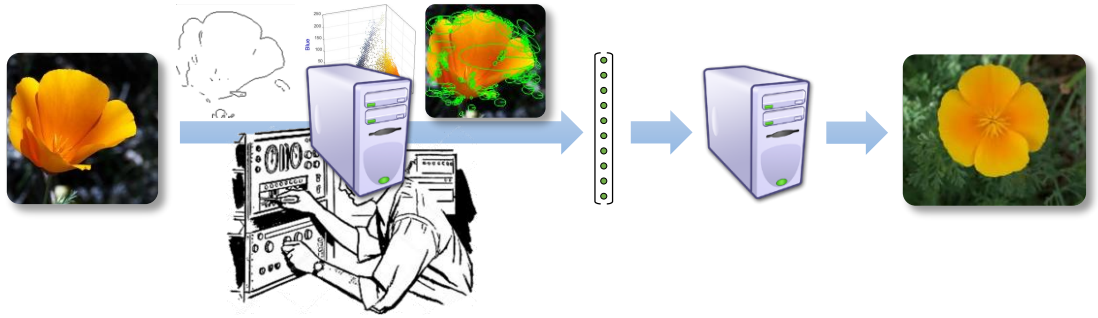




Current and Future Trends

Computer Vision has been a combination of modeling, hand-crafting/tuning and machine learning…

…with Deep Neural Networks, Computer Vision is now emphasizing machine learning and displacing the modeling and hand-crafting



Current and Future Trends

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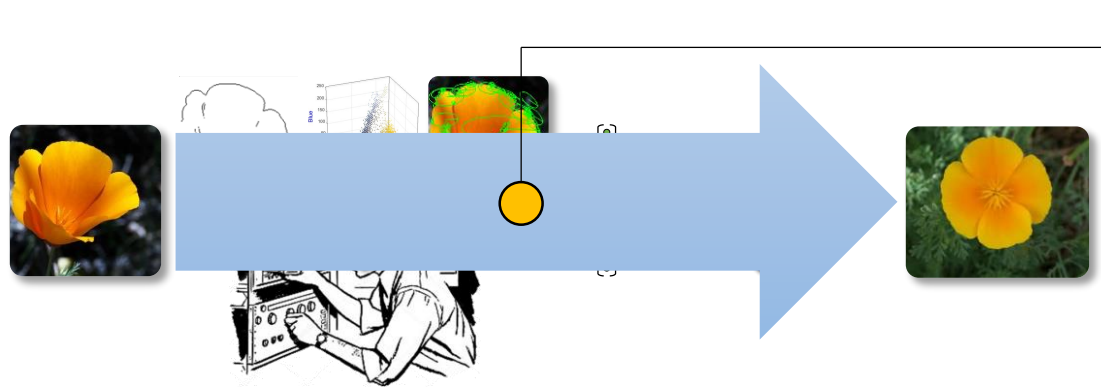

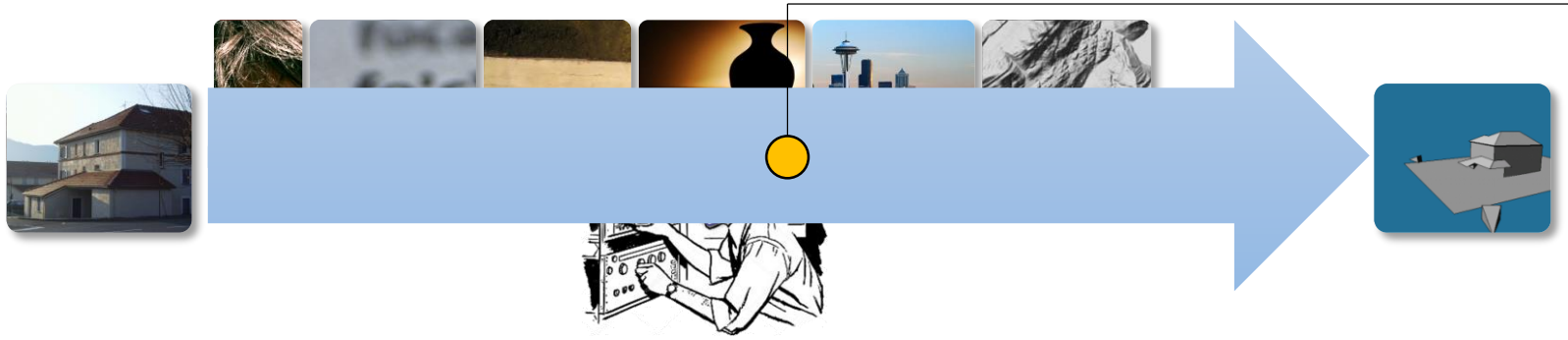

PROJECT fLEXABLE

European Research Council
Established by the European Commission

A Brief Introduction to Computer Vision

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EnCoV Institut Pascal

cnrs

UNIVERSITÉ Clermont Auvergne

CHU

CICE Centre International de Chirurgie Endoscopique

Abstract

We live in a world where digital visual data are ubiquitous. These data are very diverse in imaging modality and contents, ranging from one's holiday pictures to medical radiological images. As humans, we naturally use visual data to infer information. For instance, we are extremely good at recognizing people and places from conventional images or understanding a preoperative CT scan. Over the last few decades, a fundamental scientific question has emerged: *can we transfer the sense of vision to a computer?* In other words, *can we program a computer to see by understanding visual data?* This question lies at the heart of computer vision.

Computer vision is a scientific discipline which studies the automated interpretation of digital visual data. It is primarily a branch of computer science but is also strongly interdisciplinary, as it uses physics, geometry, optimization and artificial intelligence, to name but a few. Computer vision achieves results by modeling the visual cues and understanding their relationship to the target task or by learning from data.

Broadly speaking, the typical tasks in computer vision fall in the categories of *scene description* and *3D perception*. The former concerns object detection and recognition: who was in this picture? where was it taken from? which organs are shown in this CT? and so on. The latter concerns 3D localization and measurements: what was the 3D shape of that object? how much did the camera move in this video? how big was this lesion as seen in this endoscopy image? and so on. As humans, we are typically doing very well in scene description but much worse in 3D perception. For instance, can you tell quantitatively how big a tumor is just by looking at your laparoscopy screen? Under some circumstances, a computer can, and will do it accurately. Interestingly, there is a number of tasks at which the computer may nowadays outperform the humans.

In this presentation, I will review the original and recent approaches to computer vision and focus on describing the model based approach to some relevant tasks in 3D perception. I will show how one can make *accurate quantitative 3D measurements from images* and illustrate this by *examples in laparoscopy and colonoscopy*.