Introduction of Computer Vision

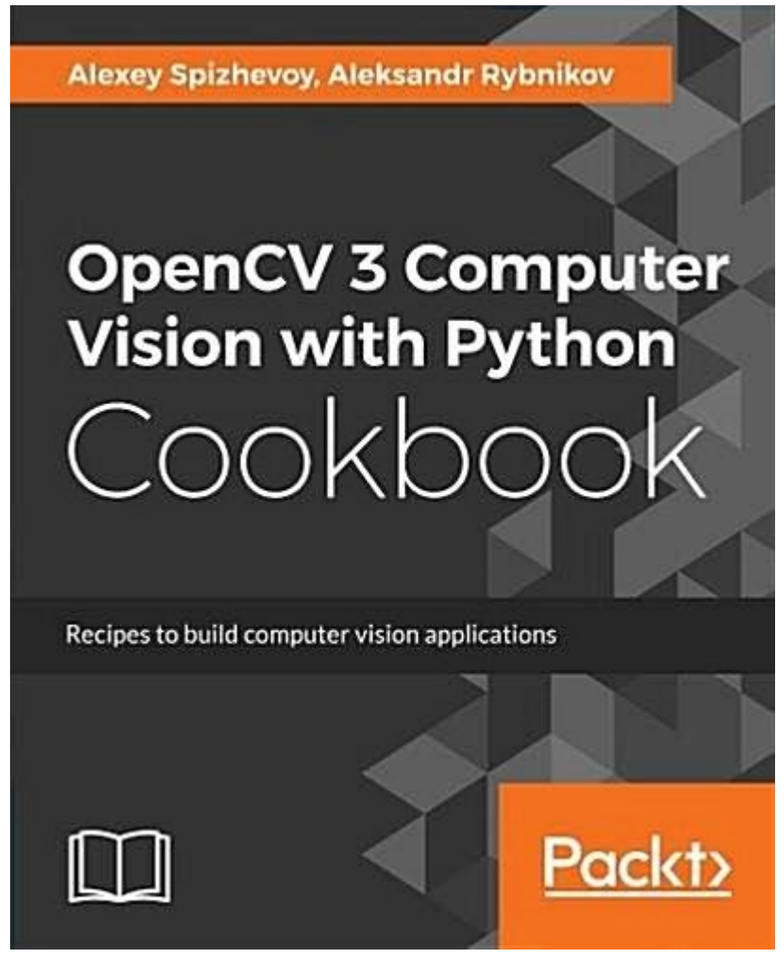
Industrial Computer Vision Course
Fall 2022, Lecture 1
Lecturer: Youngbae Hwang

Syllabus

- Evaluation
  - Attendance: 20%, Homework: 40%, Midterm/Final Project: 40%

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

TextBook



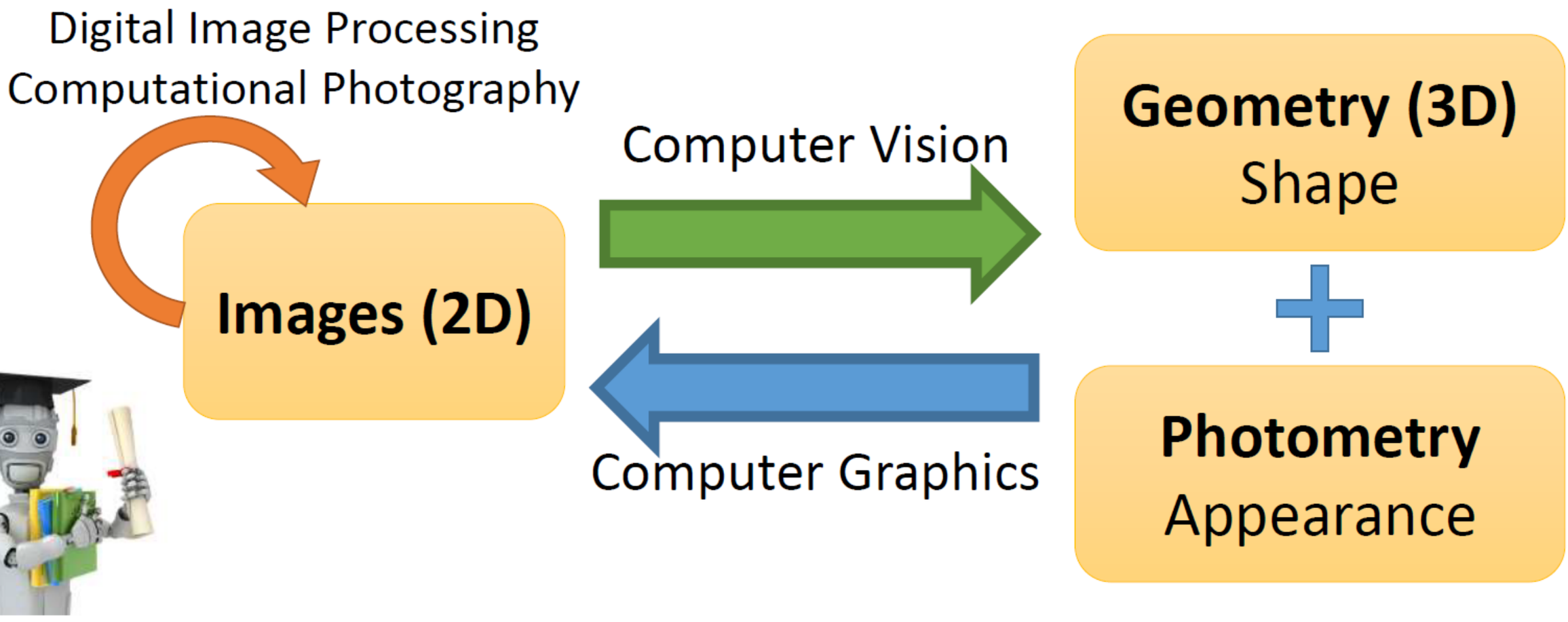
- 교재
  - 파이썬과 OpenCV를 이용한 컴퓨터 비전 학습
  - OpenCV-Python으로 배우는 영상 처리 및 응용

- 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

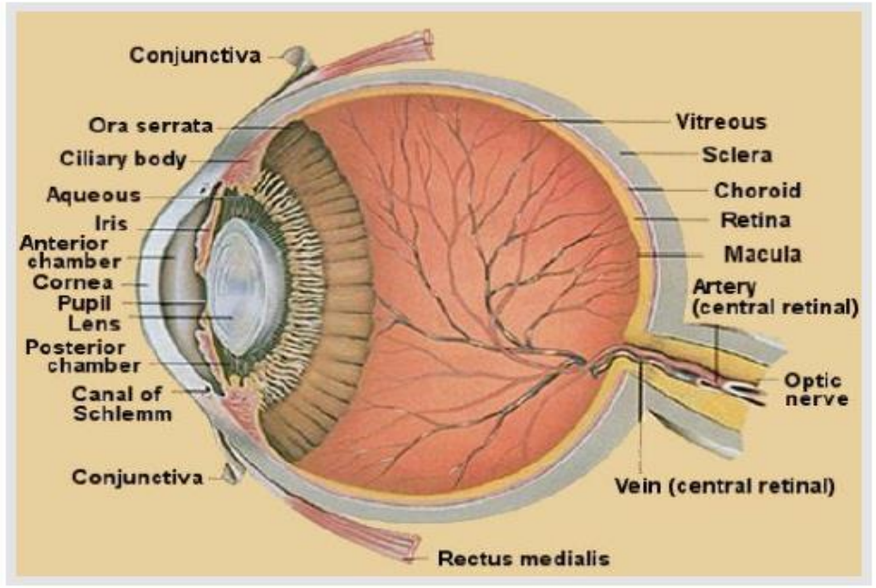
Security

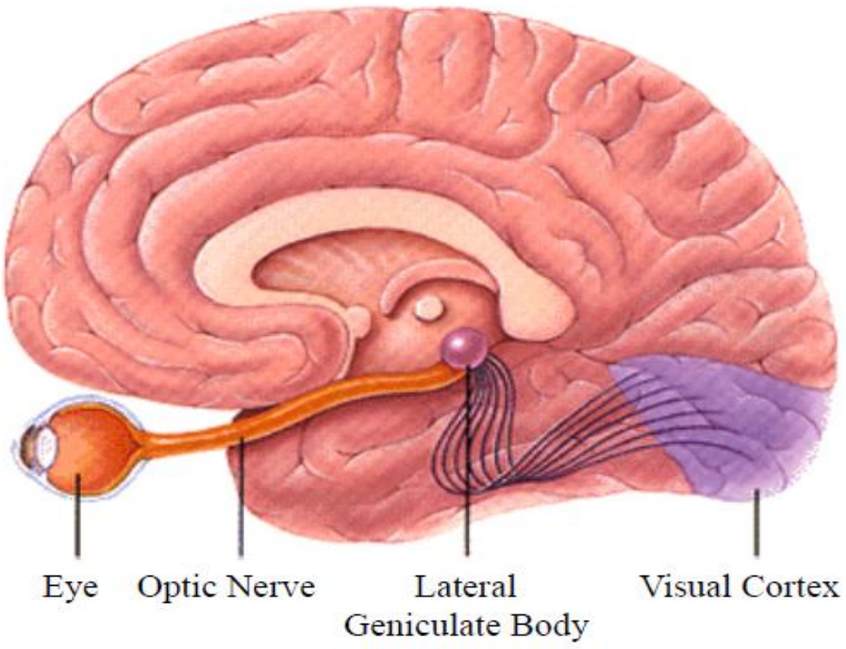
AR/VR/MR

Movie

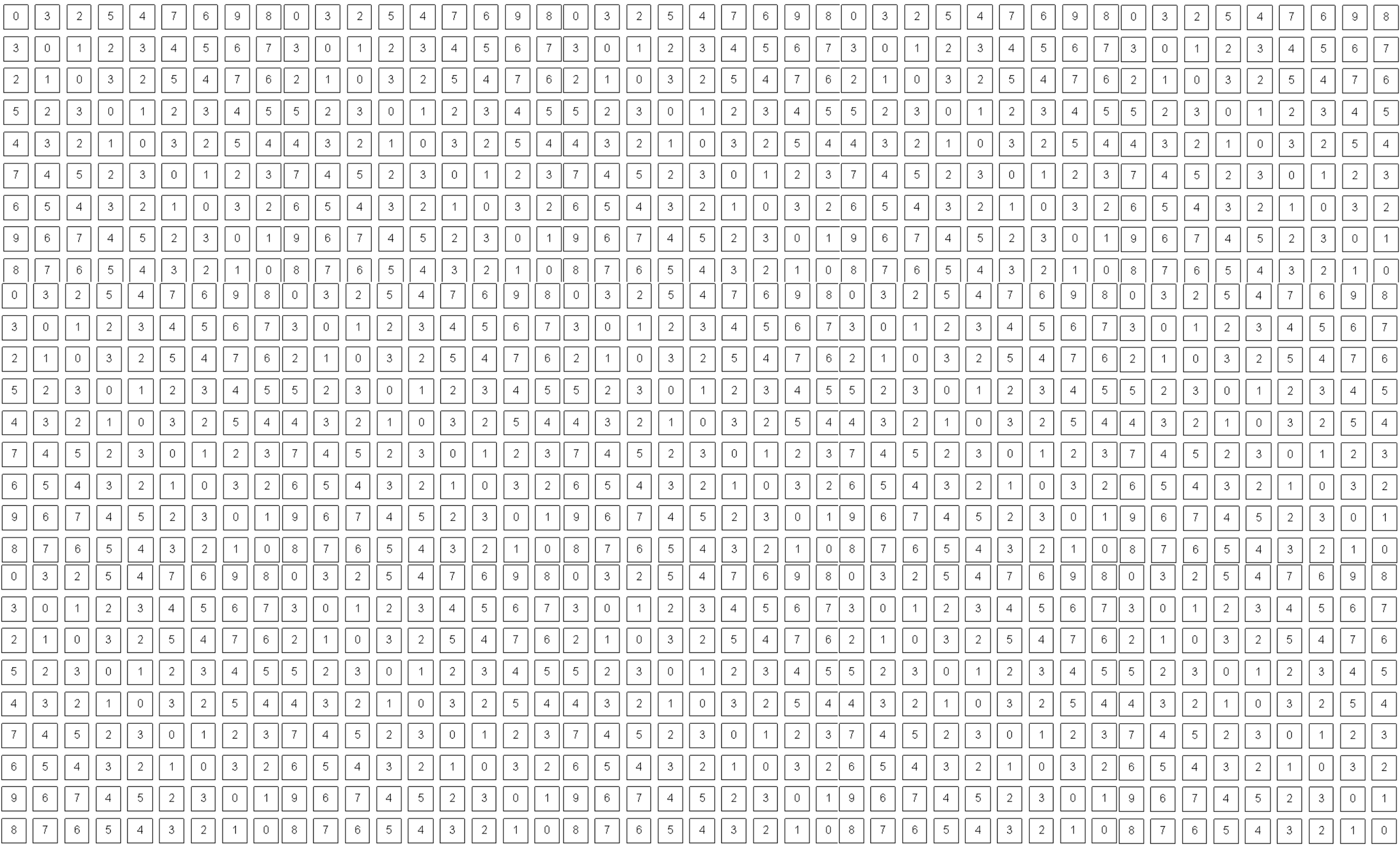
Robot

Human vs. Computer Vision





What a person sees



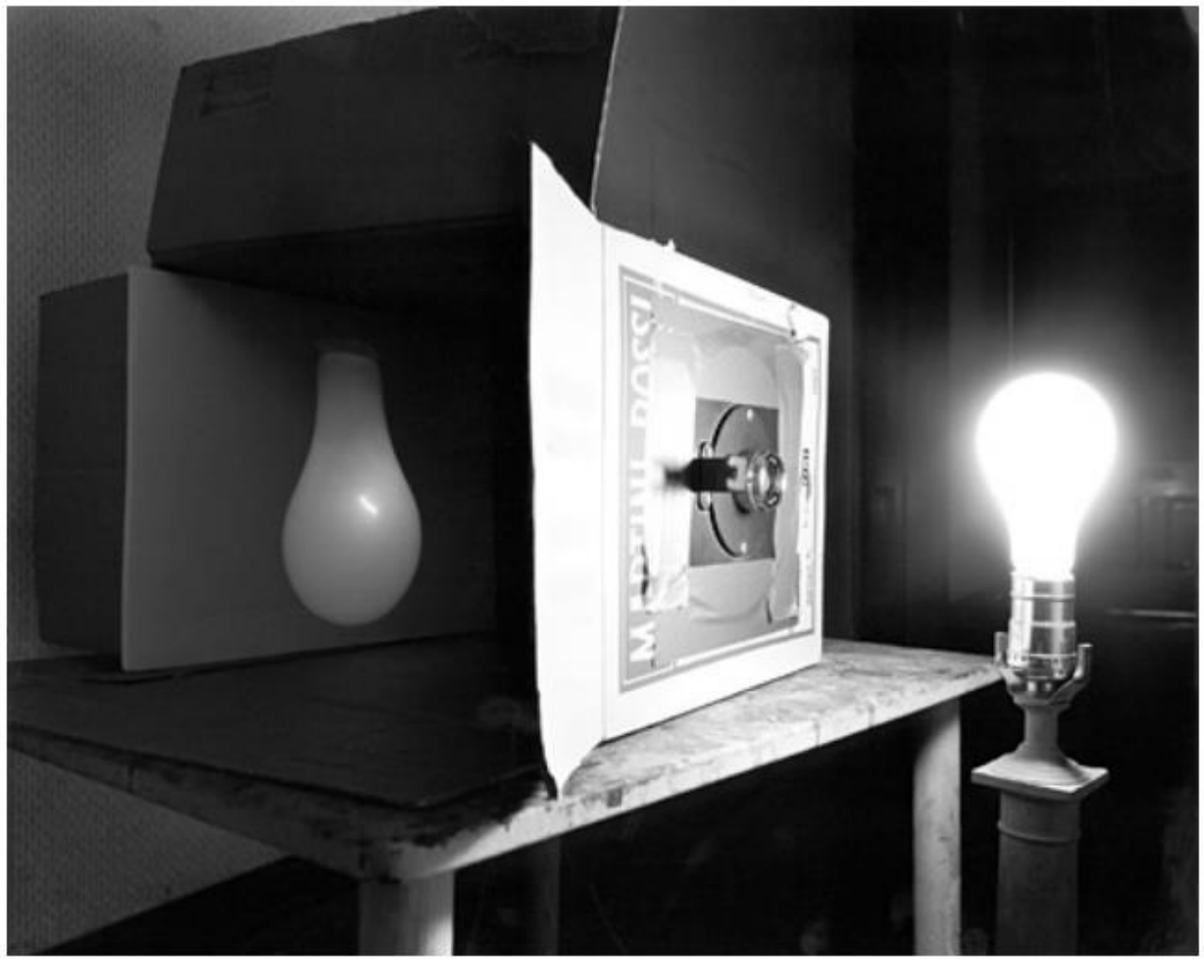
What a computer sees

Why are we able to interpret this image?

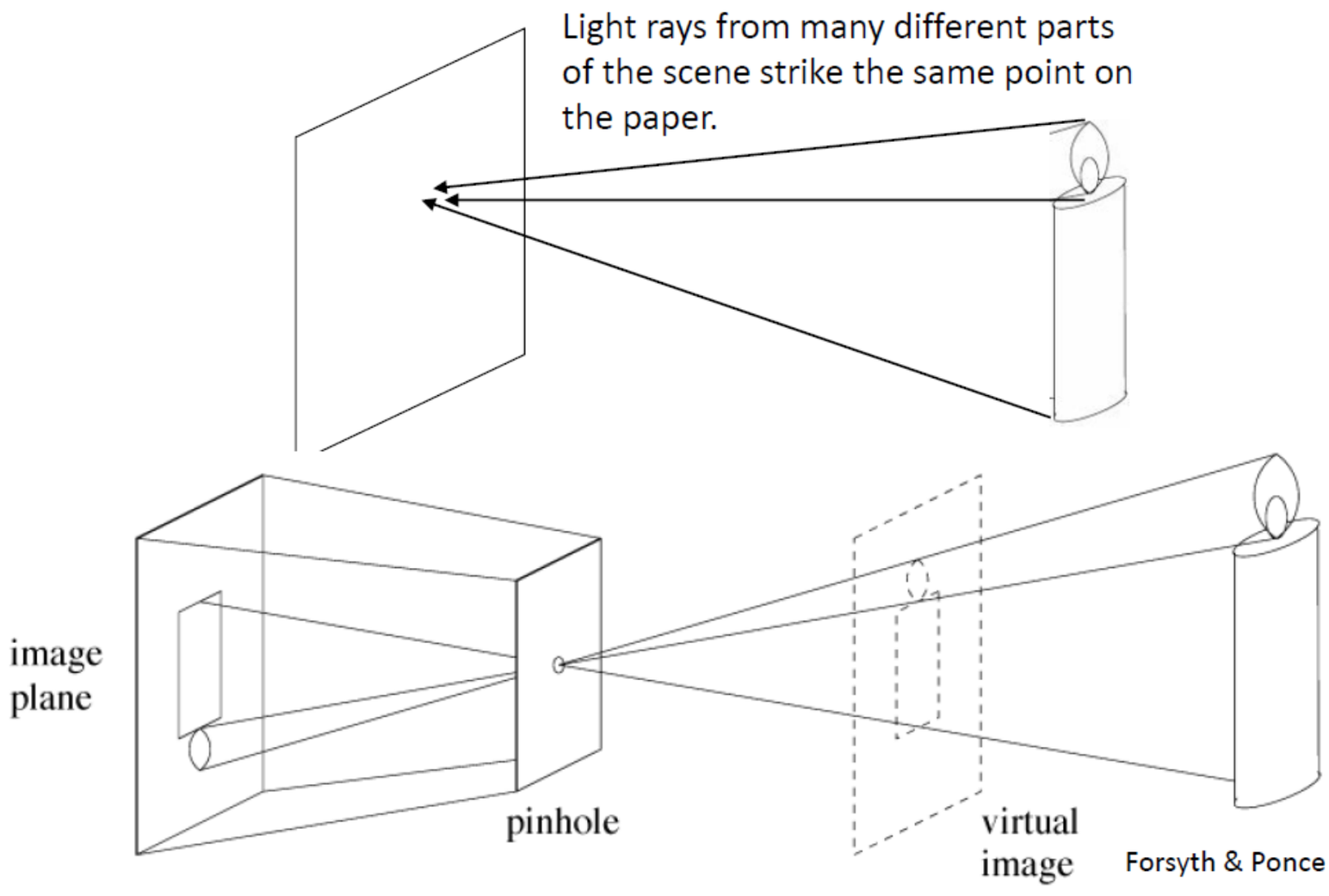
The goal of computer vision is
to give computers
(super) human-level perception

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.



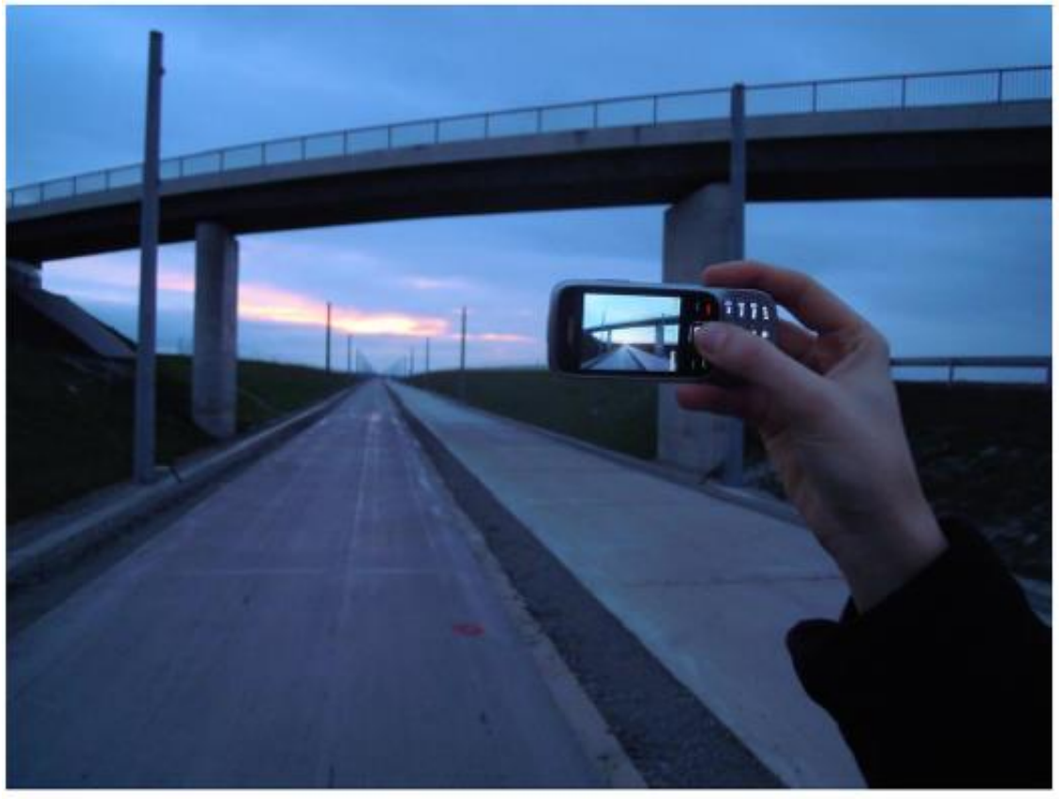
Pinhole camera model



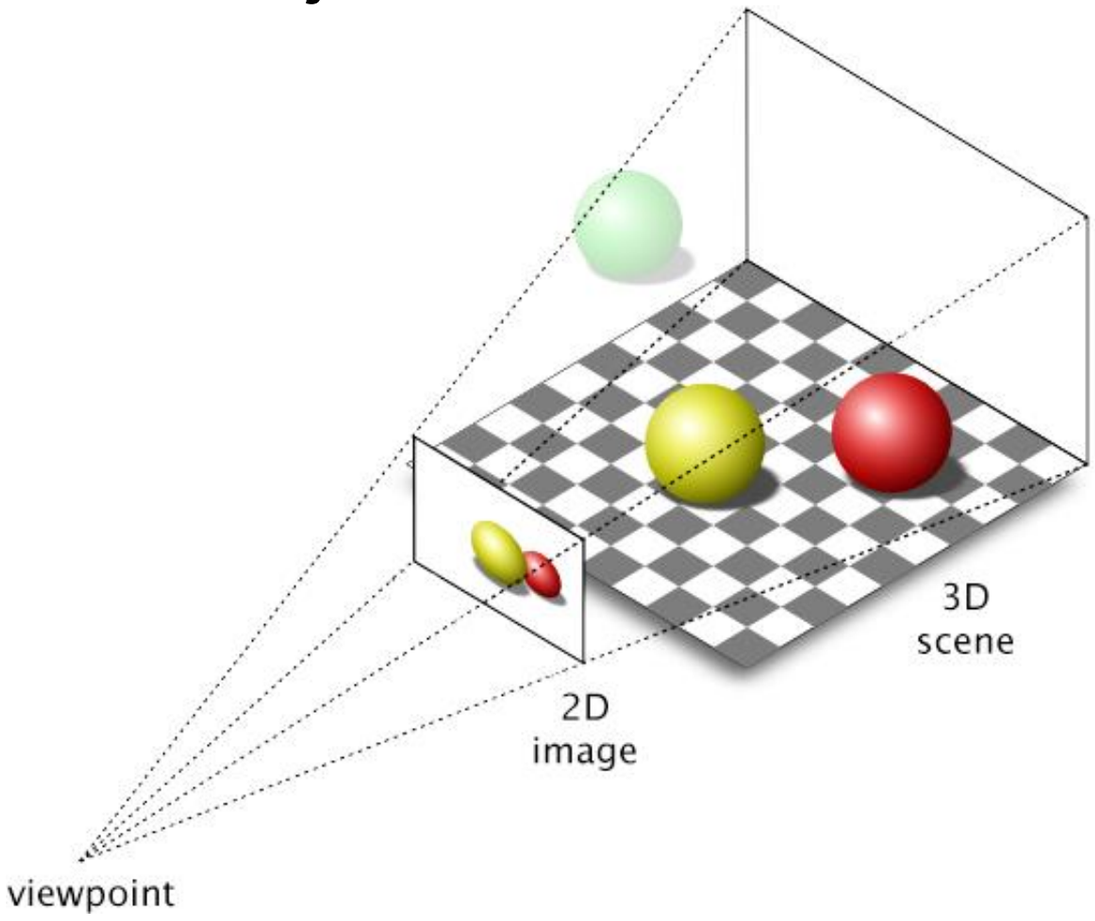
The pinhole camera only allows rays from one point in the scene to strike each point of the paper.

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

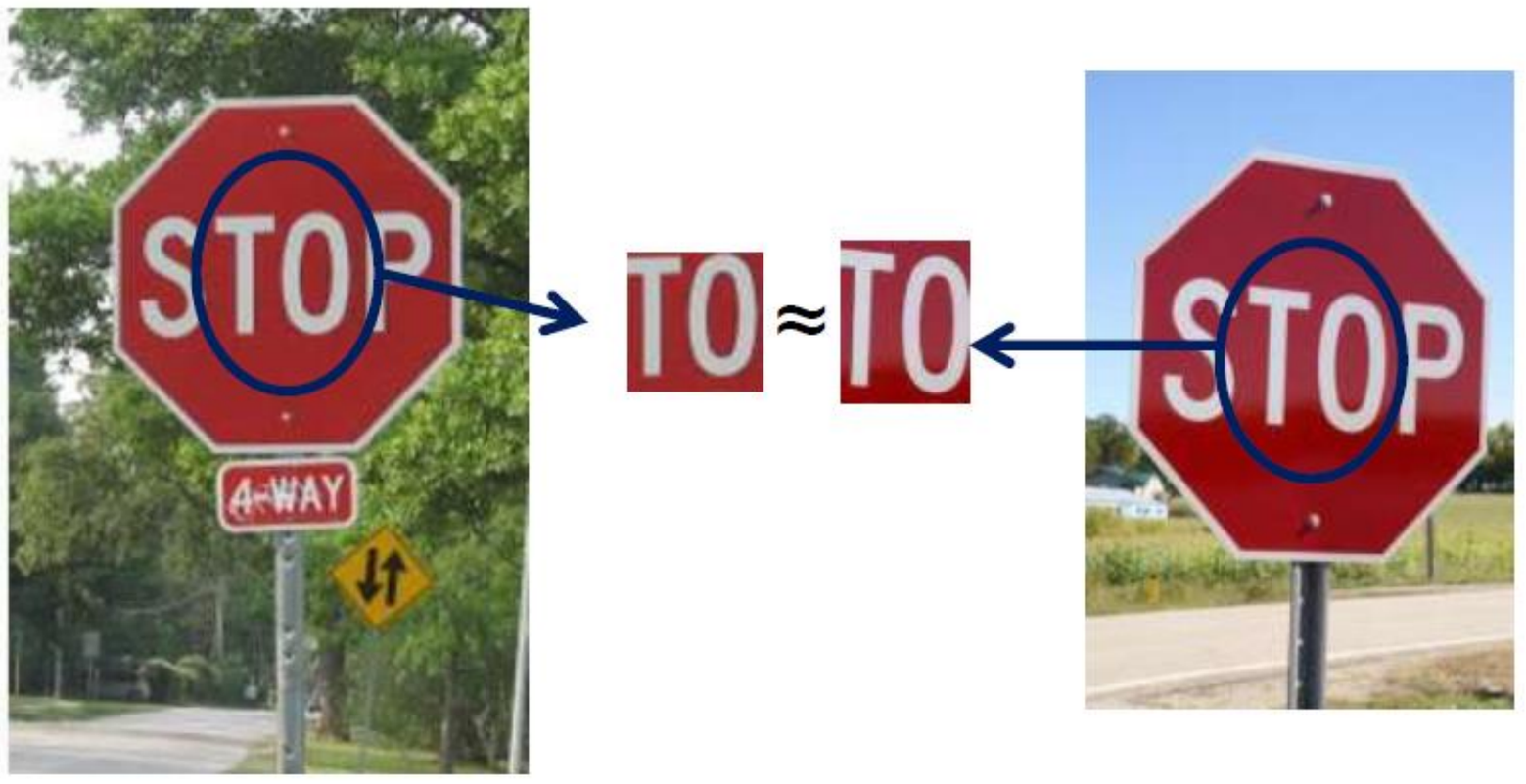


"Image created with a mobile phone" by Olaf Simons - Own work.

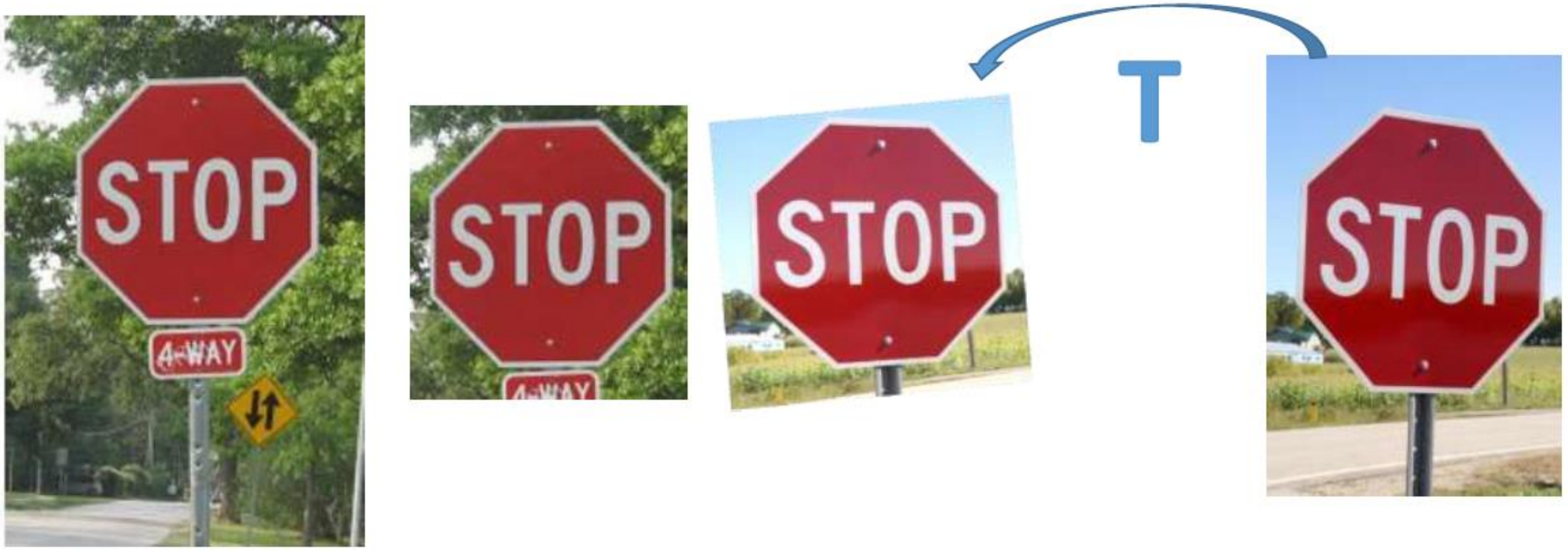


Correspondence and alignment

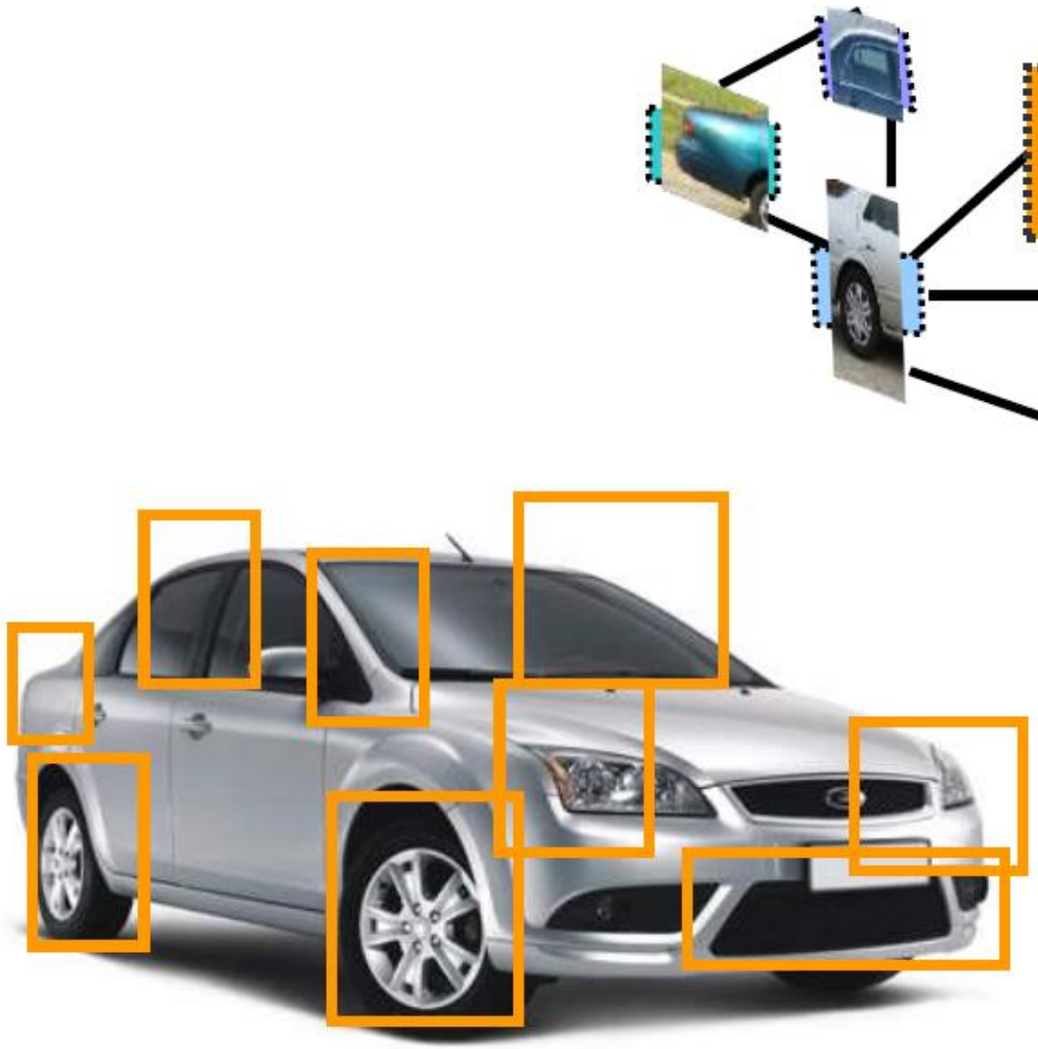
- Correspondence
  - Matching points, patches, edges, or regions across images

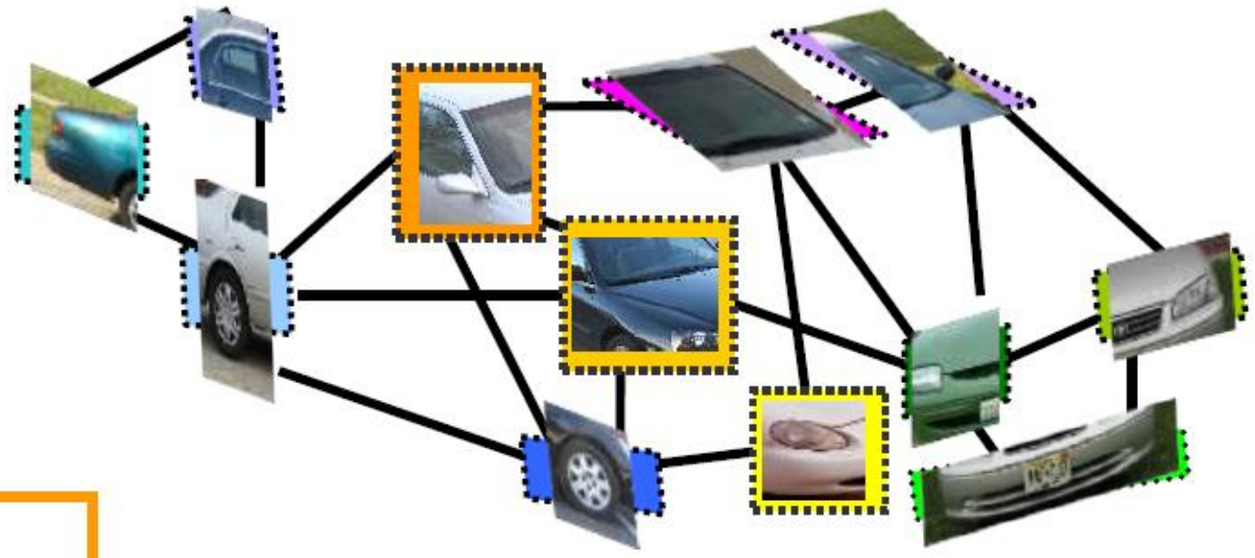


Correspondence and alignment



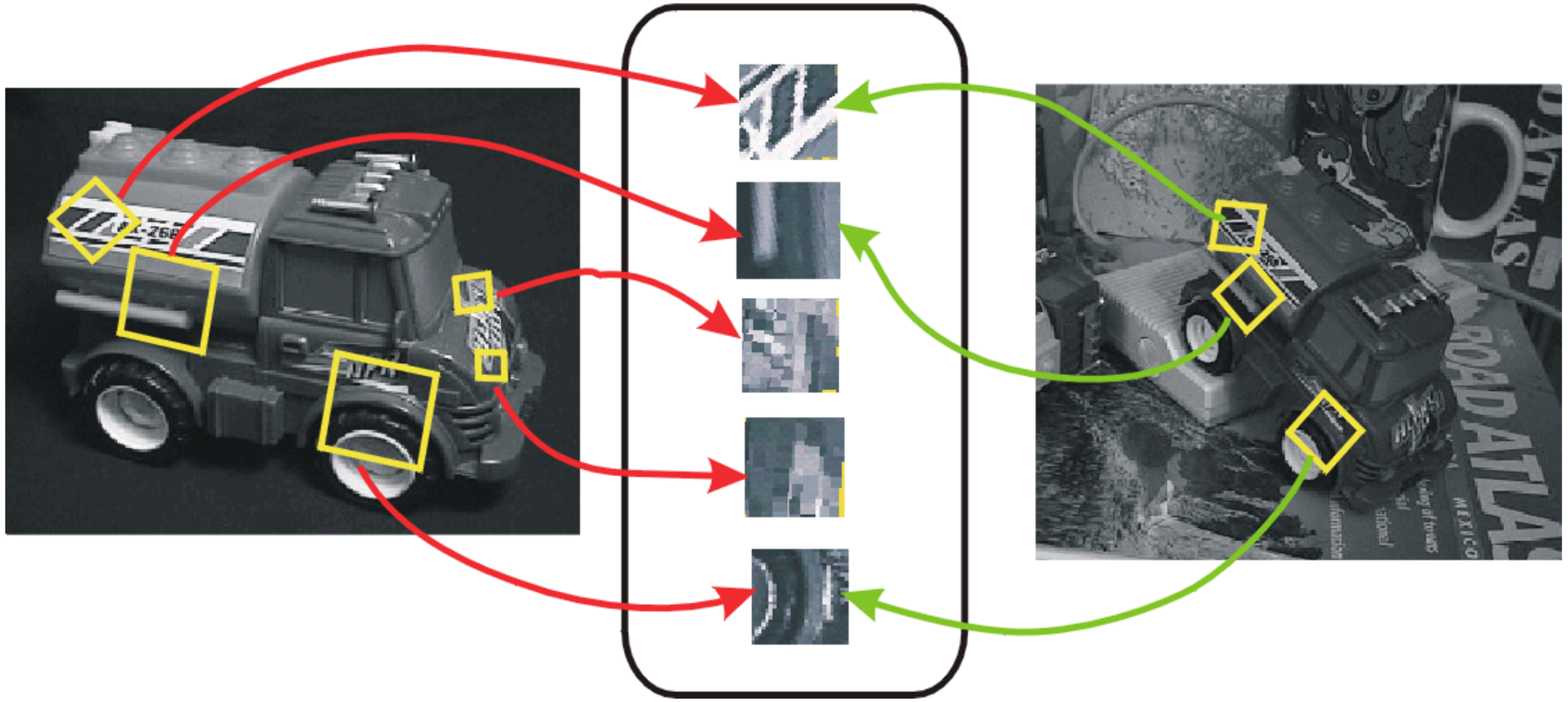
Fitting a 3D object model



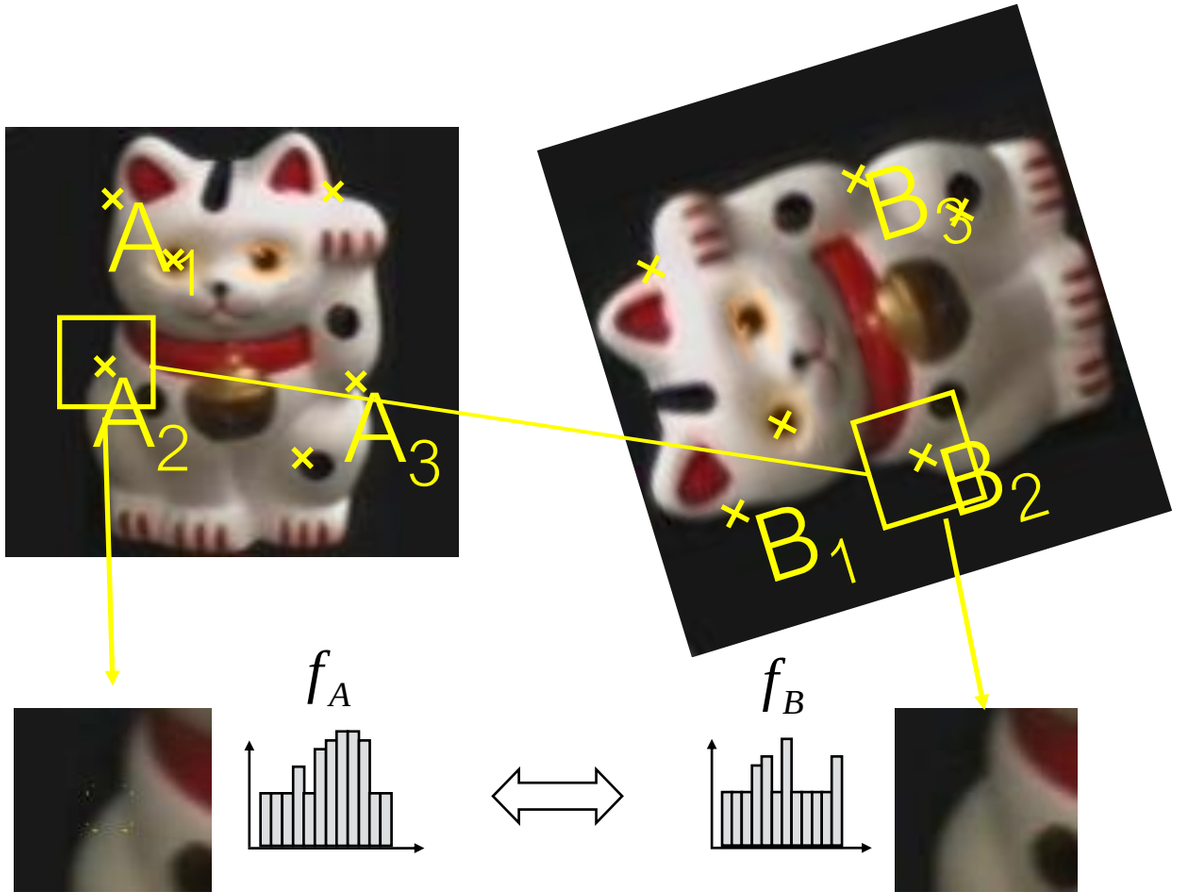


Invariant Local Features

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

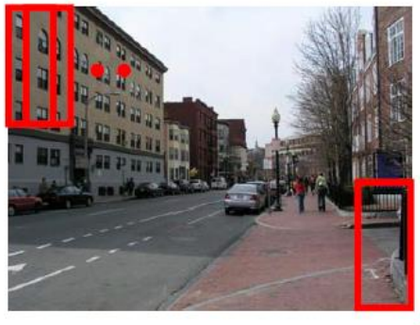


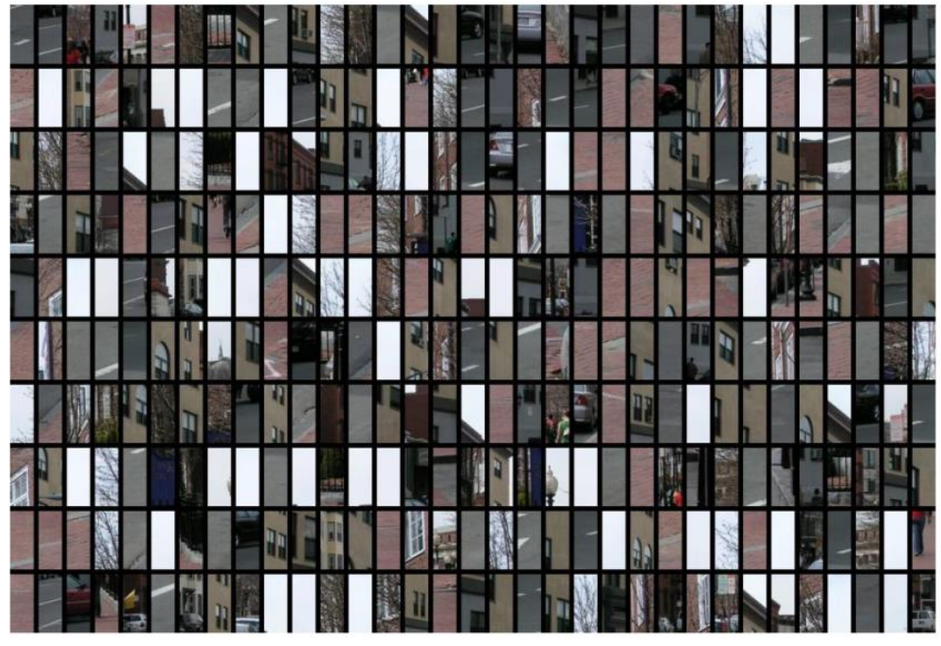
Keypoint matching



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

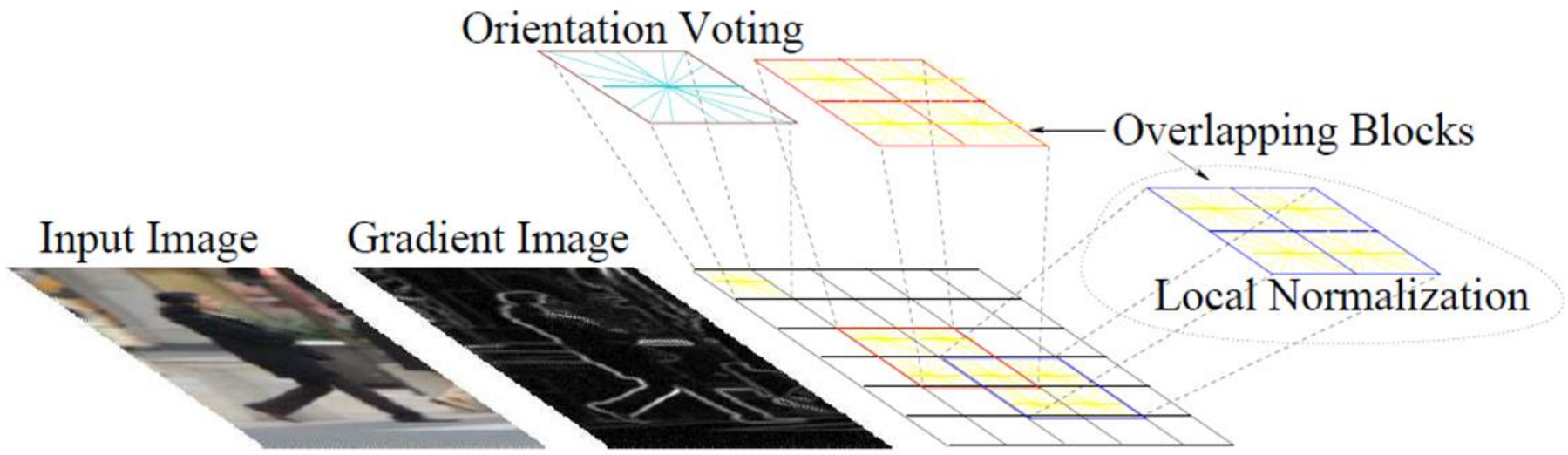
+3 +2 -2 -1 -2.5 = -0.5 ? > 7.5

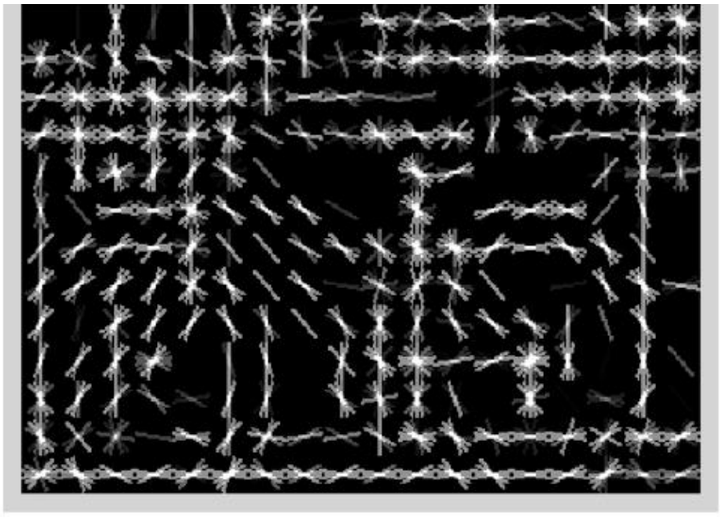
Non-object

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

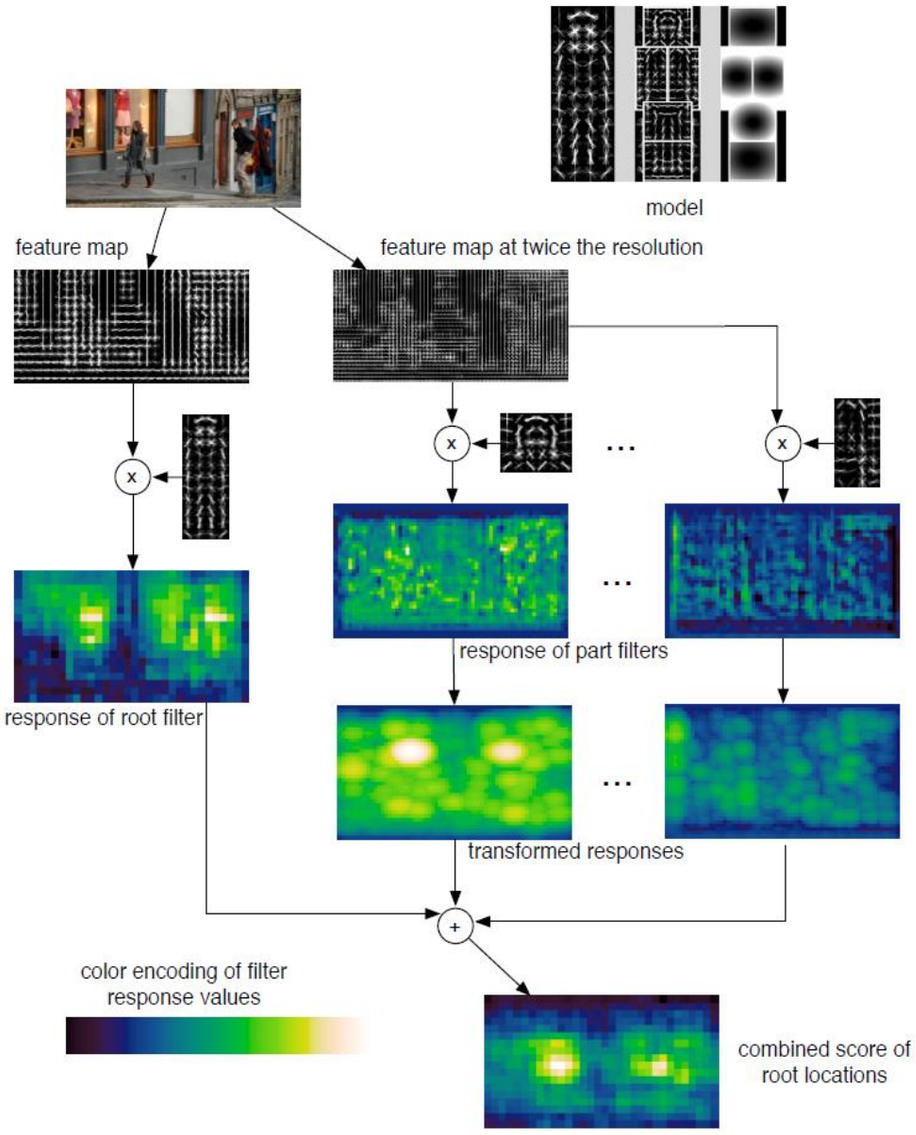
Object

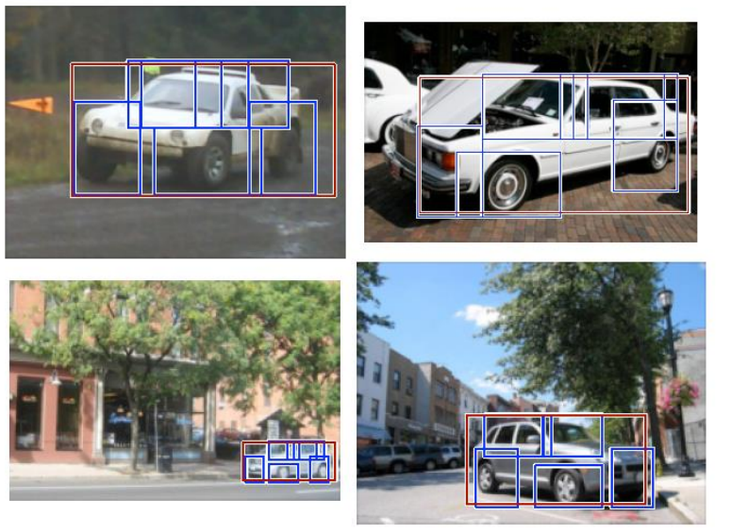
Histogram of Oriented Gradient (HOG) features

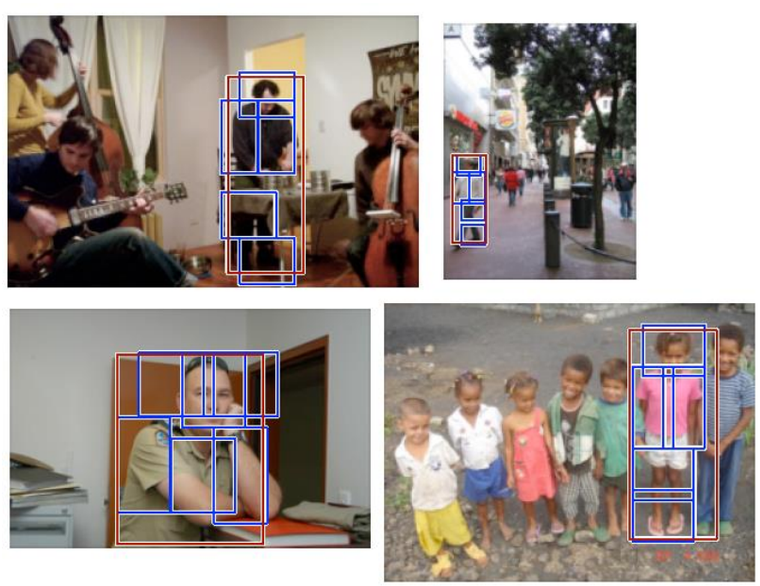




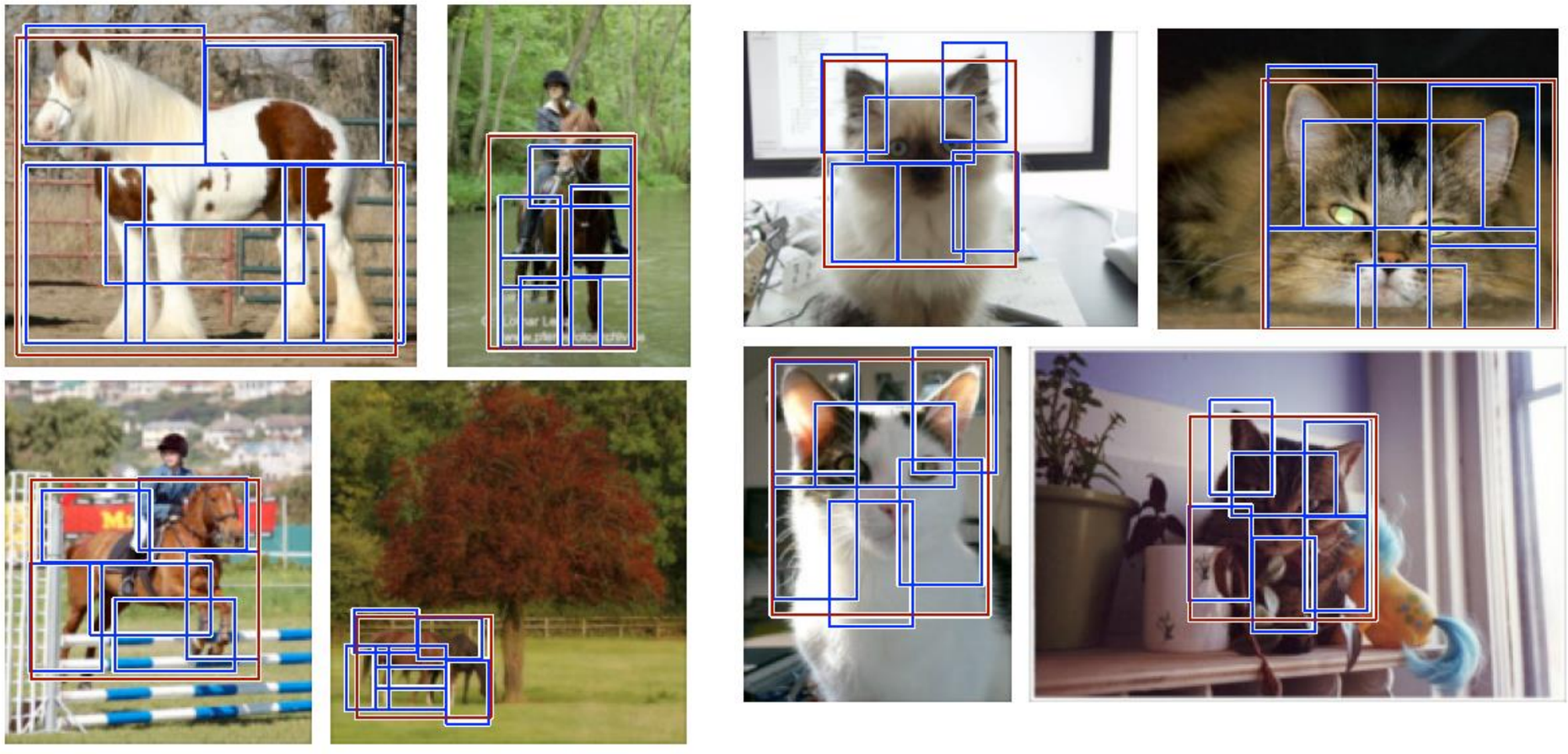
Part based models for deformable objects







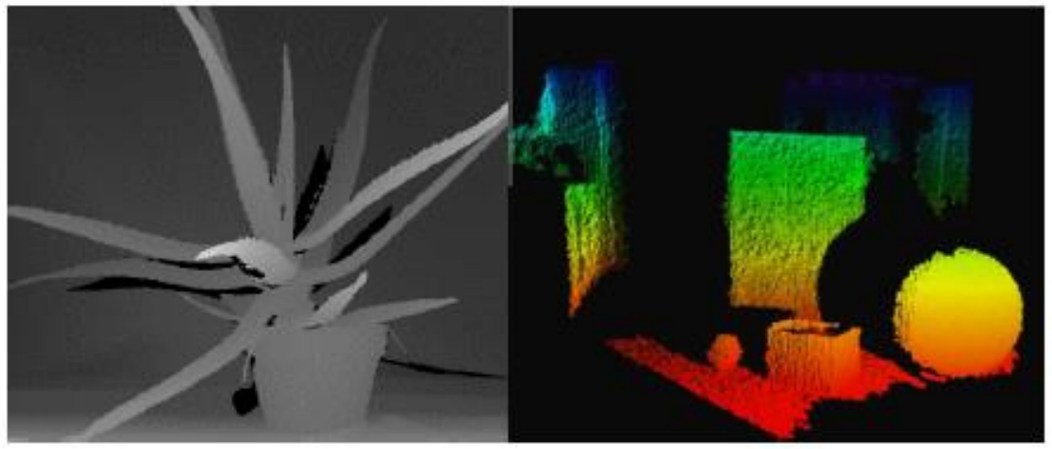
Object detection results



3D sensing

- Estimating depth or distance from a sensor to the

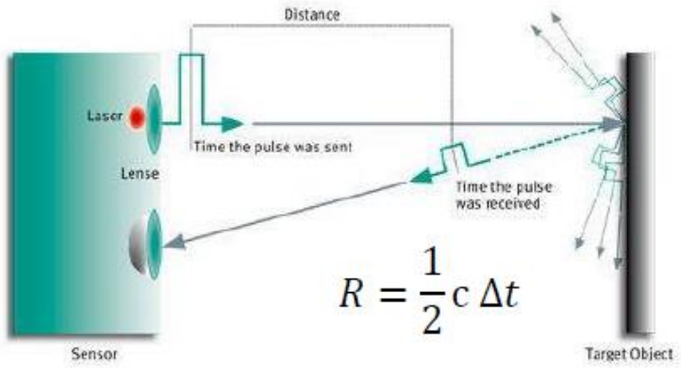
3d sensing with laser scanner

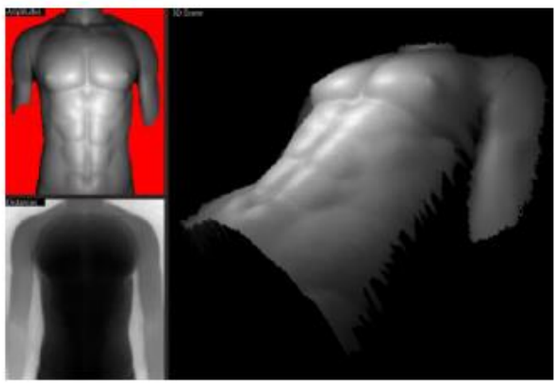


3D sensing results using stereo vision

3D Sensing Methods in Metrology

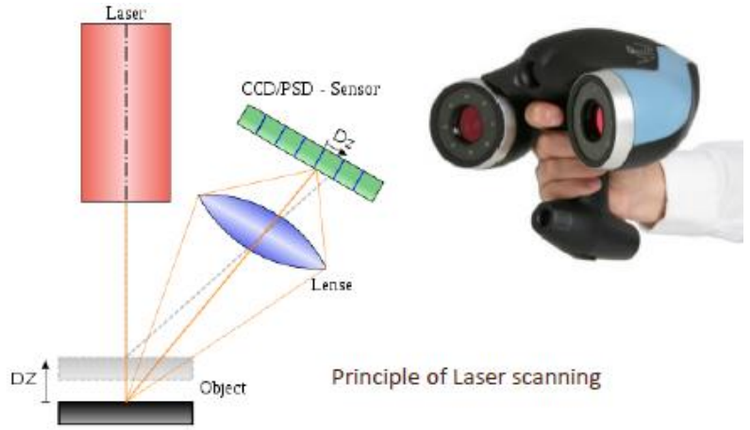
ToF (Time-Of-Flight)



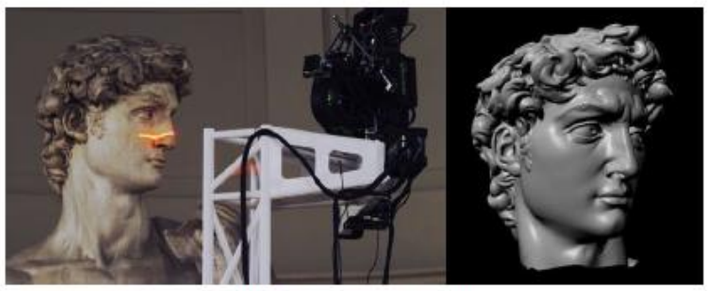


Principle of ToF sensors and acquired 3D data

Laser Scanner

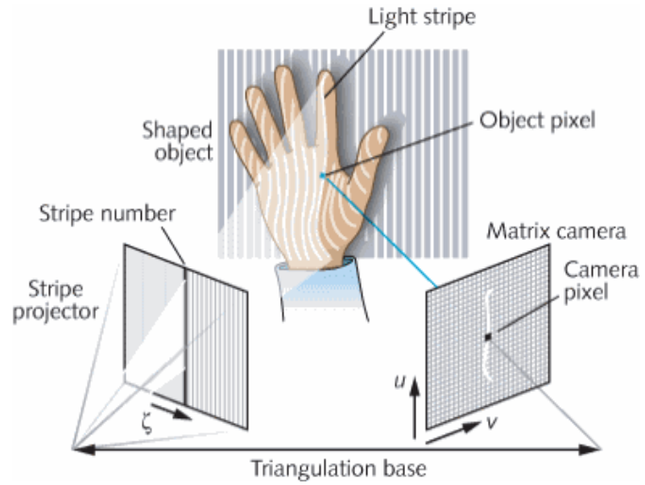


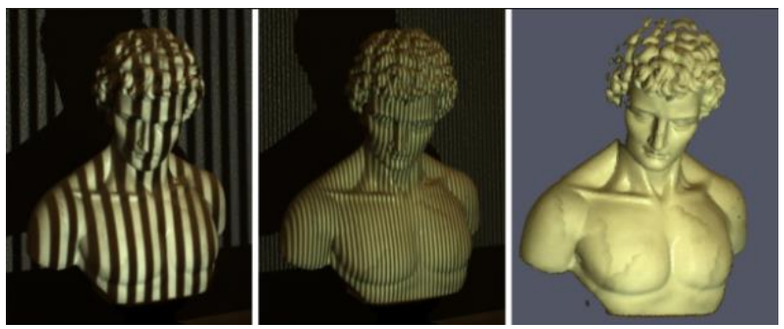
Principle of Laser scanning



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

Structured light

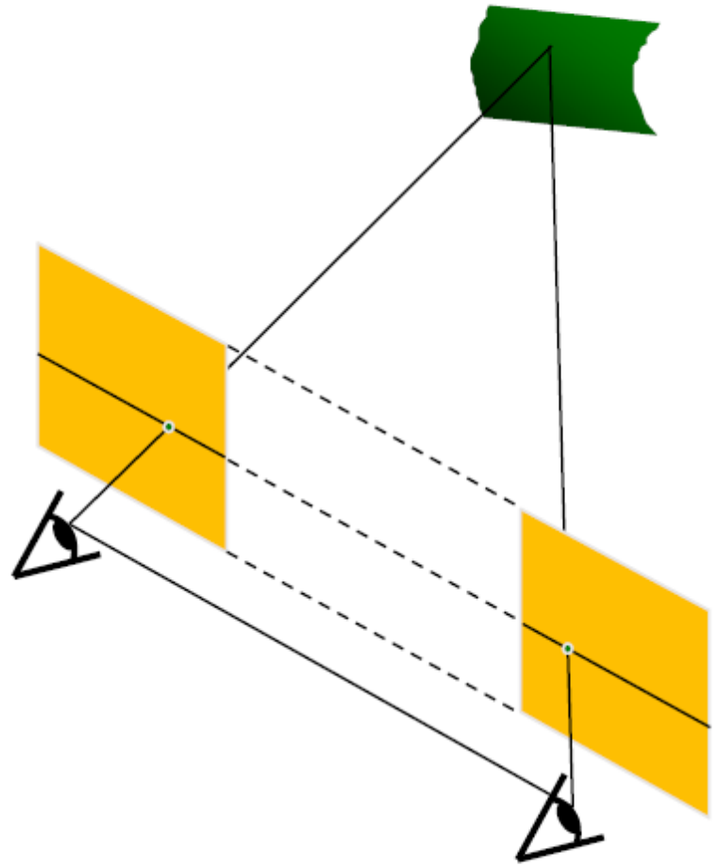




Stereo cameras

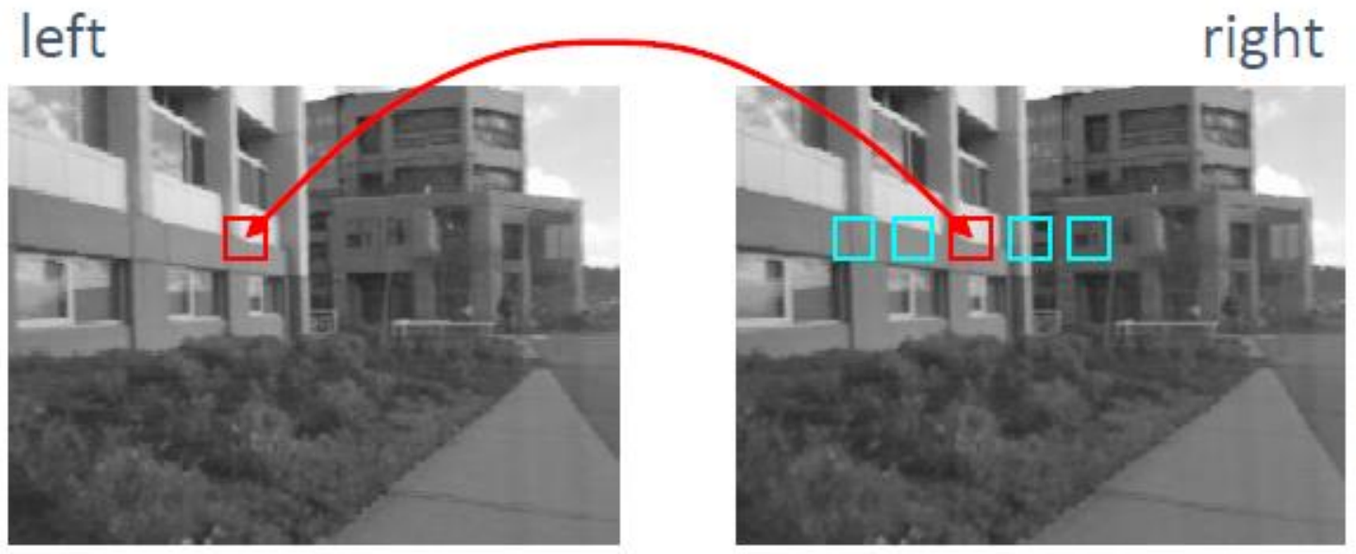
3D computation in stereo vision

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



Stereo vision

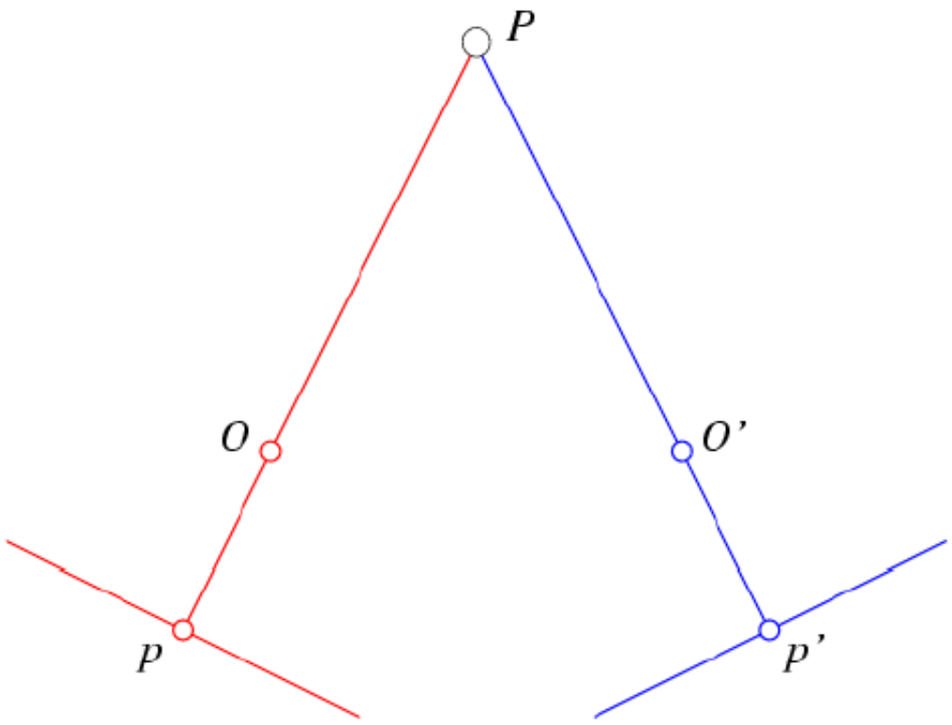
- Triangulate on two images of the same point to recover depth
    - Feature matching across views
    - Calibrated cameras



Matching correlation windows across scan lines

Stereo vision

- Reconstruction / triangulation



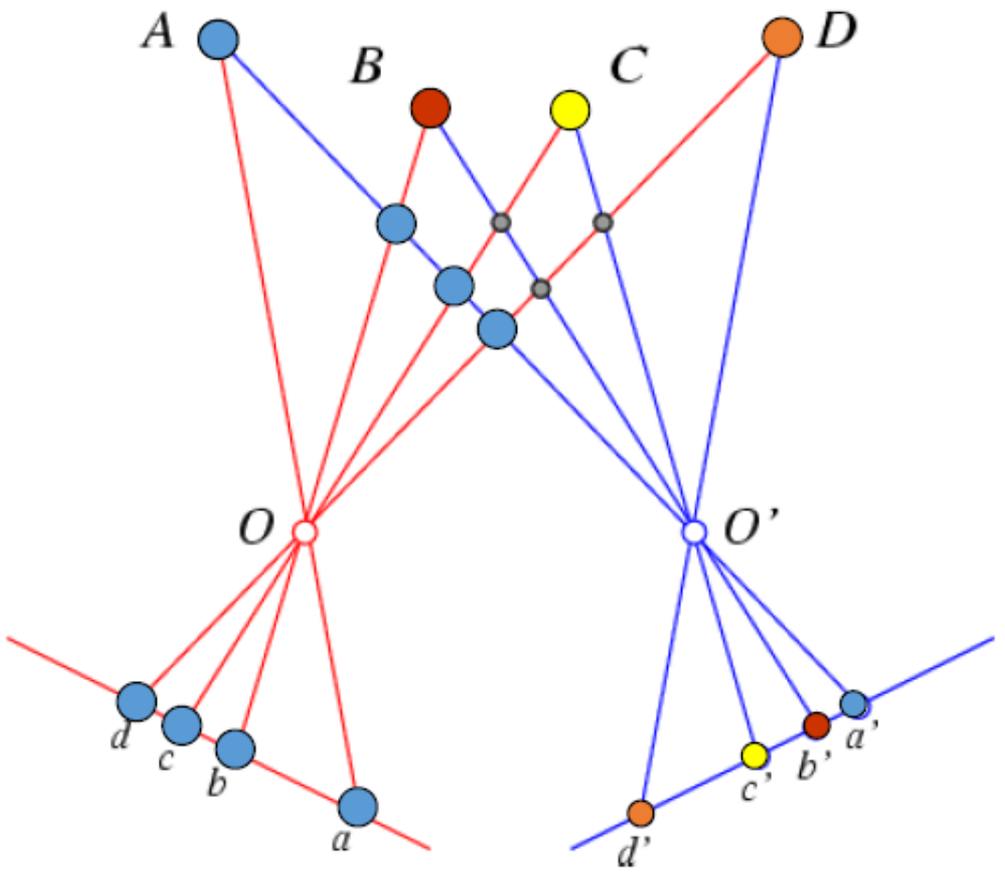
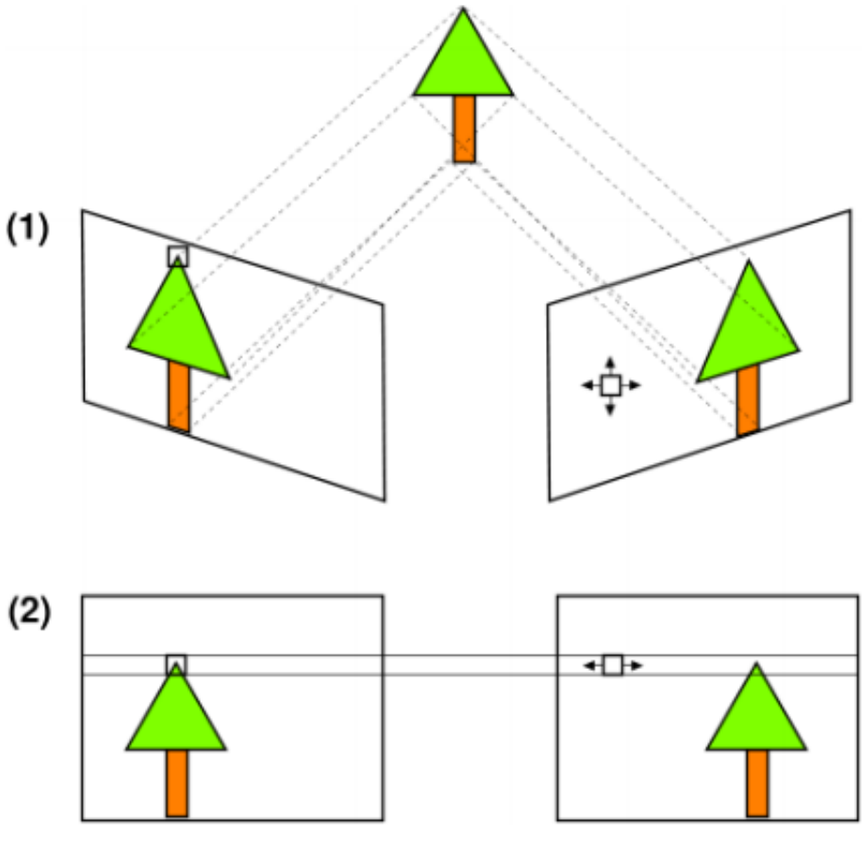
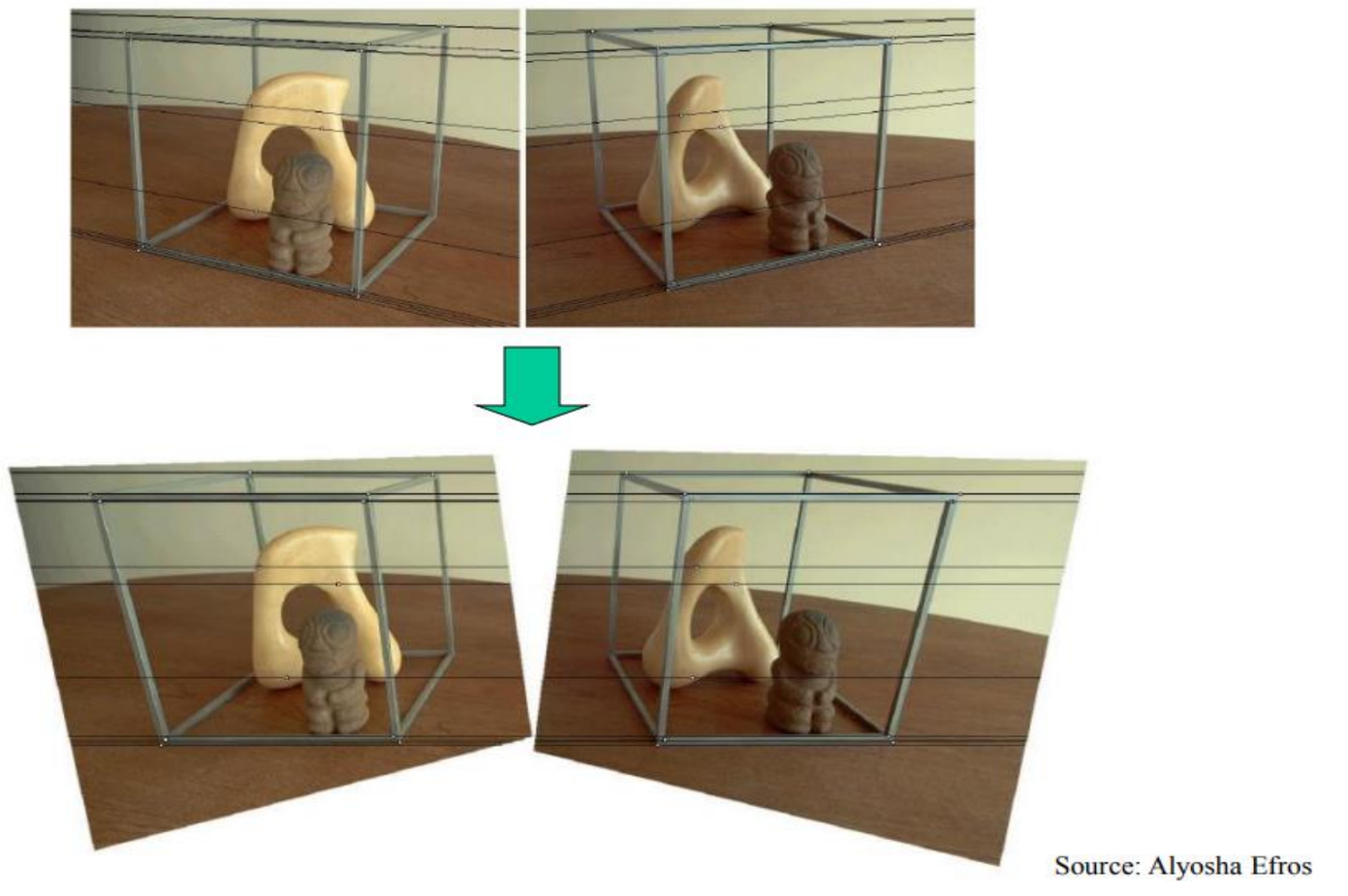


Image rectification

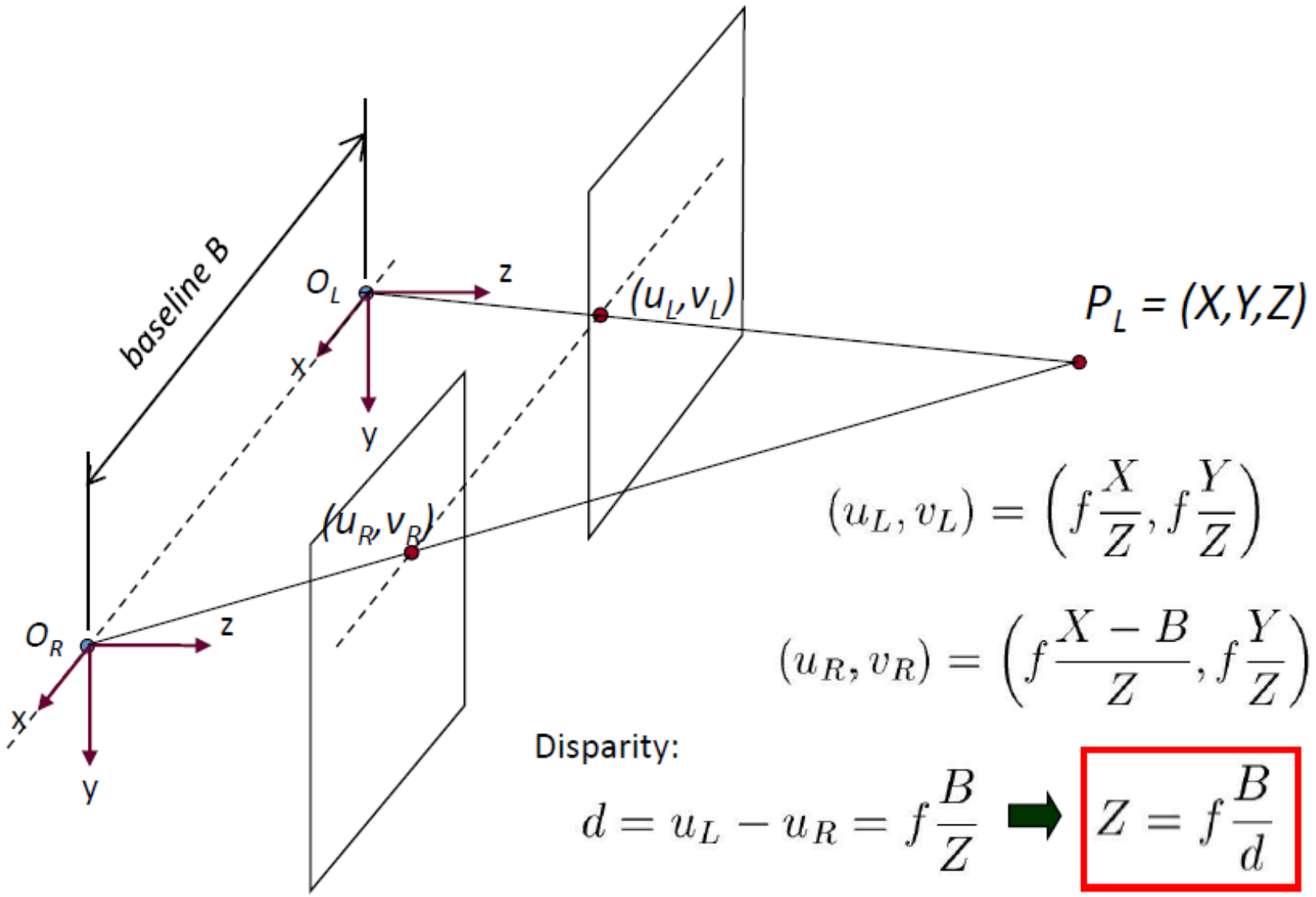
- If the two cameras are aligned to be coplanar, the search is simplified to one dimension
  - A horizontal line parallel to the baseline between the cameras





Source: Alyosha Efros

Depth estimation with rectified images



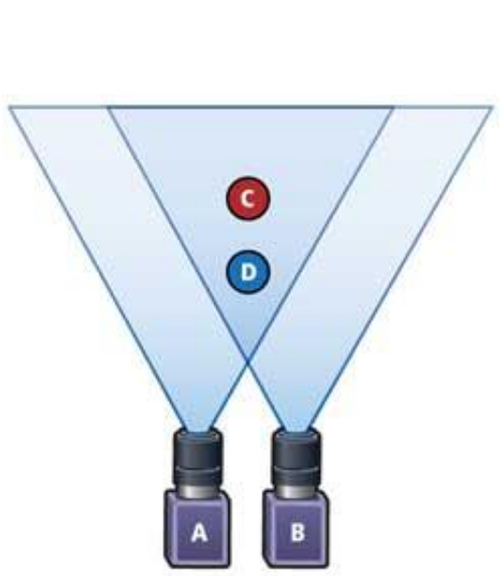
$$(u_L, v_L) = \left(f\frac{X}{Z}, f\frac{Y}{Z}\right)$$

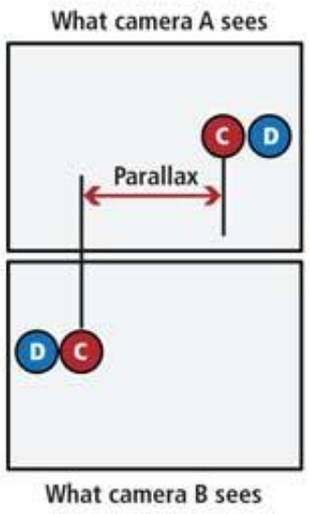
$$(u_R, v_R) = \left(f\frac{X-B}{Z}, f\frac{Y}{Z}\right)$$

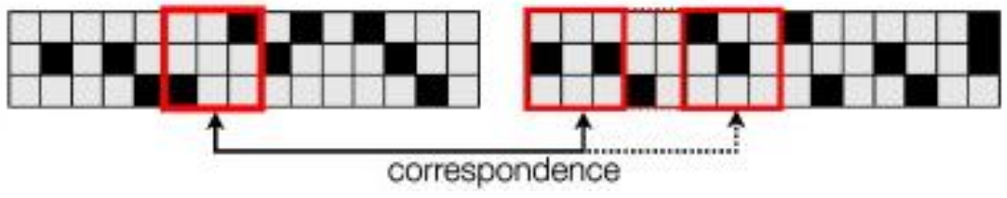
Disparity:

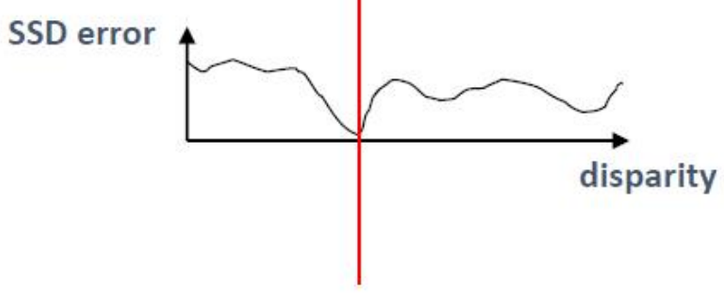
$$d = u_L - u_R = f\frac{B}{Z} \Rightarrow \boxed{Z = f\frac{B}{d}}$$

Similarity measure

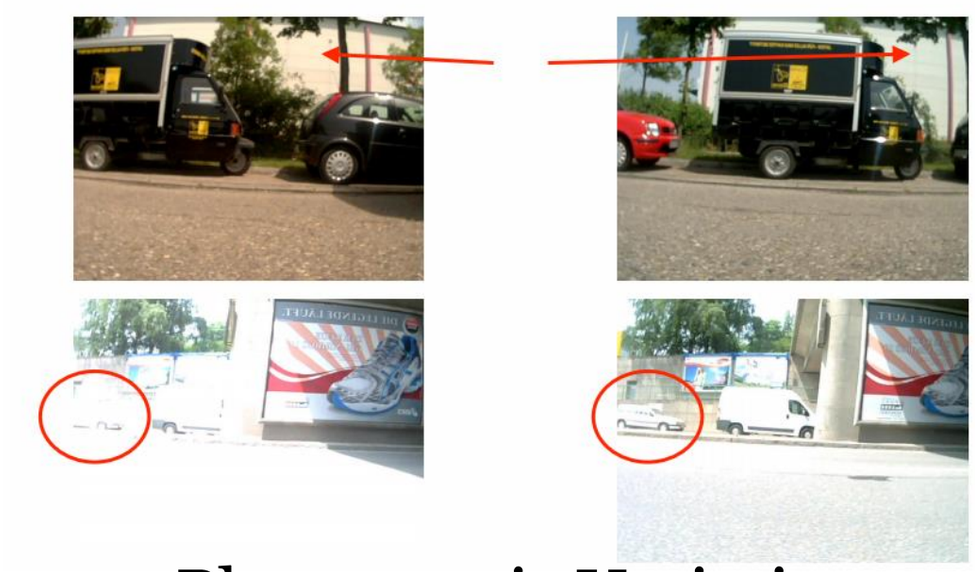








Challenges for stereo matching



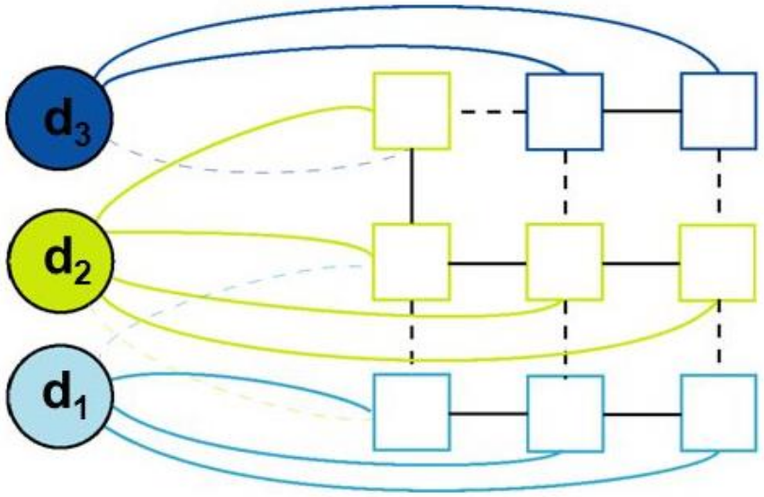
Photometric Variations

Specularities

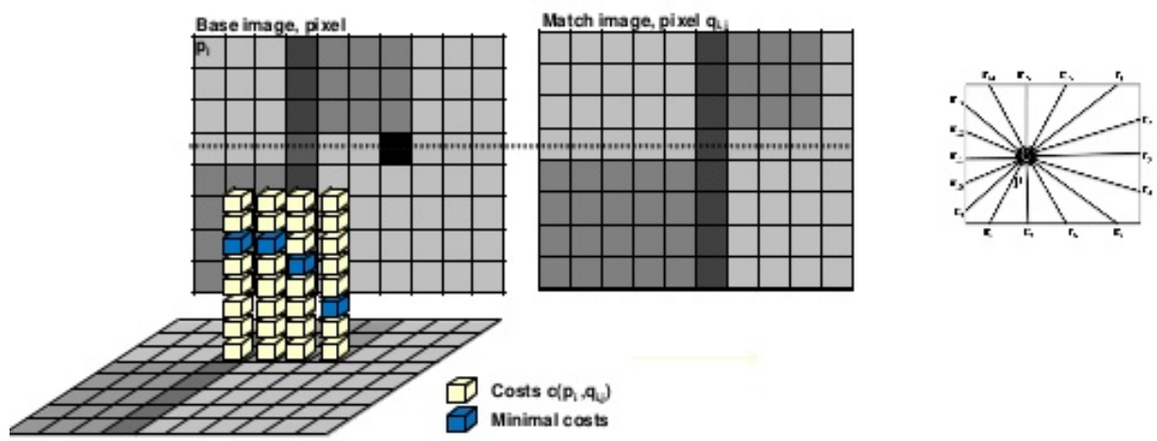
Occlusions

Transparency

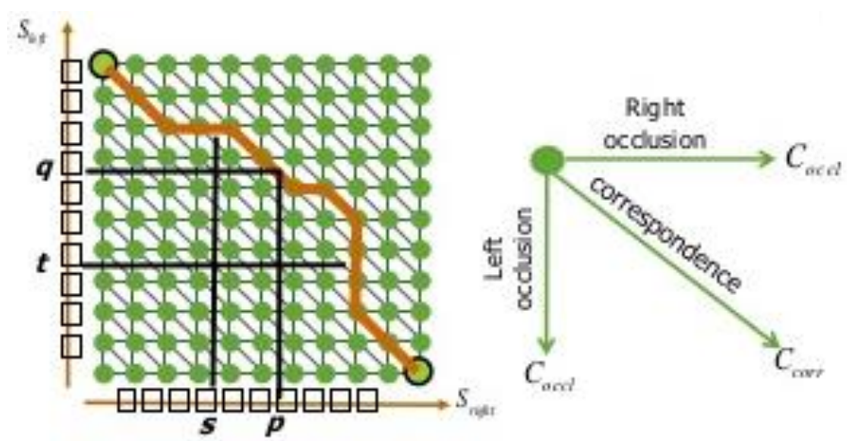
Stereo matching with global optimization



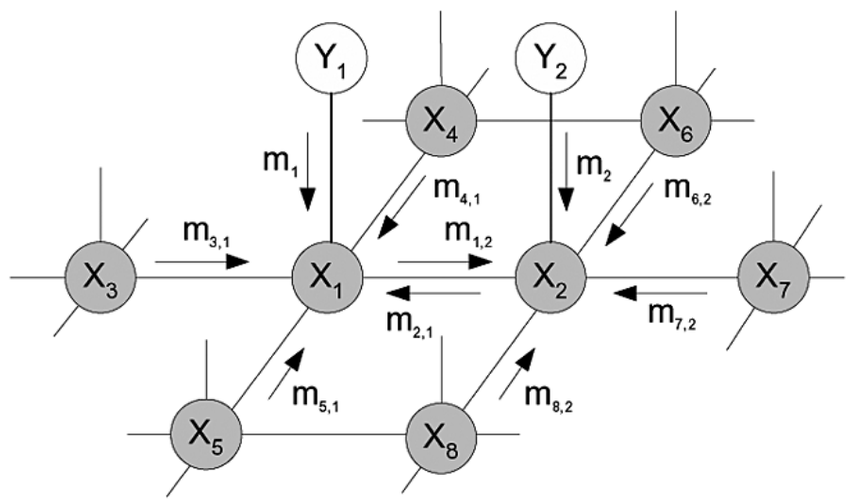
Graph cuts



Semi-Global Matching



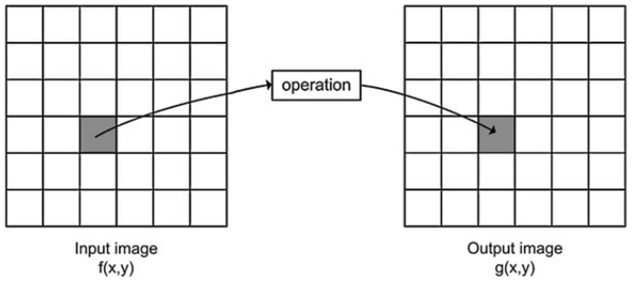
Dynamic programming

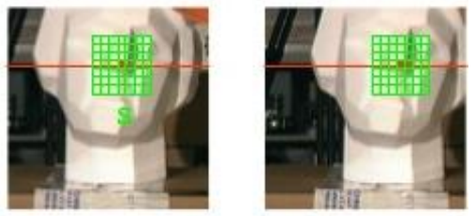


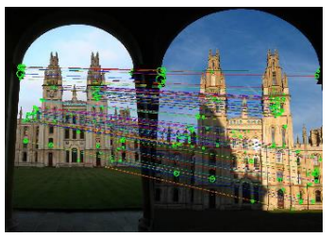
Belief Propagation

Stereo matching results

Computer Vision Categories







Low-level Computer Vision

Mid-level Computer Vision

High-level Computer Vision

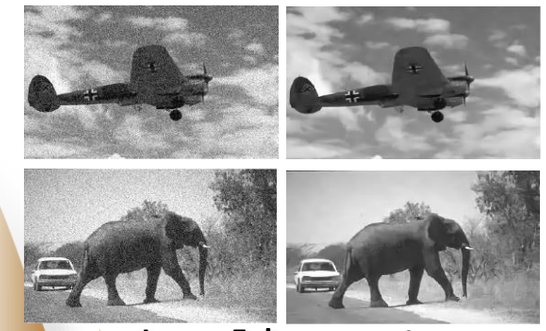
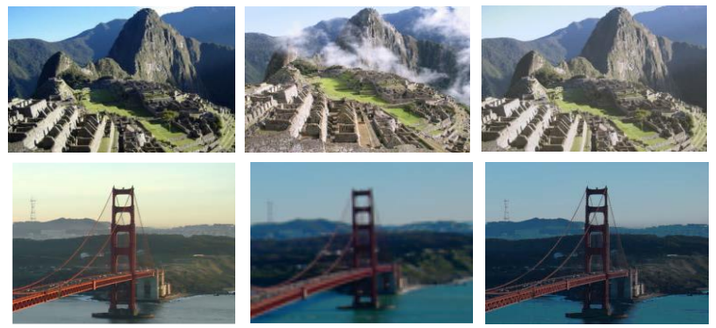
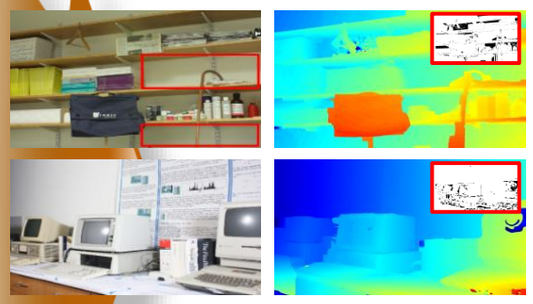


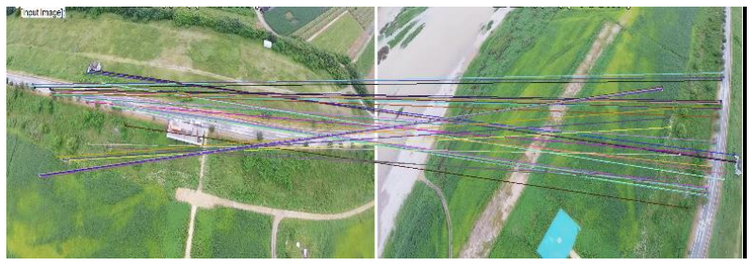
Image Enhancement



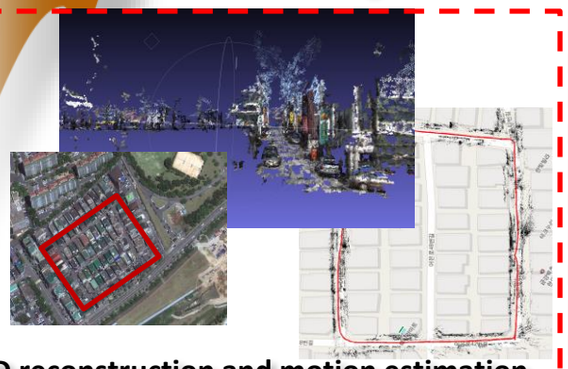
Color Transfer



Stereo Matching



Feature Extraction and Matching



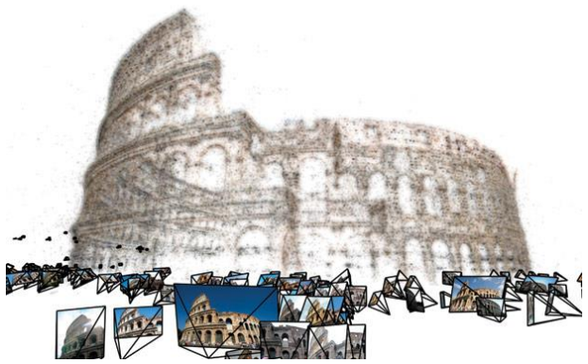
3D reconstruction and motion estimation

Object Detection, Recognition and Tracking

Main Goals of Computer Vision

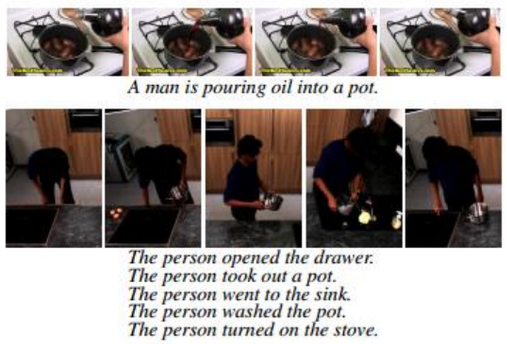
What (who)?

Object (Face) Recognition



Where?

3D reconstruction
Pose estimation

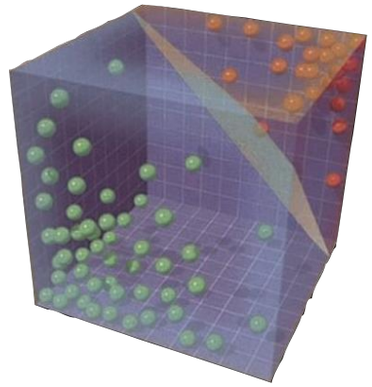


How?

Video Captioning

typical perception pipeline

representation

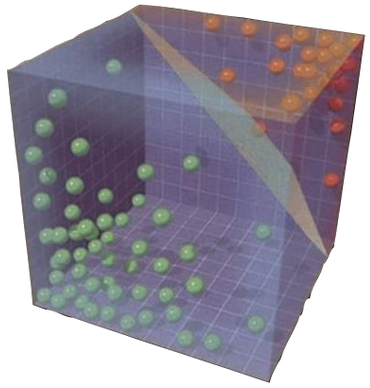


‘fancy math’

output

typical perception pipeline

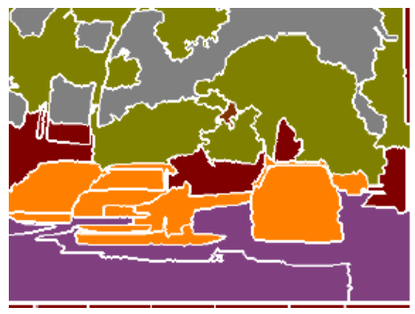
representation



‘fancy math’

output

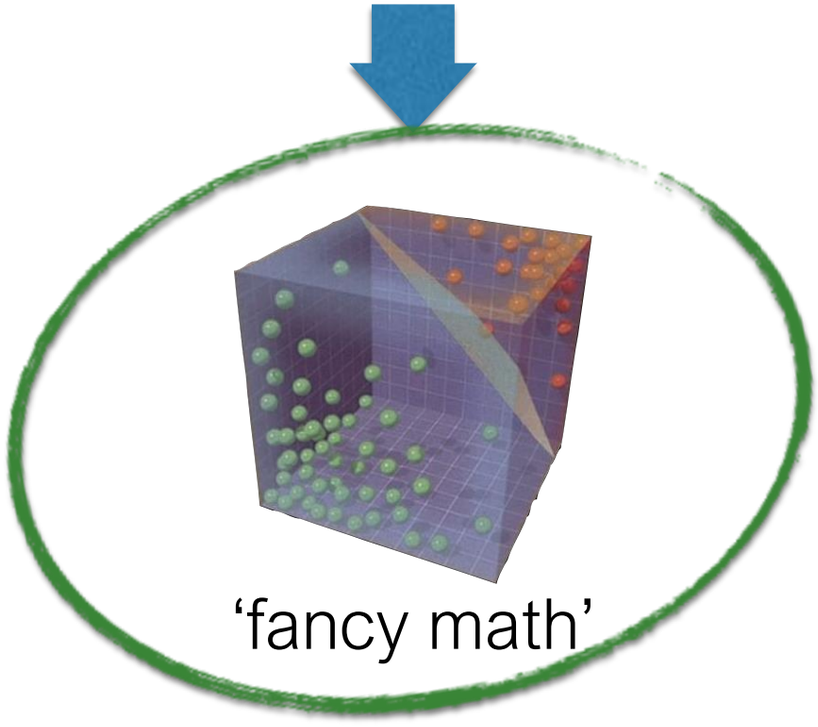
what should we look at?
(image features)



what can we understand?
(semantic segmentation)

typical perception pipeline

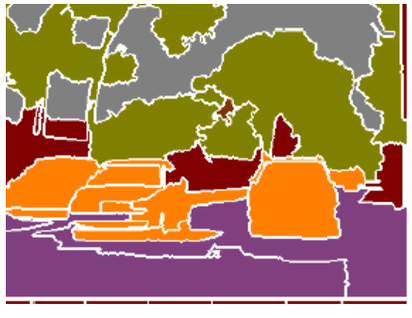
representation



easy to get lost in the techniques

output

what should we look at?
(image features)



what can we understand?
(semantic segmentation)

typical perception pipeline

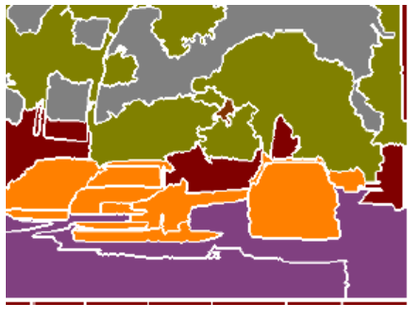
representation

The parts that we are most interested in

‘fancy math’

output

what should we look at?
(image features)



what can we understand?
(semantic segmentation)

Important note:

In general, computer vision does not work

Important note:

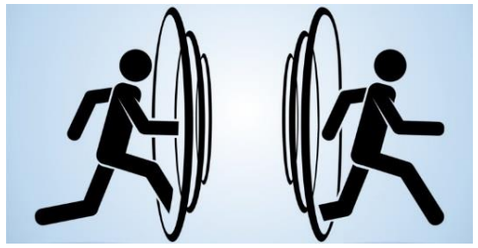
In general, computer vision does not work

(except in certain situations/conditions)

Applications of computer vision

Augmented Reality

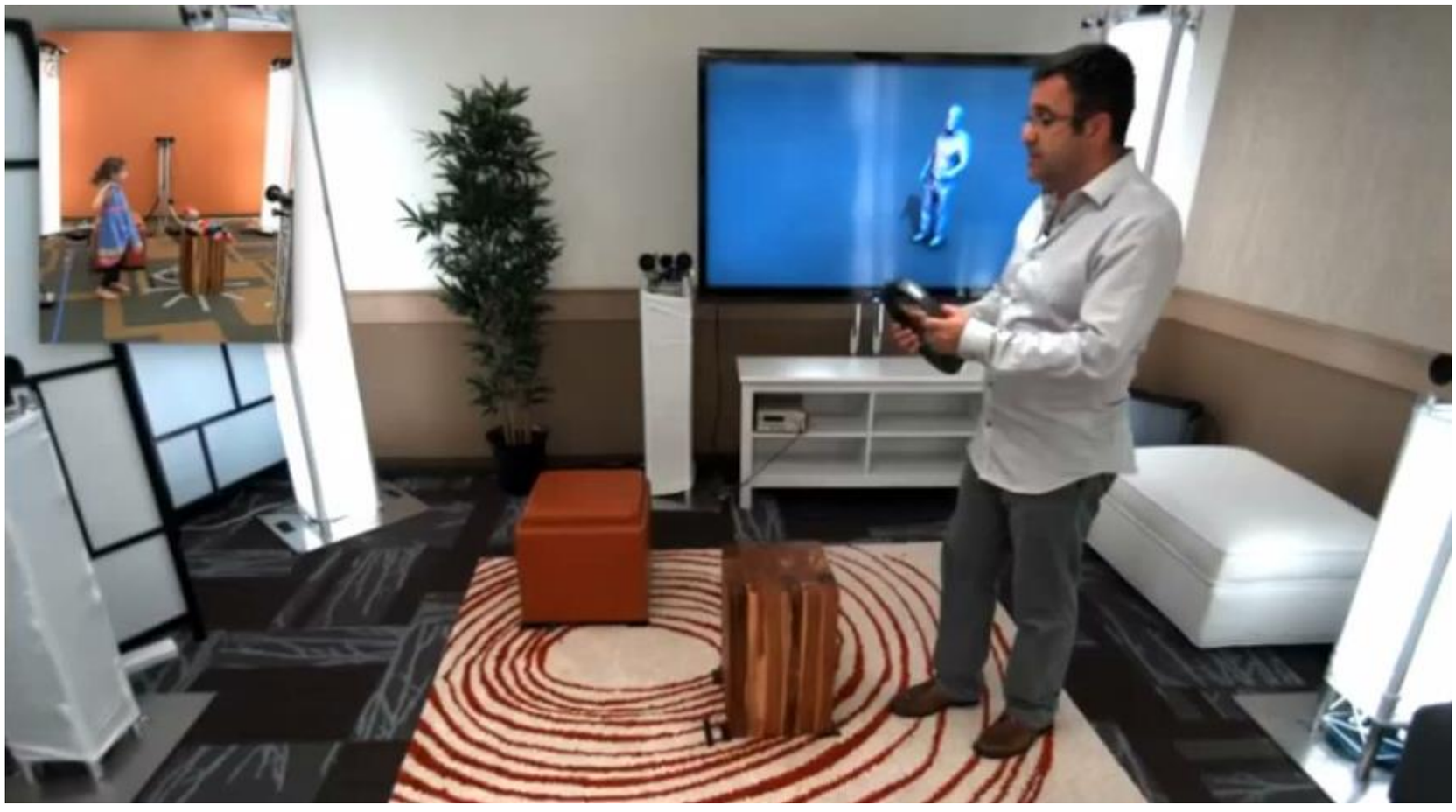
Holopotation



Teleportation

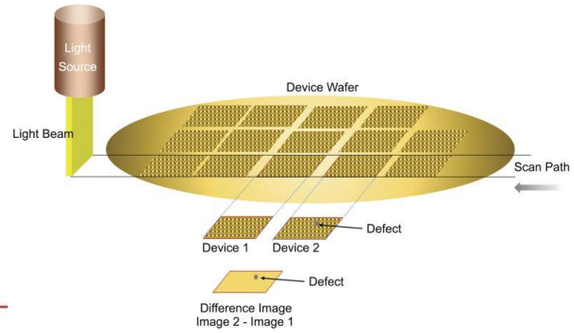
+

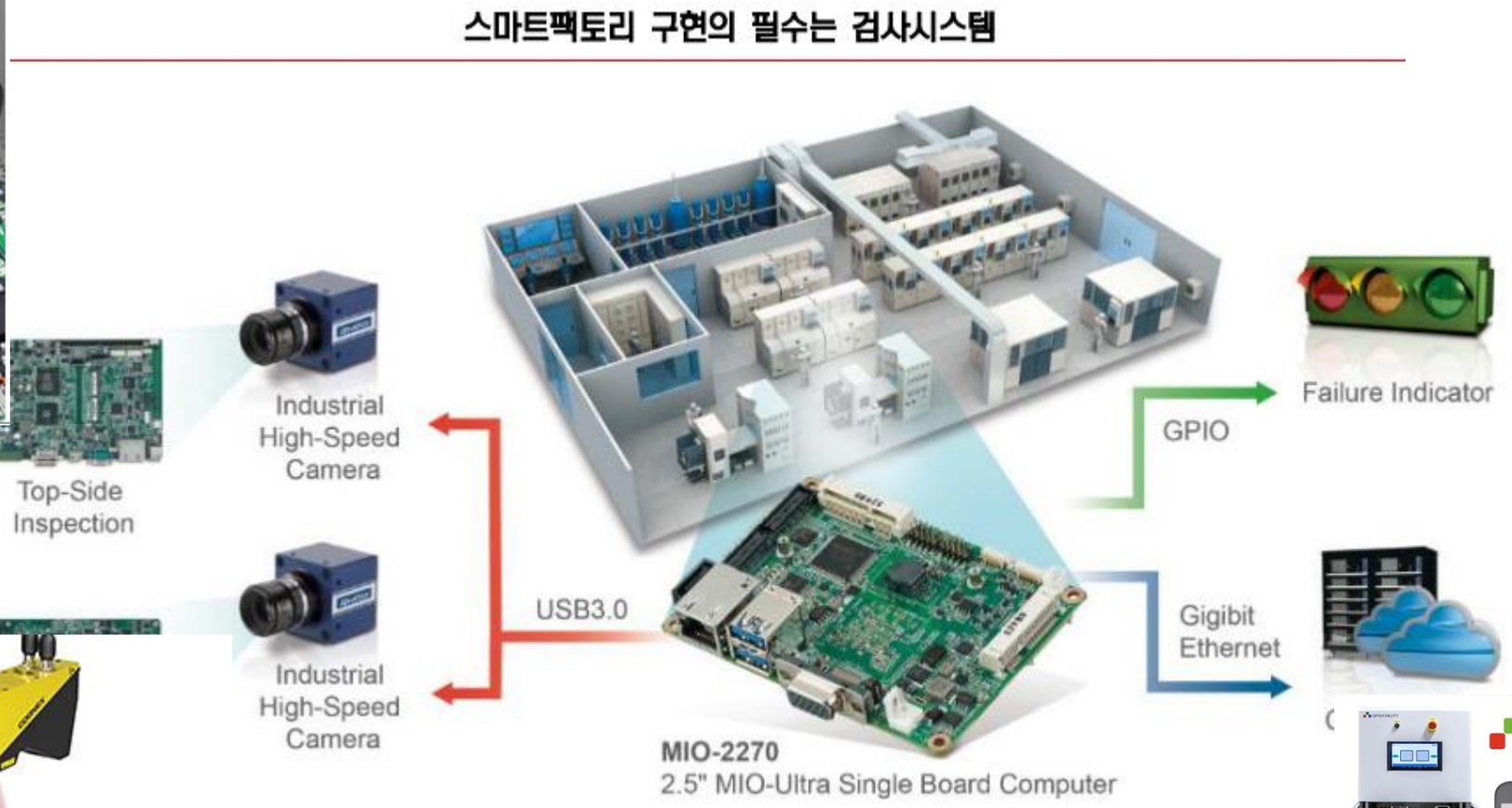
Microsoft Hololens

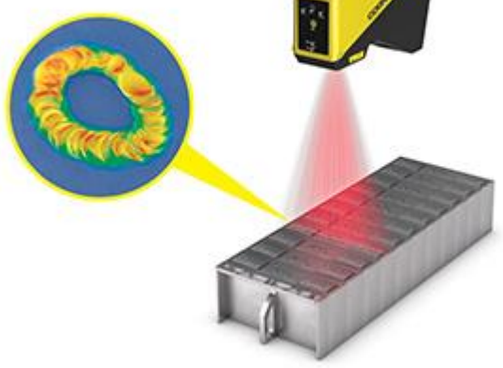


Machine vision

Automated visual inspection

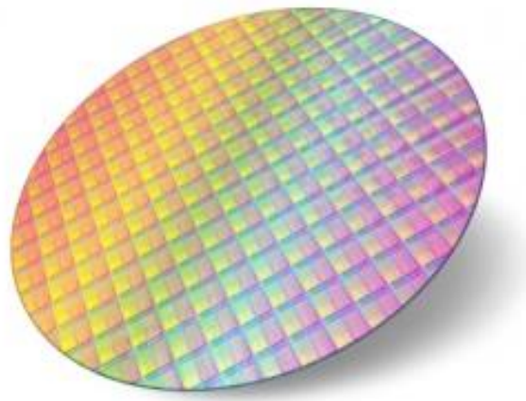






Machine vision

Automated visual inspection

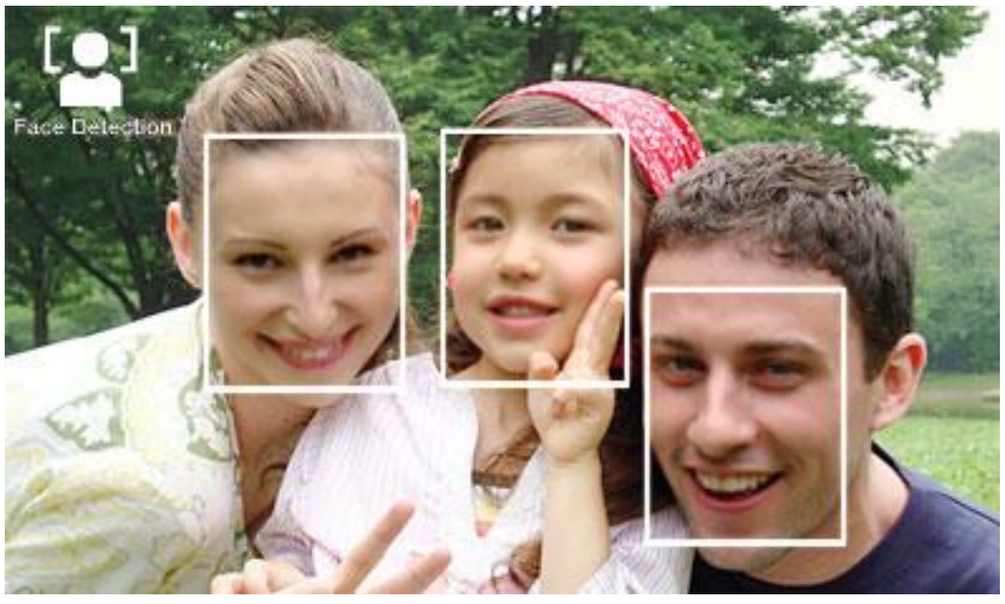


Amazon Go

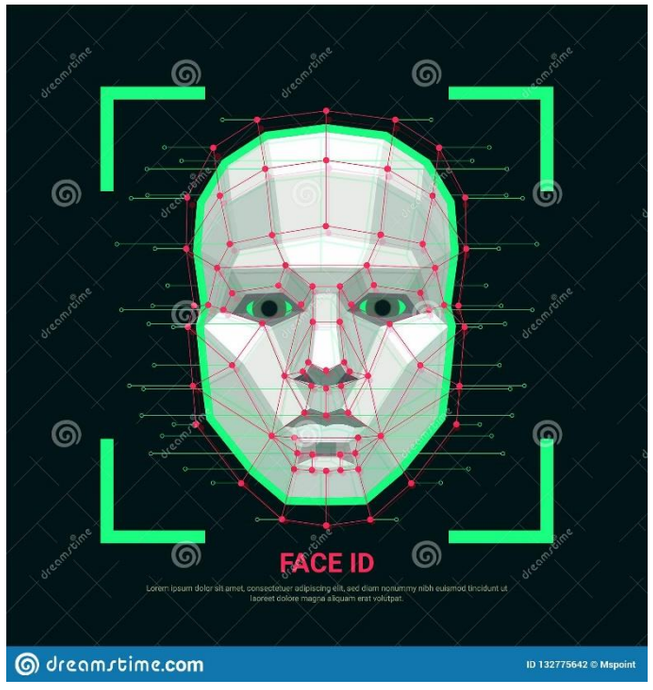
Toshiba Tech IS-910T 2013

DataLogic LaneHawk LH4000 2012

Face Recognition



Sony Cyber-shot

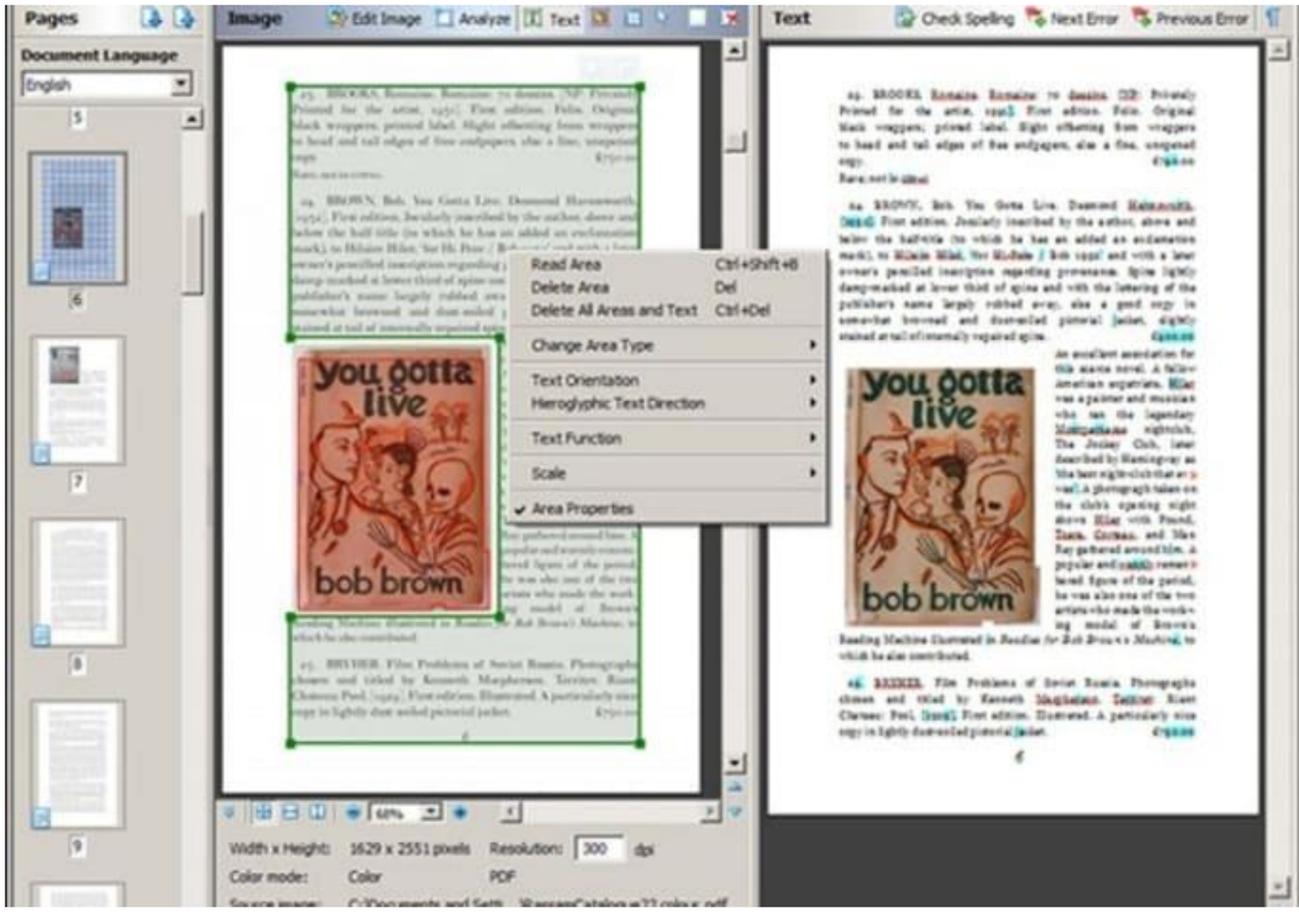


Word Lens

Word Lens

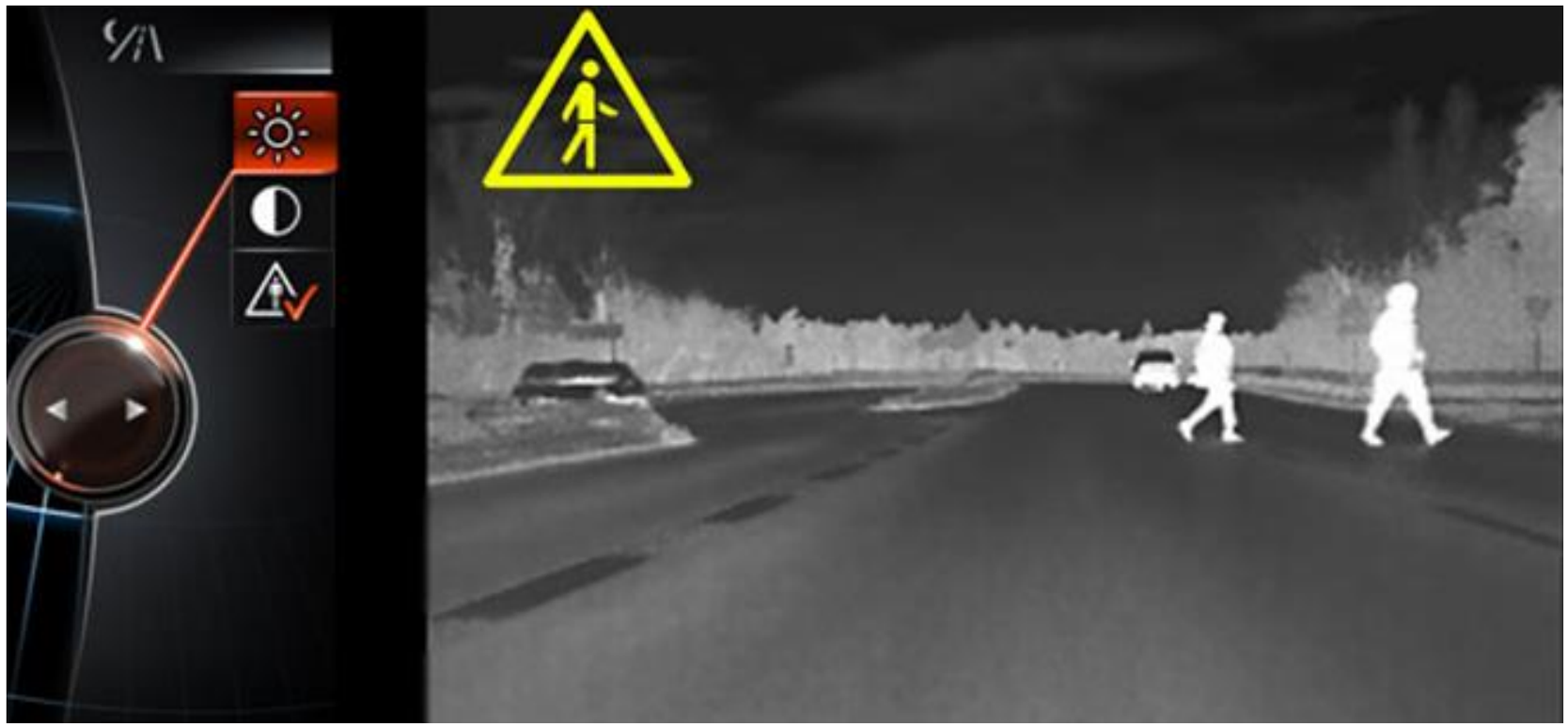
www.QuestVisual.com

Object Character Recognition



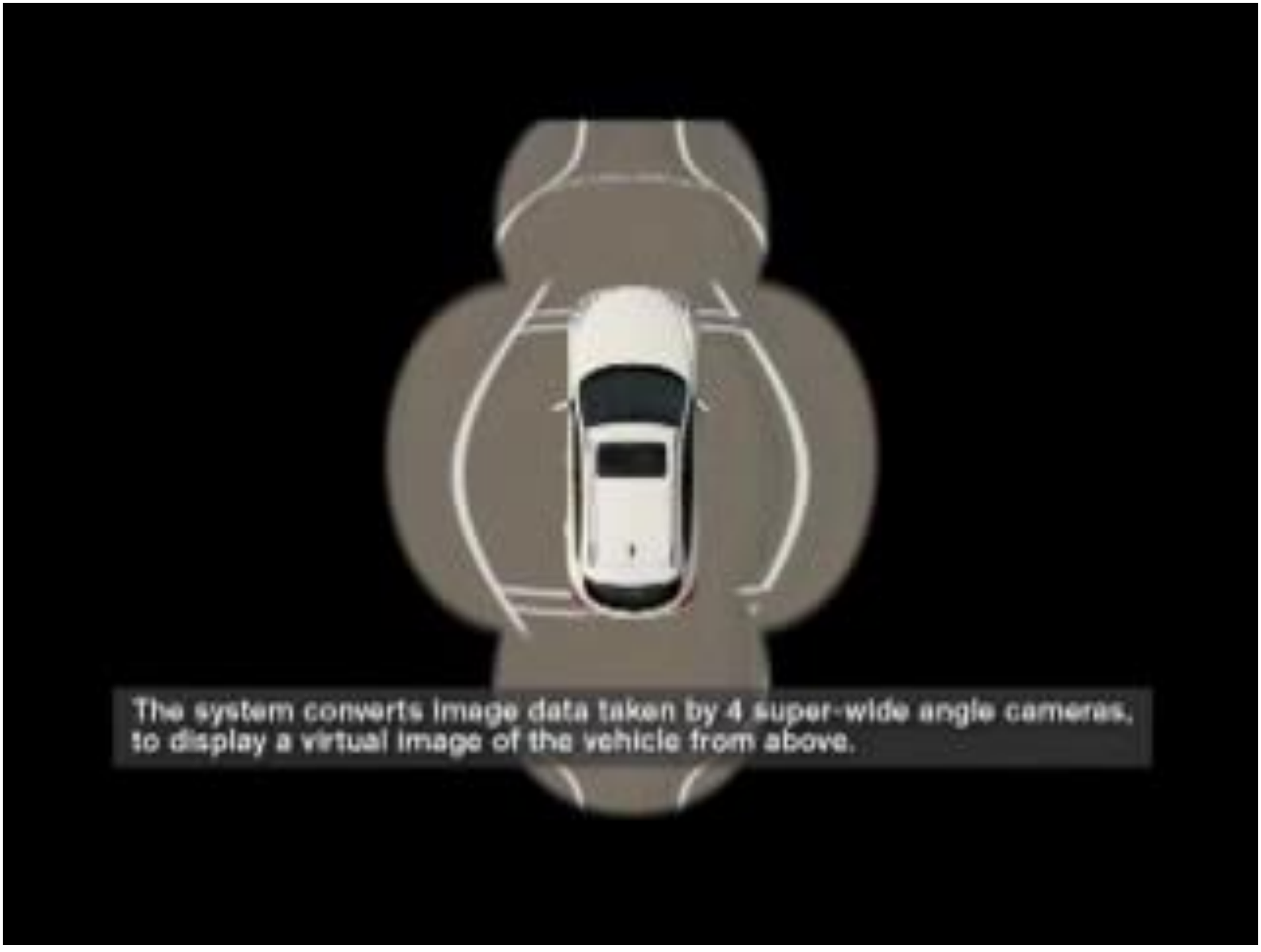
BMW 5 series

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.

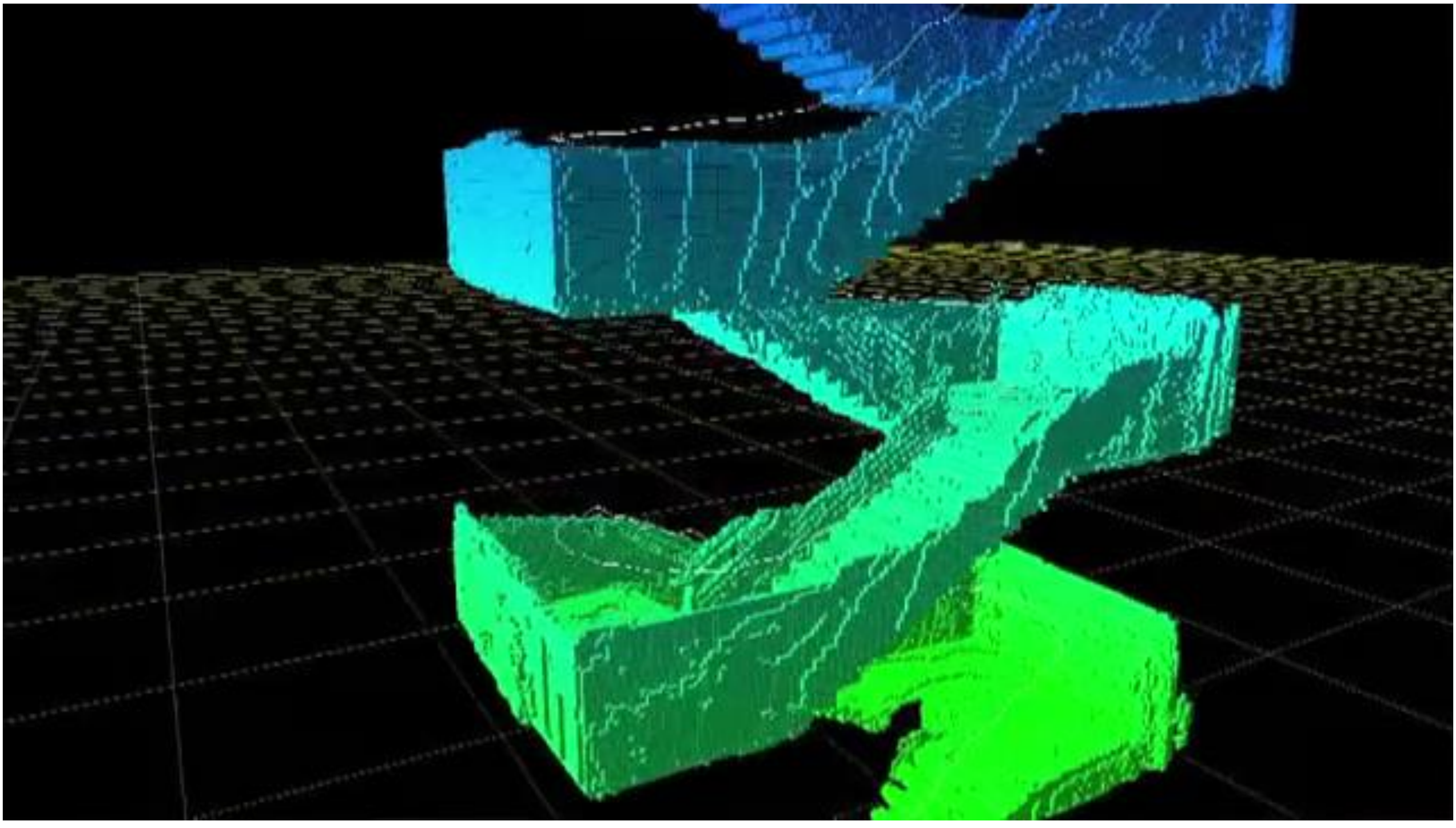
2015

Vision in Cars

Image stitching

Photosynth

Tango



Virtual Fitting

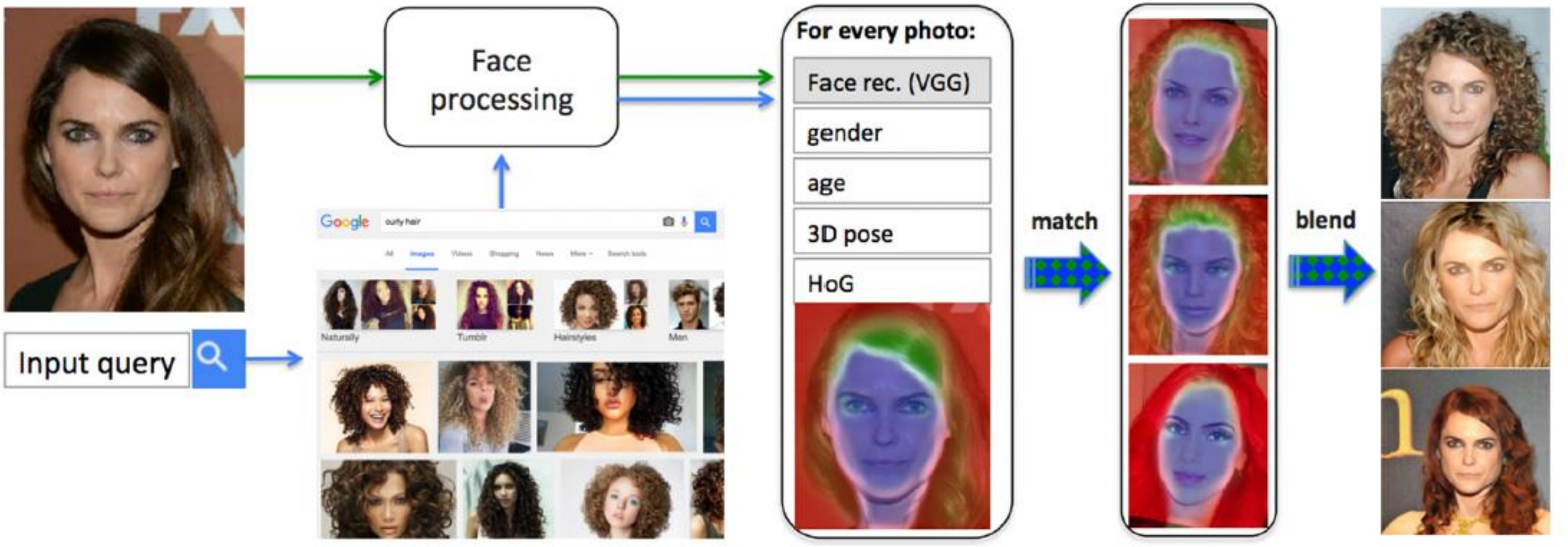
2015

Computer Vision for VR

DeepFake

DeepFake


FakeApp
2.2


Face processing
Input query
Google
curly hair
Naturally
Tumblr
Hairstyles
Men
For every photo:
Face rec. (VGG)
gender
age
3D pose
HoG
match
blend

Course logistics

Topics to be covered

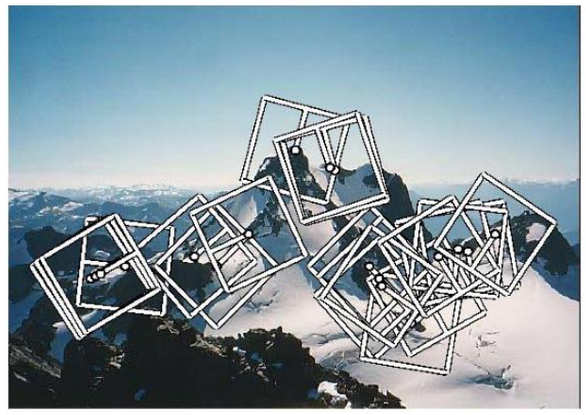
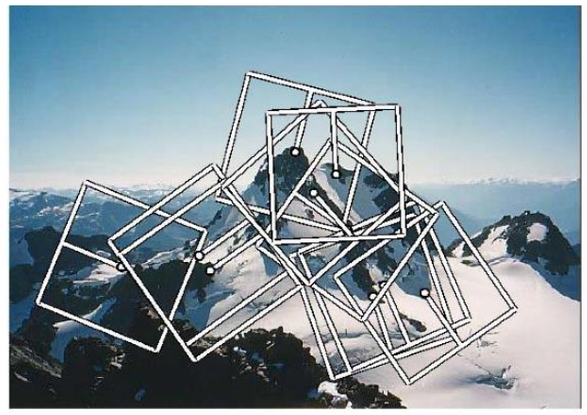
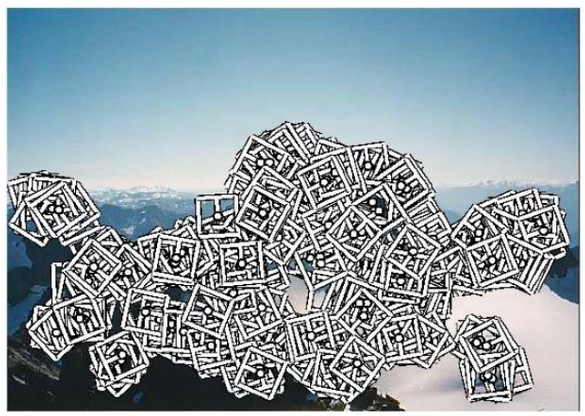
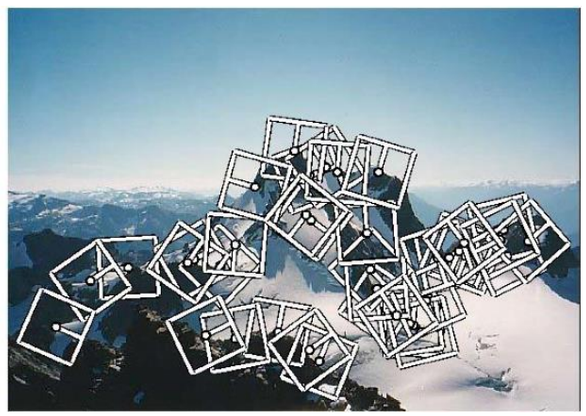
Image processing:

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

Topics to be covered

Feature detection and correspondences:

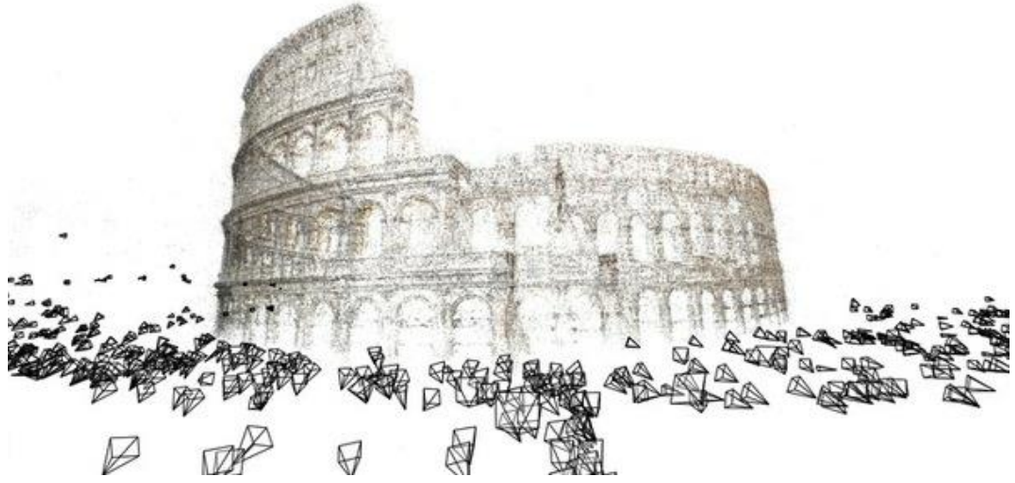
- Corner detection.
- SIFT et al.
- Feature descriptors.
- RANSAC.

Topics to be covered

Transformations and geometry:

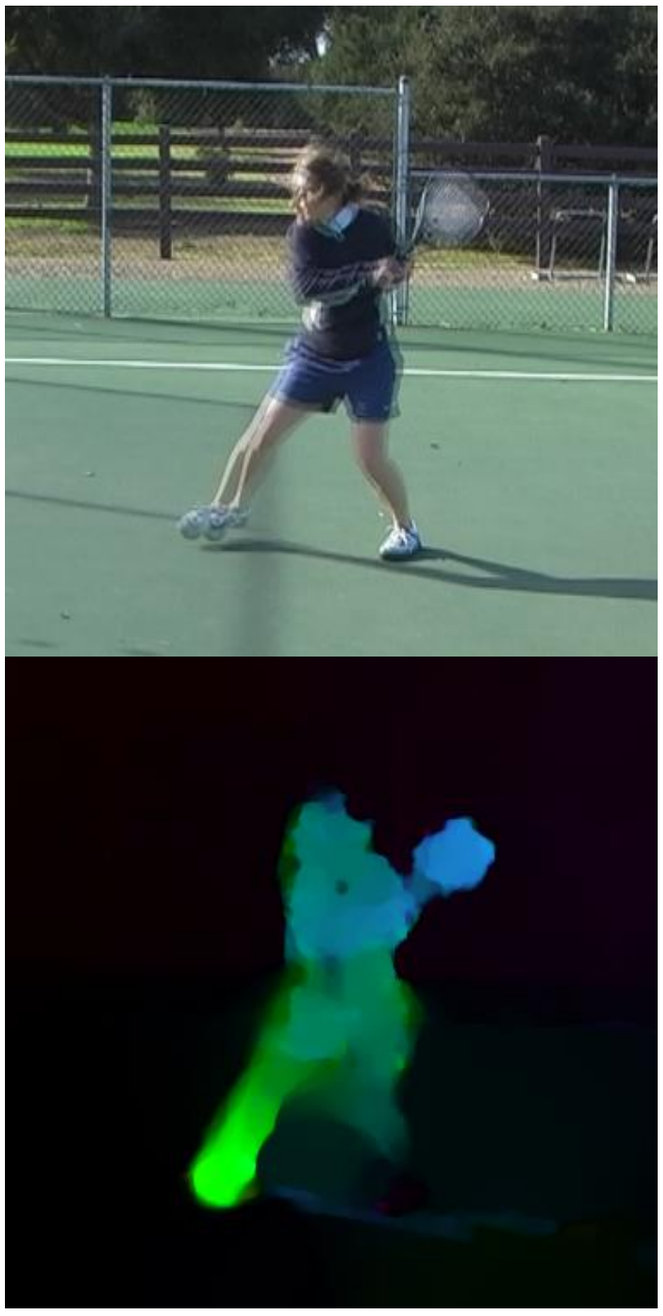
- Homographies and image alignment.
- Camera models.
- Fundamental matrix.
- Epipolar geometry and stereo.
- Structure from motion.



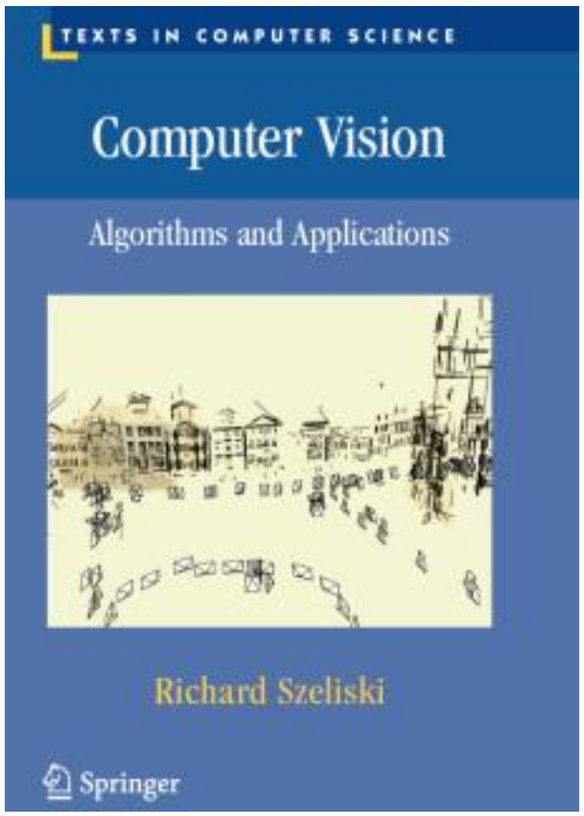
Topics to be covered

Dealing with motion:

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



Reference



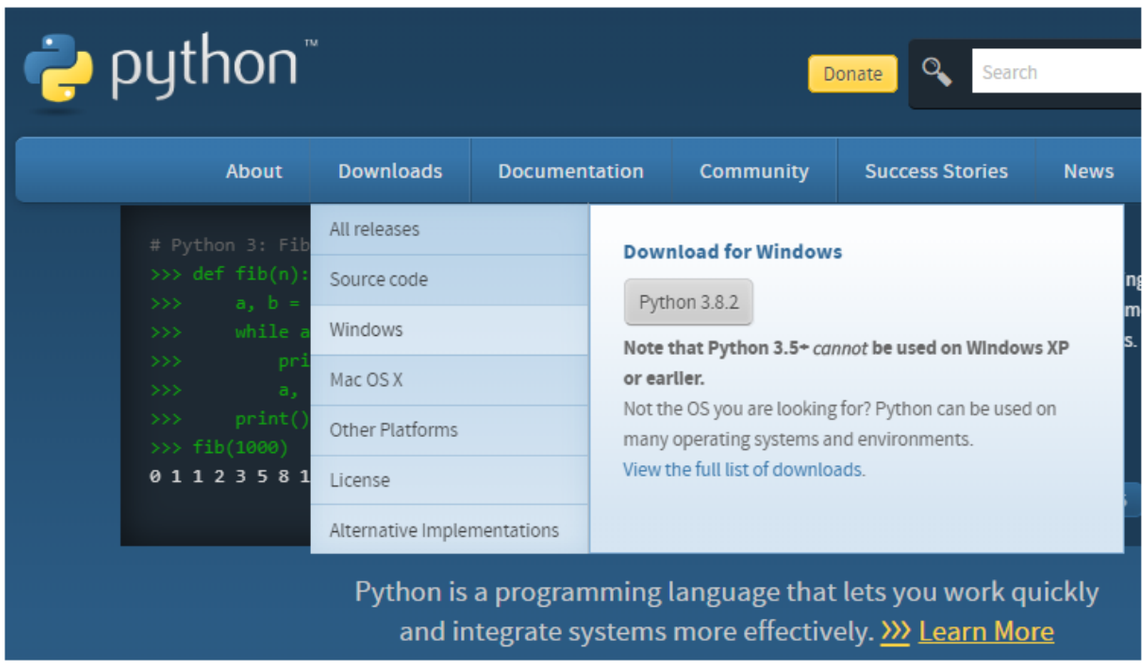
PDF online

http://szeliski.org/Book/

Python, OpenCV 설치

https://www.python.org/

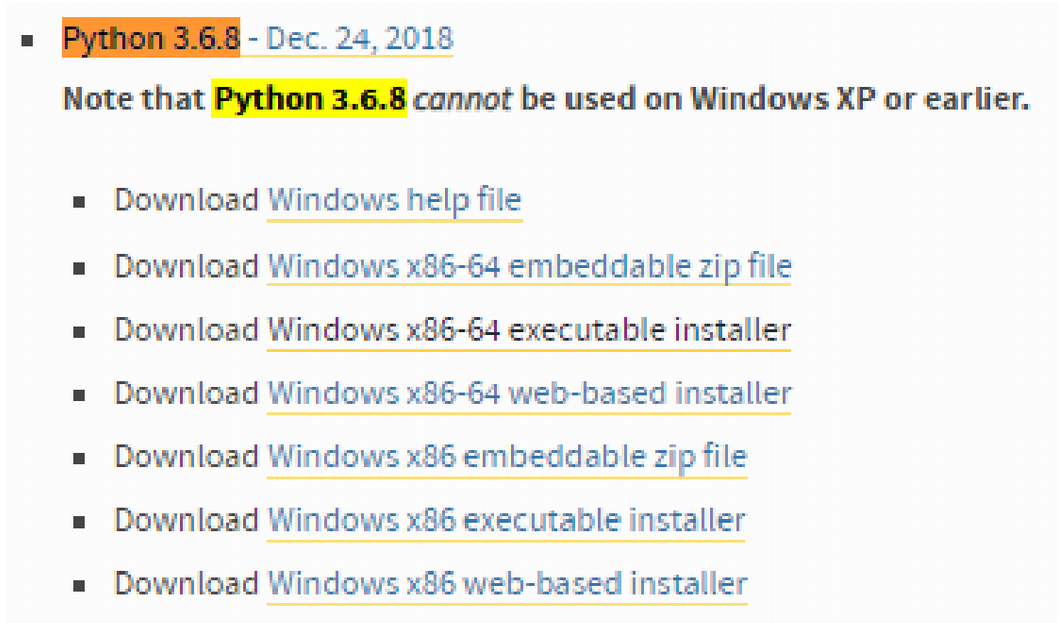
- 링크를 통해 파이썬 공식 홈페이지로 들어갑니다.



파이썬 공식 홈페이지

Python, OpenCV 설치

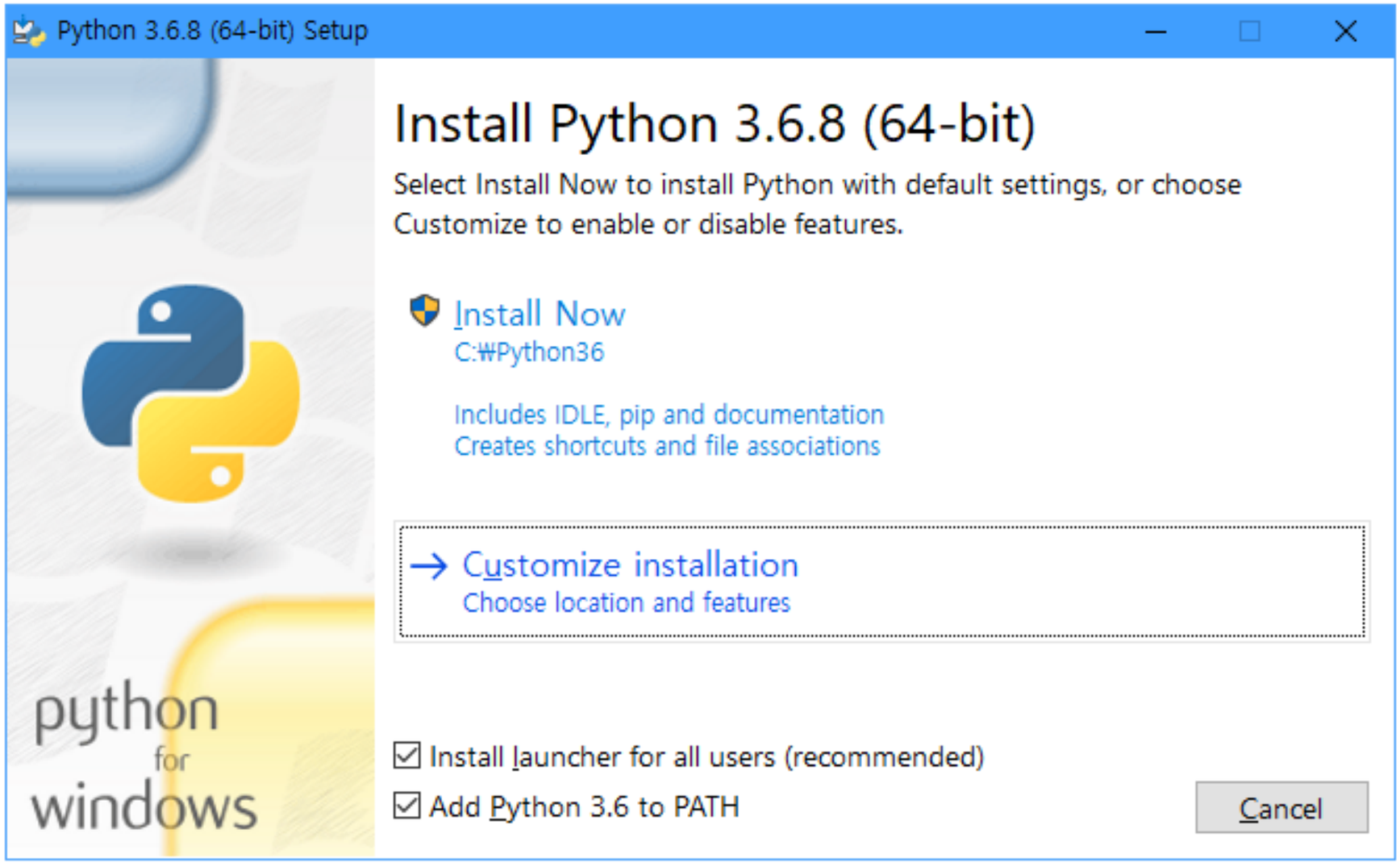
- **Downloads - Windows** 클릭



- **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 되긴할겁니다.)
```

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

- pip install opencv-contrib-python==3.3.1.11