

# Introduction of Computer Vision



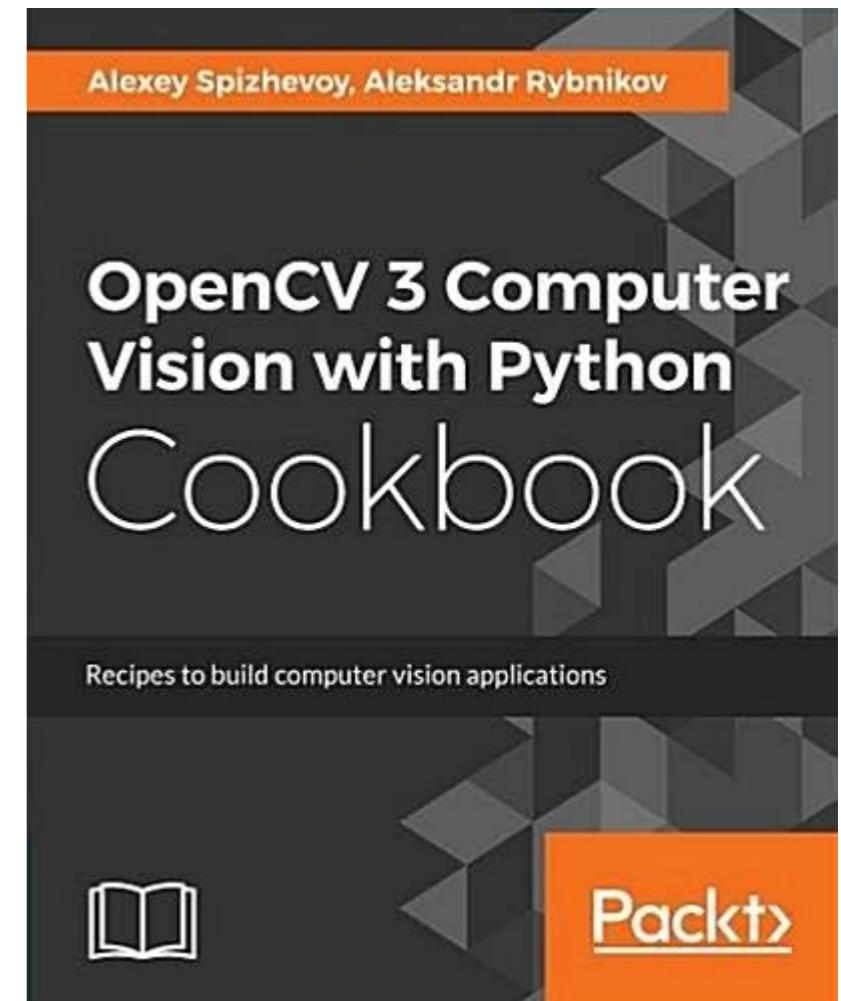
Industrial Computer Vision Course  
Fall 2022, Lecture 1  
Lecturer: Youngbae Hwang

# Syllabus

- Evaluation
  - Attendance: 20%, Homework: 40%, Midterm/Final Project: 40%
- Course schedule
  - 2<sup>nd</sup> Week - Input/Output & Graphic User Interface (GUI) (ch.1)
  - 3<sup>rd</sup> Week – Histogram & Filtering (ch. 2)
  - 4<sup>th</sup> Week – Frequency-based Image Processing (ch. 2)
  - 5<sup>th</sup> Week – Boundary Extraction (ch. 3)
  - 6<sup>th</sup> Week – Image Segmentation (ch. 3)
  - 7<sup>th</sup> Week – Corner detection (ch. 7)
  - 8<sup>th</sup> Week – Midterm Project
  - 9<sup>th</sup> Week – Invariant Feature & Descriptor (ch. 7)
  - 10<sup>th</sup> Week – Correspondence Search (ch. 8)
  - 11<sup>th</sup> Week – Optical Flow & Panorama Imaging (ch. 8)
  - 12<sup>th</sup> Week – Camera Calibration (ch. 9)
  - 13<sup>th</sup> Week – Stereo Camera Calibration (ch. 9)
  - 14<sup>th</sup> Week – Object Detector (ch. 4)
  - 15<sup>th</sup> Week – Final Project

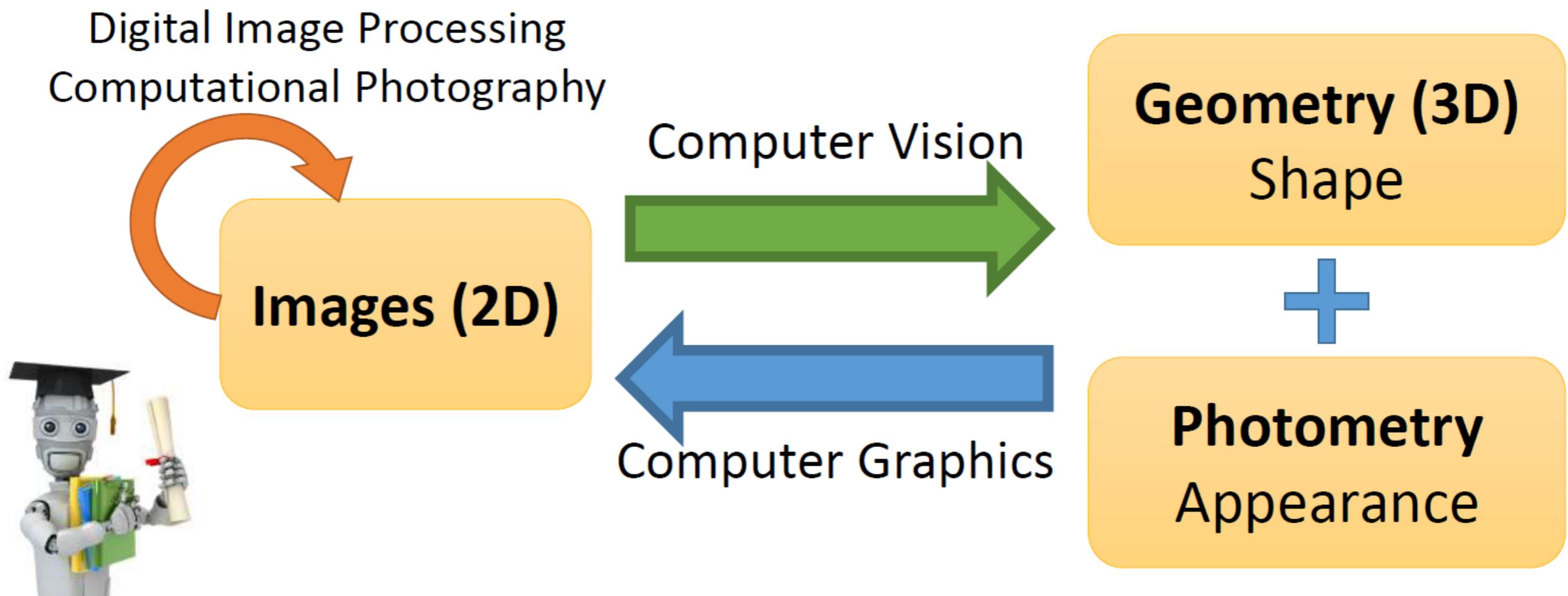
# TextBook

- 교재
  - 파이썬과 OpenCV를 이용한 컴퓨터 비전 학습
  - OpenCV-Python으로 배우는 영상 처리 및 응용
- Contents
  - 1: I/O and GUI
  - 2: Matrices, Colors, and Filters
  - 3: Contours and Segmentation
  - 4: Object Detection and Machine Learning
  - 5: Deep Learning
  - 6: Linear Algebra
  - 7: Detectors and Descriptors
  - 8: Image and Video Processing
  - 9: Multiple View Geometry



What is  
computer vision?

# Computer Vision and Nearby Fields



Machine learning:

Vision = Machine learning applied to visual data

# Computer Vision matters



Safety



Health



Security

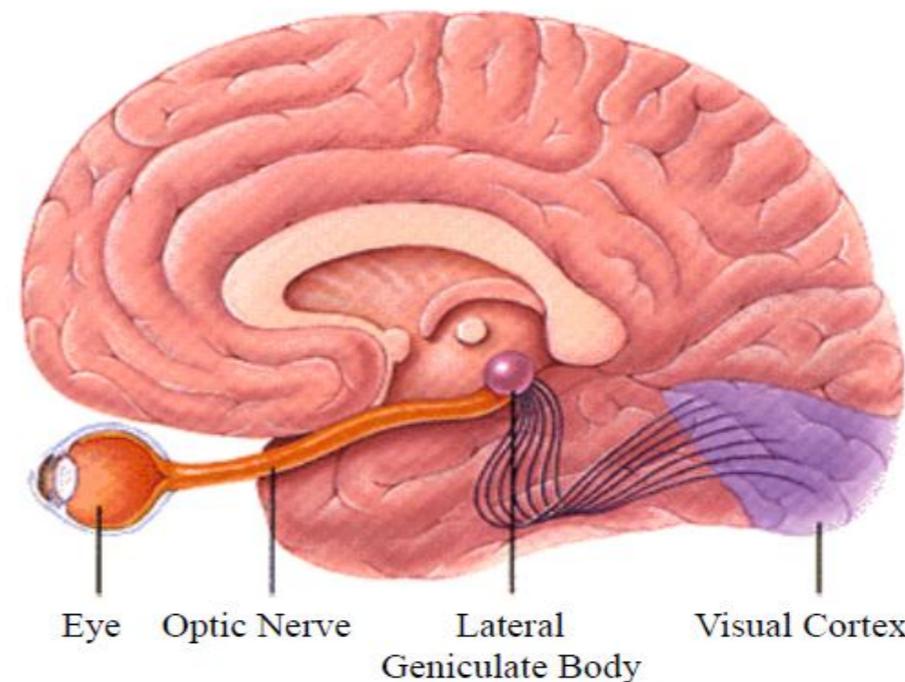
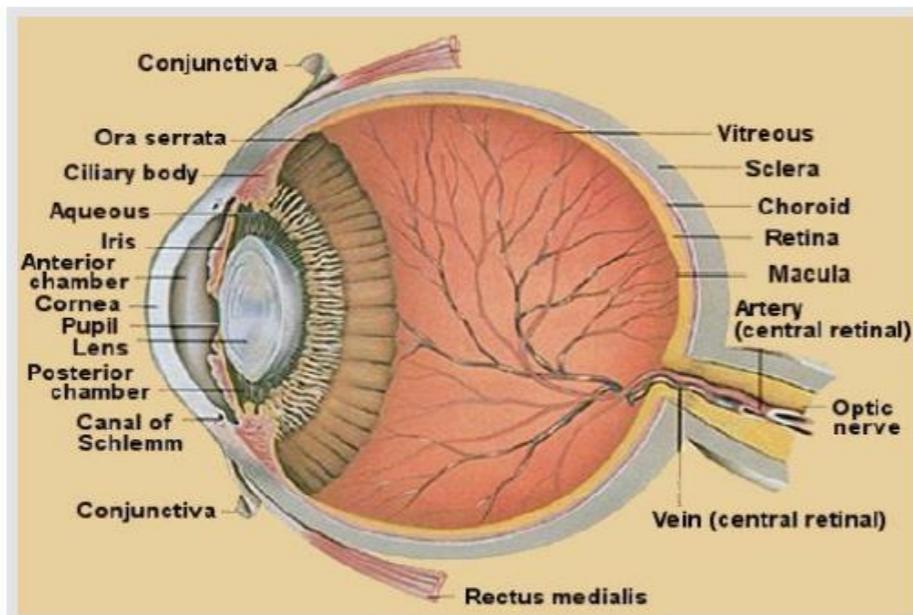


Movie



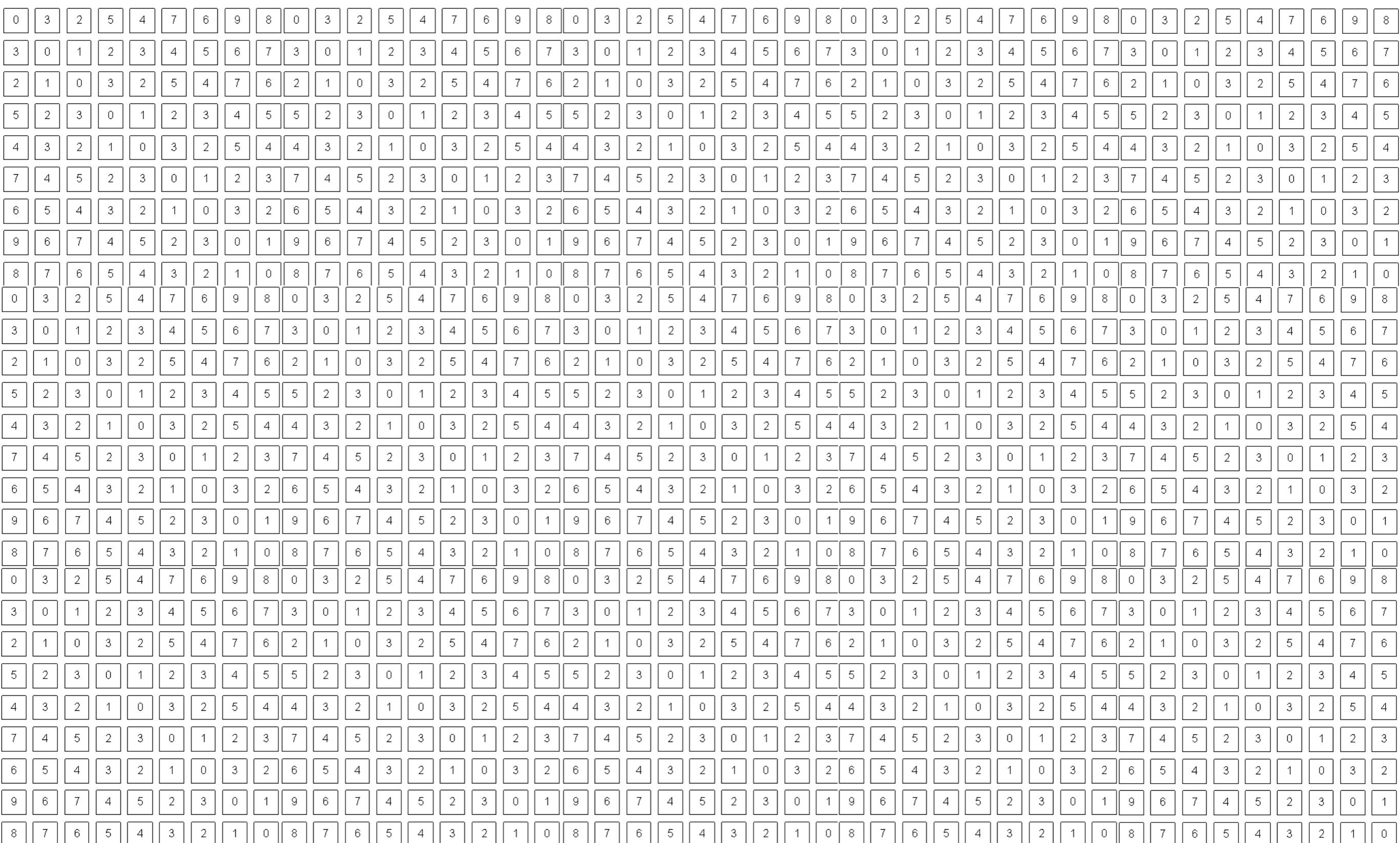
Robot

# Human vs. Computer Vision





**What a person sees**



**What a computer sees**



**Why are we able to interpret this image?**

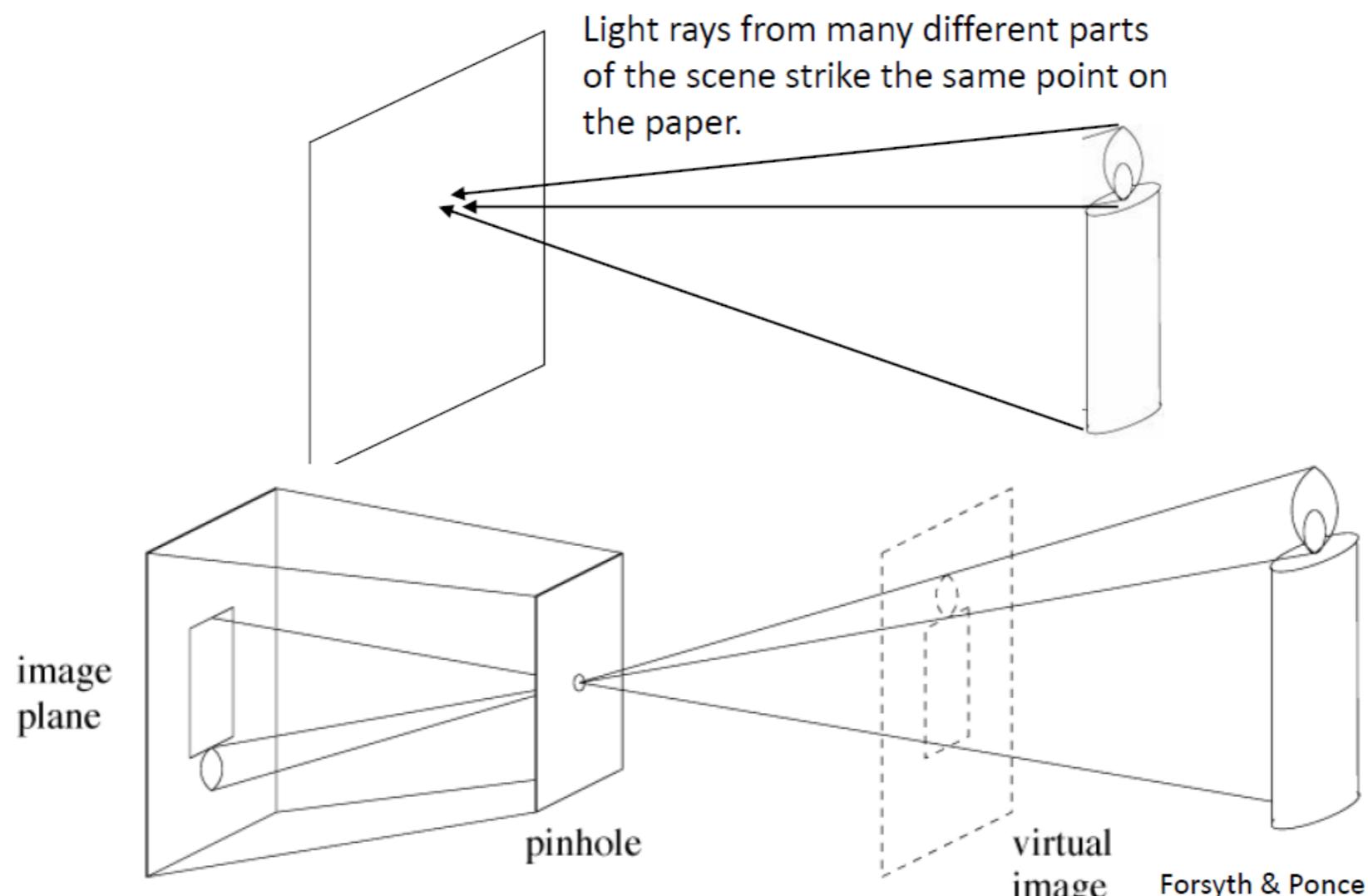
The goal of computer vision is  
to give computers  
**(super) human-level perception**

# Image formation on the backplate of a photographic camera

A camera obscura device consists of a box, tent or room with a small hole in one side. Light from an external scene passes through the hole and strikes a surface inside, where the scene is reproduced, inverted (thus upside-down) and reversed (left to right), but with color and [perspective](#) preserved.



# Pinhole camera model

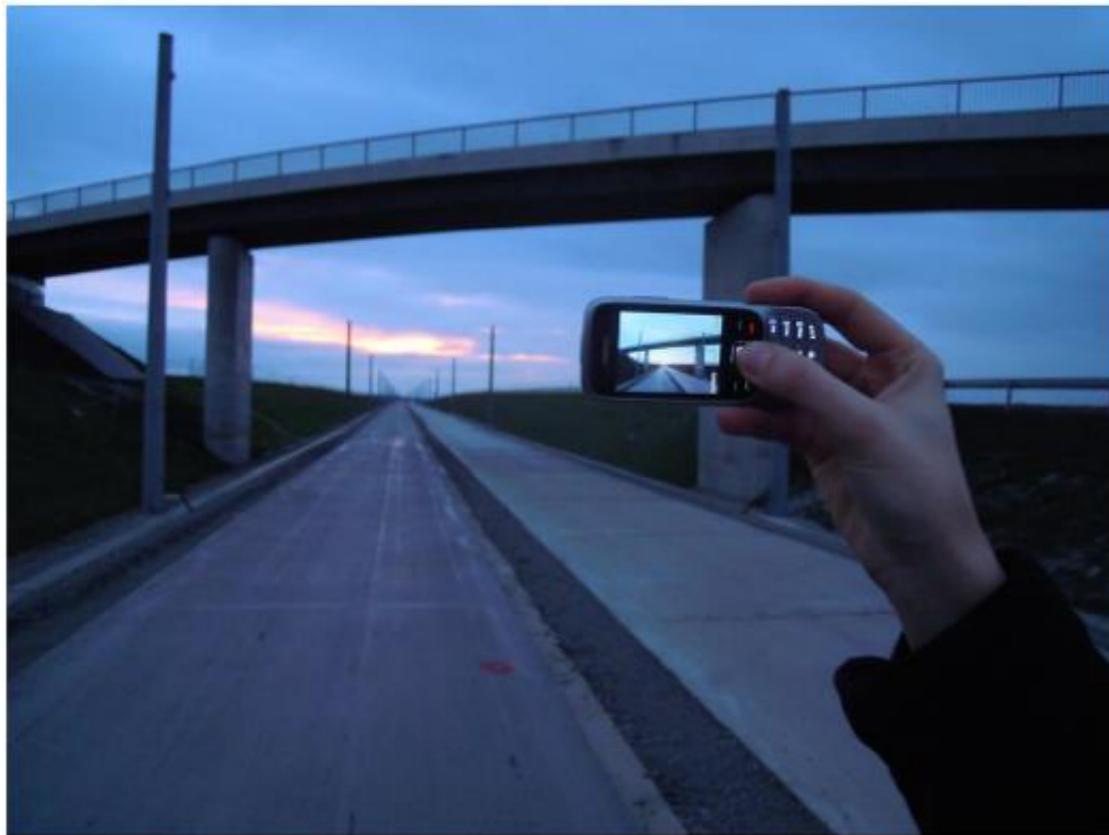


The pinhole camera only allows rays from one point in the scene  
to strike each point of the paper.

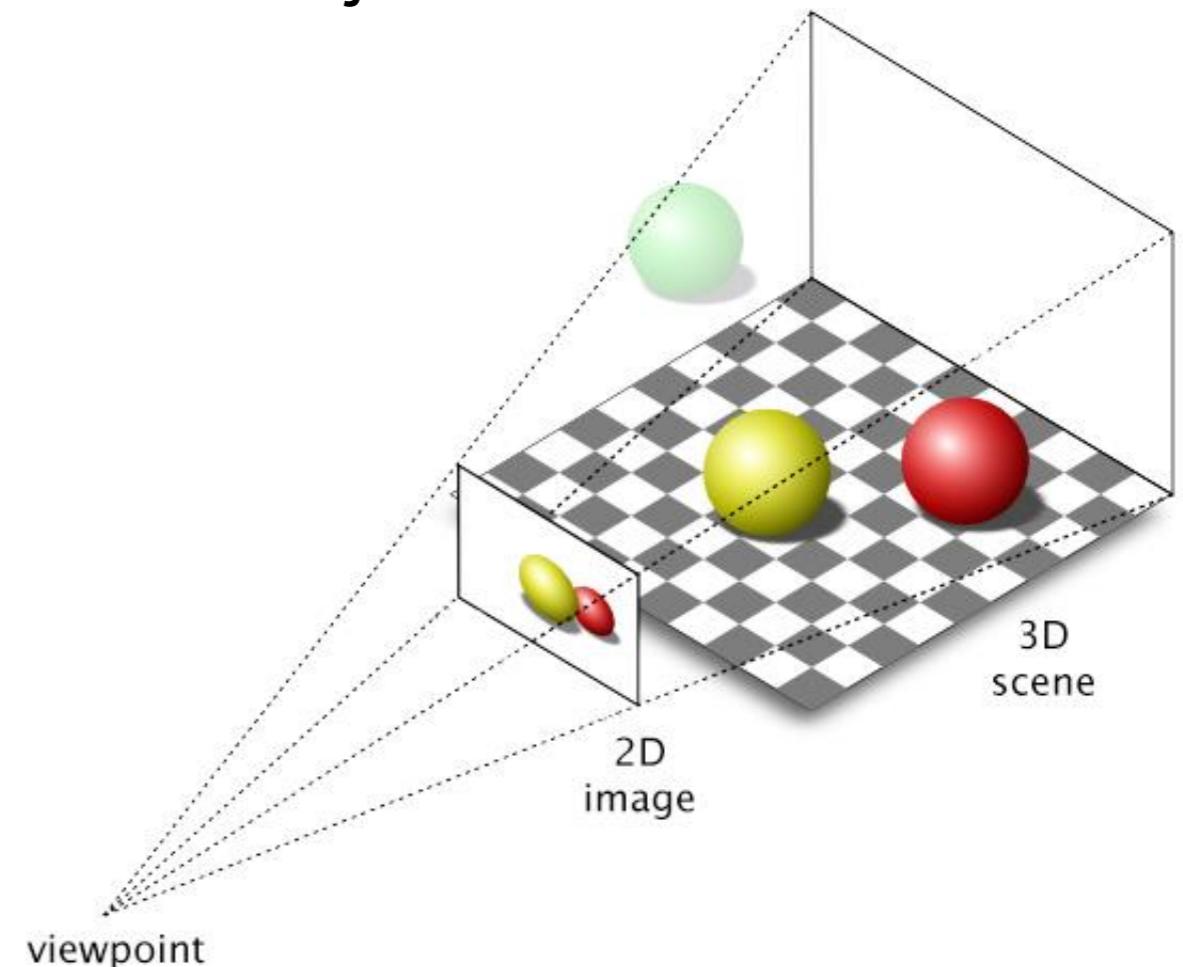
Computer Vision

# What is an Image?

- Image : Projection of the 3D world onto an (2D) image plane
  - 2-dimensional patterns of brightness values
  - Formed by the projection of 3D objects

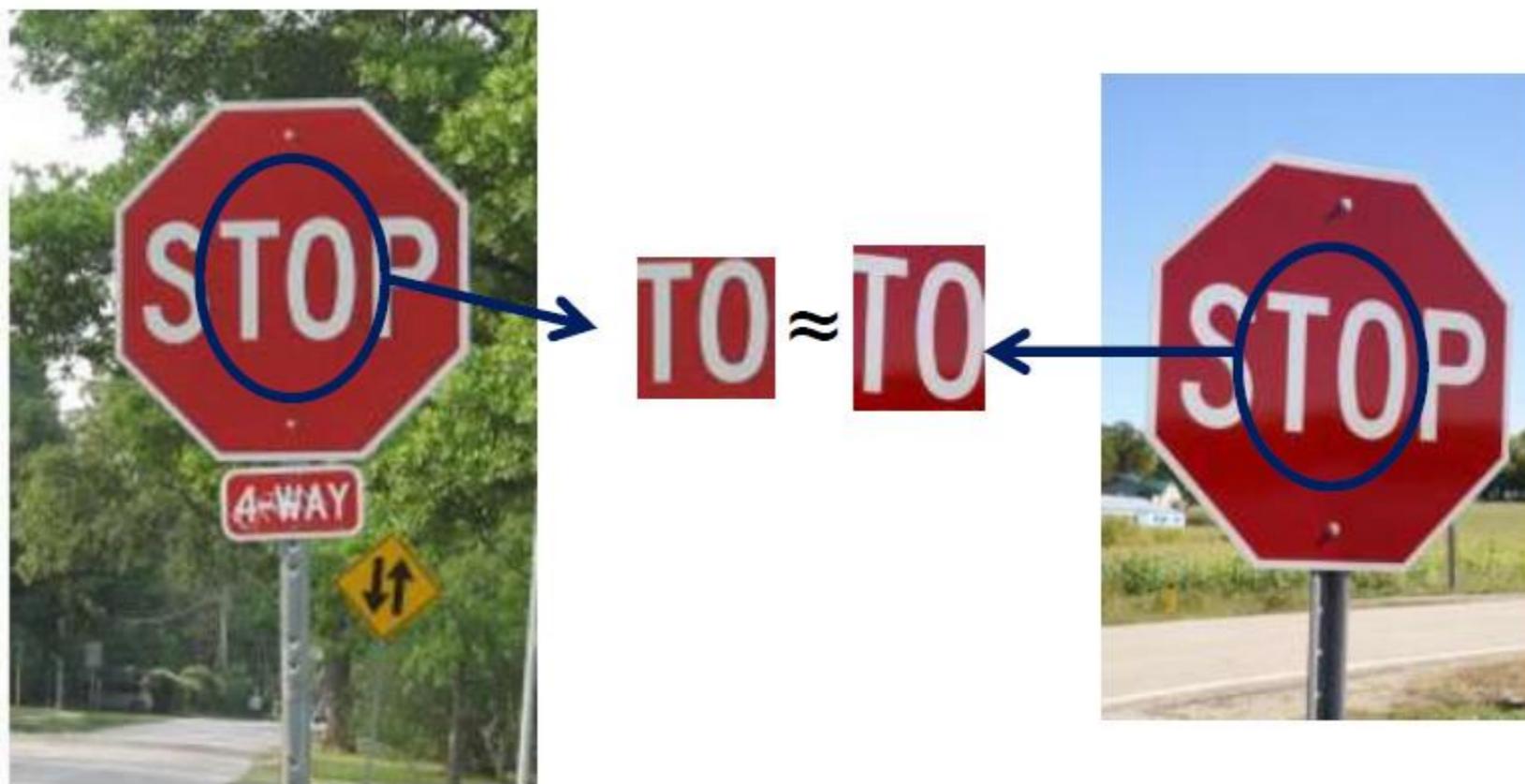


"Image created with a mobile phone" by Olaf Simons - Own work.



# Correspondence and alignment

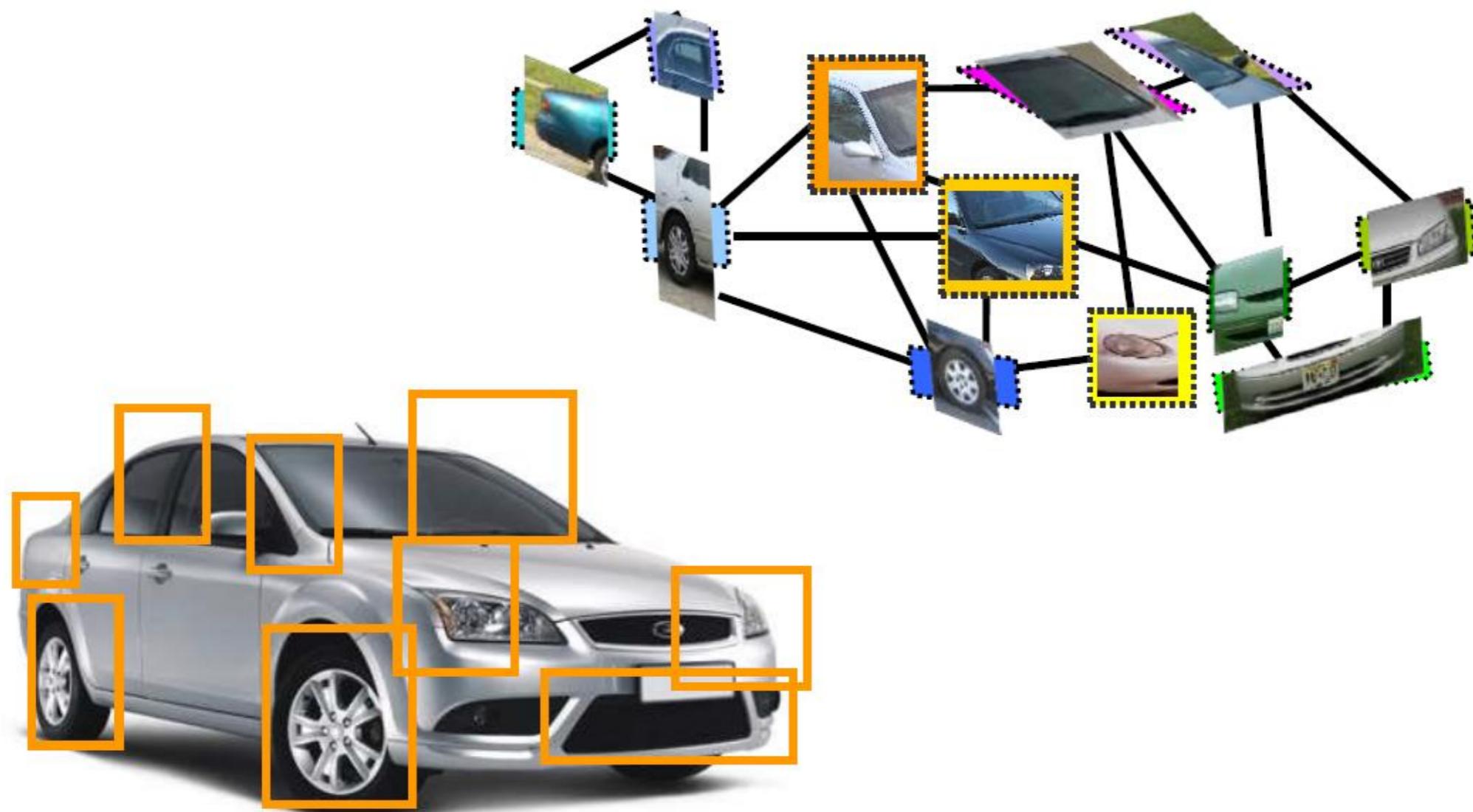
- Correspondence
  - Matching points, patches, edges, or regions across images



# Correspondence and alignment

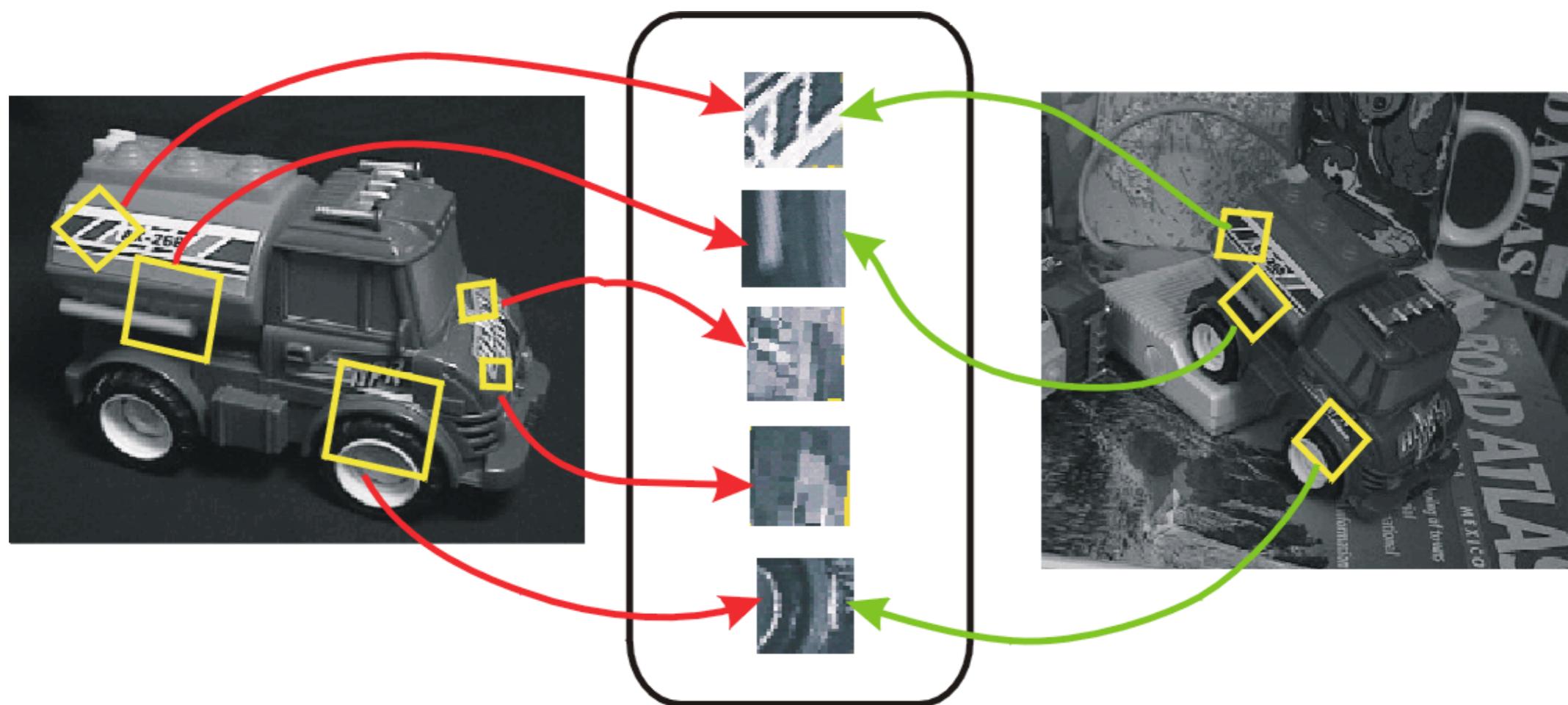


# Fitting a 3D object model

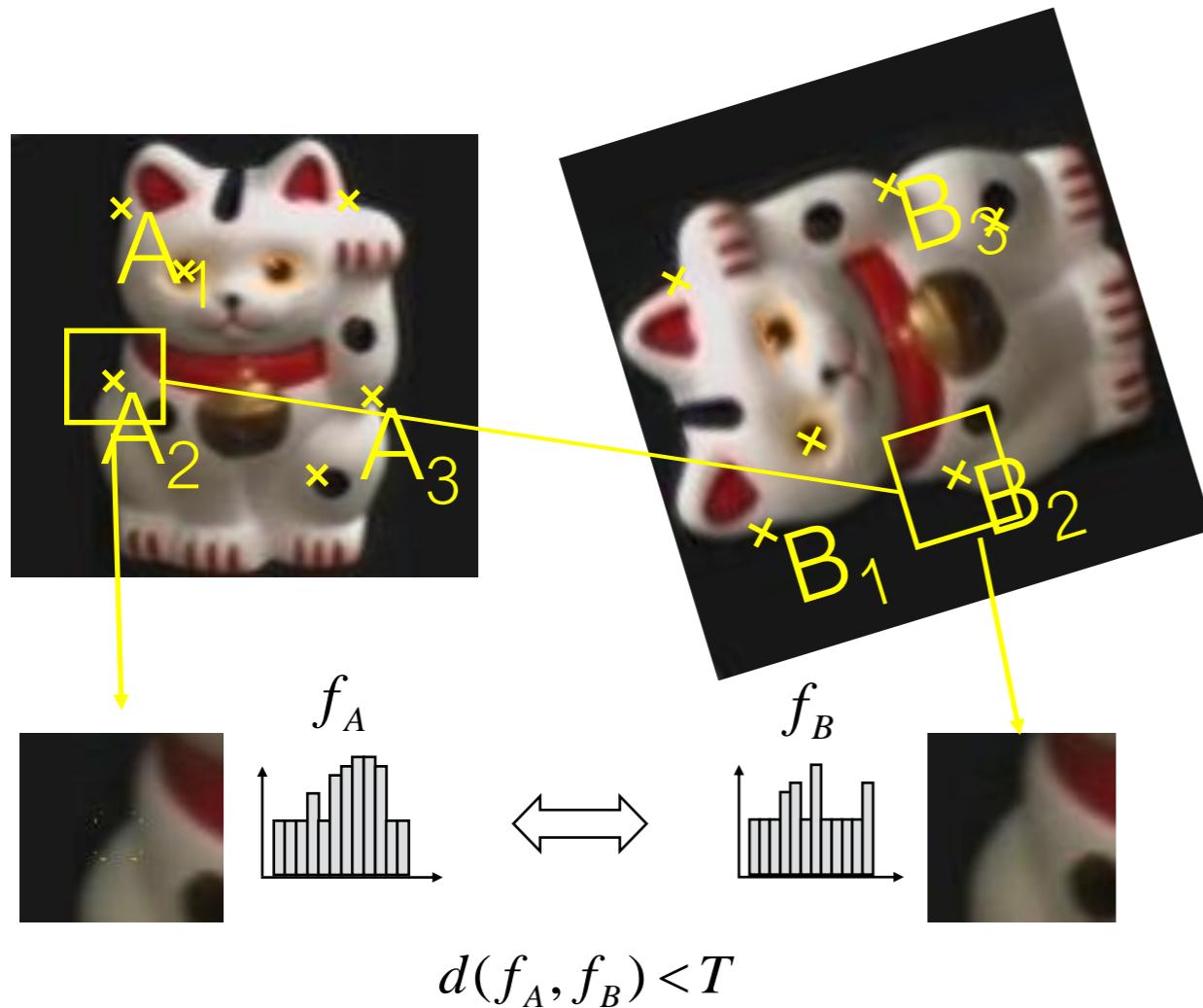


# Invariant Local Features

- Image content is transformed into local feature coordinates that are invariant to translation, rotation, scale, and other imaging parameters

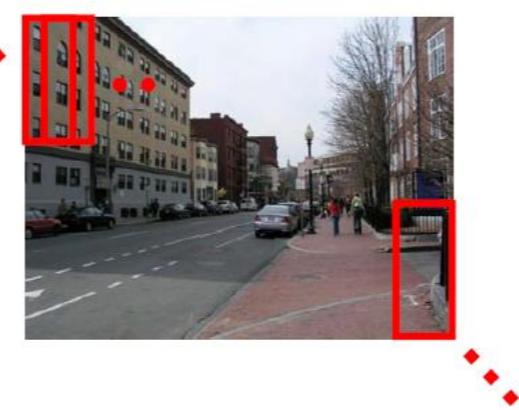


# Keypoint matching



# Object detection with sliding windows

- Find target objects for all possible image regions



# Statistical template

- Object model = sum of scores of features at fixed positions



$$+3 +2 -2 -1 -2.5 = -0.5 > 7.5$$

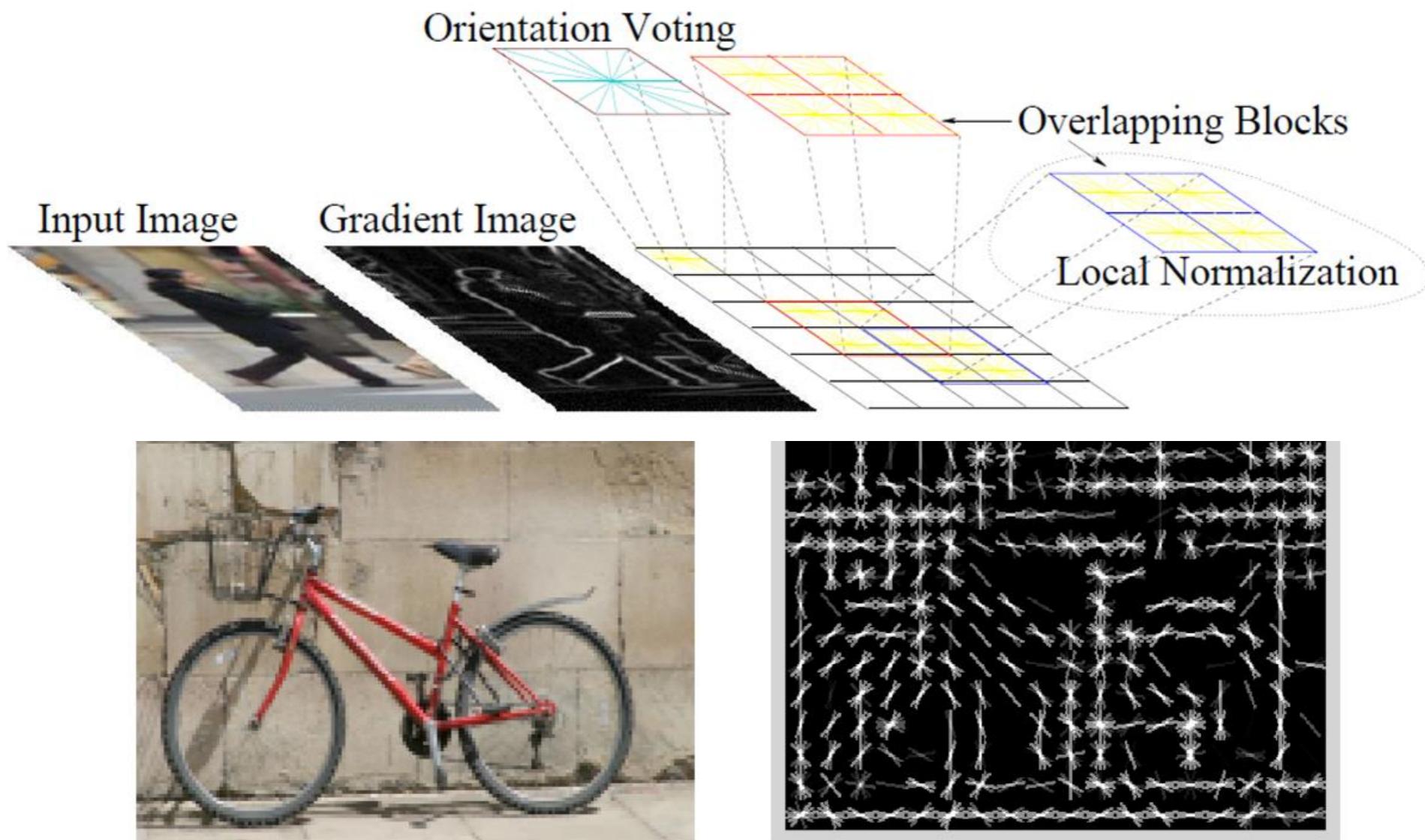
Non-object



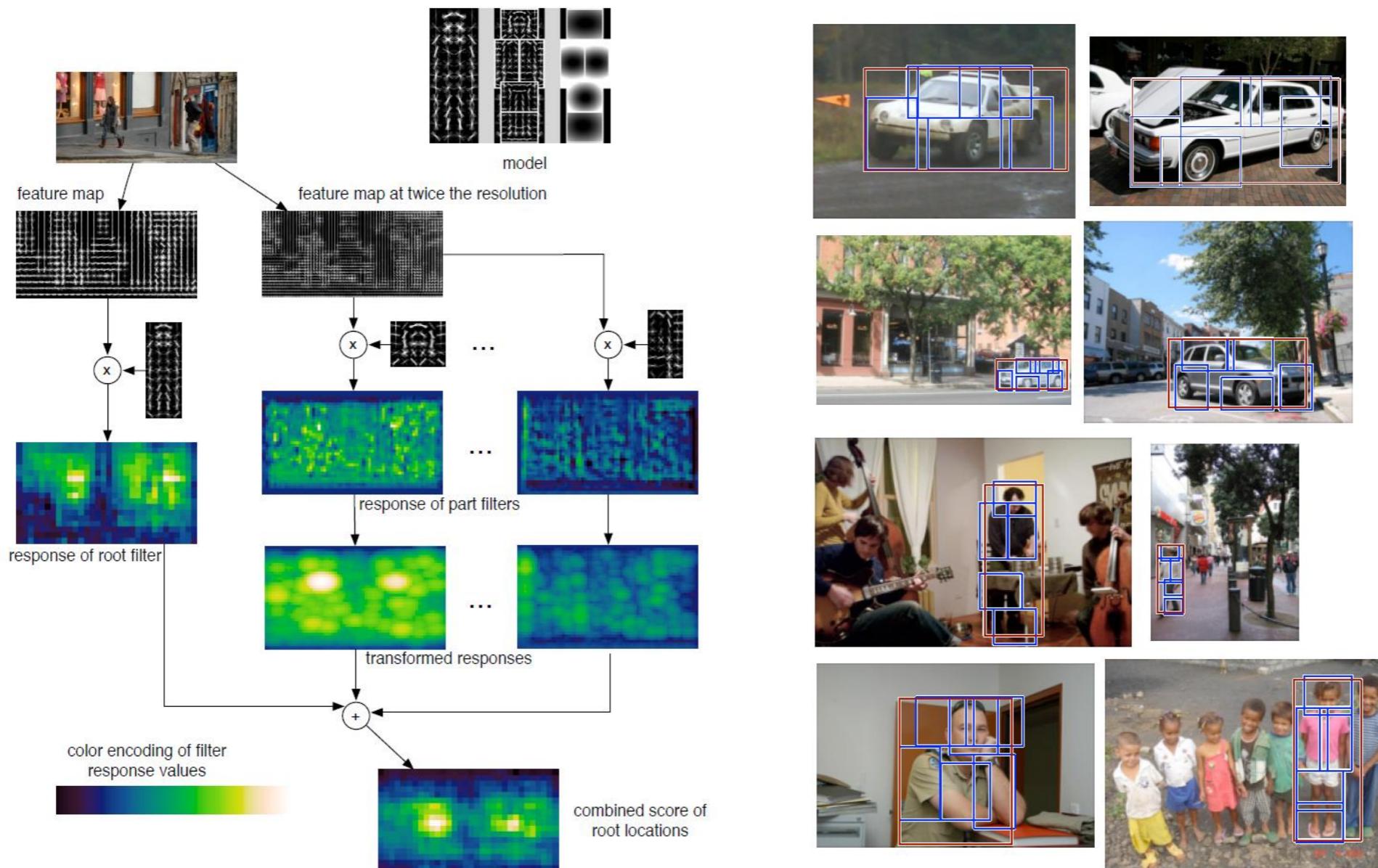
$$+4 +1 +0.5 +3 +0.5 = 10.5 > 7.5$$

Object

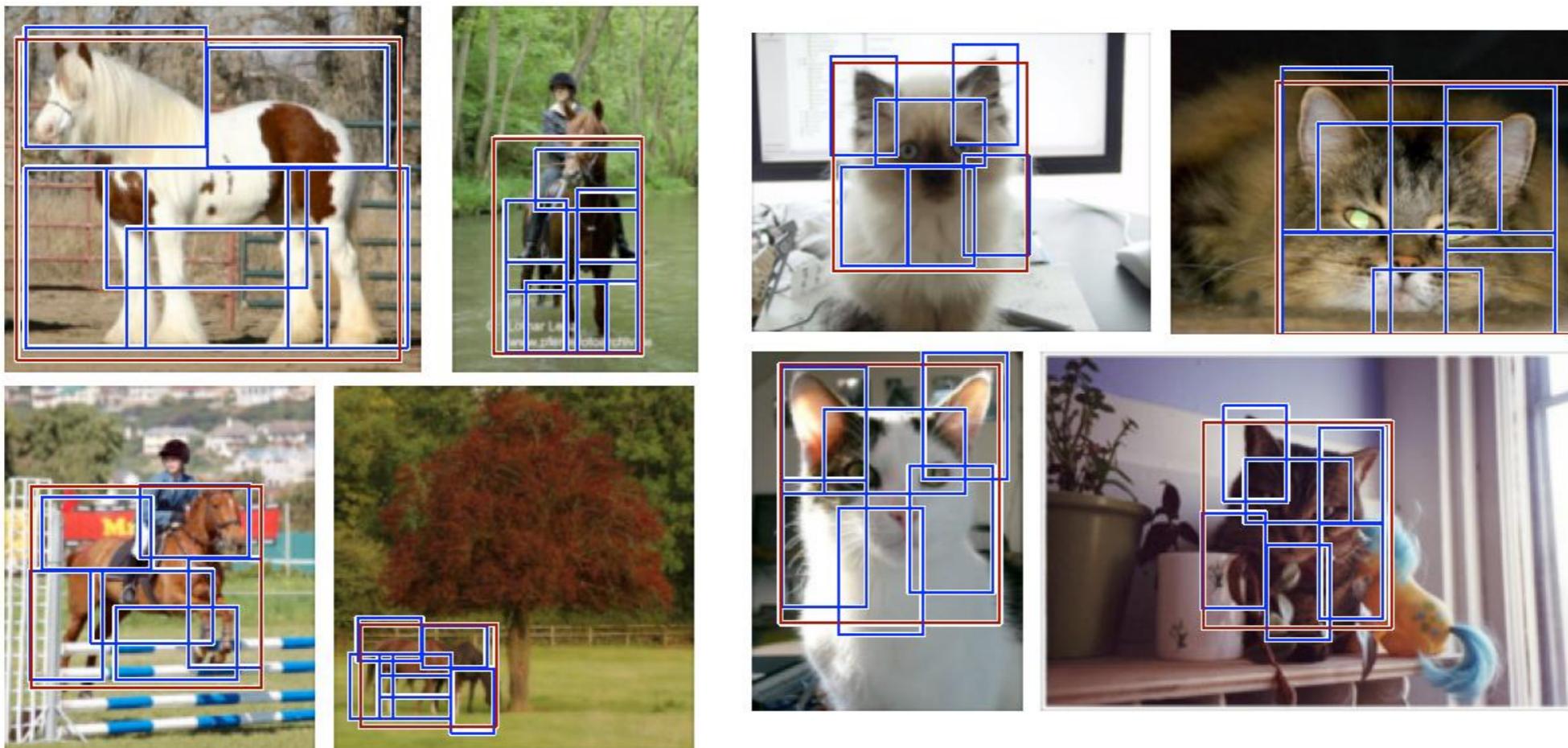
# Histogram of Oriented Gradient (HOG) features



# Part based models for deformable objects



# Object detection results

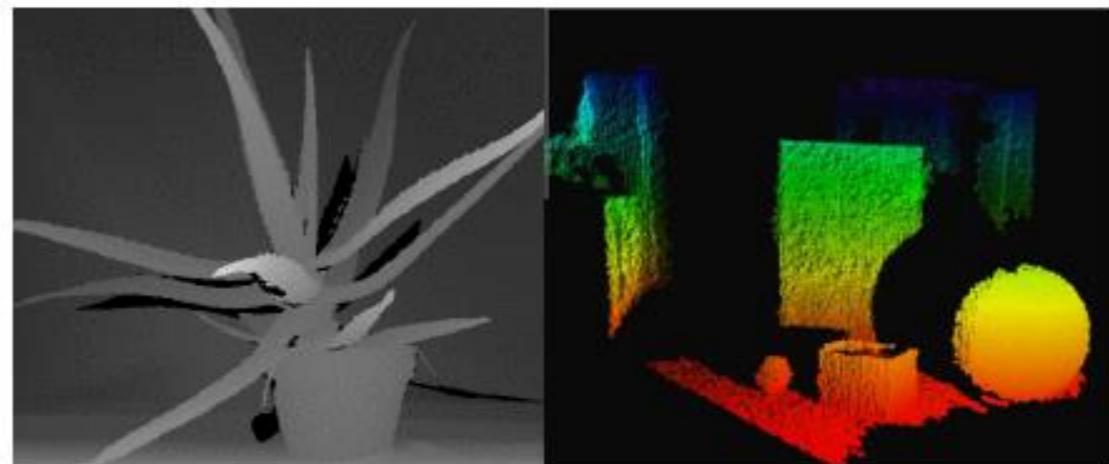


# 3D sensing

- Estimating depth or distance from a sensor to the



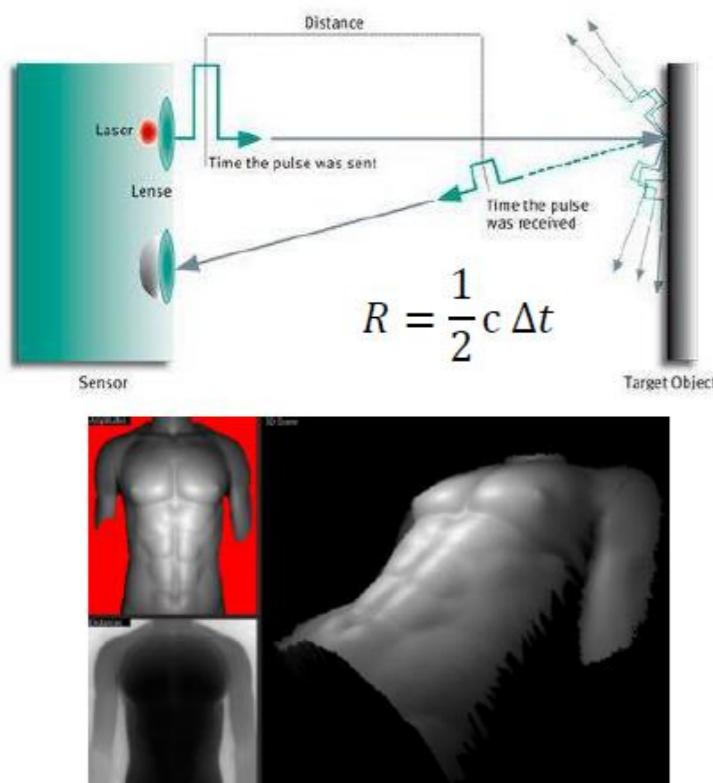
3d sensing with laser scanner



3D sensing results using stereo vision

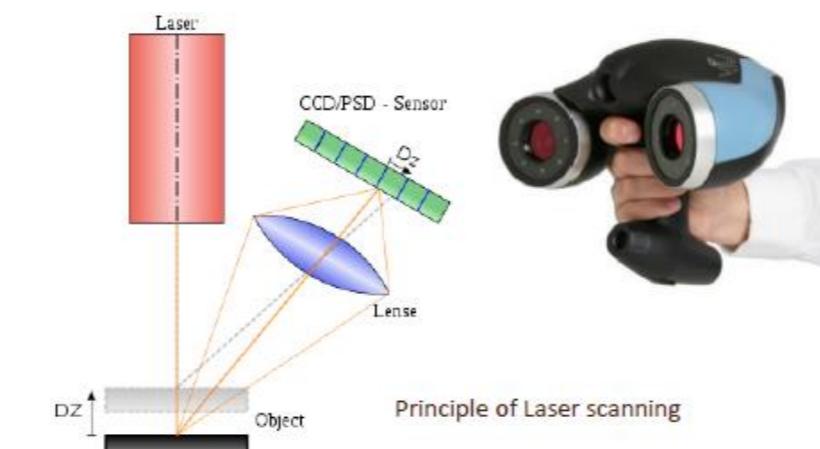
# 3D Sensing Methods in Metrology

## ToF (Time-Of-Flight)



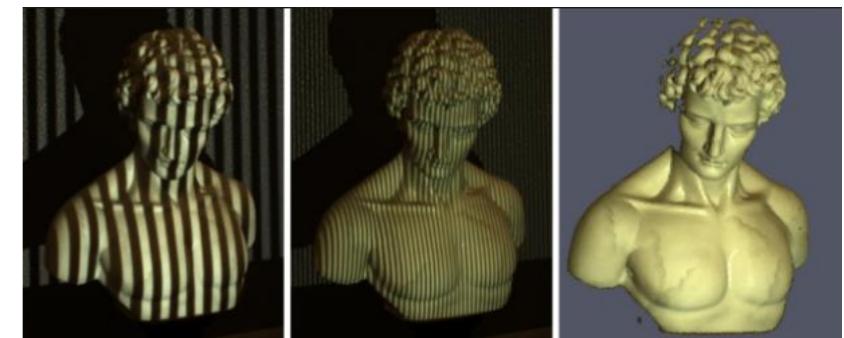
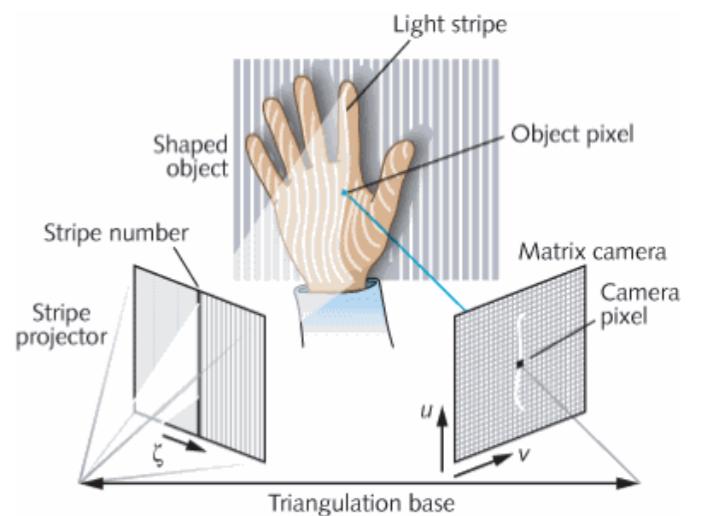
Principle of ToF sensors and acquired 3D data

## Laser Scanner



Digital Michelangelo Project  
<http://graphics.stanford.edu/projects/mich>

## Structured light

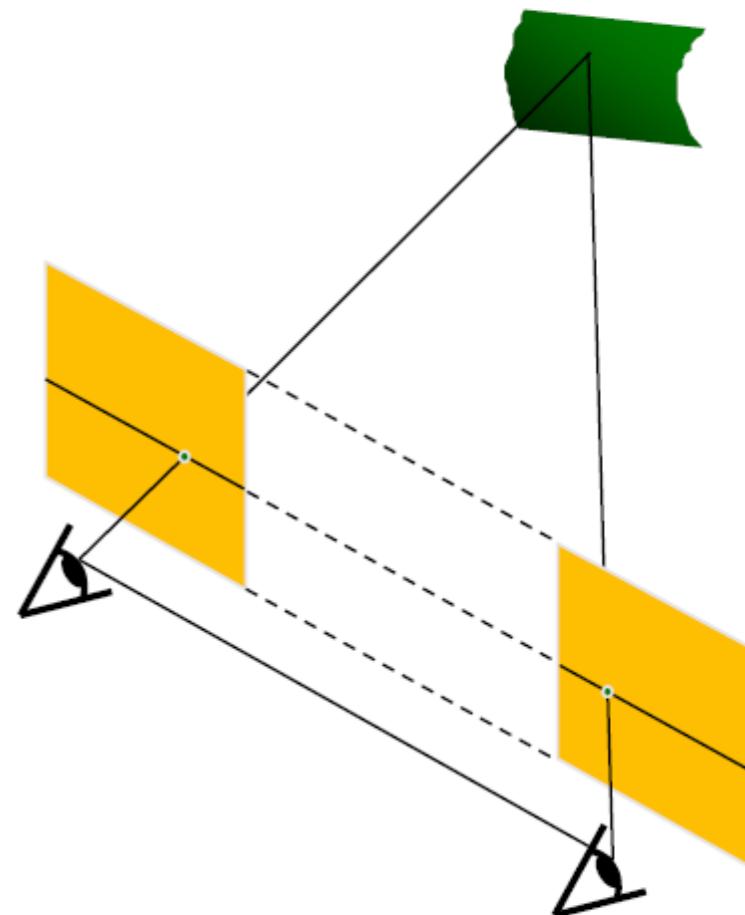


# Stereo cameras



# 3D computation in stereo vision

Given projections of a 3D point in two or more images (with known camera matrices), finding the coordinates of the point



# Stereo vision

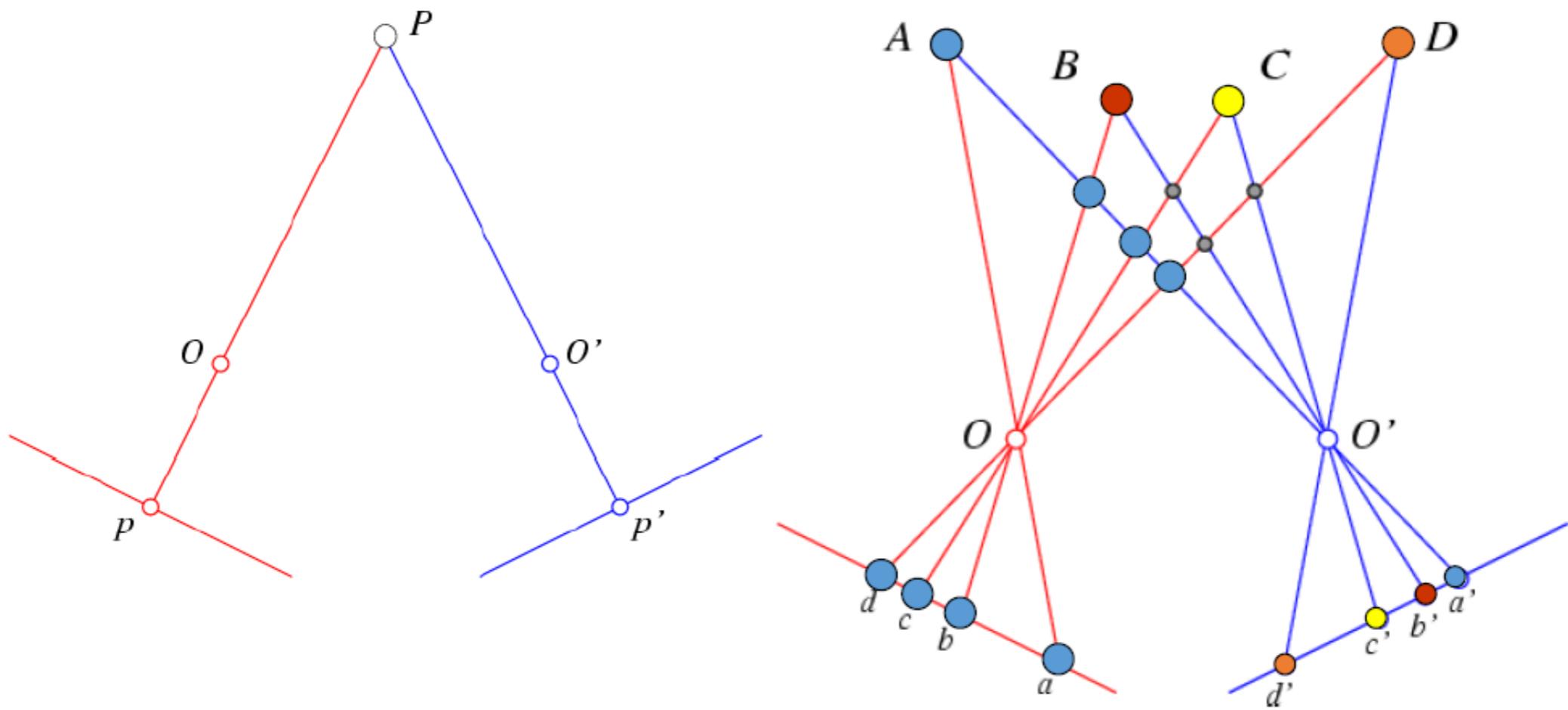
- Triangulate on two images of the same point to recover depth
  - Feature matching across views
  - Calibrated cameras



Matching correlation  
windows across scan lines

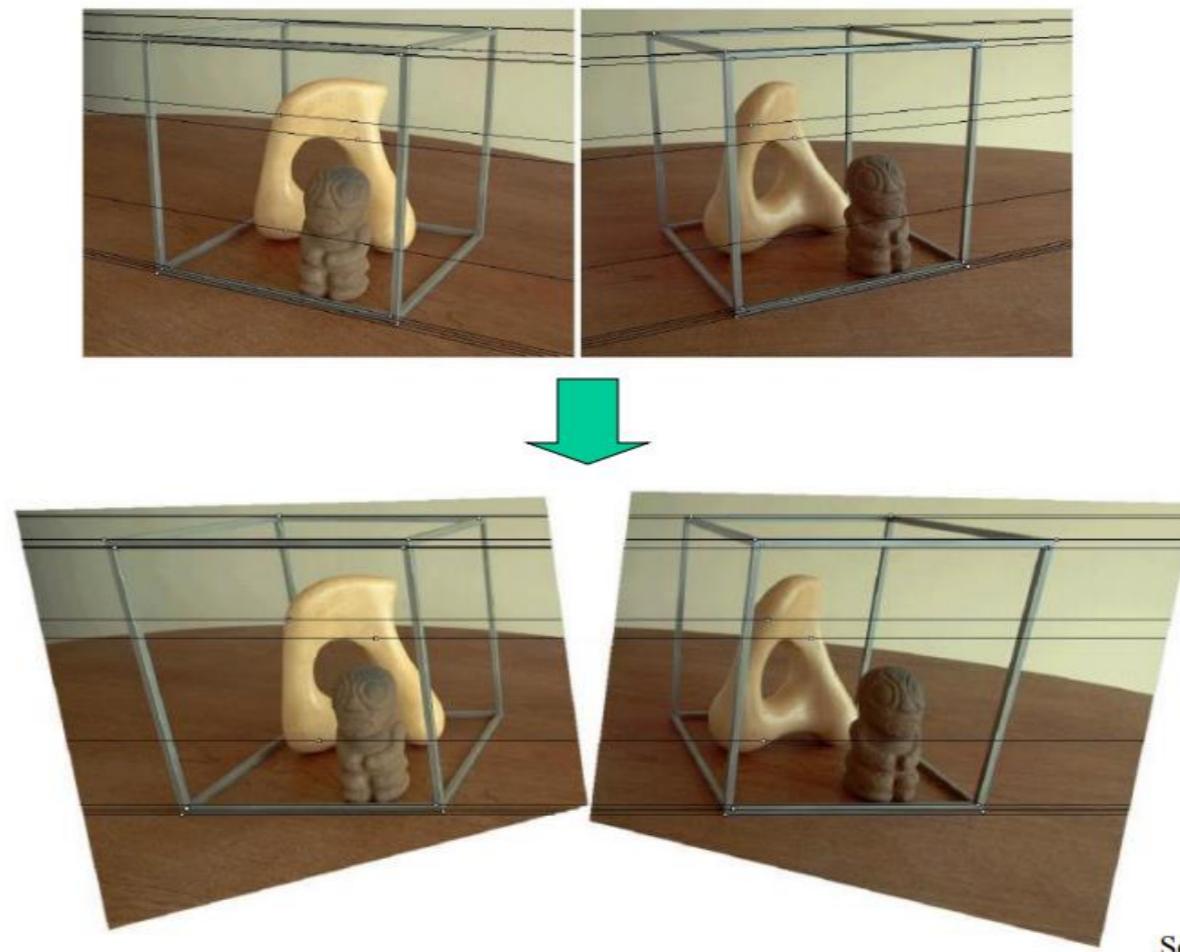
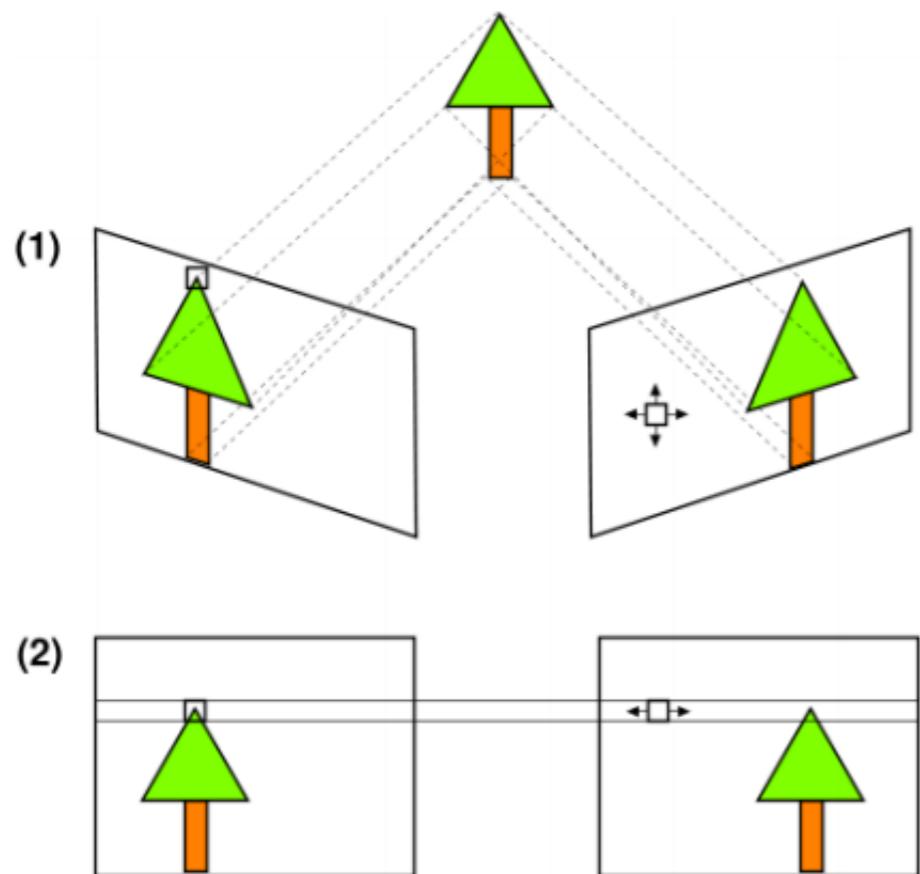
# Stereo vision

- Reconstruction / triangulation



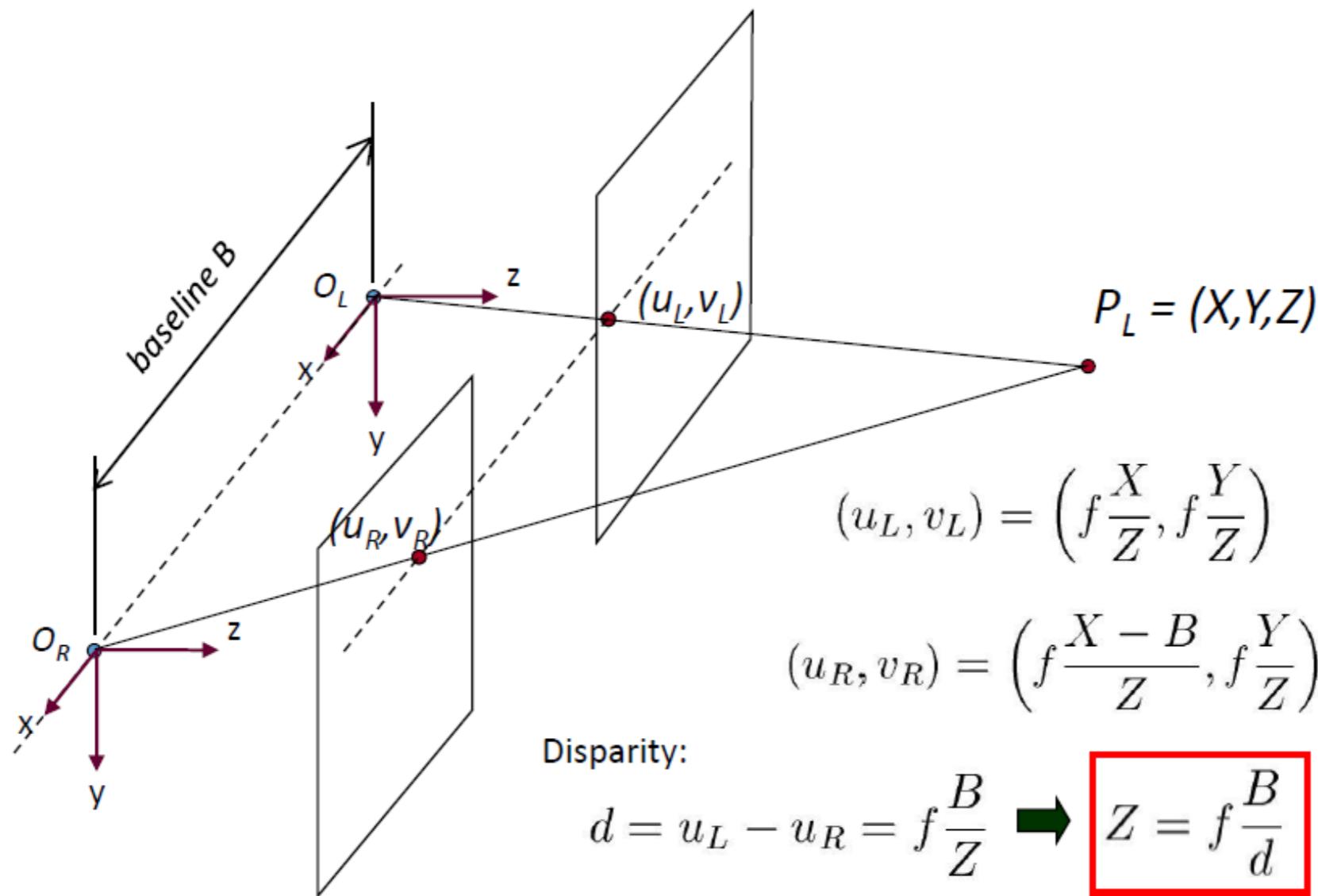
# Image rectification

- If the two cameras are aligned to be coplanar, the search is simplified to one dimension
  - A horizontal line parallel to the baseline between the cameras

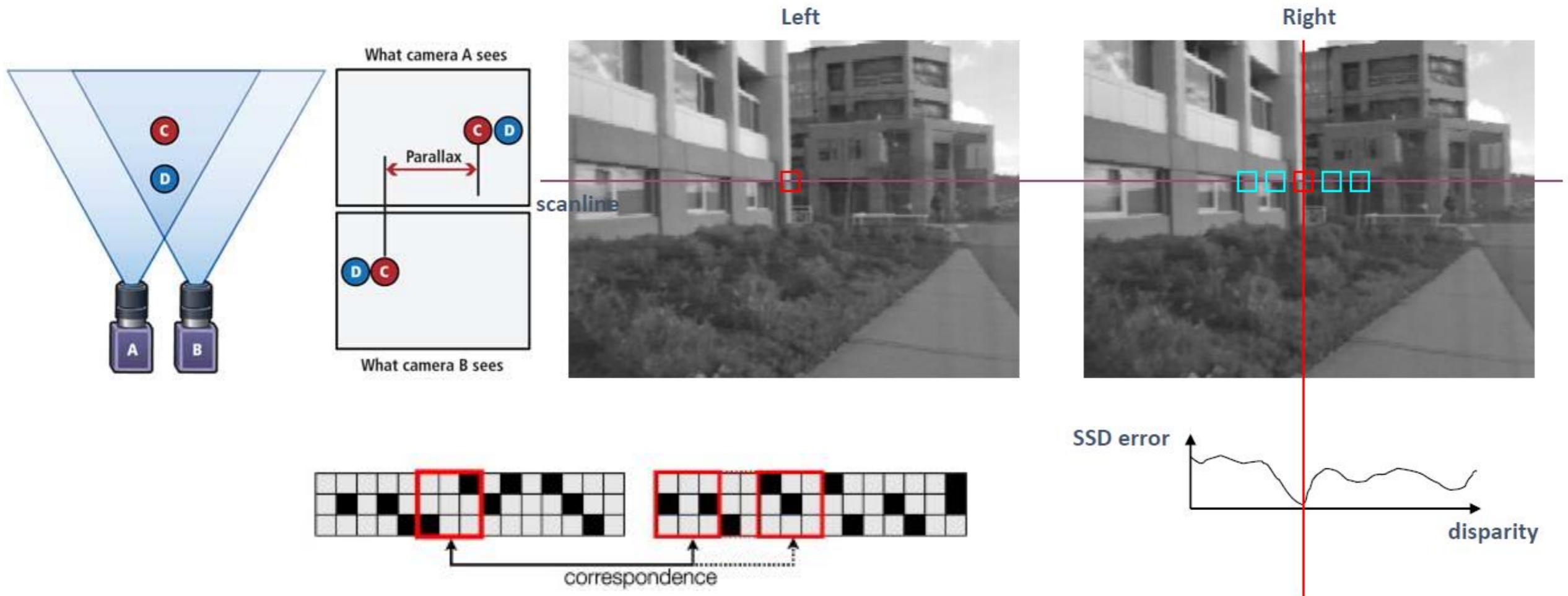


Source: Alyosha Efros

# Depth estimation with rectified images



# Similarity measure



# Challenges for stereo matching



Photometric Variations



Specularities

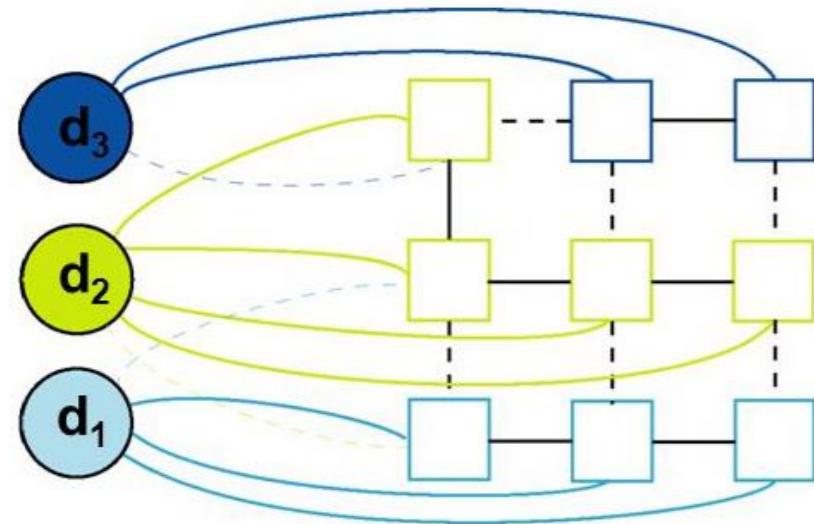


Occlusions

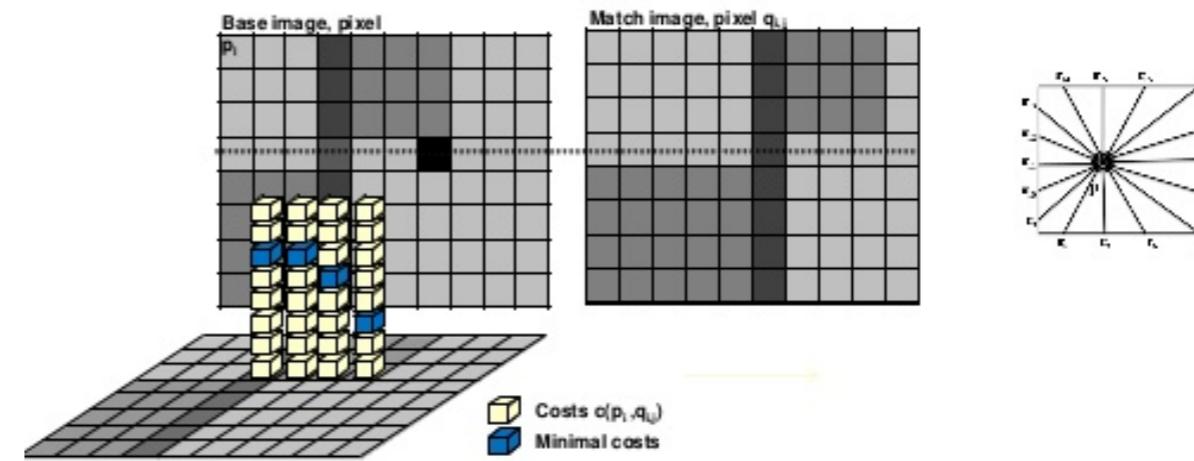


Transparency

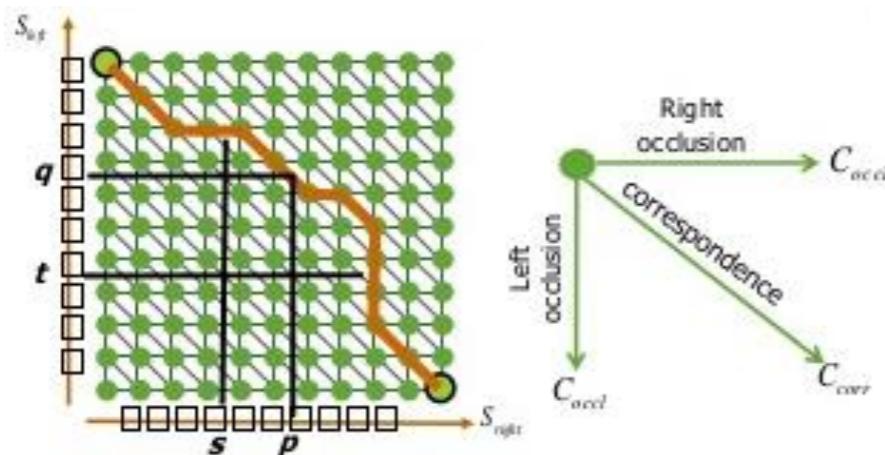
# Stereo matching with global optimization



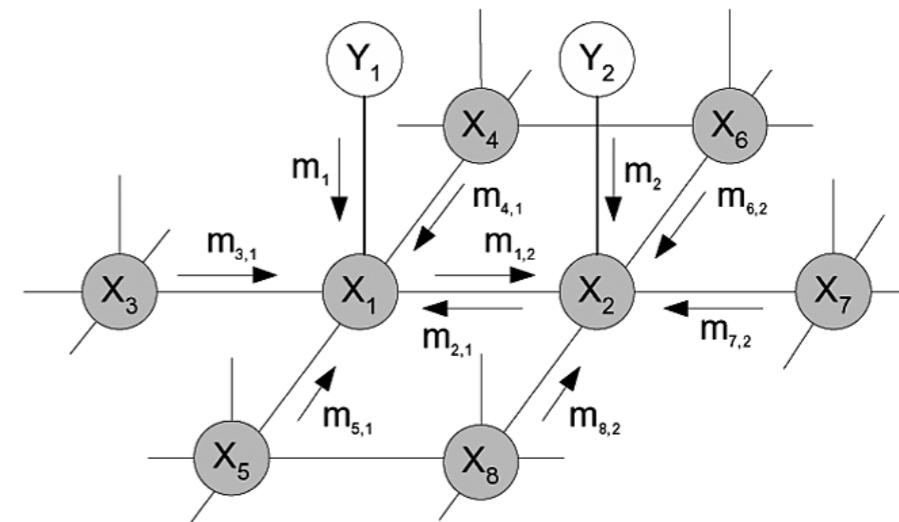
Graph cuts



Semi-Global Matching



Dynamic programming

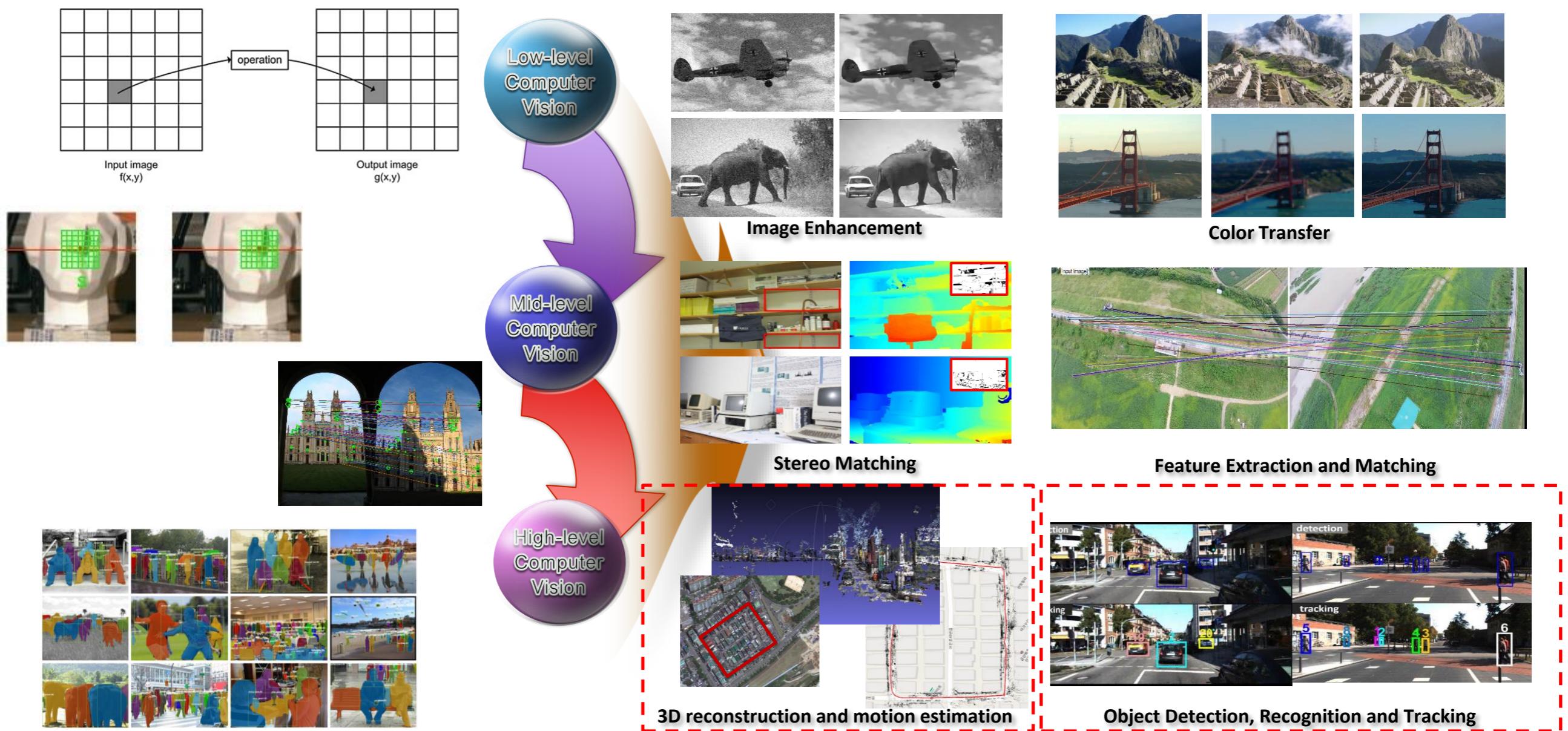


Belief Propagation

# Stereo matching results



# Computer Vision Categories

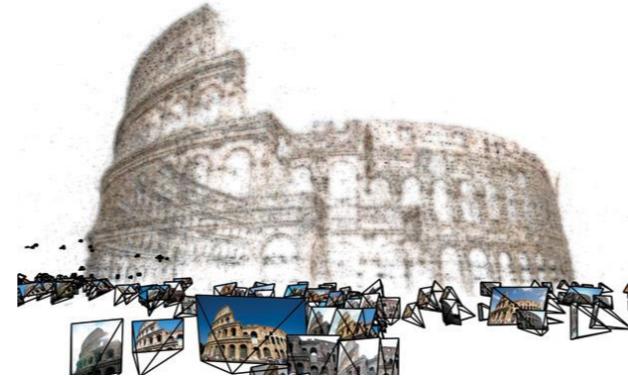


# Main Goals of Computer Vision



What (who)?

Object (Face) Recognition



Where?

3D reconstruction  
Pose estimation



A man is pouring oil into a pot.



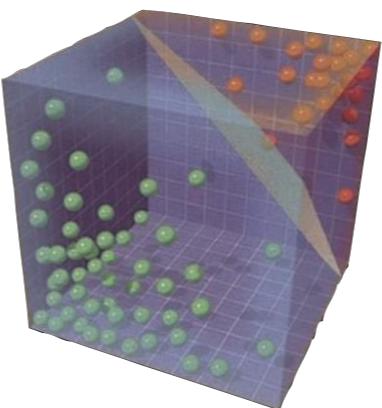
The person opened the drawer.  
The person took out a pot.  
The person went to the sink.  
The person washed the pot.  
The person turned on the stove.

How?

Video Captioning

# typical perception pipeline

**representation**



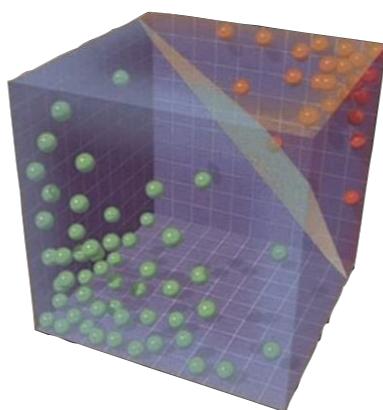
'fancy math'



**output**

# typical perception pipeline

**representation**



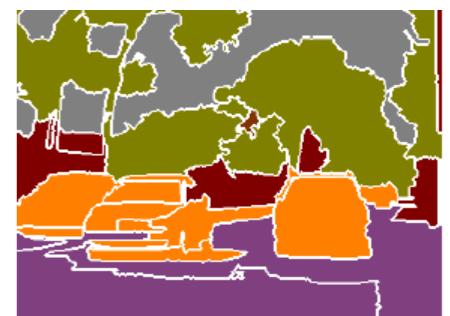
‘fancy math’



**output**

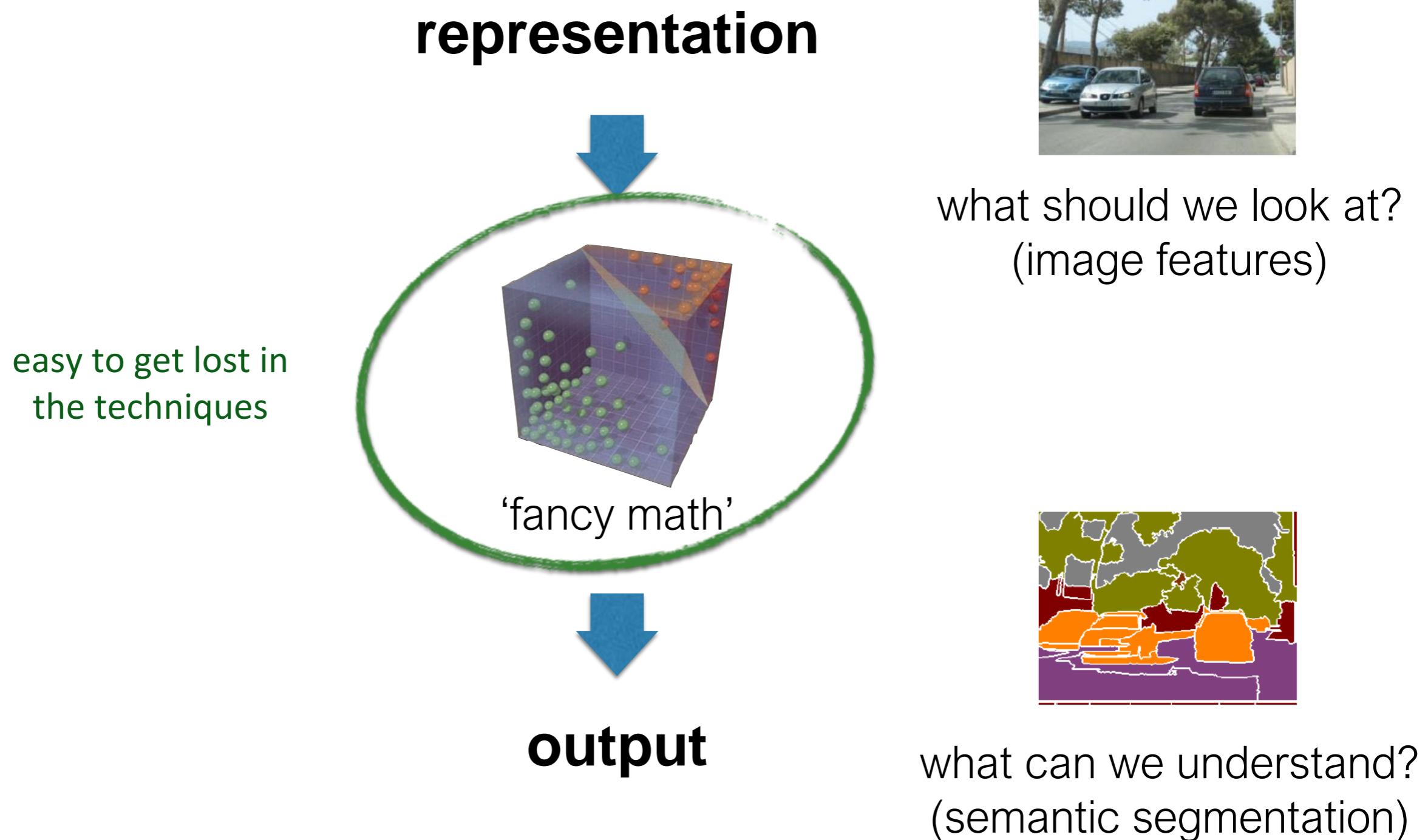


what should we look at?  
(image features)

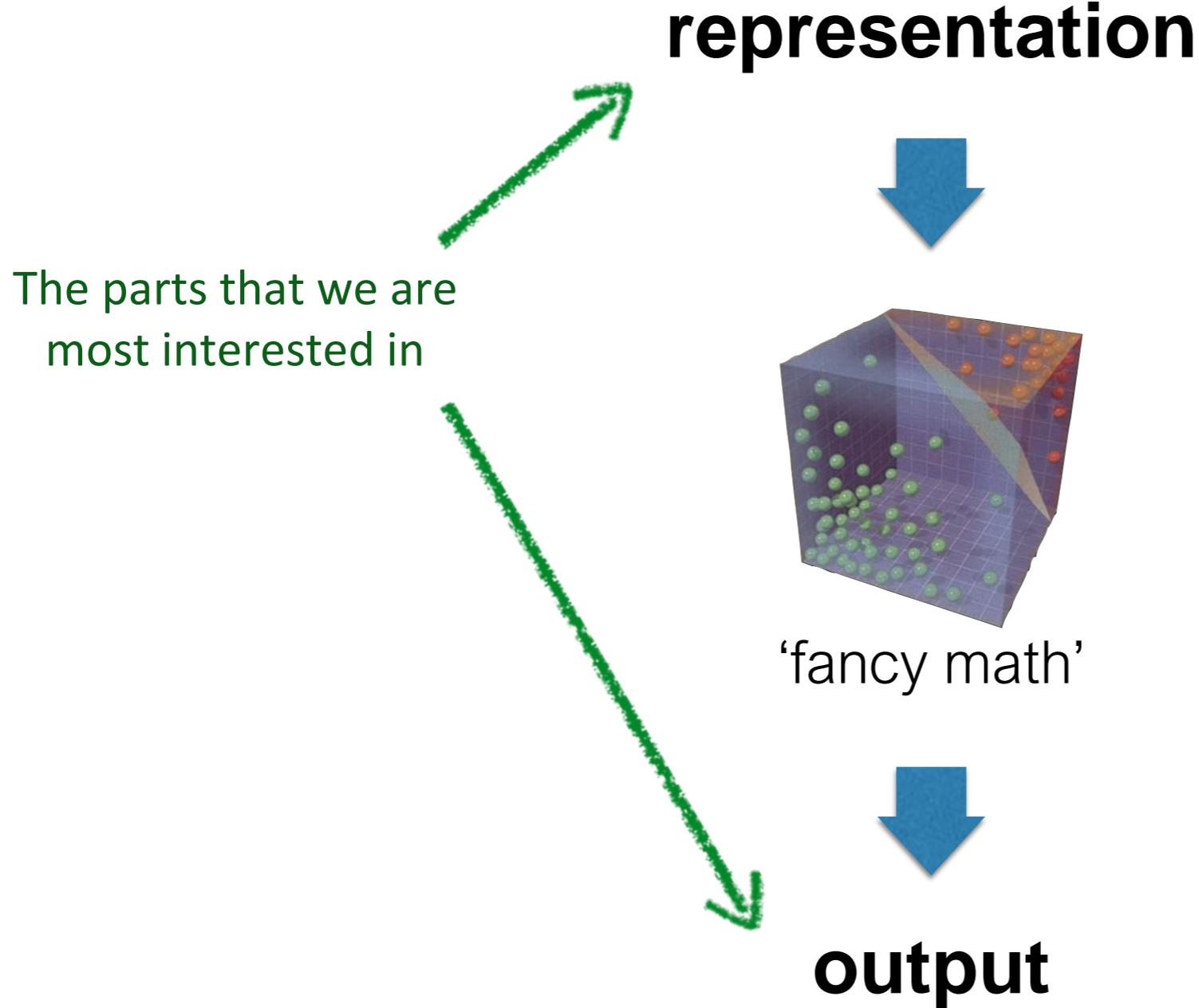


what can we understand?  
(semantic segmentation)

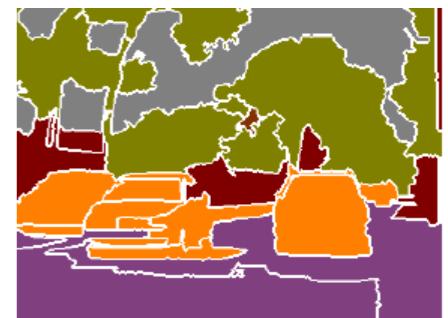
# typical perception pipeline



# typical perception pipeline



what should we look at?  
(image features)



what can we understand?  
(semantic segmentation)

Important note:

**In general, computer vision does not work**

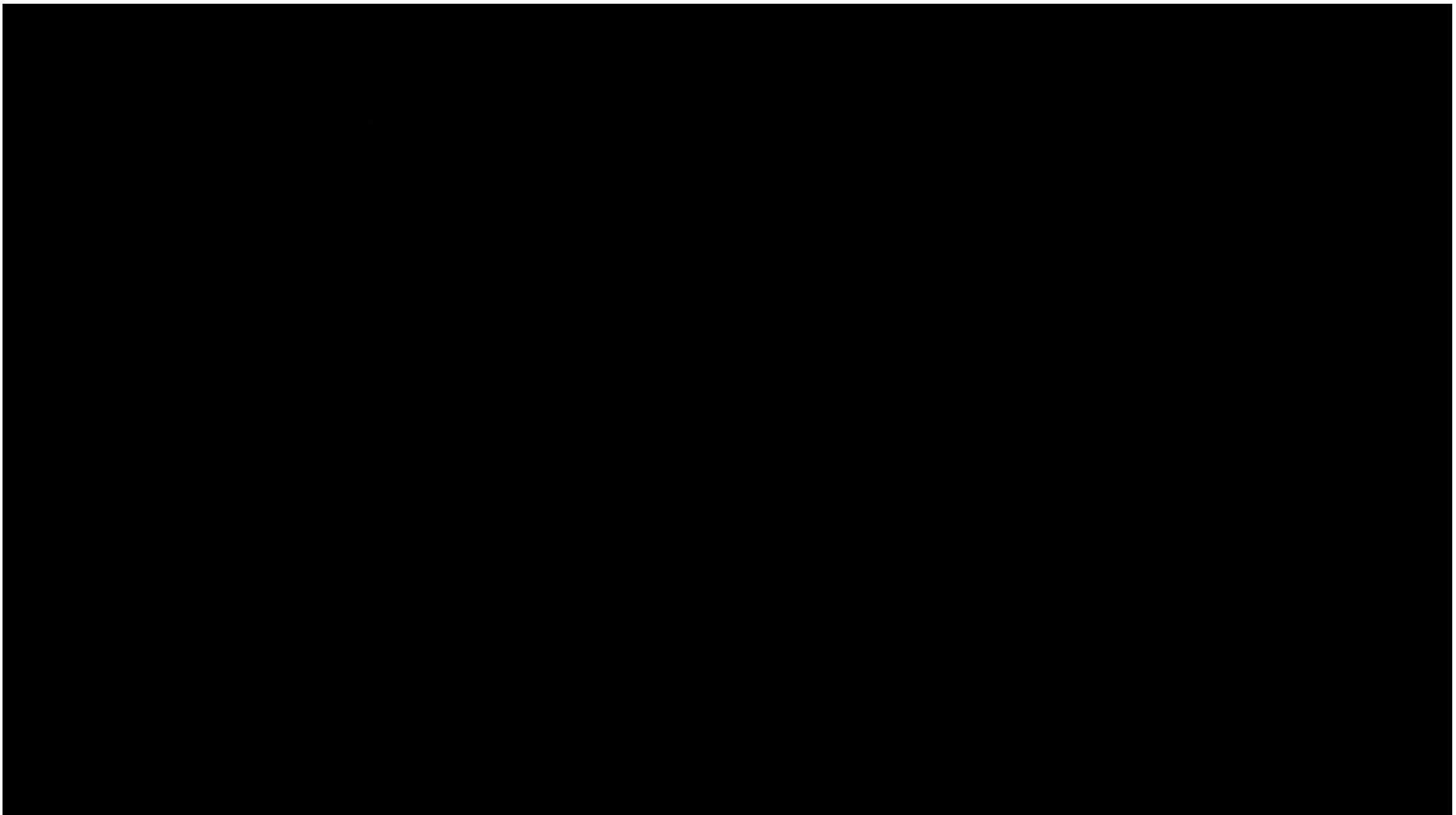
Important note:

**In general, computer vision does not work**

(except in certain situations/conditions)

# Applications of computer vision

# Augmented Reality



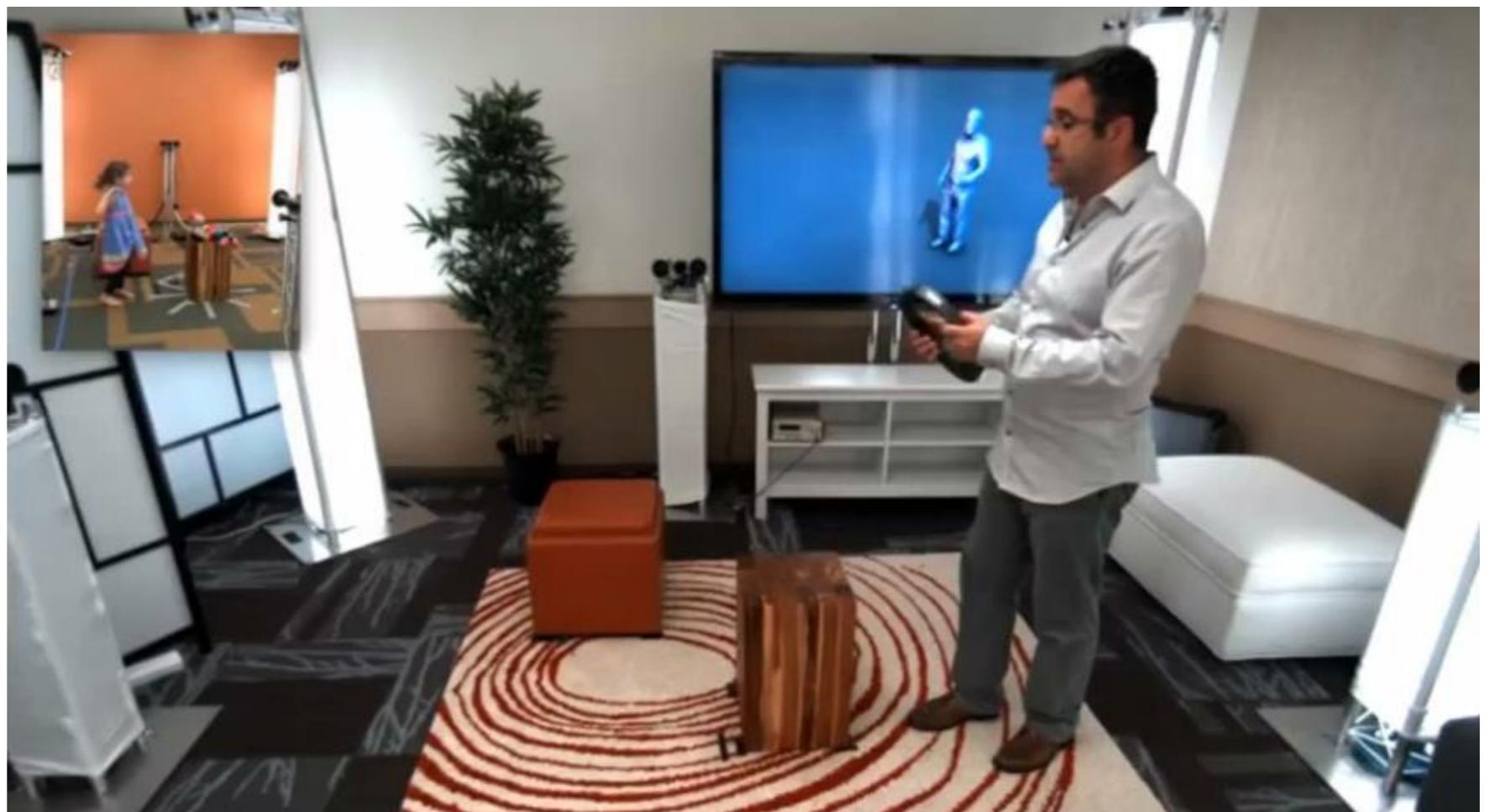
# Holopotion



Teleportation



Microsoft  
HoloLens

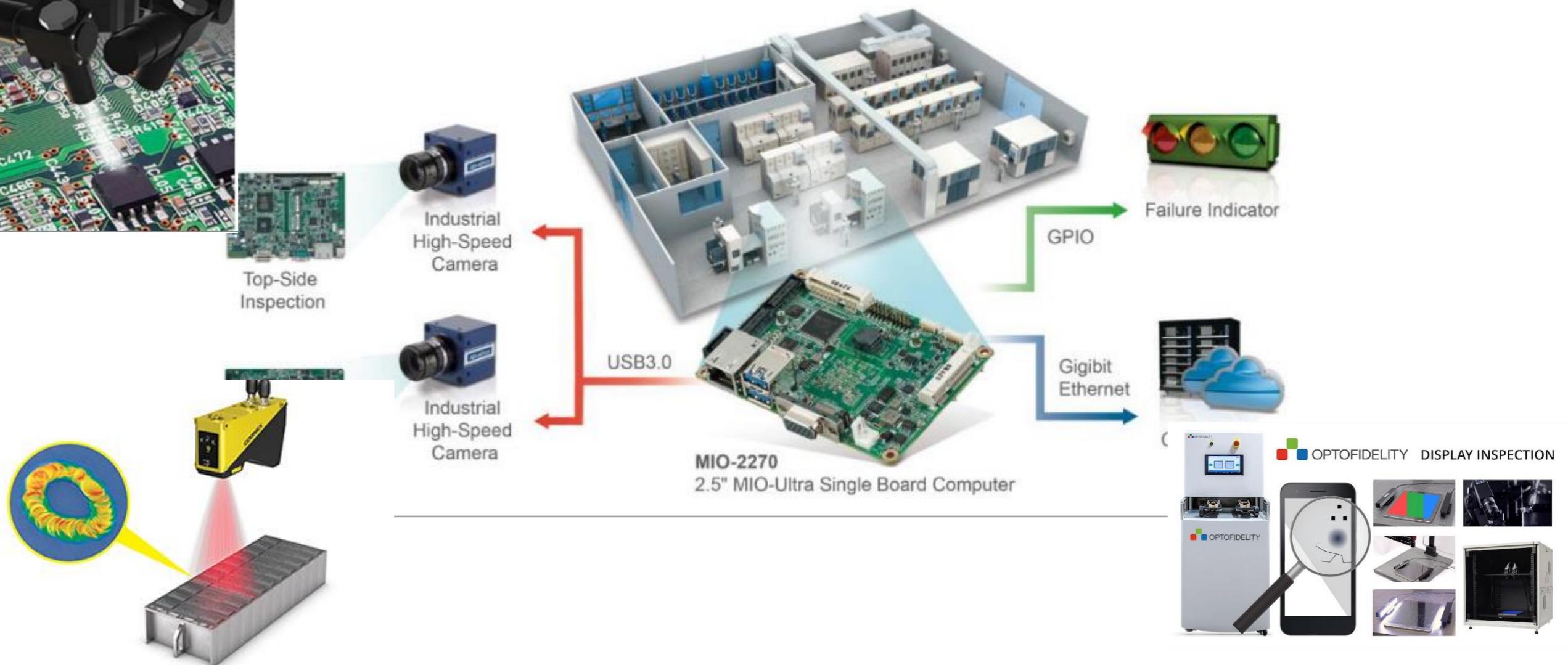


# Machine vision

## Automated visual inspection

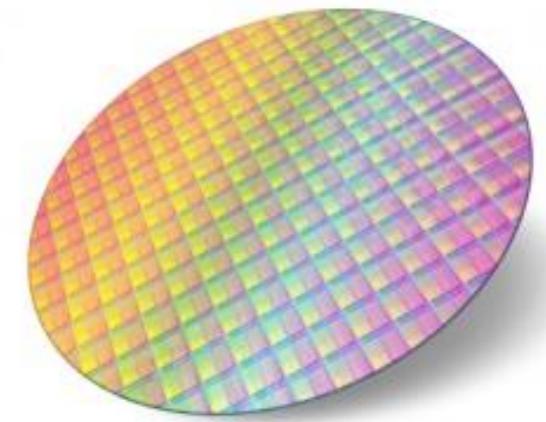


스마트팩토리 구현의 필수는 검사시스템



# Machine vision

Automated visual inspection



# Amazon Go



Toshiba Tech IS-910T

2013



DataLogic LaneHawk LH4000

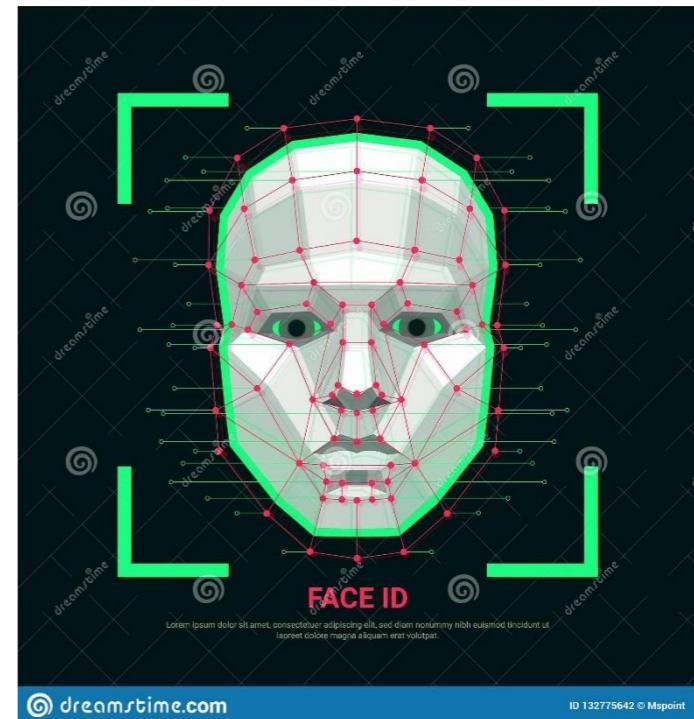
2012



# Face Recognition



Sony Cyber-shot





**Word Lens**



Word Lens

[www.QuestVisual.com](http://www.QuestVisual.com)

# Object Character Recognition



Snap OCR - FormMaker

File Edit OCR Engine About

1. 한국\_주민등록증\_1999년  
2. 한국\_운전면허증\_2014년  
3. 한국\_여권\_2008년  
4. 한국\_등본\_2019년\_온라인발급  
5. 한국\_등본\_2019년\_온라인발급  
6. 한국\_등본\_2019년\_온라인발급  
7. 한국\_등본\_2019년\_온라인발급  
8. 한국\_사업자등록증\_법인사업자  
9. 한국\_사업자등록증\_법인사업자

**주민등록증**

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950717-9120274  
경기도 포천시 신북면 중앙로  
207번길 54, 368-144  
2012. 5. 17  
경기도 포천시장  
[Redacted]

서식 정보  
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이름: [Redacted]  
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후보경단어: 주민등록증  
재인식: None

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Pages Image Edit Image Analyze Text

Document Language: English

Pages: 5 6 7 8 9

Text

Check Spelling Next Error Previous Error

43. BROOKS, Harrison. *Re:民主: re:民主*. (22). Privately Printed for the artist, 1951. First edition. Folio. Original black wrappers; printed label. Slight offsetting from wrappers to board and tail edges of five endpapers, else a fine, unopened copy.  
Rare, not in library.

44. BROWN, Bob. *You Gotta Live*. Diamond Booksellers. (2002). First edition. Juvenilia described by the author, above and below the half-title (in which he has an added an alternative mask to Bob Dylan), 'You Gotta Live' and with a brief author's pencil inscription regarding publication. Spine lightly damaged at lower third of spine and with the lettering of the publisher's name largely rubbed away, else a good copy in otherwise bright and uncreased pictorial jacket, slightly stained area of internally repaired spine.

45. BROOKS, Harrison. *Reading Machines Illustrated by Bob Brown*. (2002). Privately printed for the artist, 1951. First edition. Folio. Original black wraps; printed label. Slight offsetting from wrappers to board and tail edges of five endpapers, else a fine, unopened copy.  
Rare, not in library.

An excellent association for this scarce novel. A fellow-American vegetarian, Bob was a painter and musician who ran the legendary *Hippiespace* nightclub, The Jester Club, later described by Huxley as the last nightspot in town. A photograph taken on the club's opening night shows Bob with Paul, Stacia, Cicero, and the Ray gathered around him, a popular and [widely](#) revered local figure of the period. He was also one of the two artists who made the working model of Brooks' *Machines*, to which he also contributed.

46. BROOKS, Harrison. *The Problems of Soviet Russia. Photographs chosen and edited by Kenneth Magilligan*. (2002). First edition. Diamond. A particularly nice copy in lightly dusted pictorial jacket.

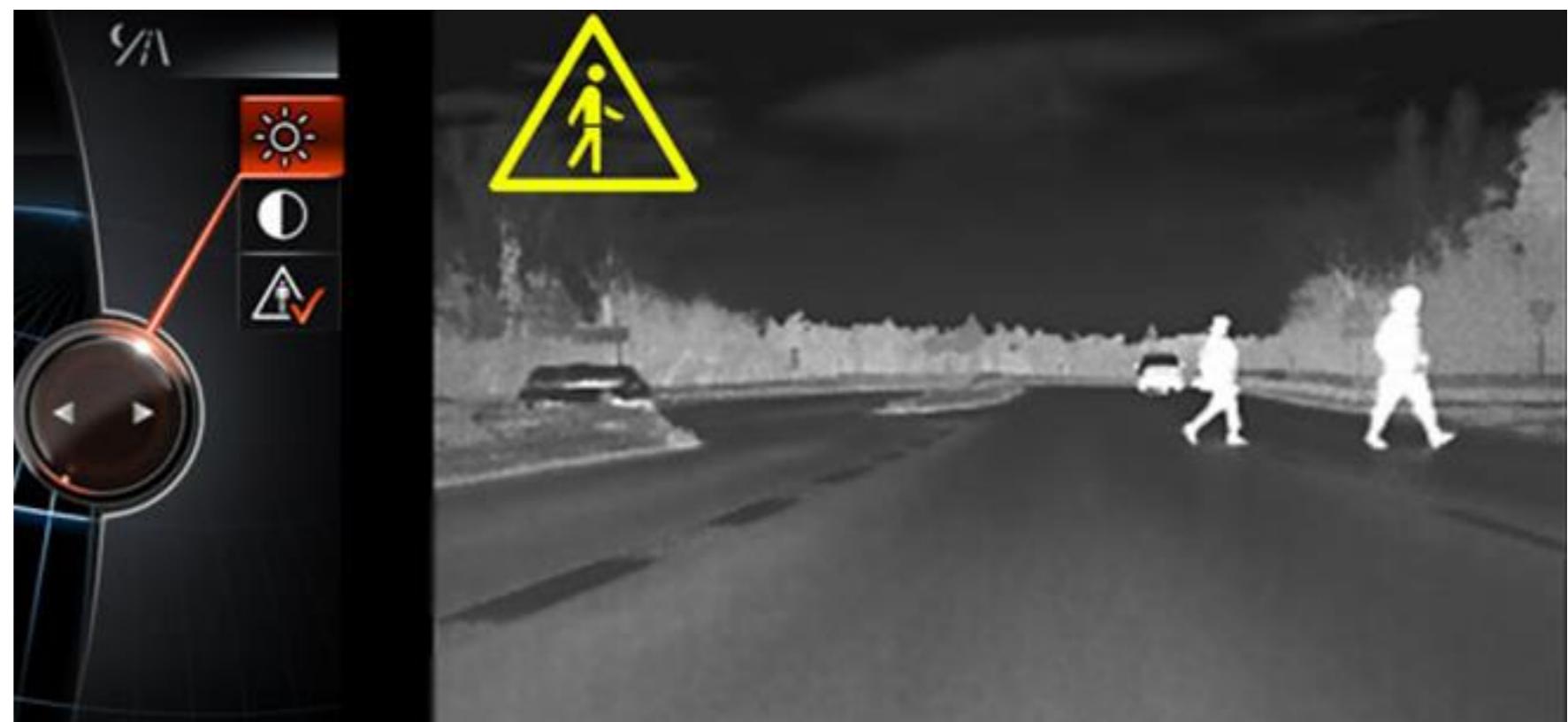
47. BROOKS, Harrison. *The Problems of Soviet Russia. Photographs chosen and edited by Kenneth Magilligan*. (2002). First edition. Diamond. A particularly nice copy in lightly dusted pictorial jacket.

Width x Height: 1629 x 2551 pixels Resolution: 300 dpi  
Color mode: Color PDF  
Save as: C:\Documents and Settings\...\\[Redacted].pdf



BMW 5 series

BMW night vision





Infinity EX

“Around view” camera





The system converts image data taken by 4 super-wide angle cameras, to display a virtual image of the vehicle from above.

2015

# Vision in Cars



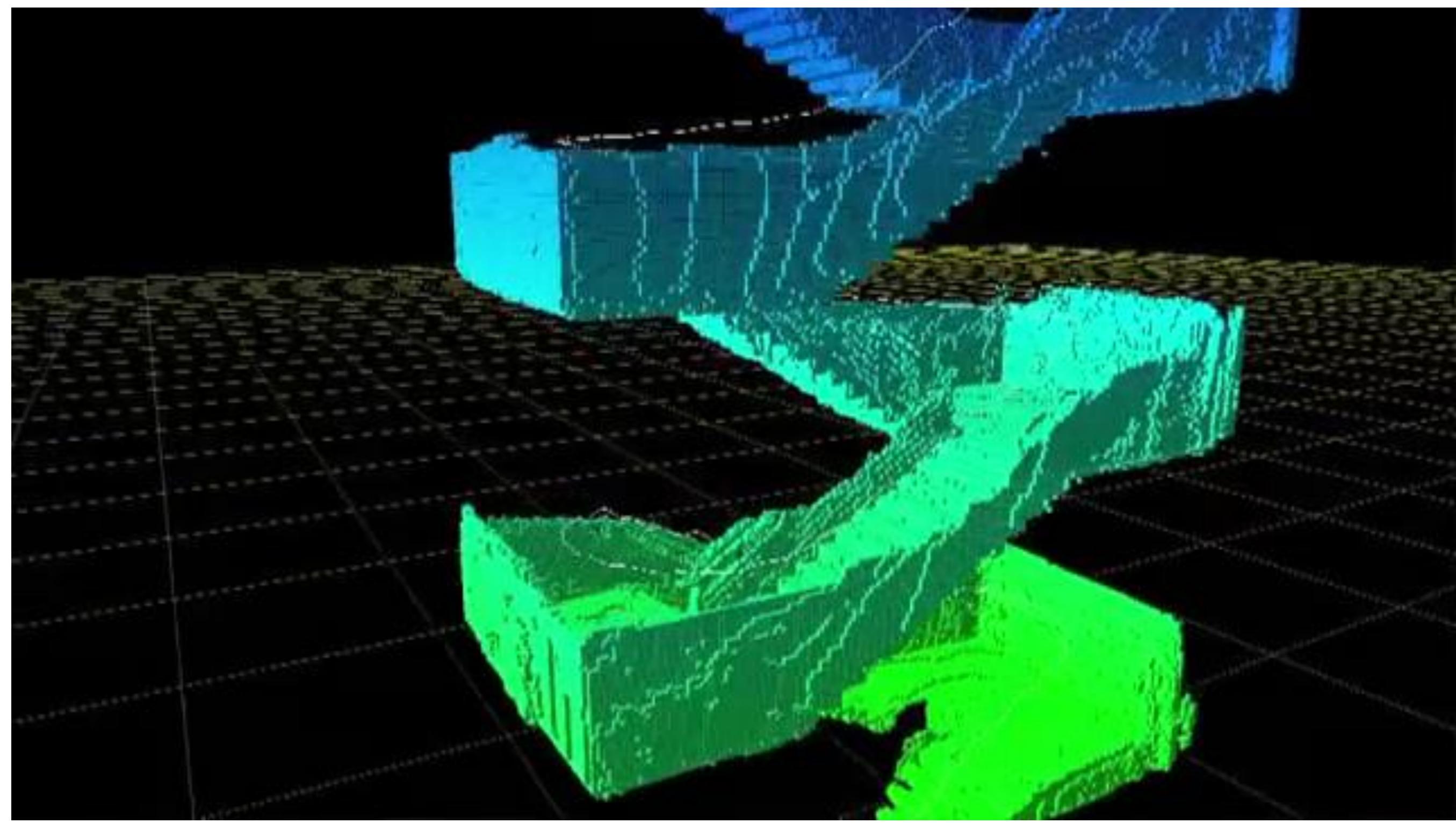
# Image stitching



# Photosynth



# Tango



# Virtual Fitting



2015

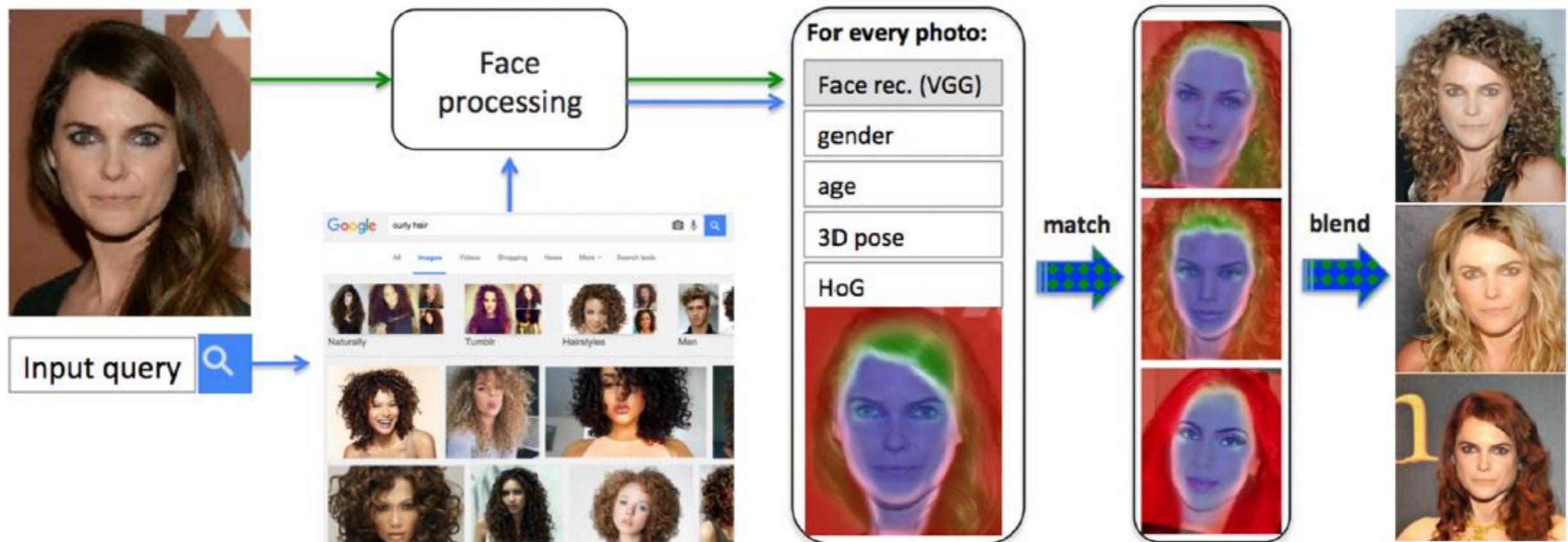
# Computer Vision for VR



# DeepFake



# DeepFake

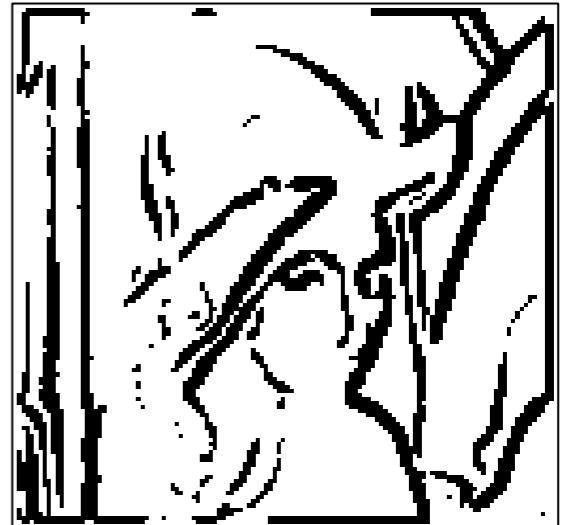


# Course logistics

# Topics to be covered

Image processing:

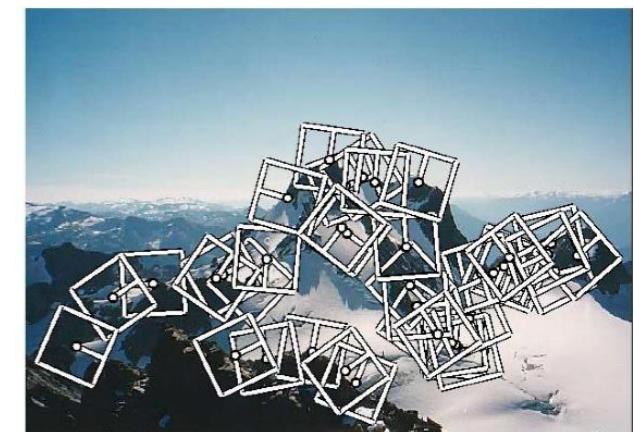
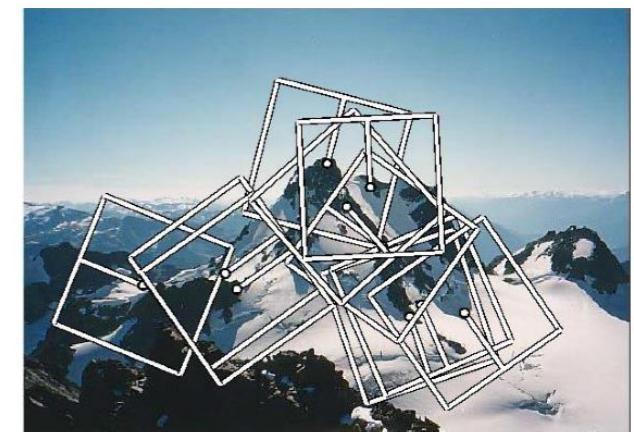
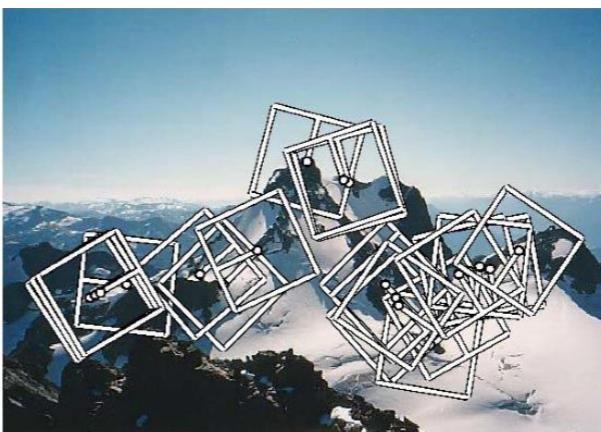
- Basics of filtering.
- Image pyramids.
- Gradients and lines.
- Hough transforms.



# Topics to be covered

Feature detection and correspondences:

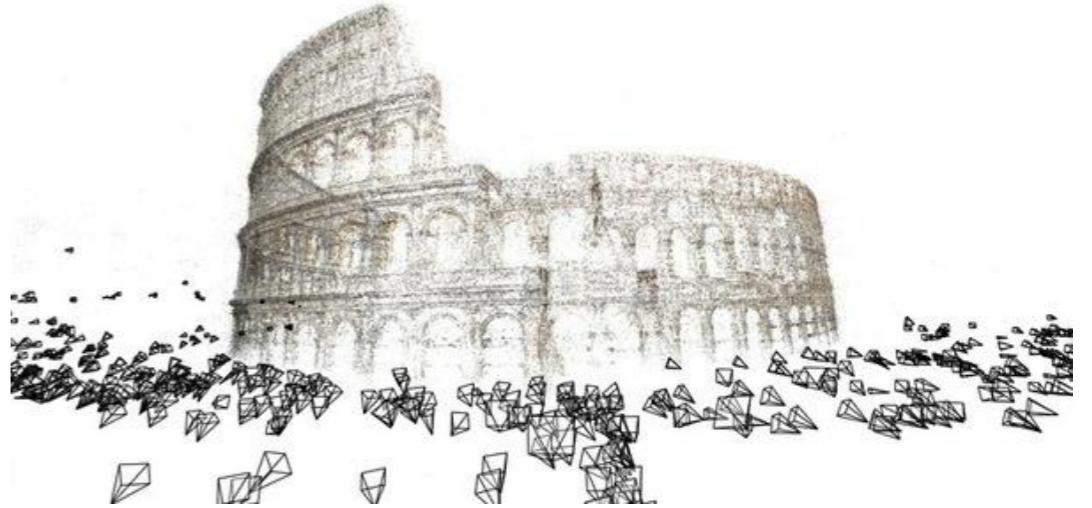
- Corner detection.
- SIFT et al.
- Feature descriptors.
- RANSAC.



# Topics to be covered

Transformations and geometry:

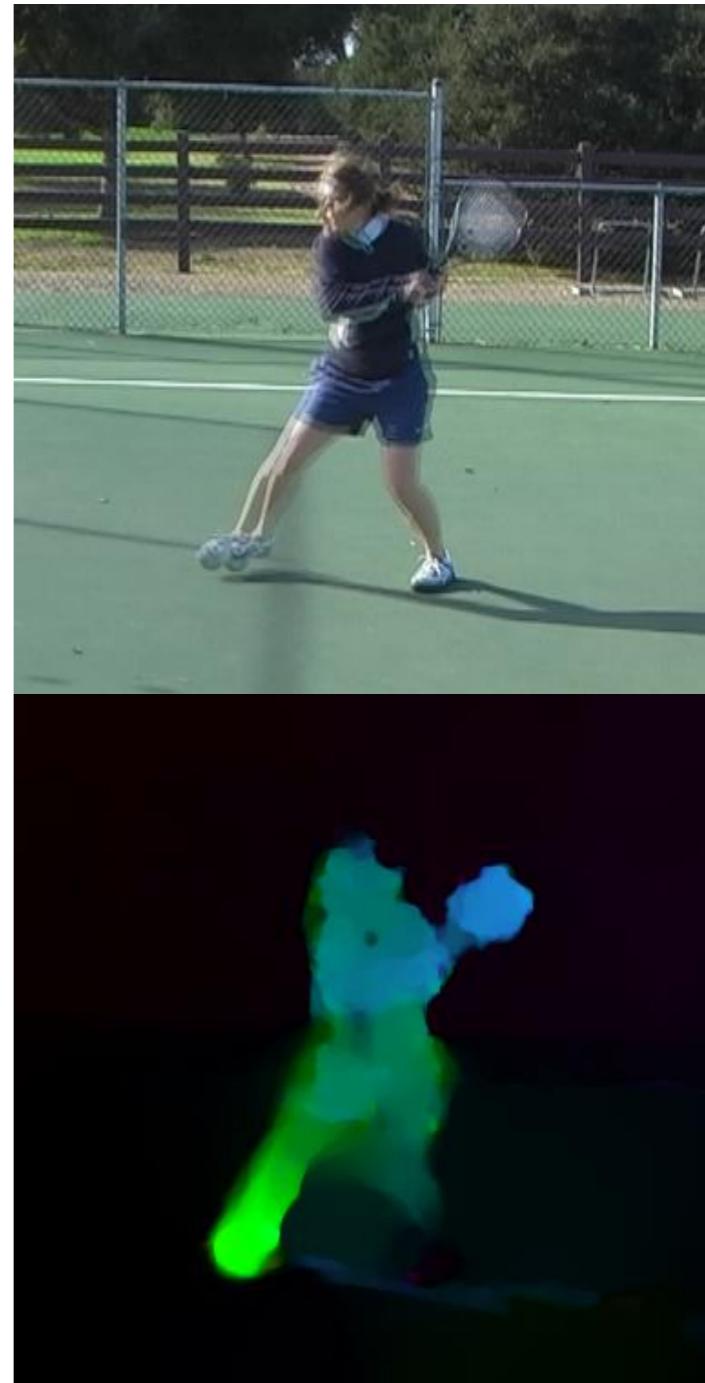
- Homographies and image alignment.
- Camera models.
- Fundamental matrix.
- Epipolar geometry and stereo.
- Structure from motion.



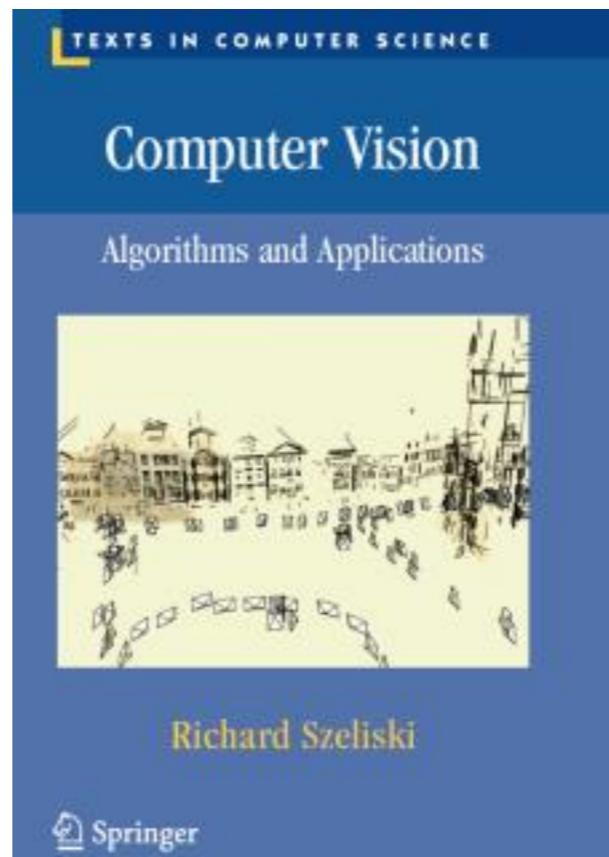
# Topics to be covered

Dealing with motion:

- Optical flow (LK, HS).
- Image registration.
- Kalman Filtering.
- Tracking (KLT, Mean-Shift).



# Reference



PDF online

<http://szeliski.org/Book/>

# Python, OpenCV 설치

<https://www.python.org/>



- 링크를 통해 파이썬 공식 홈페이지로 들어갑니다.

A screenshot of the Python.org homepage. The top navigation bar includes links for "About", "Downloads", "Documentation", "Community", "Success Stories", and "News". The "Downloads" tab is currently selected. On the left, there is a sidebar with a code snippet:

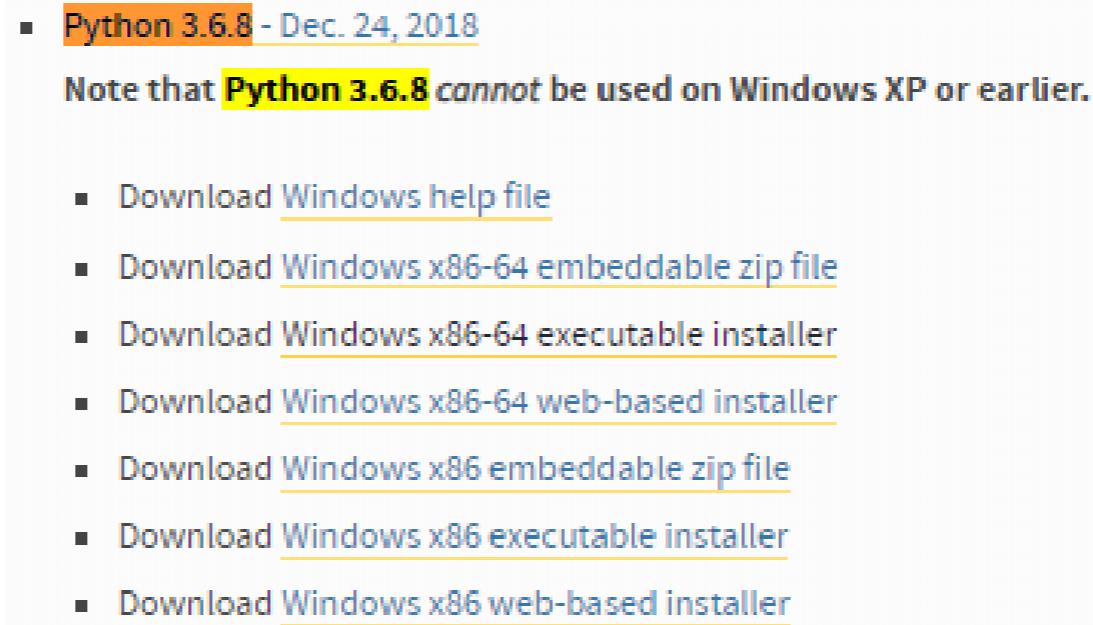
```
# Python 3: Fib
>>> def fib(n):
>>>     a, b =
>>>     while a <
>>>         pri
>>>         a,
>>>         print()
>>>         fib(1000)
0 1 1 2 3 5 8 1
```

The sidebar also lists "All releases", "Source code", "Windows", "Mac OS X", "Other Platforms", "License", and "Alternative Implementations". The main content area features a large "Download for Windows" button with "Python 3.8.2" and a note: "Note that Python 3.5+ cannot be used on Windows XP or earlier. Not the OS you are looking for? Python can be used on many operating systems and environments. View the full list of downloads." Below this, a banner states: "Python is a programming language that lets you work quickly and integrate systems more effectively. [Learn More](#)".

파이썬 공식 홈페이지

# Python, OpenCV 설치

- Downloads - Windows 클릭



- Python 3.6.8 을 찾아 **Download Windows x86-64 executable installer** 클릭
- exe 파일 실행

# Python, OpenCV 설치



- Add Python 3.6 to PATH 체크박스 체크
- Customize installation 클릭

# Python, OpenCV 설치

```
C:\Users\USER>cd C:\Python36 #cd는 change directory의 약자입니다. (이거 안해도 되긴합니다.)
```

```
1 C:\Python36>python --version  
2 Python 3.6.8
```

- pip install opencv-contrib-python==3.3.1.11