Computer Vision Course

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Sumary

- Motivation
- Objectives
- Methods
- Grading
- Bibliography

Motivation: what is Computer Vision

148	123	52	107	123	162	172	123	64	89 ···
147	130	92	95	98	130	171	155	169	163 ···
141	118	121	148	117	107	144	137	136	134 ···
82	106	93	172	149	131	138	114	113	129 ···
57	101	72	54	109	111	104	135	106	125 ···
138	135	114	82	121	110	34	76	101	111 ···
138	102	128	159	168	147	116	129	124	117 ···
113	89	89	109	106	126	114	150	164	145 ···
120	121	123	87	85	70	119	64	79	127 ···
145	141	143	134	111	124	117	113	64	112 ···
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

$I(u, v)$

$F(x, y)$

Motivation: what is Computer Vision

- Every Picture tells a story

Goal of CV:

- write computer programs that can understand something in the images

CV (Computer Vision)

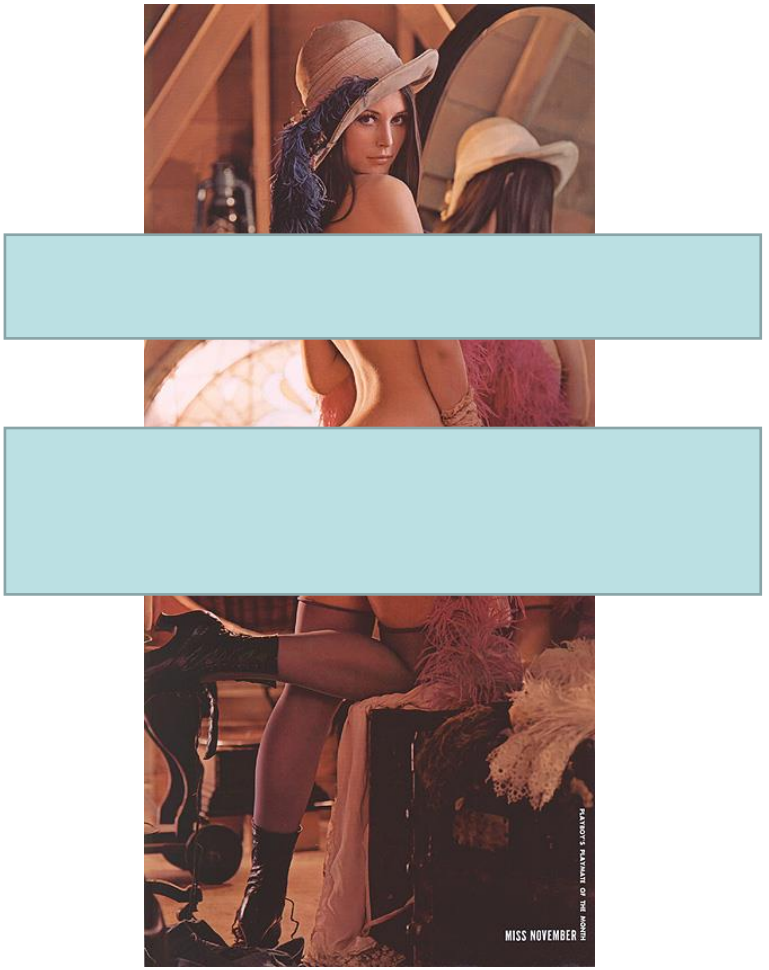
- Image In -> Meaning Out

IP (Image Processing)

- Image In > Image Out

Motivation

- A picture is worth a million words



http://www.lenna.org/l

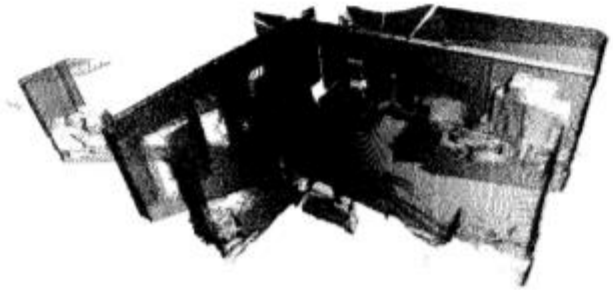
Motivation

- Goal of Computer Vision:
  - Perceive the “story” behind the picture.
  - Compute properties of the world: 3D shape, names of people or objects, what happened?

- Frustrating:
  - Computers still far from humans that are much better at hard things.
  - Rapid progress : what is considered hard keeps changing.

Motivation

- Frustrating
  - depth range and image registration



Range 3D image

+

Digital Image

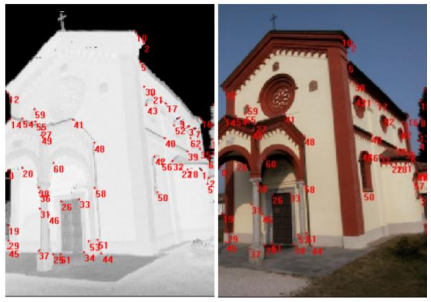
=

Nice 3D Model

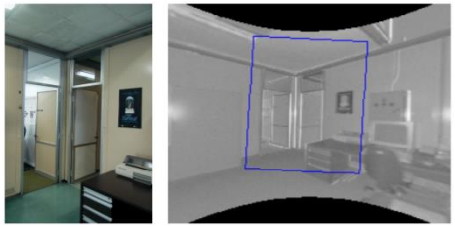
Motivation

- Frustrating
  - depth range and image registration

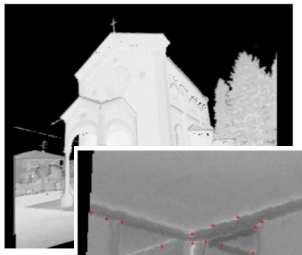
Need to find correspondences



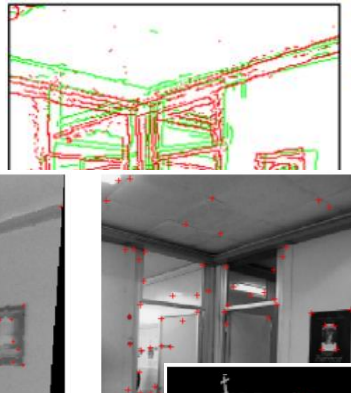
Distance transform

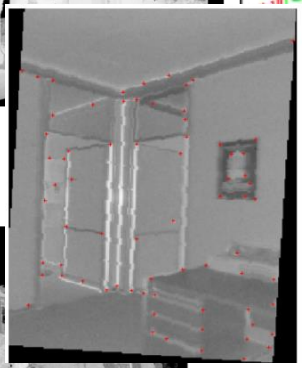


Manual Input

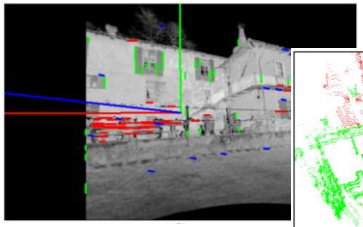


Conversion from spherical

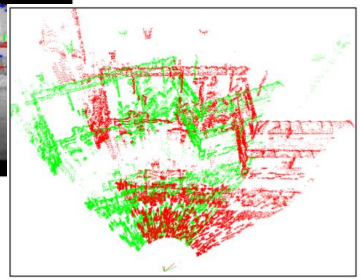




Corner detection



Vanishing point estimation



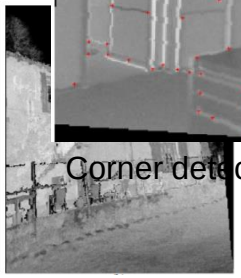
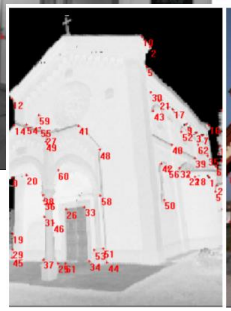
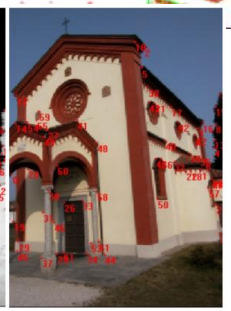


Image rotation and reprojection





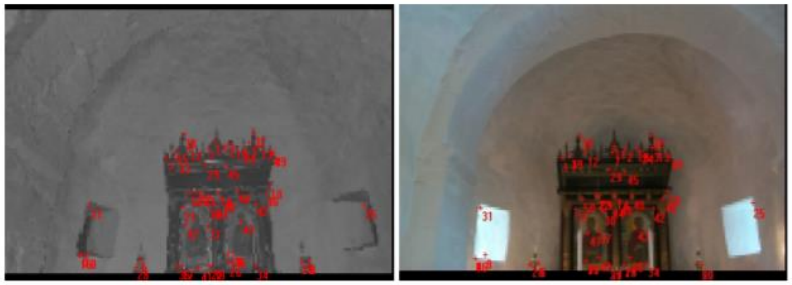
Template Matching

Motivation

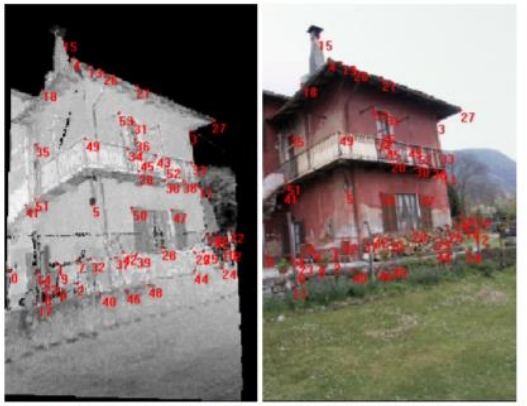
- At the end

The process still presents limitations and needs some rules during data acquisition to perform well

For this reason, a user interface gives the possibility to interact with the process in several points to check and/or guide the resizing and matching steps.



Bornholm: 51 correspondences (average distance between correspondences: 2.5 pixels)



Laveno farmhouse: 54 correspondences (average distance between correspondences: 4.3pixels)

Figure 2-21: results of the matching algorithm between resized reflectance (left) and intensity image (right)

2.5 User interaction

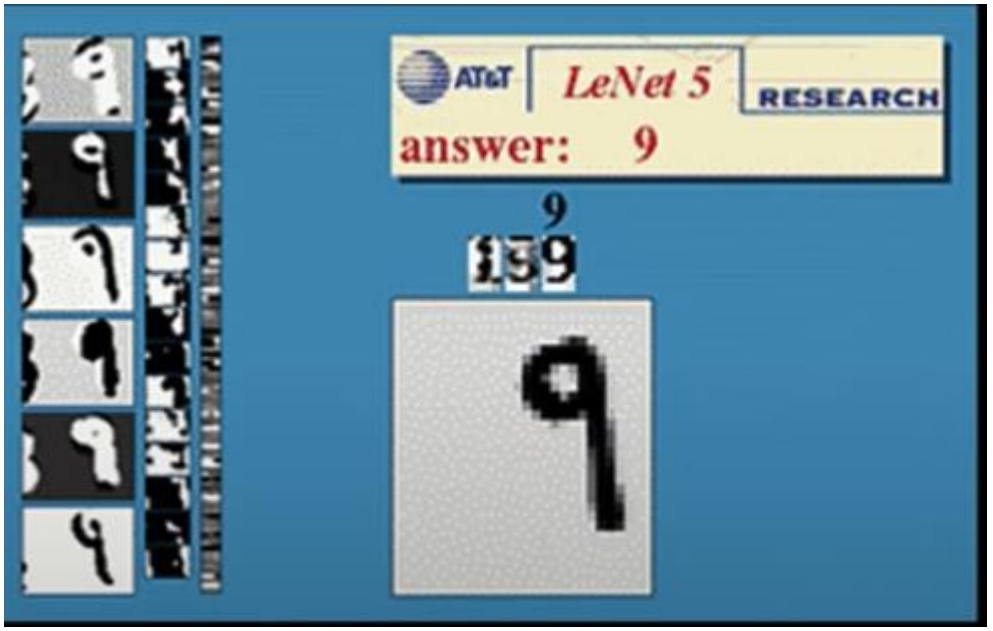
The system presented in this chapter is almost fully automatic. The only step where user-interaction is necessary is the selection of the area of interest in the reflectance image at the beginning of the resizing process (see Figure 2-9).

The process still presents limitations and needs some rules during data acquisition to perform well. The resizing algorithm performance is related to the initial similitarity between the images. It will fail with images taken from very different viewpoints. The *dfd* matching also has some limitations due to the different nature of the images. Its performance will be reduced in images with little texture information.

Computer Vision - applications

- OCR

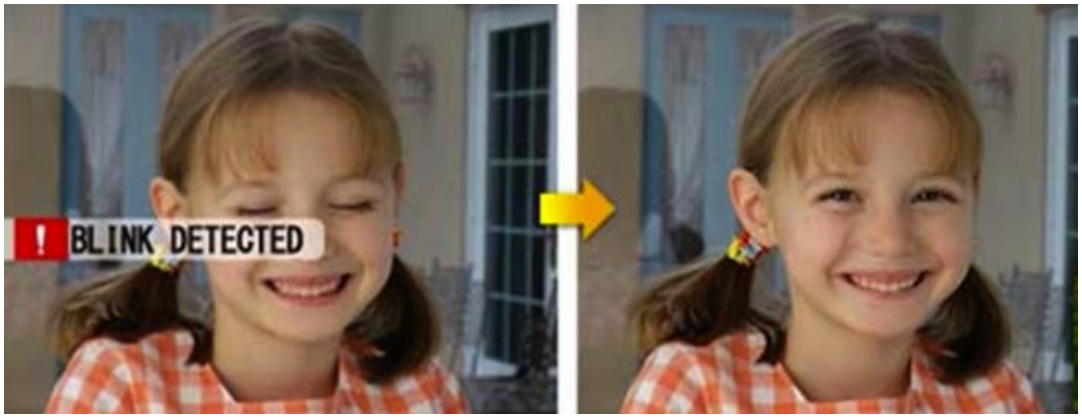
License plate detection

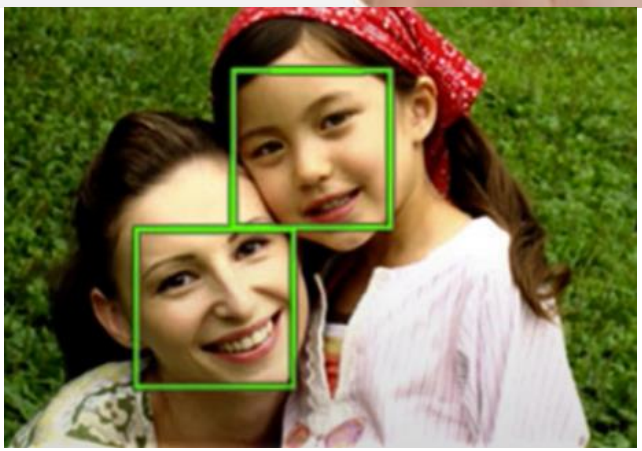


Automatic Hand-written recognition
Post office – Zip Code

Computer Vision - applications

- Face Detection / Recognition

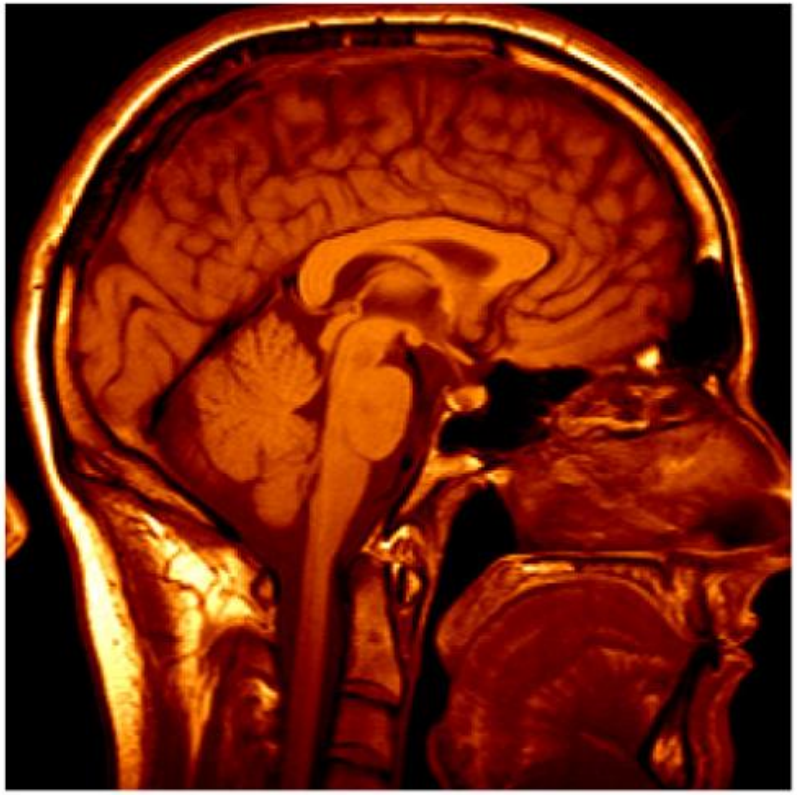




Sony Smile detection

Computer Vision - applications

- Medical Imaging

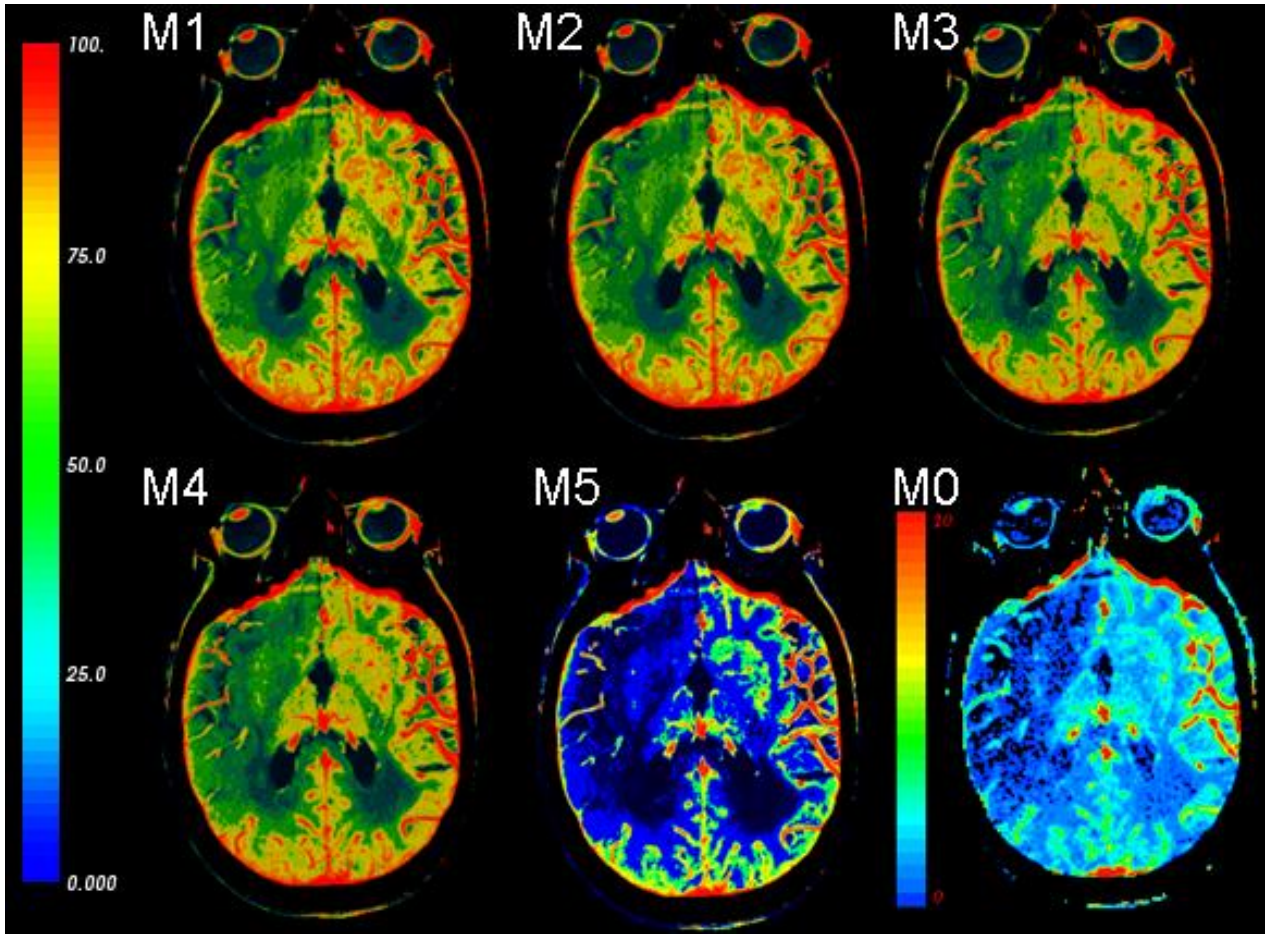


3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

Computer Vision - applications

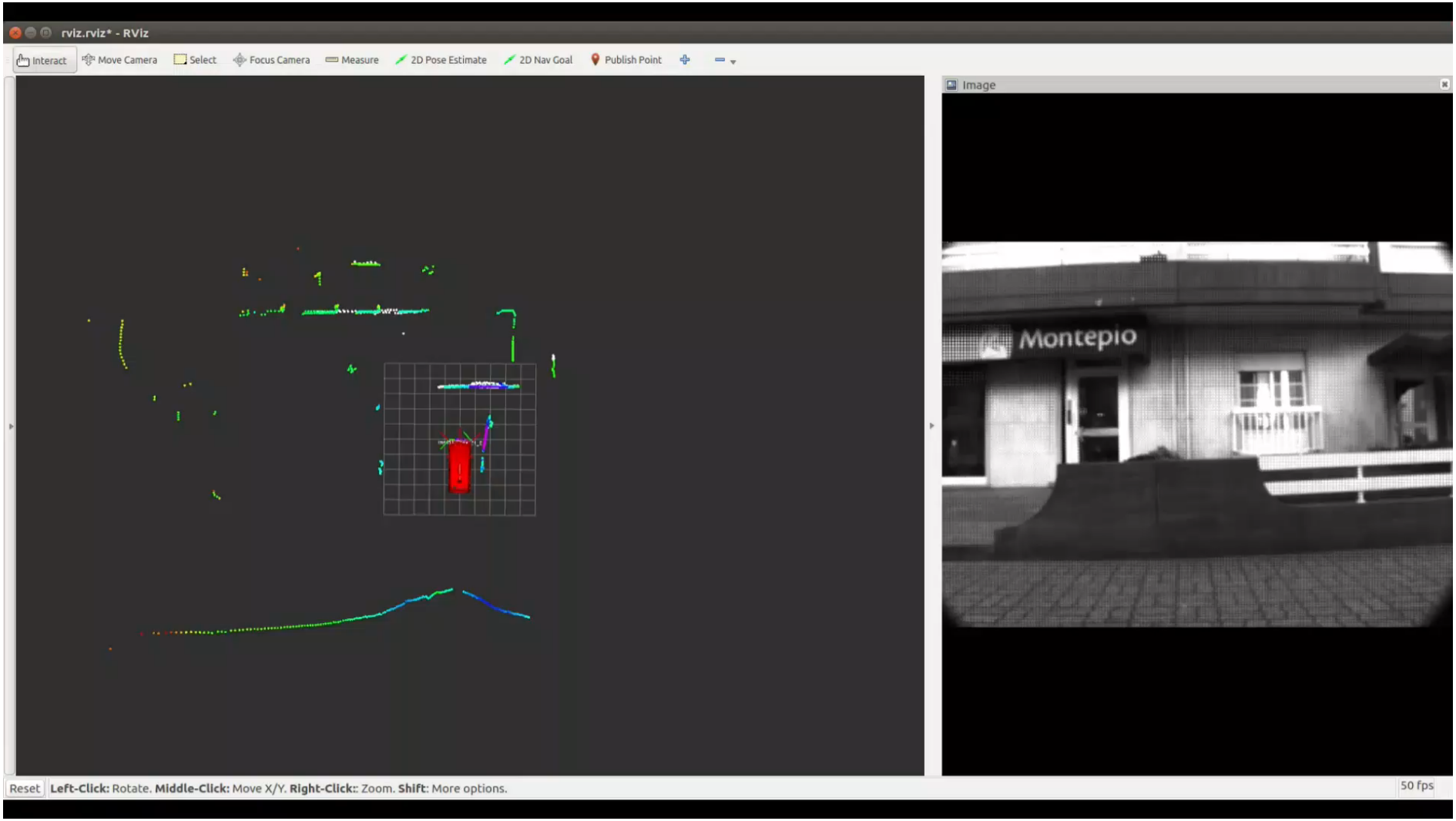
- Medical Imaging



Suporte ao diagnóstico em Acidentes Cardio Vasculares / Miguel Moreira 2010

Computer Vision – applications – Autonomous Driving

Computer Vision – applications – Autonomous Driving



Computer Vision - applications

- Interaction

Ex: camera-based IR tracking.

KINECT
for Windows

Computer Vision - applications

- Sports

Highlights of the men's 4x200m relay final on Day 5.

Computer Vision - applications

- Shape and Motion Capture

Computer Vision - applications

- Robotics

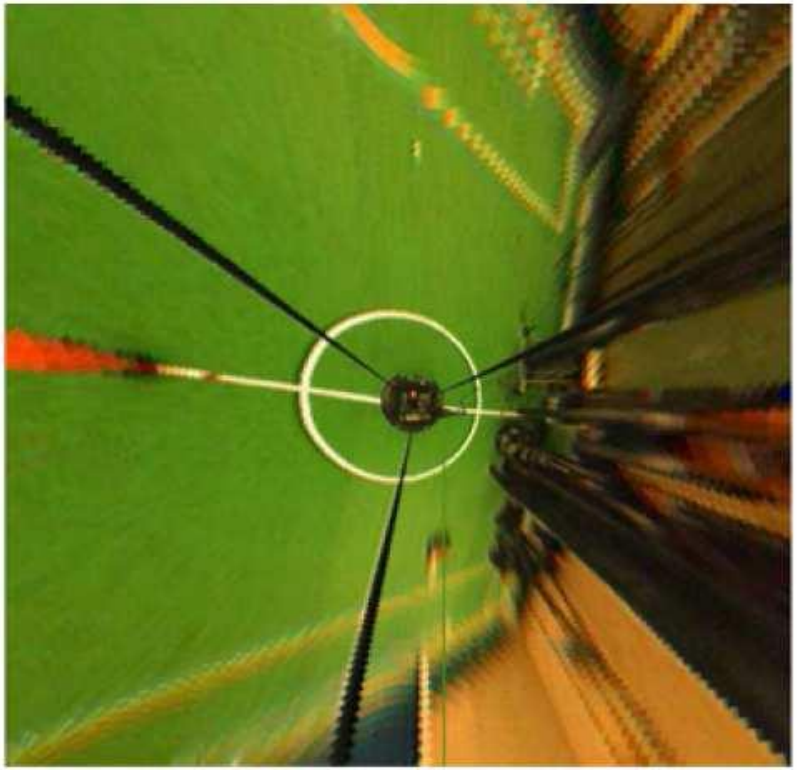
Computer Vision - applications

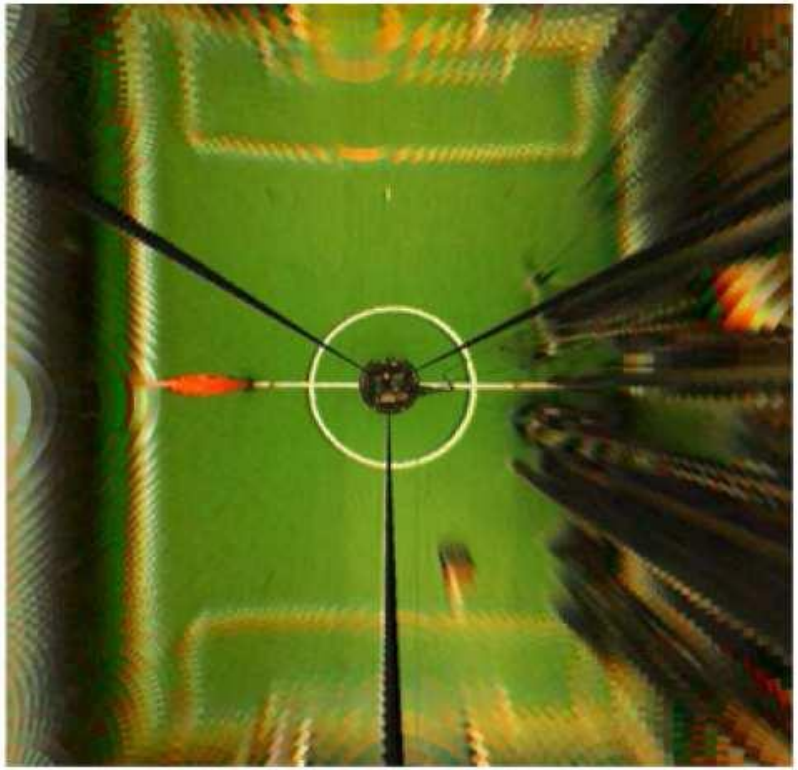
- Space

The Heights of Mount Sharp
http://www.nasa.gov/mission_pages/msl/multimedia/pia16077.html
Panorama captured by Curiosity Rover, August 18, 2012 (Sol 12)

Computer Vision - applications

- Robotics





3D reconstruction - applications

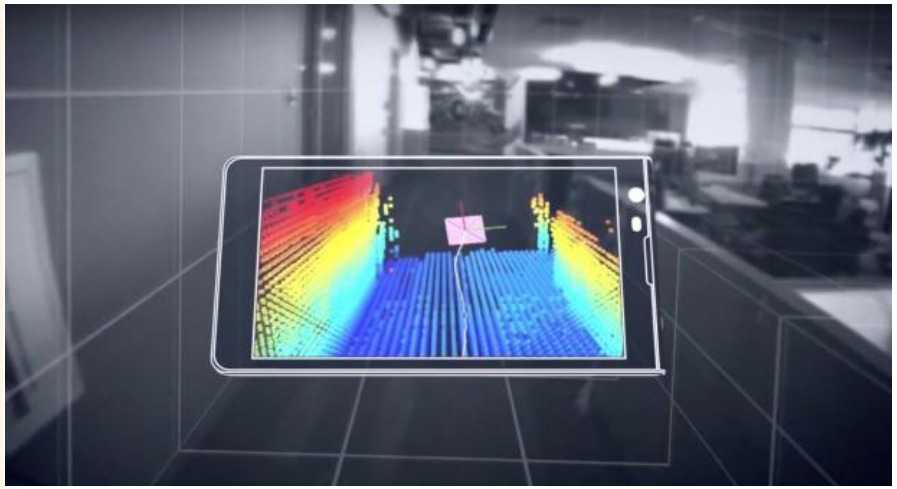
Internet Photos (“Colosseum”)

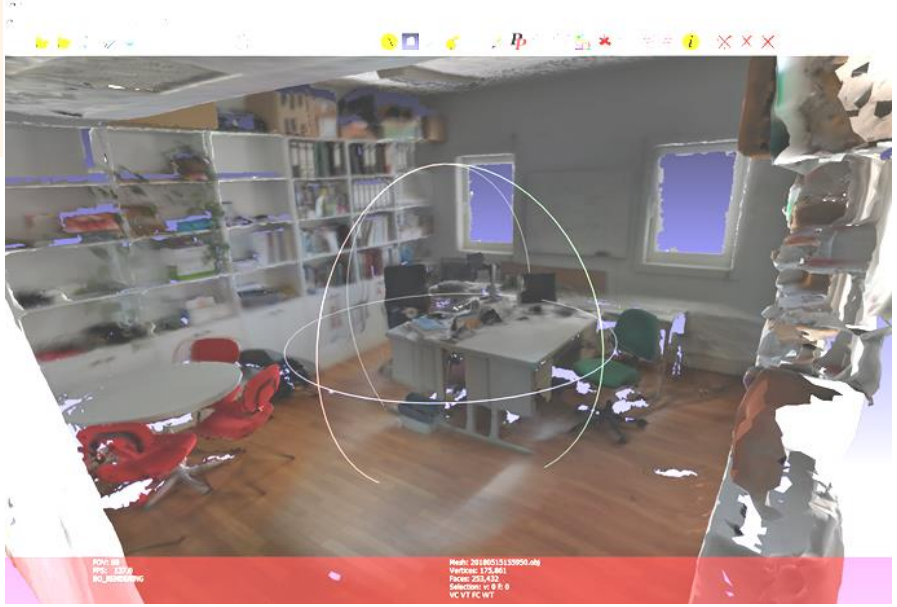
Reconstructed 3D cameras and points

Dense 3D model

3D Reconstruction - Applications

Anfiteatro IEETA



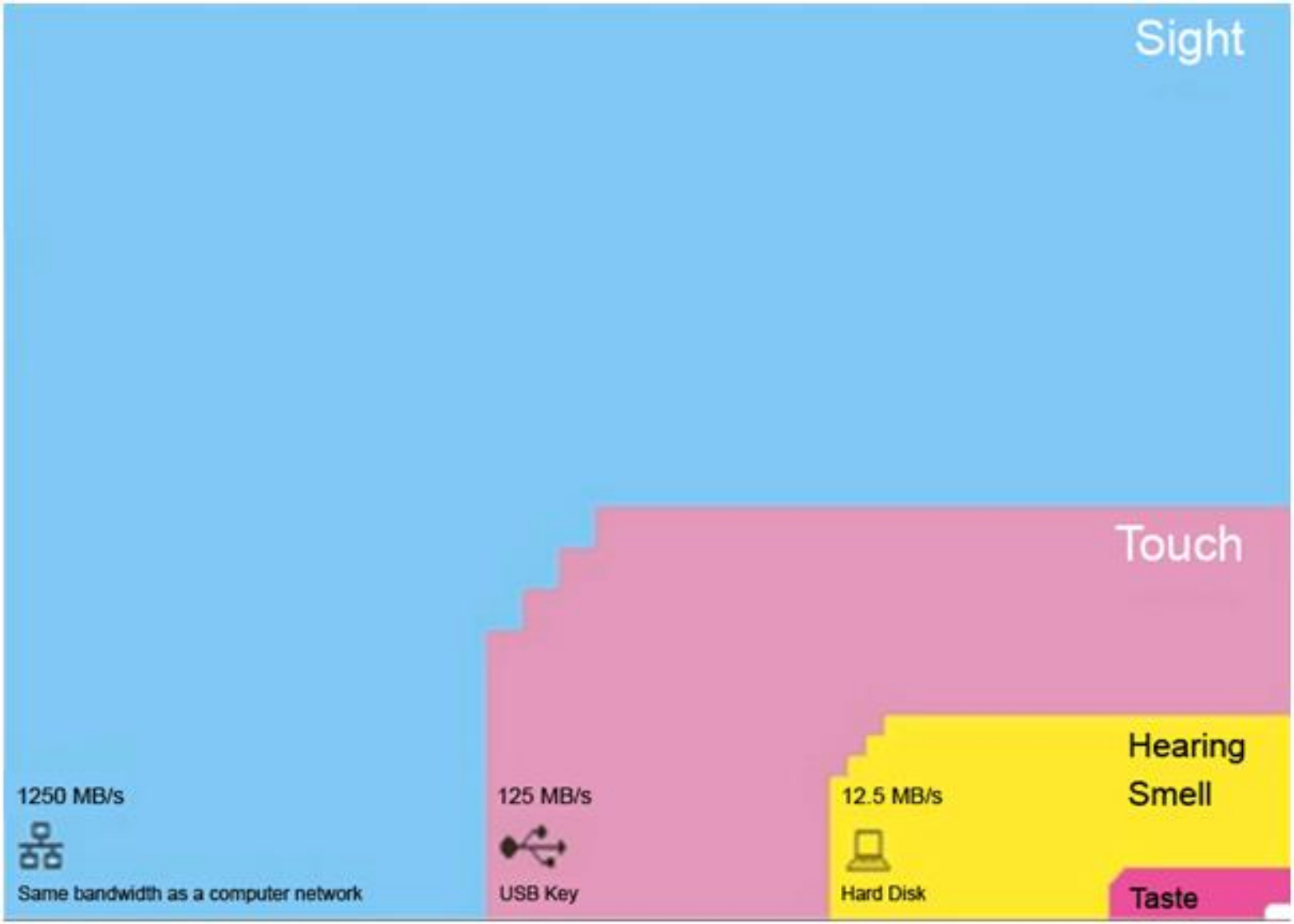


Gab. 005

Why it is hard : Human Vision

- Can do amazing things like:
  - Recognize people and objects
  - Navigate through obstacles
  - Understand mood in the scene
  - Imagine stories
- But:
  - Suffers from illusions
  - Ignores many details
  - Ambiguous description of the world
  - Does not care about accuracy of world

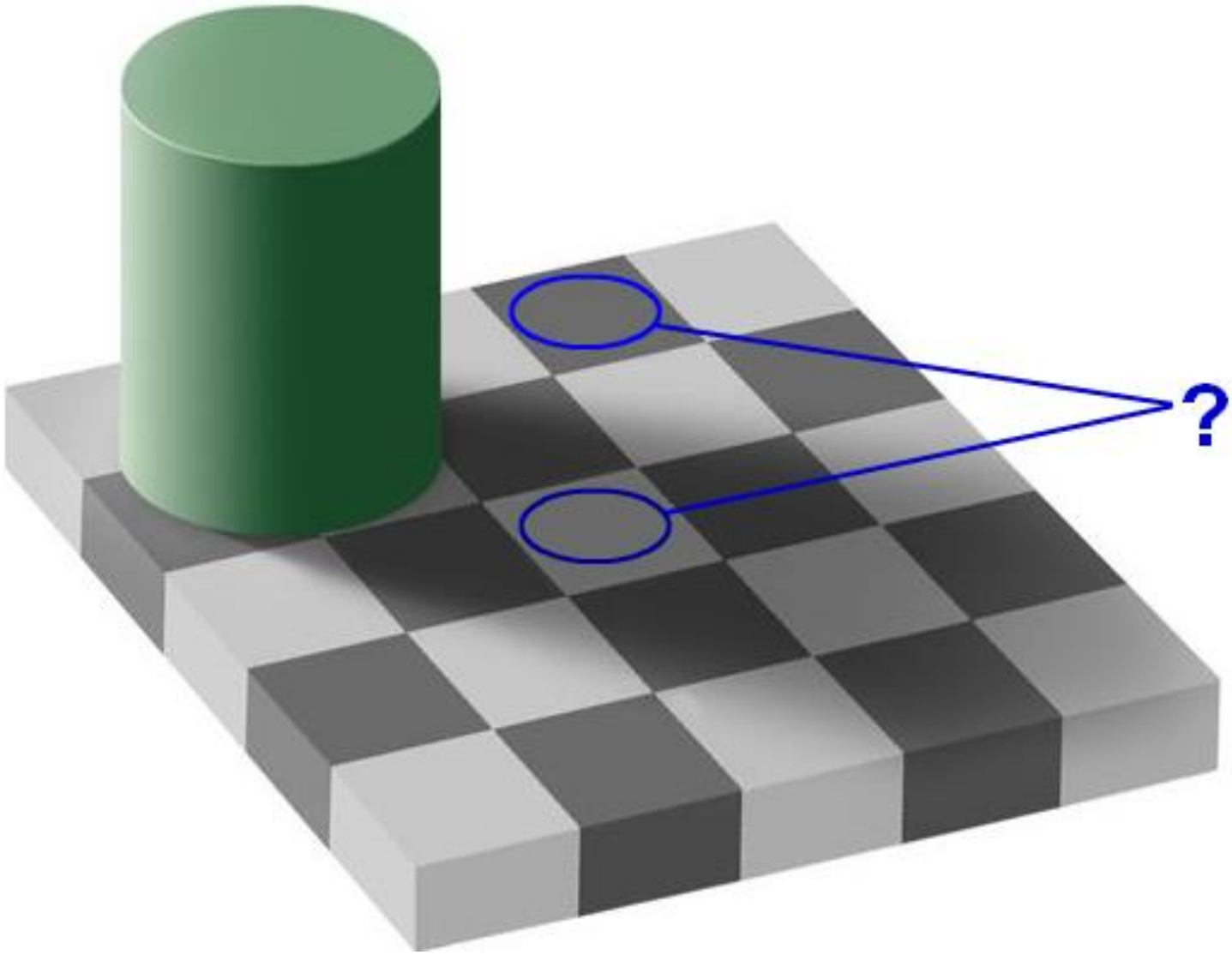
Why vision is preferred



Danish Physicist - Tor Nørretranders

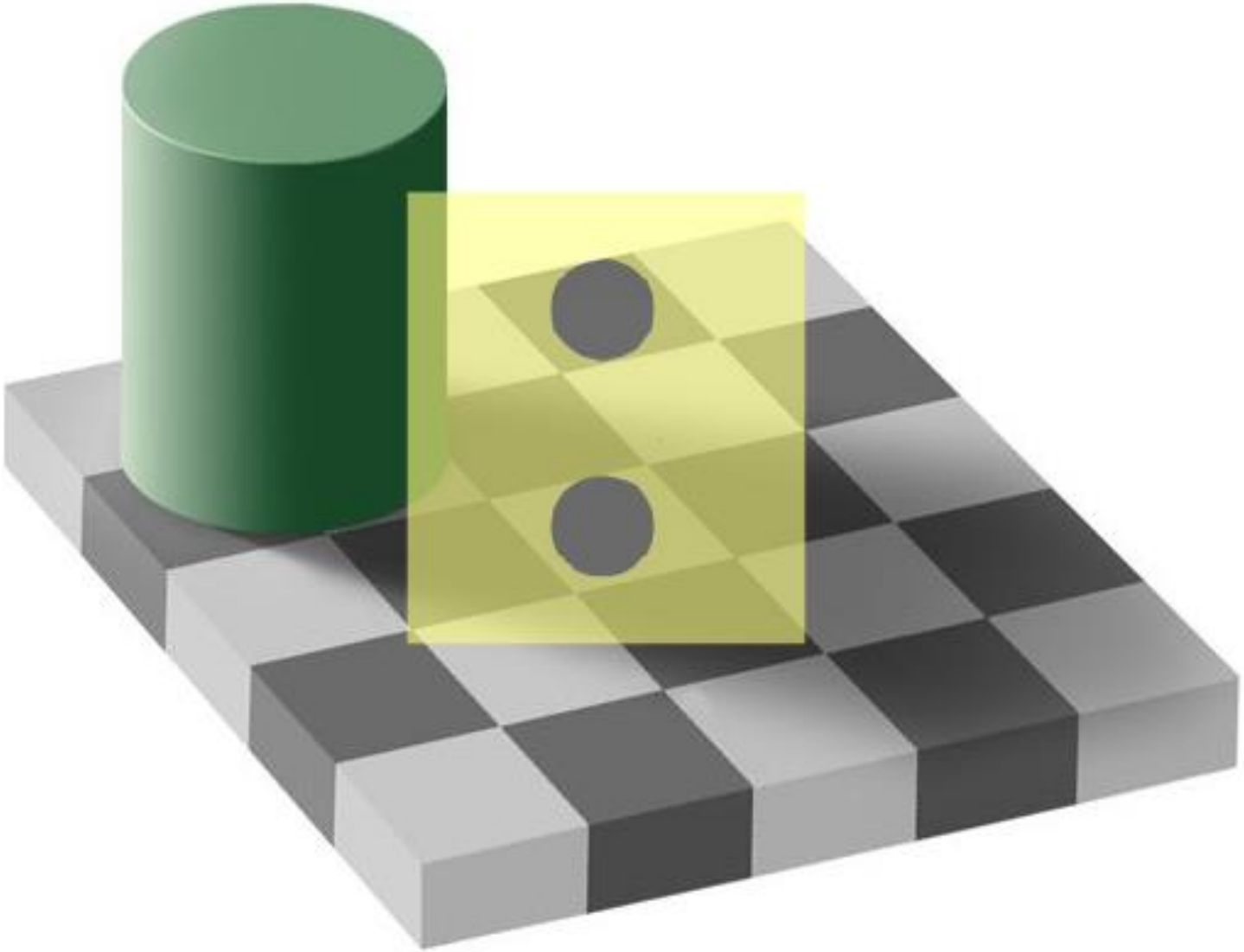
Visual Illusions

Adelson's "Checker-shadow illusion"

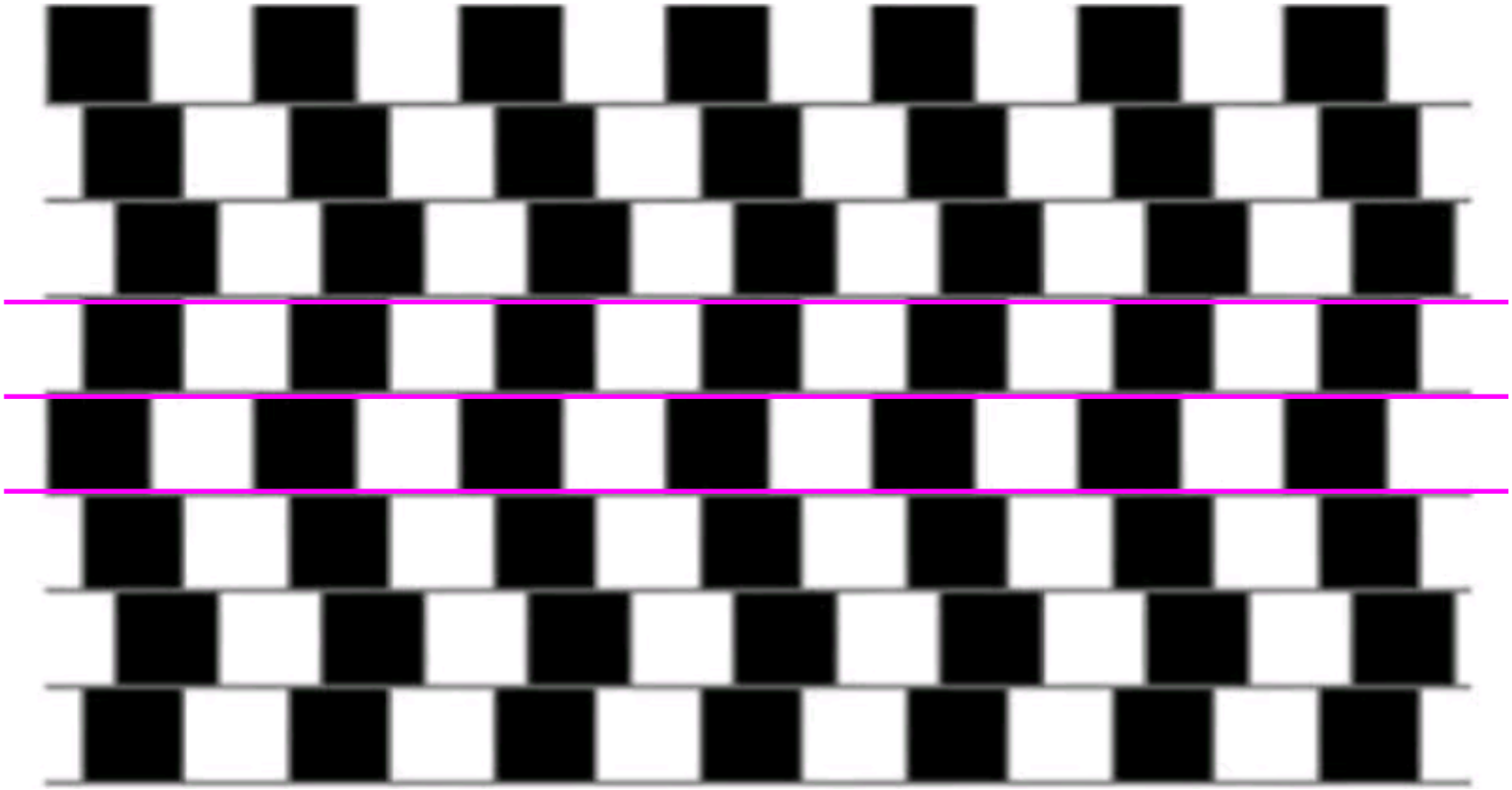


Visual Illusions

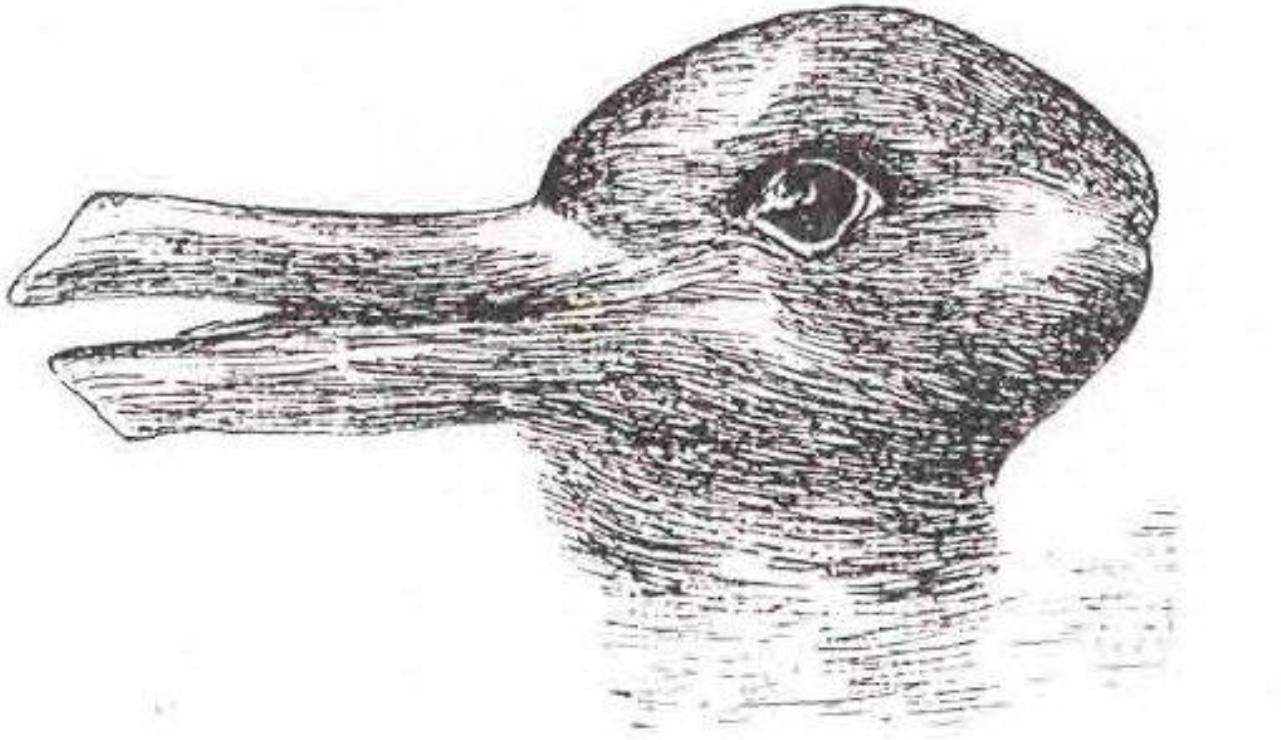
Adelson's "Checker-shadow illusion"



Visual Illusions



Other illusions



'Gestalt switch' between seeing the image as a duck and a rabbit.

Pattern Recognition

- Process that matches information from a stimulus with information retrieved from memory
  - very powerful process
  - subconscious
  - does not use only current data
  - solves ambiguities

Pattern recognition

Aoccdrnig to a rseearch sduty at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be in the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

http://www.positscience.com/games-teasers

Why it is hard : Human Vision

Viewpoint variation

Illumination

Scale

Why it is hard : Human Vision

Intra-class variation

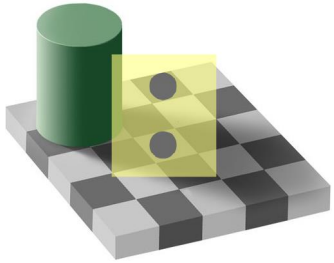
Motion (Source: S. Lazebnik)

Background clutter

Occlusion

Computer Vision vs Image Processing

- In the illusion, pixels have the same values



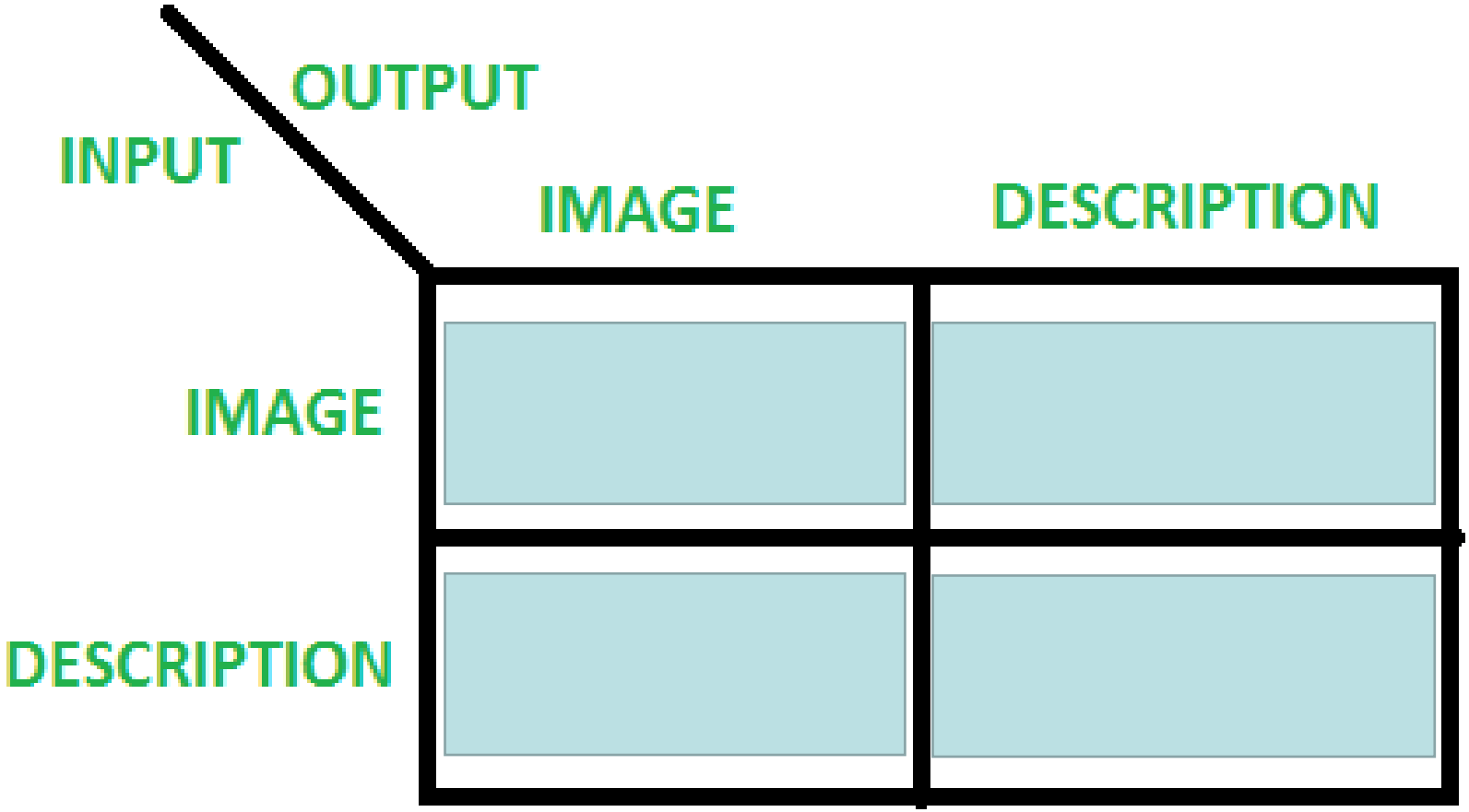
- Seeing is not just measuring images properties

- Seeing is to build some understanding of the world based on the measurement of an image sensor

Computer Vision vs Image Processing

- Difference between CV and IP are the goals (not the methods).
  - if the goal is, for example, to enhance an image for later use, then this may be called image processing.
  - If the goal is to emulate human vision, like object recognition, defect detection or automatic driving, then it may be called computer vision.

Computer Vision vs Image Processing vs …



Topics

- Image acquisition and representation
  - digital cameras, digital images, colour spaces, . . .
- Low-level image processing
  - neighbours, filtering, histograms, contours, morphological operators . . .
- Digital camera calibration
  - intrinsic and extrinsic parameters, colour calibration, . . .
- Stereo image processing
  - camera calibration, 3D reconstruction, . . .
- 3D imaging
  - 3D cameras, point clouds, . . .
- Video processing
  - tracking, optical flow, . . .
- High-level image processing (little)
  - template matching, pattern recognition, descriptors, deep learning, . . .

Lecture organization

- Low-level image processing (4)
- 3D Vision (4)
- High-level image processing (2)
- Project development and evaluation (3)

Course Timeline – proposal

#	Date	Topic
1		Introduction to the course
		OpenCV Install
2		Cameras, Images and colour spaces
		Lab 1
3		Low Level Image Processing – Pixel processing, Histograms, Image smoothing
		Lab 2
4		Low Level Image Processing – Segmentation, Morphology
		Lab 3
5		Edges detection & Corner detection
		Lab 4
6		Camera Calibration
		Lab 5
7		Stereo Vision
		Lab 6

#	Date	Topic
8		3D Vision
		Lab 7
9		Project presentation
		Lab 7
10		Video Processing and Object detection
		Project support
11		exam?
		Project mid-term presentation
12		Template Matching / Classification ?
		Project support
13		Deep Learning?
		Project support
14		Project Presentation

Methods

- Expository lectures
- Laboratory work
  - Use of digital cameras
  - OpenCV - open source based C/C++/Phyton Computer Vision library (http://opencv.org/)
- Homework
- Project

Grading

- Final exam – 40%
- Practical Component – 60%
  - In class Tutorials – 20 %
  - Final project 40%
    - 15 % mid term evaluation
    - 25 % final deliverable with presentation)

Code

- The platform `code.ua.pt` will be used as repository of the software developed, as well as all the files that the groups need or produce.

- Each group should create a project for the course `vc2122-nmec1-nmec2` and subversion or git can be used as repository of the source code developed during the classes and for the final project.

Reports

- The latex or docx template or of the IEEE journal should be used to produce your pdf reports (available in the course website and web).
- Academic dishonesty cannot be condoned. Academic dishonesty, as a general rule, involves one of the following acts:
  - Cheating on an examination or quiz.
  - Substituting for another person during an examination or allowing such substitution for one's self.
  - Plagiarism. This is the act of appropriating passages from the work of another individual, either word for word or in substance, and representing them as one's own work. This includes any submission of written work other than one's own.
  - Collusion with another person in the preparation or editing of assignments submitted for credit, unless such collaboration has been approved in advance by the instructor.

Bibliography

- **Textbook**
  - Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London, 2011 (Available online: http://szeliski.org/Book/).
- **Other references**
  - Making Things See, Greg Borenstein, O'Reilly 2012 Learning OpenCV: Computer Vision in C++ with the OpenCV Library, Gary Bradski, Adrian Kaehler, O'Reilly 2012
  - Machine vision: Theory, algorithms, practicalities, E. R. Davies, Morgan Kaufmann 2005.
  - W. Burger, M. J. Burge, Principles of Digital Image Processing, Vol.1 and Vol. 2, Springer, 2009
  - Digital Image Processing, Rafael C. Gonzalez, Richard E. Woods, Prentice Hall, 2007
  - Image Processing: Analysis and Machine Vision, Milan Sonka et al., Chapman & Hall, 2007
  - D. Forsyth, J. Ponce, Computer Vision: A Modern Approach, Prentice Hall, 2002.
- **Thanks: To Profs. Joaquim Madeira, António Neves, and PhD students**

OpenCV Install

OpenCV Install

- Installation

  Follow the steps to perform Python and OpenCV installation for python

  https://www.python.org/downloads/

  https://pypi.org/project/opencv-python/

- Documentation

  http://docs.opencv.org

- Test

  Run and test the file Aula_01_ex 01.py with the lena.jpg image

  Analyze the code and the OpenCV functions that are used.

  Note how an image is read from file and displayed.