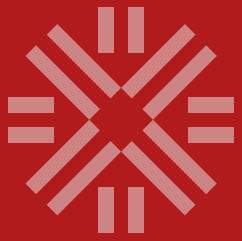


Master SIF - REP (Part 0)
Digital Image Processing: Introduction

Thomas Maugey
thomas.maugey@inria.fr

Fall 2023

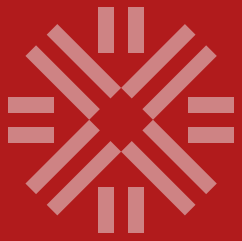


Table of Contents

1. About Digital Images
2. Digital Image Processing
3. Course Overview
4. Reference

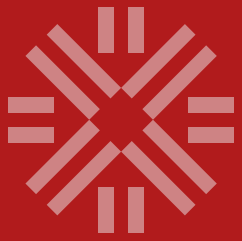


Table of Contents

1 About Digital Images

2 Digital Image Processing

3 Course Overview

4 Reference

What's an image?

Definition

An image (from Latin: imago) is an artifact that depicts visual perception (..), that has a similar appearance to some subject, (..), thus providing a depiction of it. [Wikipedia]

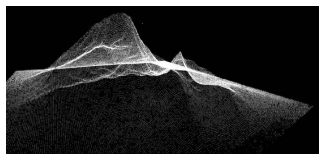
picture

satellite picture

drawing

360°

hologram

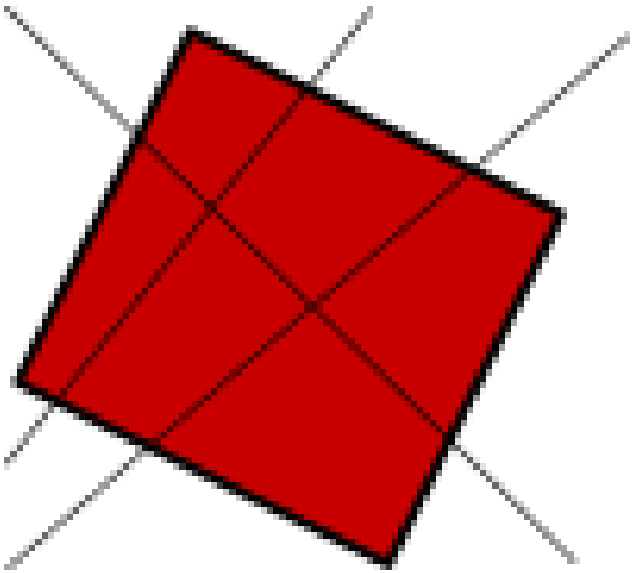


pointcloud

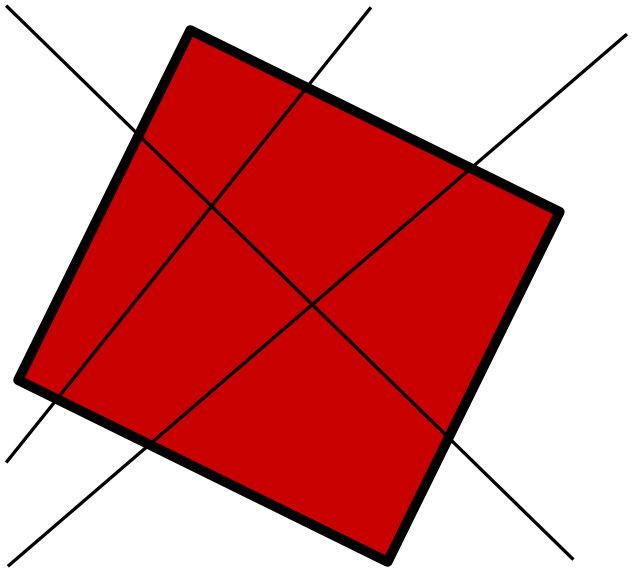
Digital image

Definition

A digital image is a numeric representation, normally binary, of a two-dimensional image. (..) It may be of vector or raster type [Wikipedia]



Raster or bitmap image (4Ko)

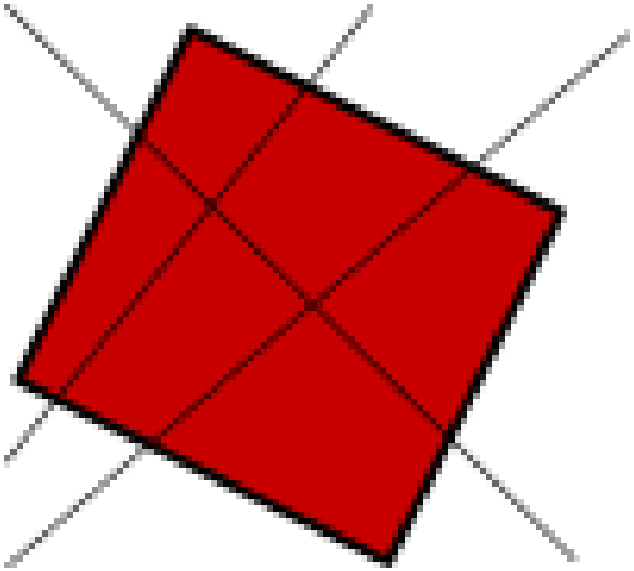


Vector image (3Ko)

Digital image

Definition

A digital image is a numeric representation, normally binary, of a two-dimensional image. (..) It may be of vector or raster type [Wikipedia]



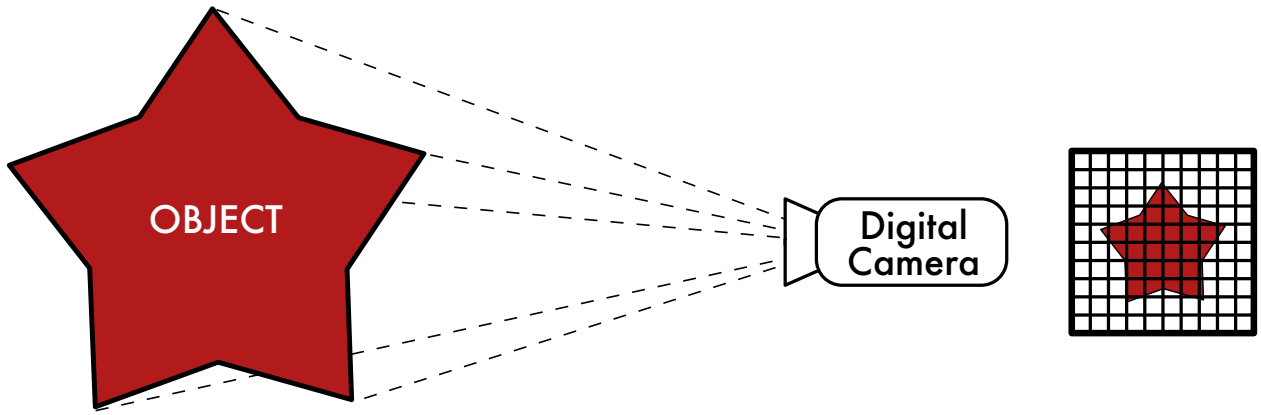
Raster or bitmap image (4Ko)

```
%%Page: 1 1
%%BeginPageSetup
%%PageBoundingBox: 0 -1 151 136
%%EndPageSetup
q 0 -1 151 137 rectclip q
0.784314 0 0 rg
44.785 129.739 m 133.973 85.856 l 92.41 1.38 l 3.223 45.262 l h
44.785 129.739 m f
0 g
2.153469 w
1 J
1 j
[] 0.0 d
4 M q 1 -0.492004 -0.492004 -1 0 135.949997 cm
38.517 -12.74 m 127.706 -12.738 l 127.706 71.739 l 38.517 71.737 l h
38.517 -12.74 m S Q
0.8 w
0 J
0 j
q 1 0 0 -1 0 135.949997 cm
0.715 135.648 m 150.219 7.156 l S Q
q 1 0 0 -1 0 135.949997 cm
0.312 110.594 m 88.398 0.691 l S Q
q 1 0 0 -1 0 135.949997 cm
0.312 0.285 m 137.289 134.031 l S Q
Q Q
showpage
%%Trailer
end restore
%%EOF
```

Vector image (3Ko)

Bitmap Digital Image

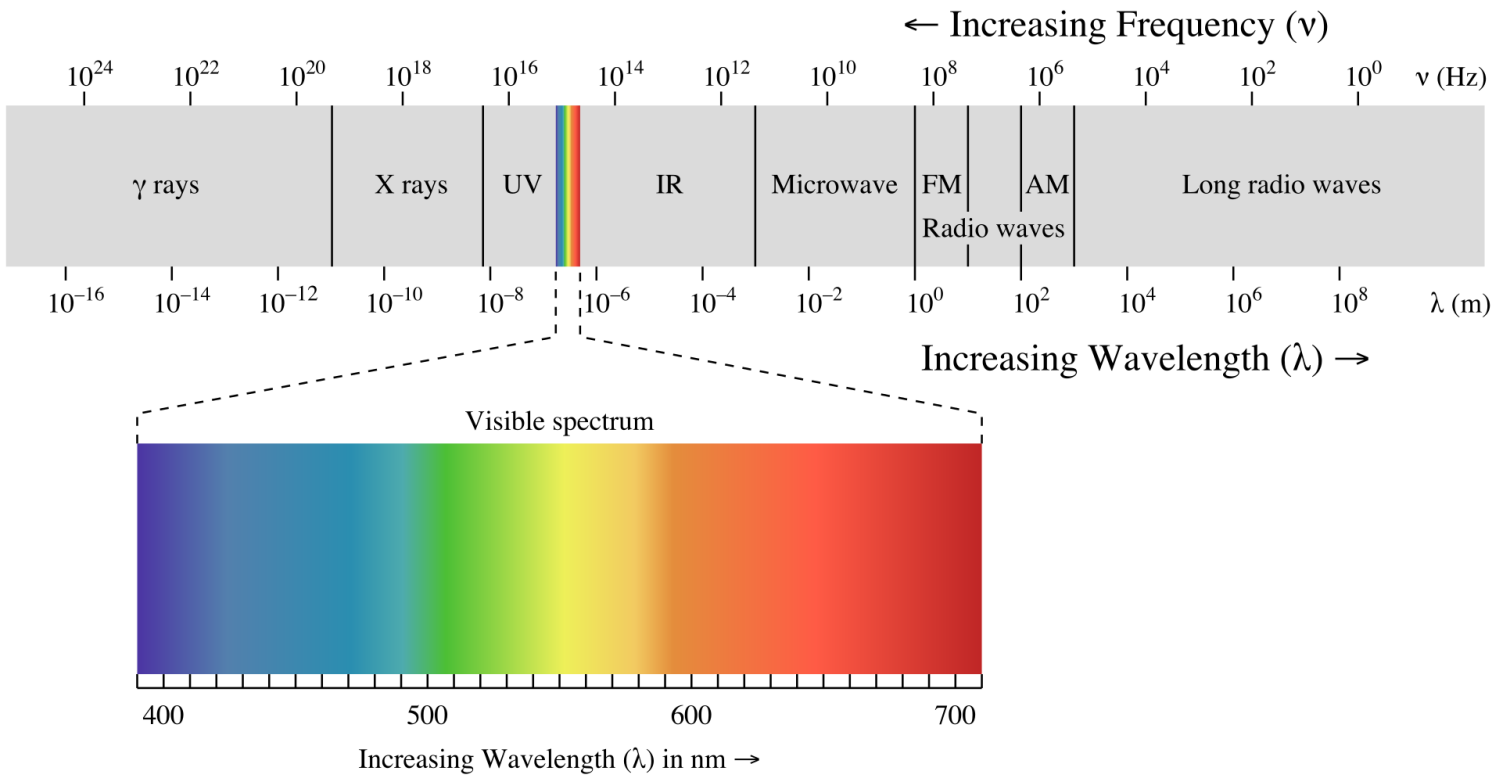
This course will mainly focus on the Bitmap Digital Image.
They are usually captured by digital cameras.



But not only ...

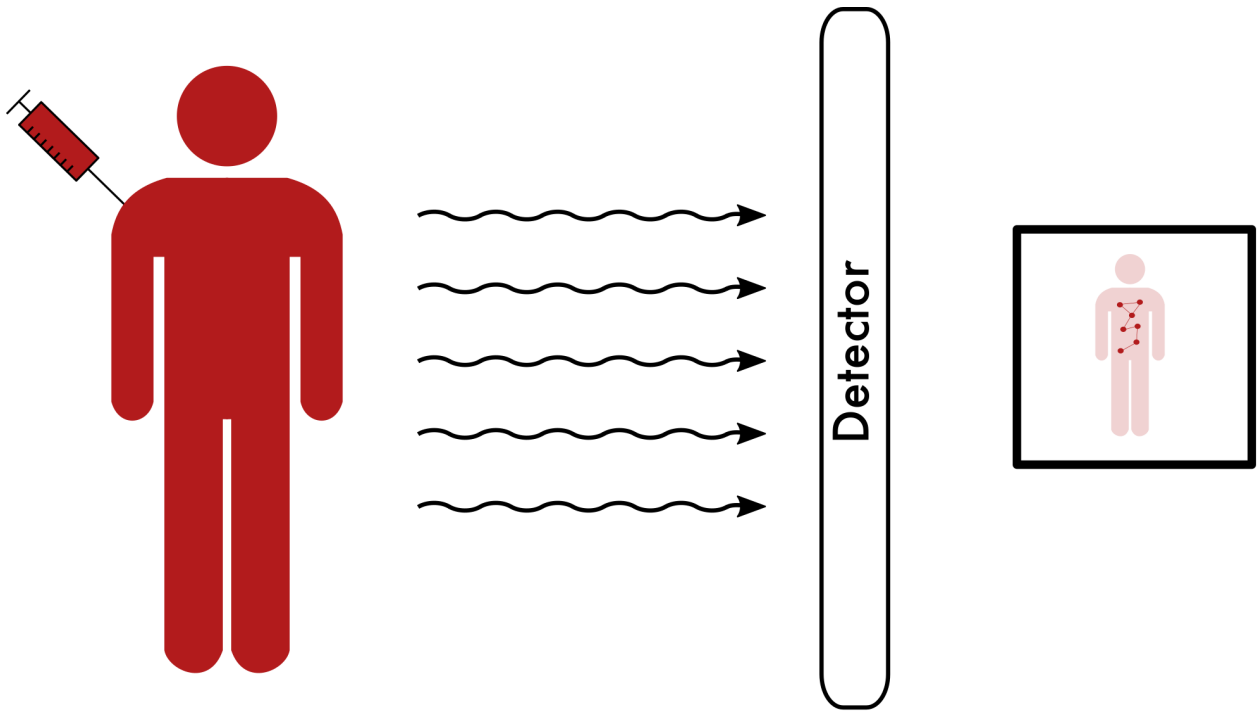
Where do digital images come from ?

The system depends on the type of electro-magnetic activity that is captured.

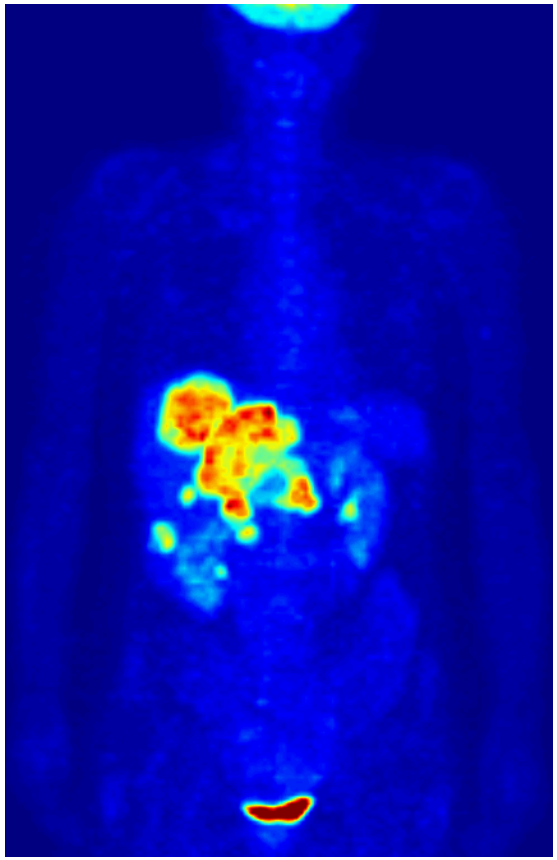


γ-rays imaging ($\lambda < 10^{-11}$ m)

Injection of an isotope that is radioactive during a certain period.



Example of γ-rays captures

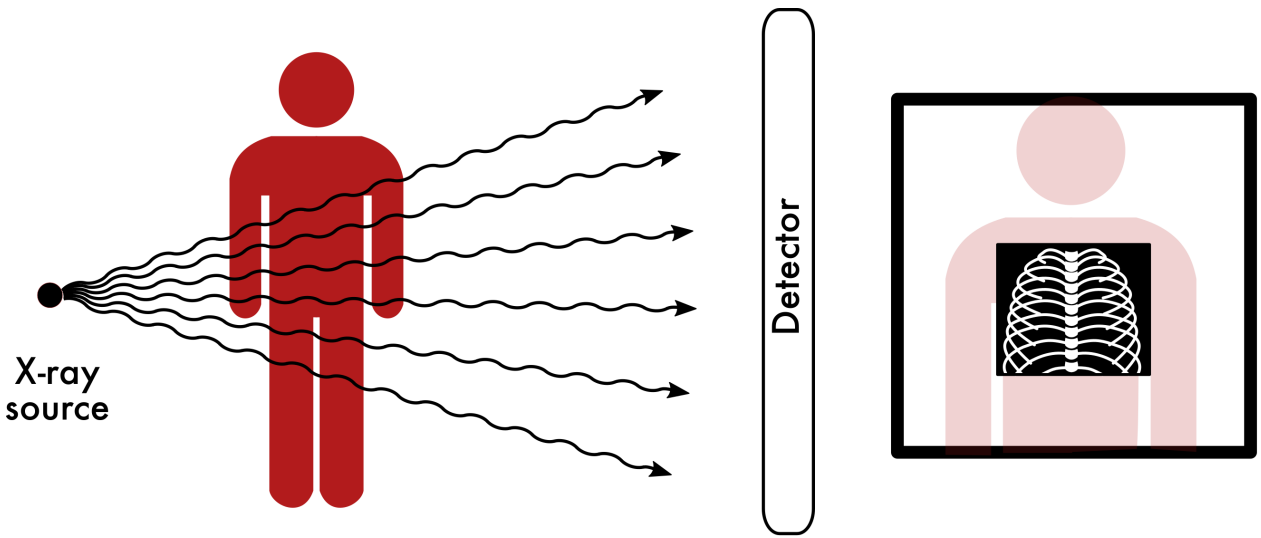


PET-scan

Transport security

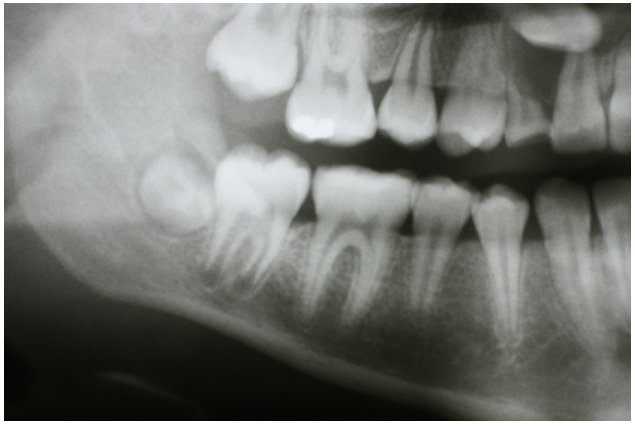
X-ray imaging ($10^{-11} < \lambda < 10^{-8}$ m)

Emission of a X-ray source, and capture of the non-absorbed rays.



Example of X-ray capture

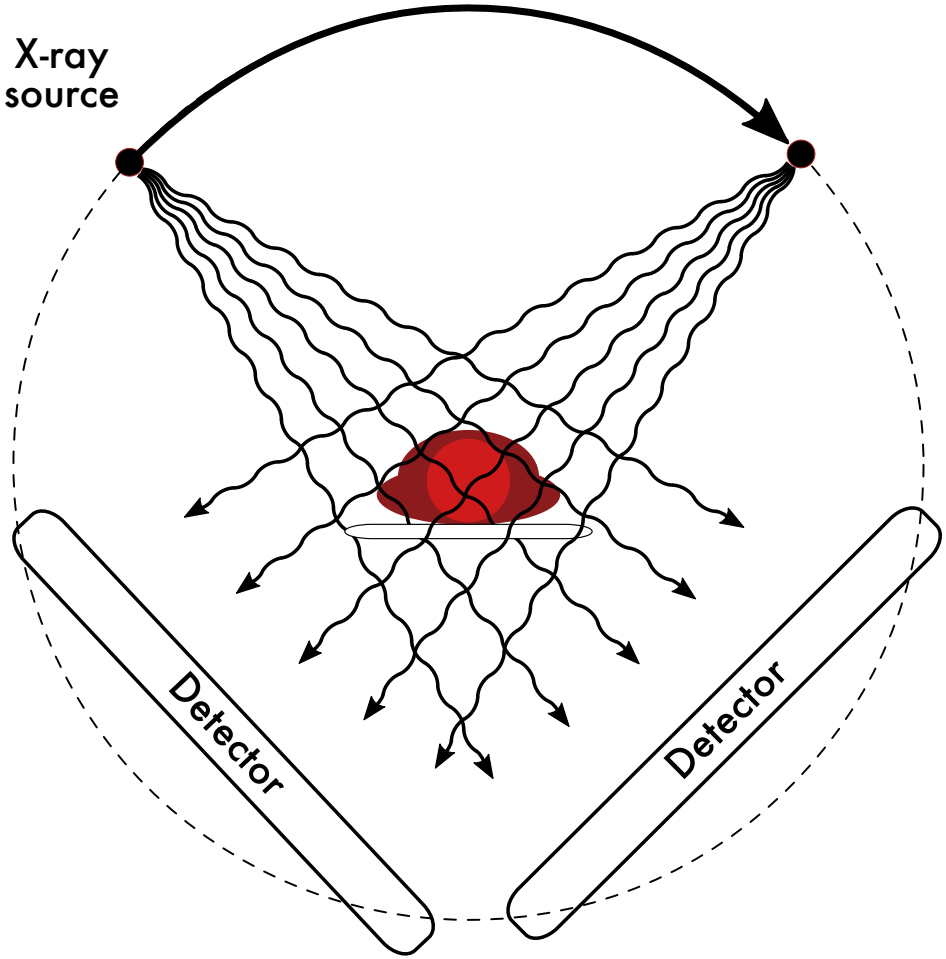
Bones



Teeth

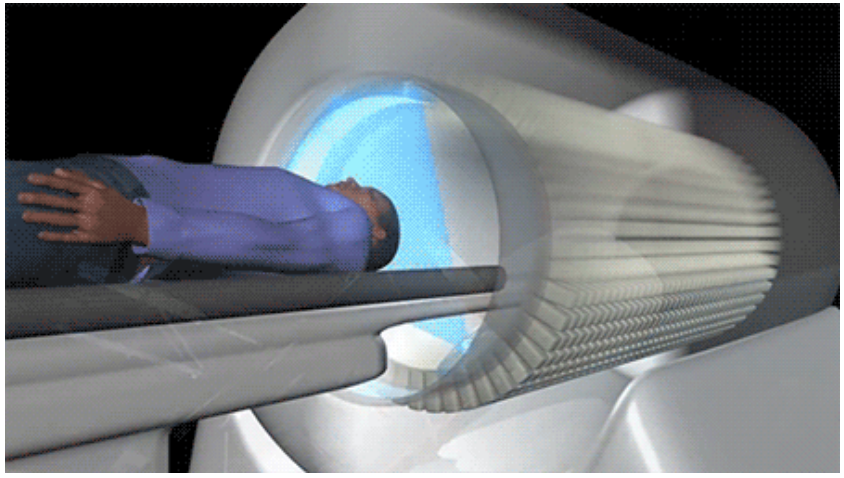
Airport security

Computed tomography imaging (X-ray)

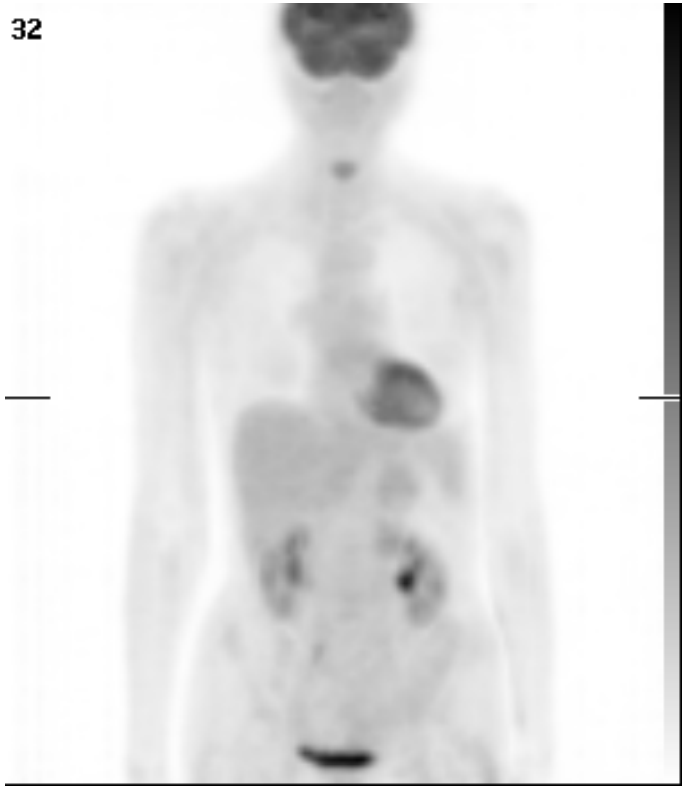


Fusion of the different captures in order to reconstruct a volume
X-ray images

Example of CT imaging



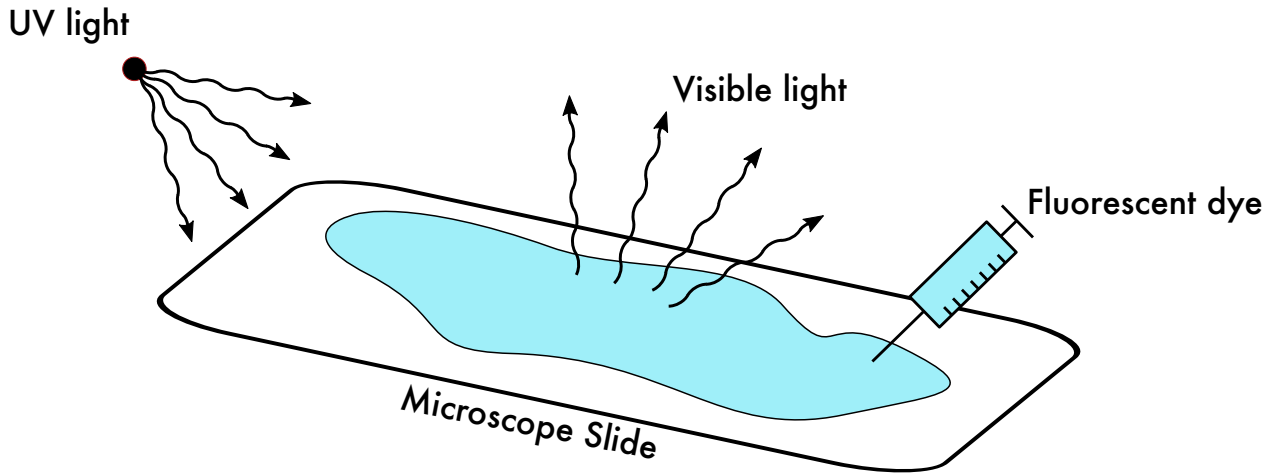
Scanner



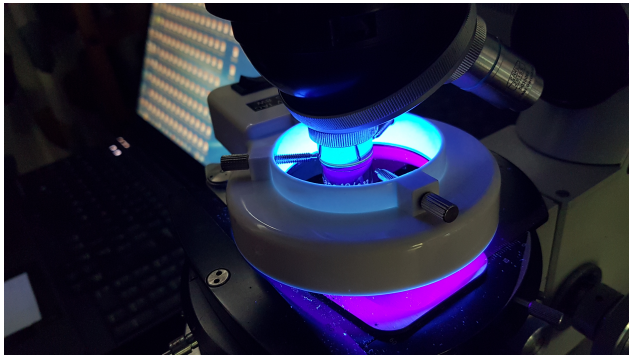
3D X-ray image

UV imaging ($10^{-8} < \lambda < 4.10^{-7}$ m)

Fluorescent microscopy

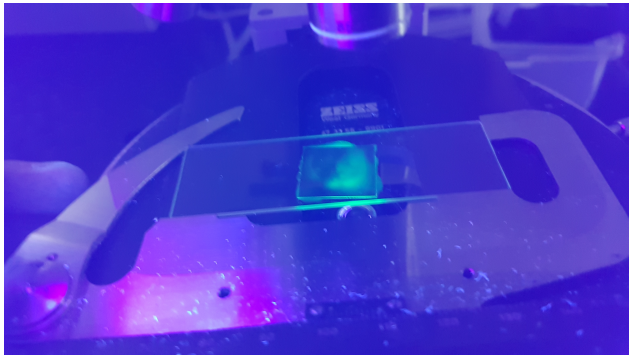


Examples of UV images



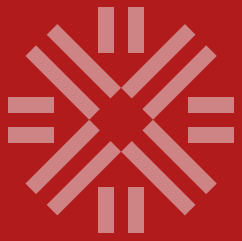
Microscope

Under a UV light



Lighted slide

Effect of sun cream

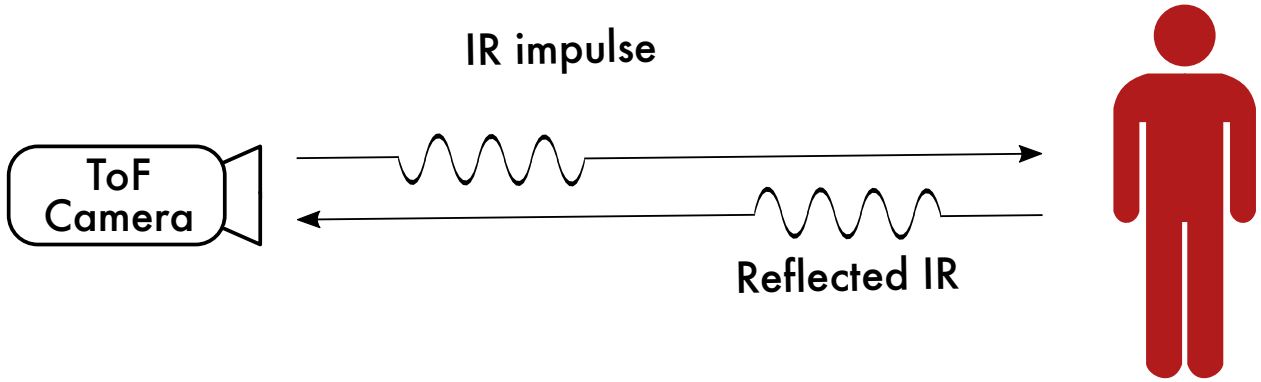


Visible imaging ($4.10^{-7} < \lambda < 7.10^{-7}$ m)

- Professional digital cameras
- Smartphone digital cameras
- Microscopy
- Remote sensing (satellite)
- Biometric
- Spherical imaging
- HDR
- Computational Imaging
- ...

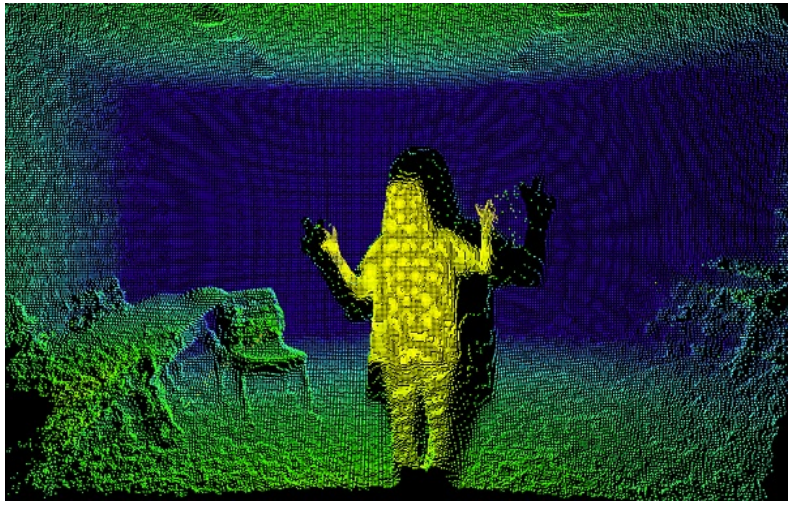
IR imaging ($7.10^{-7} < \lambda < 10^{-3}$ m)

Time of flight cameras measure the delay of the reflection and deduce the distance.



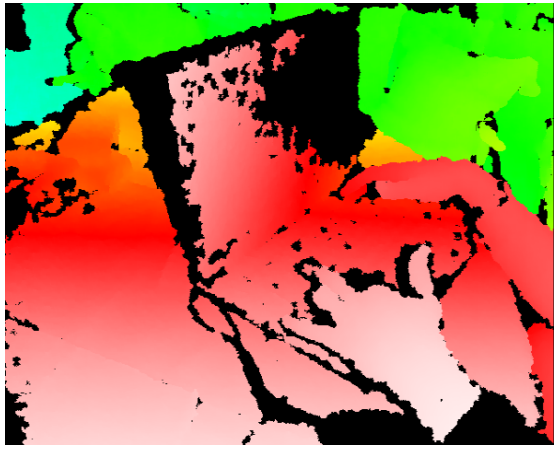
Same with structured light (*e.g.*, Kinect camera)

Examples of IR imaging



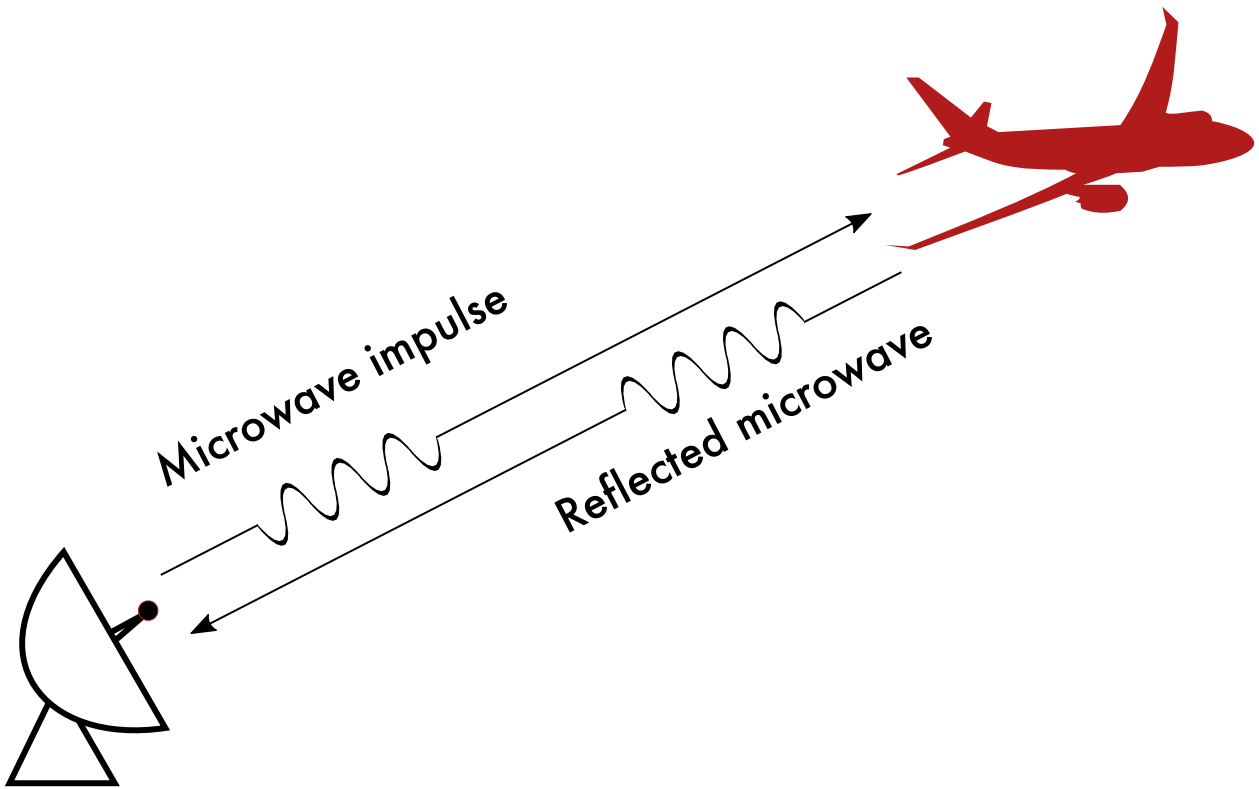
ToF depth map

IR pattern by Kinect2

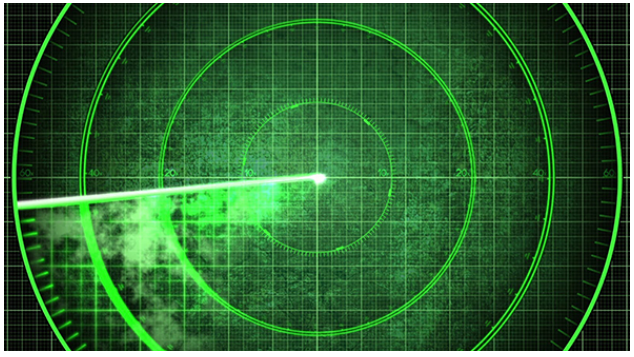


Estimated Depth Map

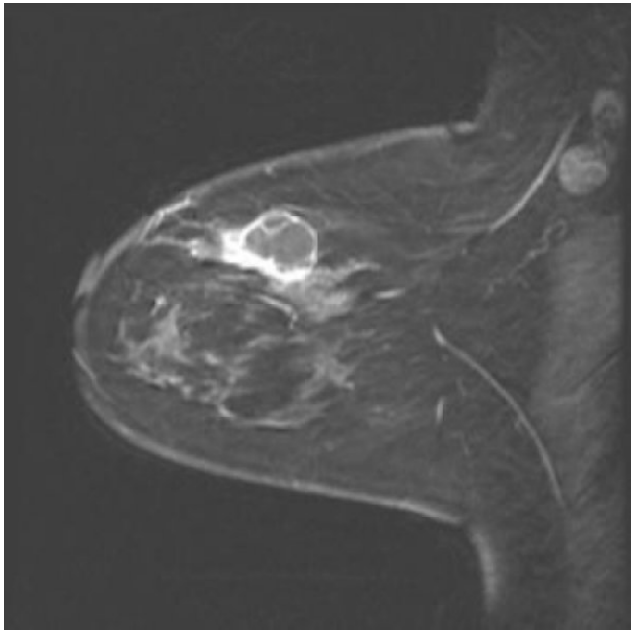
Microwave imaging ($7.10^{-3} < \lambda < 10^{0}$ m)



Example of Microwave images



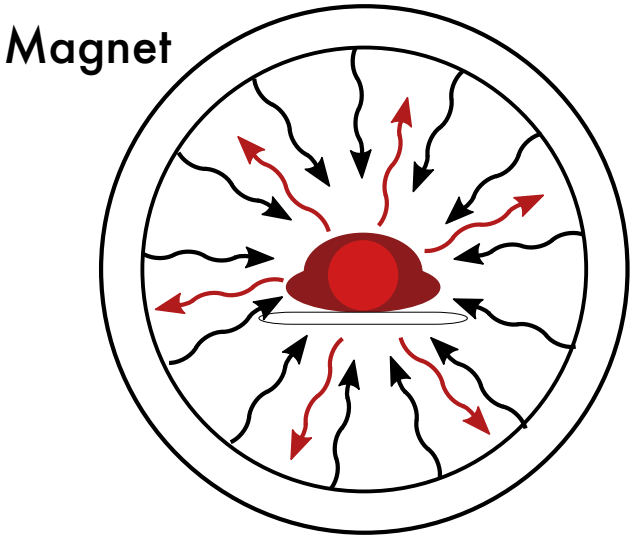
Radar image



Medical Microwave measurement

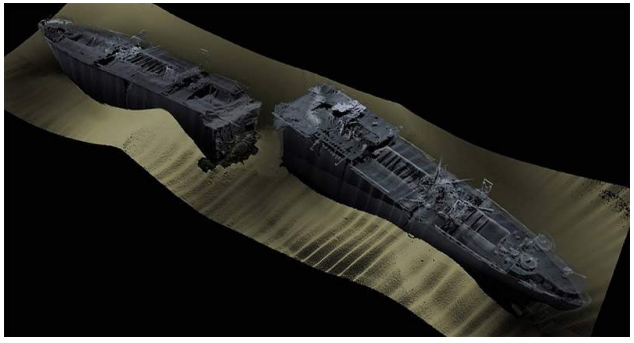
Radio-band imaging ($10^0 < \lambda < 10^3$ m)

Magnetic Resonance Imaging (MRI)



Not Electro-Magnetic images

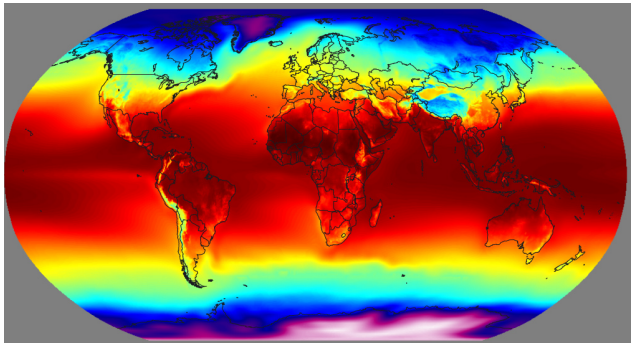
Sound



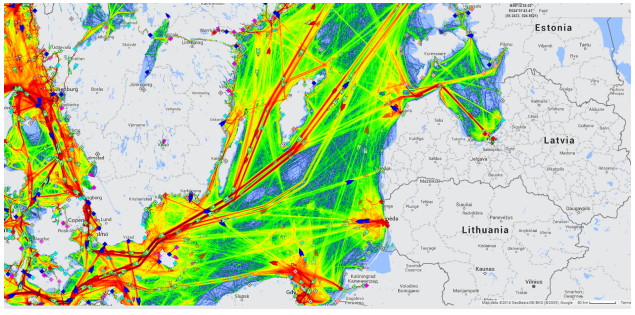
Sonar

Ultra-sound

Data-driven



Temperature Map



Baltic Sea Traffic Map

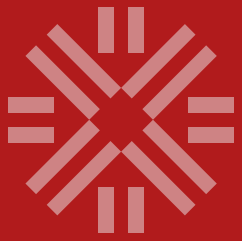


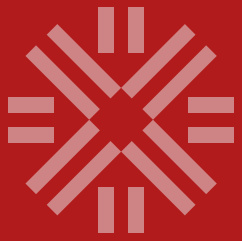
Table of Contents

1 About Digital Images

2 Digital Image Processing

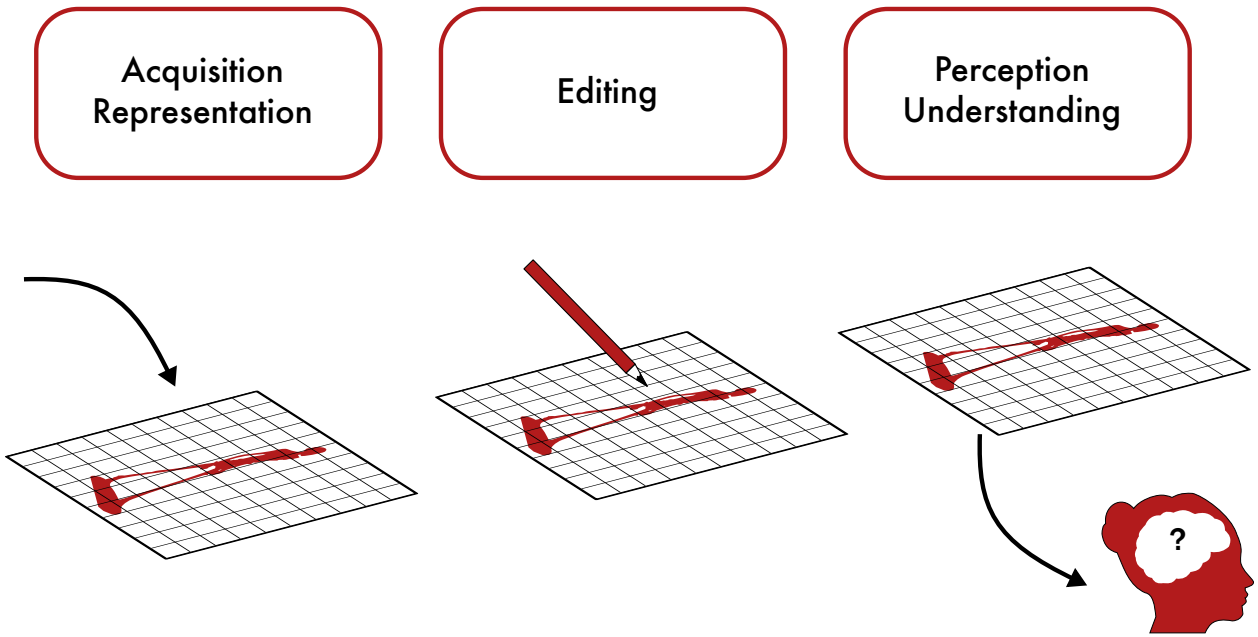
3 Course Overview

4 Reference



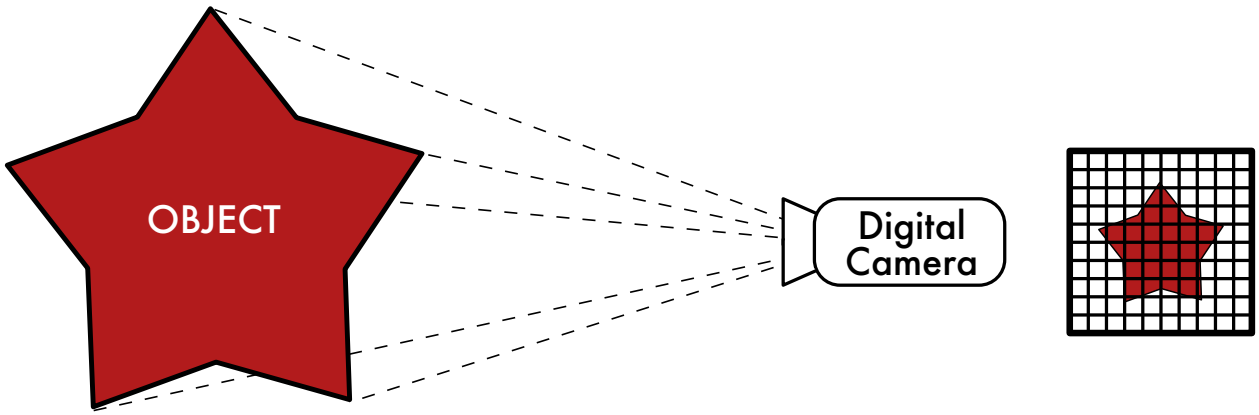
What's Digital Image Processing?

The use of computer algorithms on Digital Imaging, in order to perform various tasks:



Acquisition / Representation

- Projection model
- Calibration



- Transform / Sparse representation
- Compression
- Compressive sensing

Introduction
T. Maugey
About Digital Images
Digital Image Processing
Course Overview
Reference

Denoising - Restoration

[IRISA Team-project VISTA (now Fluminance and SERPICO)]

[C. Kervrann, J. Boulanger. "Local adaptivity to variable smoothness for exemplar-based image denoising and representation". Int. J. Computer Vision, 2007.]

Editing / Enhancement

Super Resolution

(a) 86 × 86 (b) Nearest (c) Dong et al.'s ASDS (d) SE-ASDS (e) Zoom between (c) and (d)

[IRISA Team-project SIROCCO]

[J. C. Ferreira, O. Le Meur, C. Guillemot, E. A. B. da Silva and G. A. Carrijo, "Single image super-resolution using sparse representations with structure constraints," 2014 IEEE International Conference on Image Processing (ICIP), Paris, 2014, pp. 3862-3866.]

Editing - Modification

Inpainting

[IRISA Team-project SIROCCO]

[Christine Guillemot, Olivier Le Meur. Image inpainting: Overview and recent advances. IEEE Signal Processing Magazine, Institute of Electrical and Electronics Engineers, 2014.]

Editing - Modification

Color Transfer

Input image

Reference image

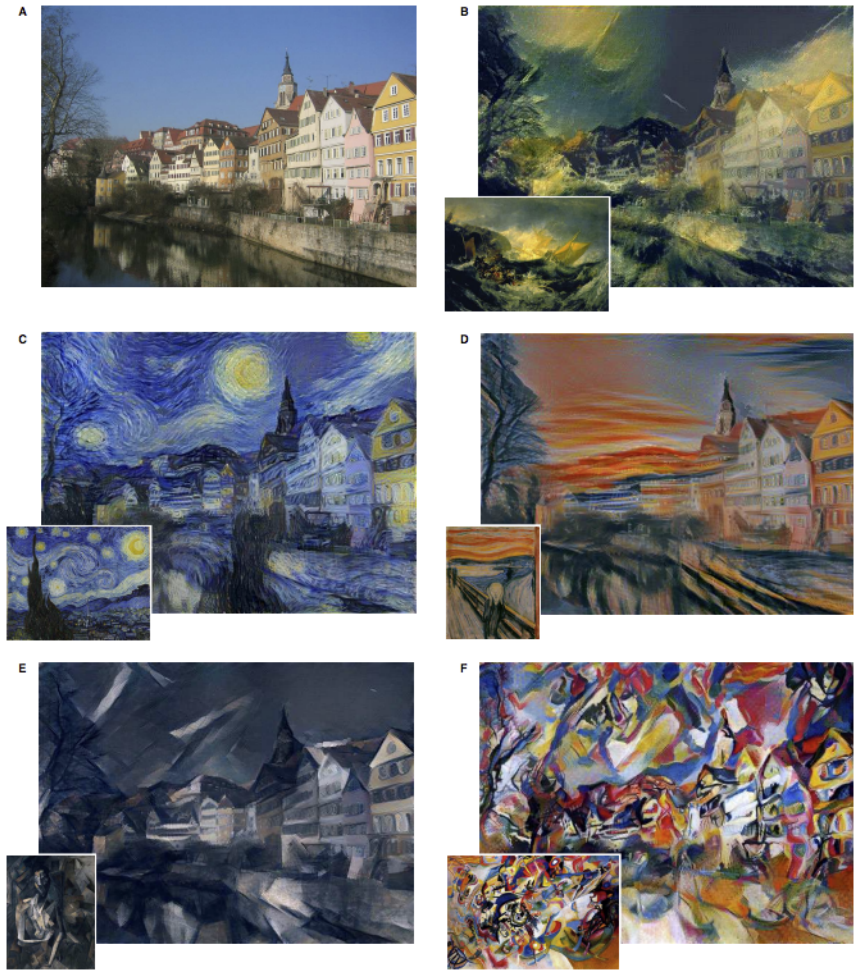
Result

[IRISA Team-project PERCEPT]

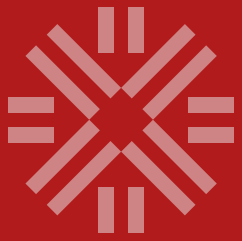
[Hristova, Hristina and Le Meur, Olivier and Cozot, Remi and Bouatouch, Kadi (2015). Style-aware robust color transfer, Expressive 2015]

Editing - Modification

Style Transfer

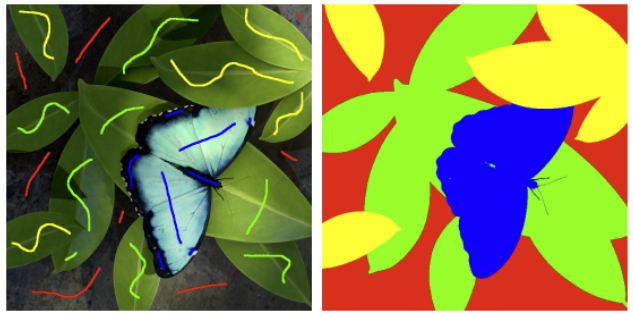


[L. A. Gatys, A. S. Ecker and M. Bethge, "Image Style Transfer Using Convolutional Neural Networks," 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Las Vegas, NV, 2016, pp. 2414-2423.]



Perception/Understanding

- Attribute
  - Segmentation



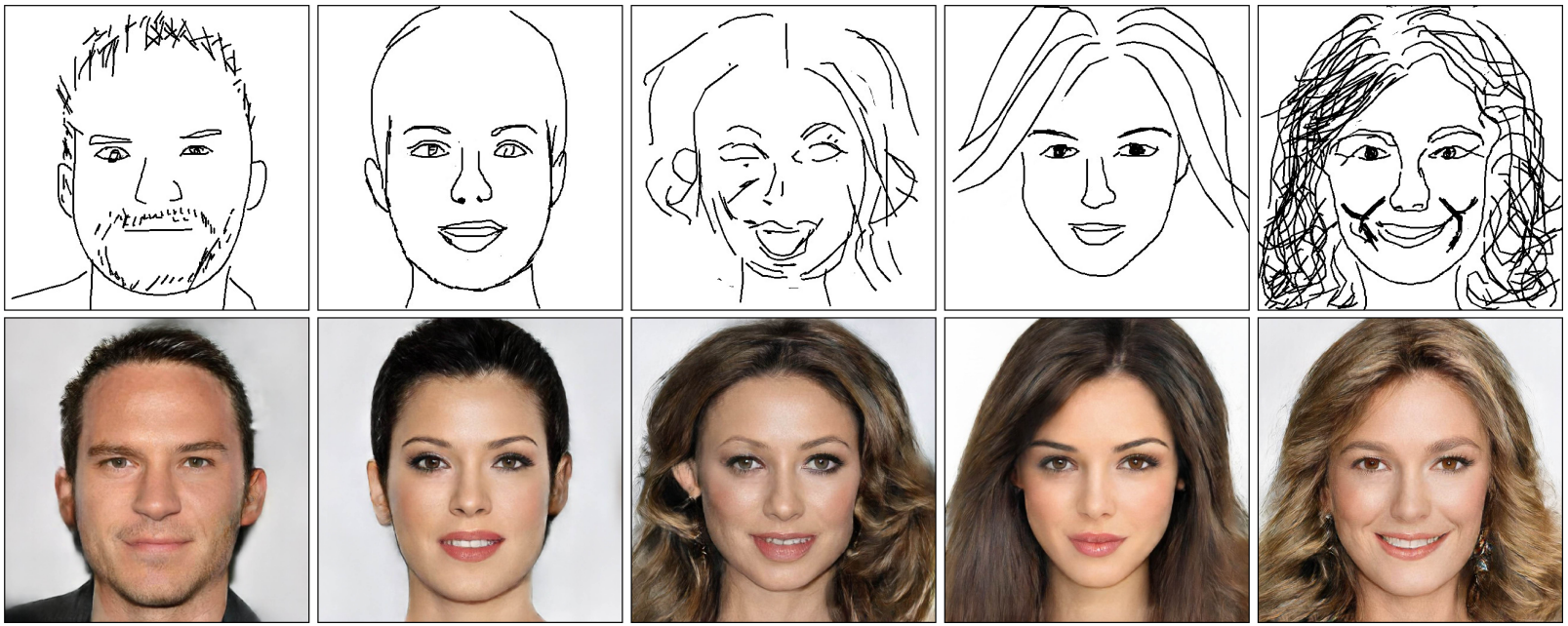
  - Object detection
- Understanding
  - Classification
- User's perception modeling

[IRISA Team-project SIROCCO]

[Matthieu Hog, Neus Sabater, Christine Guillemot. Light Field Segmentation Using a Ray-Based Graph Structure. European Conference on Computer Vision - ECCV, Oct 2016,]

The great potential of Deep Learning

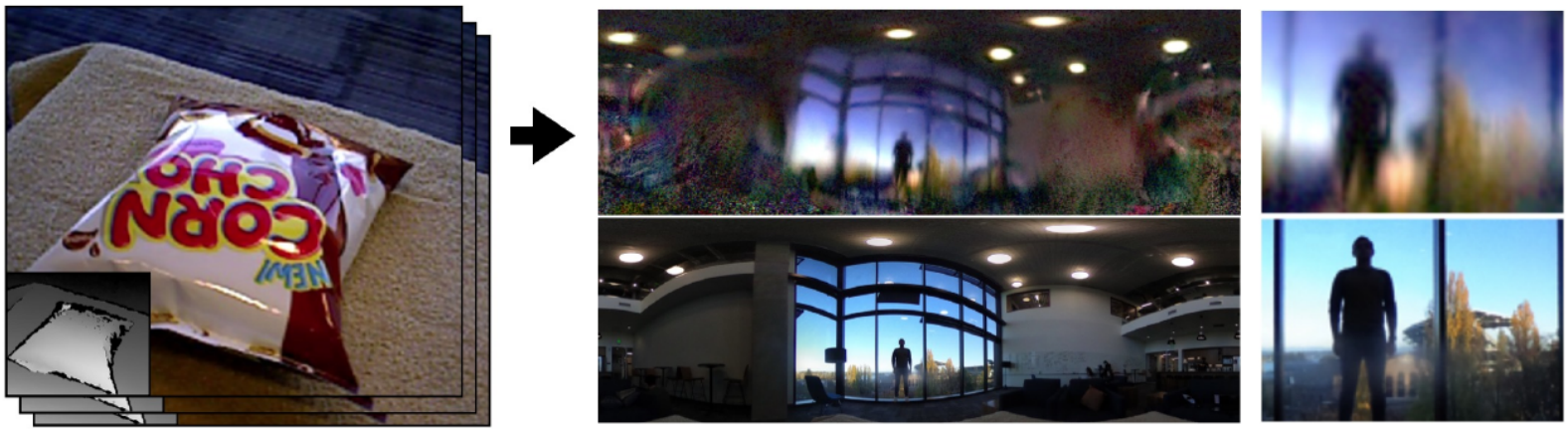
Image synthesis from sketches:



[Chen, S. Y., Su, W., Gao, L., Xia, S., Fu, H. (2020). DeepFaceDrawing: deep generation of face images from sketches. ACM Transactions on Graphics (TOG), 39(4), 72-1.]

The great potential of Deep Learning

Scene rendering from reflections:



[Park, J. J., Holynski, A., Seitz, S. (2020). Seeing the World in a Bag of Chips. arXiv preprint arXiv:2001.04642.]

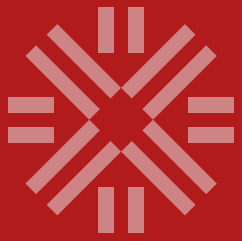


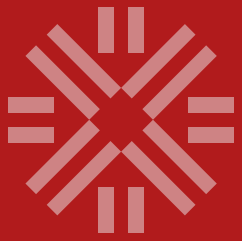
Table of Contents

1 About Digital Images

2 Digital Image Processing

3 Course Overview

4 Reference



Flow of the course

How digital images are acquired and represented?

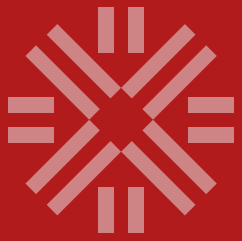
- **0**: Introduction
- **1**: Projection models for perspective and spherical cameras
- **2**: Pixel organisation/representation (2D image, 360°, Light fields)
- **3**: Color representation
- **4**: Transforms and dictionaries

Basics of digital image processing

- **5**: Filtering
- **6**: Advanced Filtering
- **7**: Basics on Deep learning

Advanced image processing tools

- **8**: Inpainting, Super-resolution
- **9**: focus of your choice
- **10**: Perception



Evaluation

Written exam (6th Nov): article analysis (with authorized lecture notes)

Oral exam (8th Nov): summary and presentation of an article

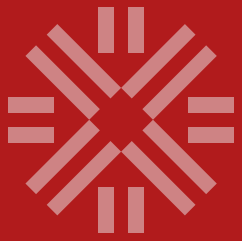


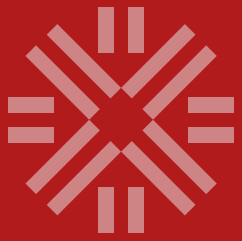
Table of Contents

1 About Digital Images

2 Digital Image Processing

3 Course Overview

4 Reference



References

- Jain, A. K. (1989). Fundamentals of digital image processing. Englewood Cliffs, NJ: Prentice Hall,.
- Gonzalez, R. C., and Woods, R. E. (2002). Digital image processing.
- `http://www-percept.irisa.fr/`
- `https://team.inria.fr/sirocco/`