Elec4A - Traitement du Signal

Introduction & Logistique

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UFR Sciences & Techniques, 2026

Brief Intro

- Ph.D. in Computer Science from **Mines Paris/PSL (**prepared at **INRIA Sophia Antipolis),** 2017
  - **Topics:** Computer vision; Image registration; 3D scene reconstruction

- Since 2021: Maître de Conférences at **Université Bourgogne Europe**
  - Teaching: UFR Sciences et Techniques
  - Research lab: **ICB UMR CNRS 6303** / CO2M team (https://icb.u-bourgogne.fr/)
  - **Topics:** Feature learning; Image matching; Video prediction; Human motion analysis; Robot vision; Physics-informed AI; ...

- Contact info: renato.martins@ube.fr and https://renatojmsdh.github.io/

Brief Intro

AI

Vision for Robotics

Data Fusion

Video

Scene Understanding

Deformable objects

VISION

Sensors

Action Recognition

Multimodal Perception

Deep Learning

Virtual Humans

Logistics & Course Details

- Course material shared on website:

  https://renatojmsdh.github.io/courses/ELEC4A/index.html

- **10 lectures and 10 tutorials (TD)**
- **4 practical sessions (TP)** along 12 weeks! (05 Janvier to end April)
- Classes mostly on **Mondays** ~ 55h
- There are no bad questions (respectfull environment towards colleagues).

  Please participate!

Contents

Course Goals:

- 1) Provide students understanding of what are **basic techniques of signal processing and analysis**:
  - Analysis in spatial and frequential domains
  - Signal reconstruction and synthesis
  - Application of filtering (noise elimination)
  - When to use each technique!

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  - Signal reconstruction and synthesis
  - Application of filtering (noise elimination)
  - When to use each technique!
- 2) A strong emphasis will be given to applications and practical cases with real sensor signals (images, audio, temperature, ...).
- 3) After this course, students should be able to **develop and apply existing signal filtering and reconstruction techniques** in real scenarios.

Motivation

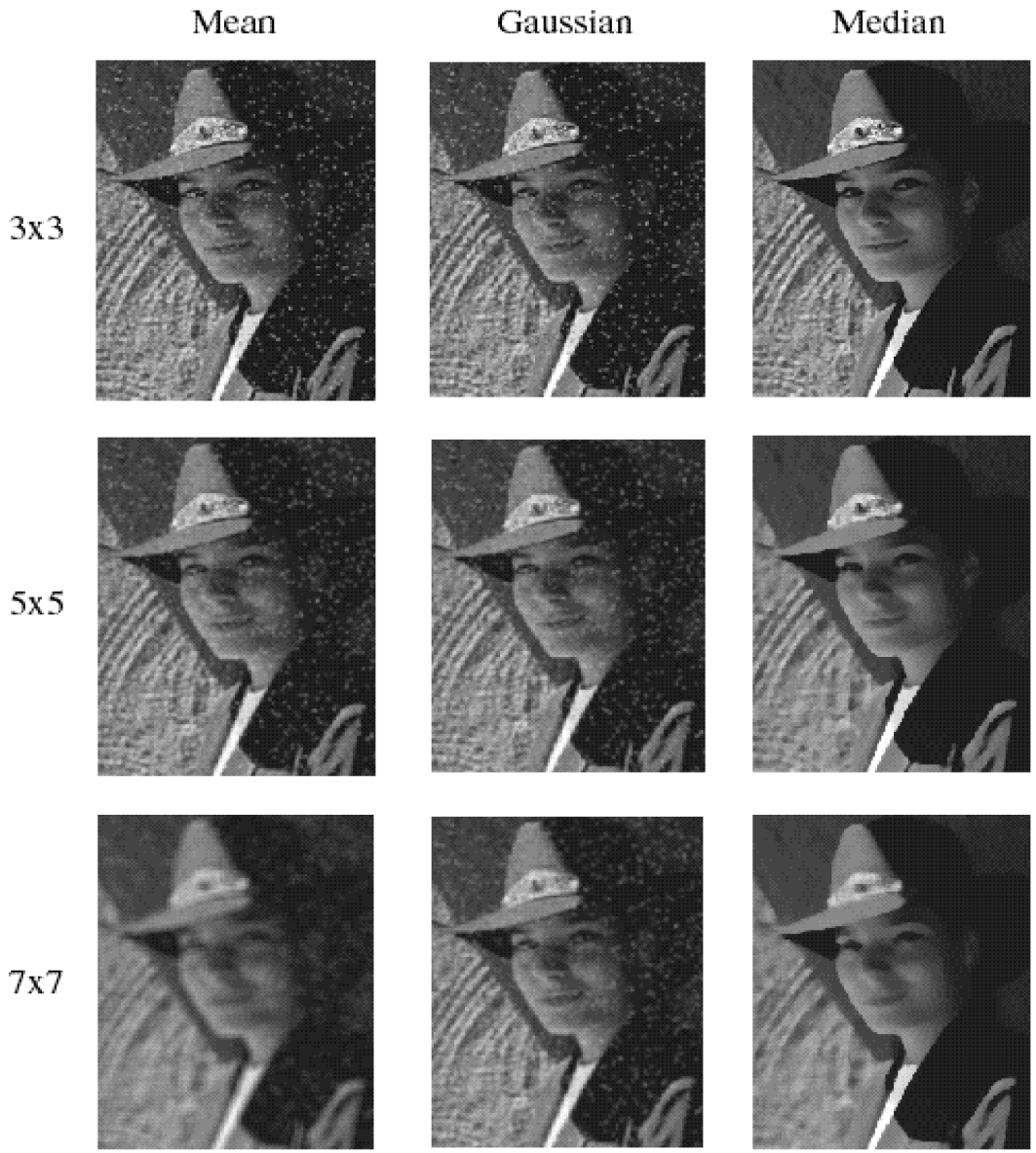
- Spatial signal filtering (signals in 1D, 2D, 3D, ...)

- **Really important!**
  - Enhance images
    - Denoise, smooth, increase contrast, etc.
  - Extract information from images
    - Texture, edges, distinctive points, etc.
  - Detect patterns
    - Template matching

Original

Salt and pepper noise

Comparison: salt and pepper noise



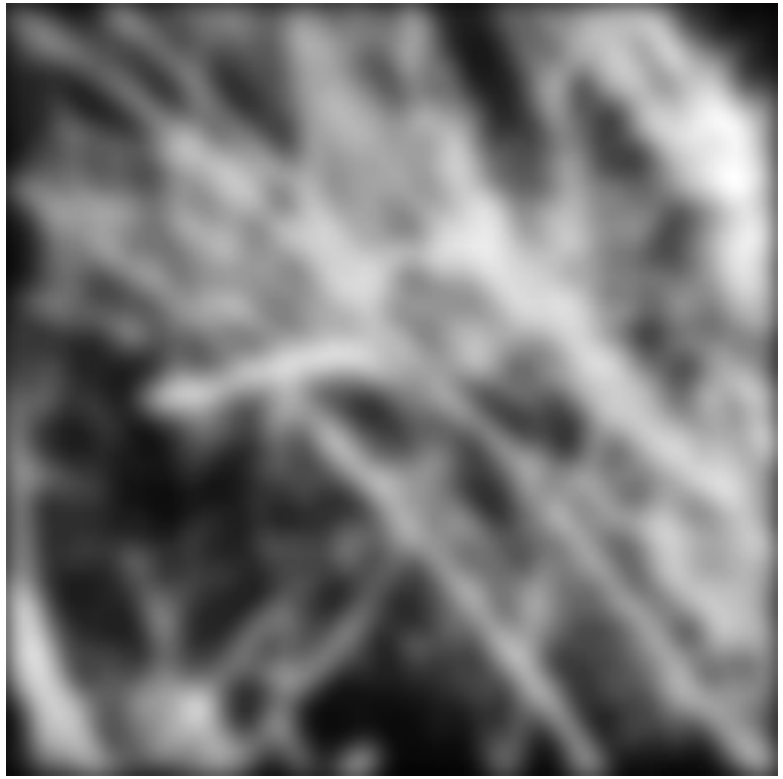
Slide: Steve Seitz

Motivation

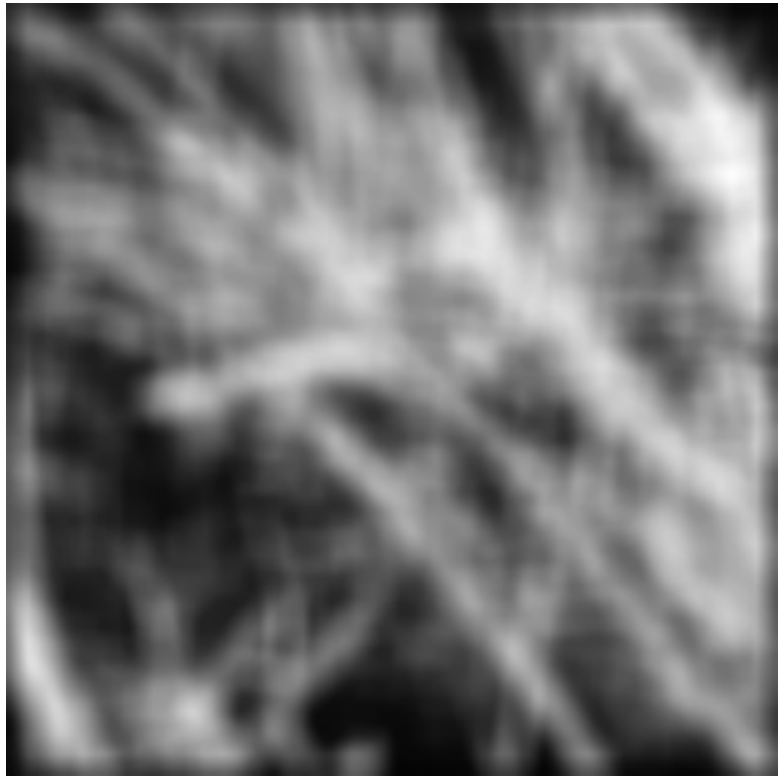
Motivation

Why does the Gaussian give a nice smooth image, but the square filter give edgy artifacts?

Gaussian 



Box filter 



Motivation

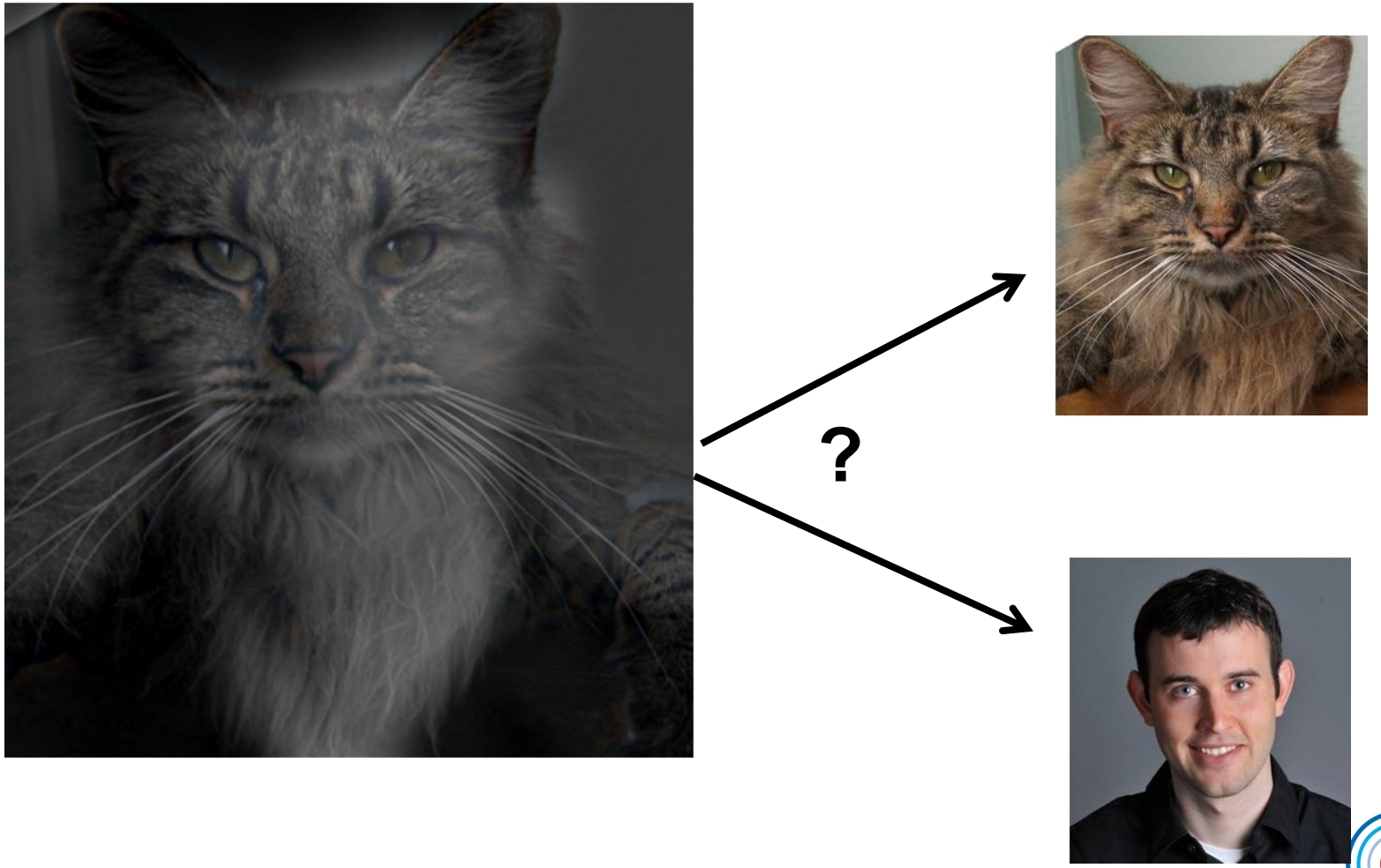
Why does a lower resolution image still make sense to us? What do we lose?

Image: http://www.flickr.com/photos/igorms/136916757/

Slide: Hoiem

Motivation

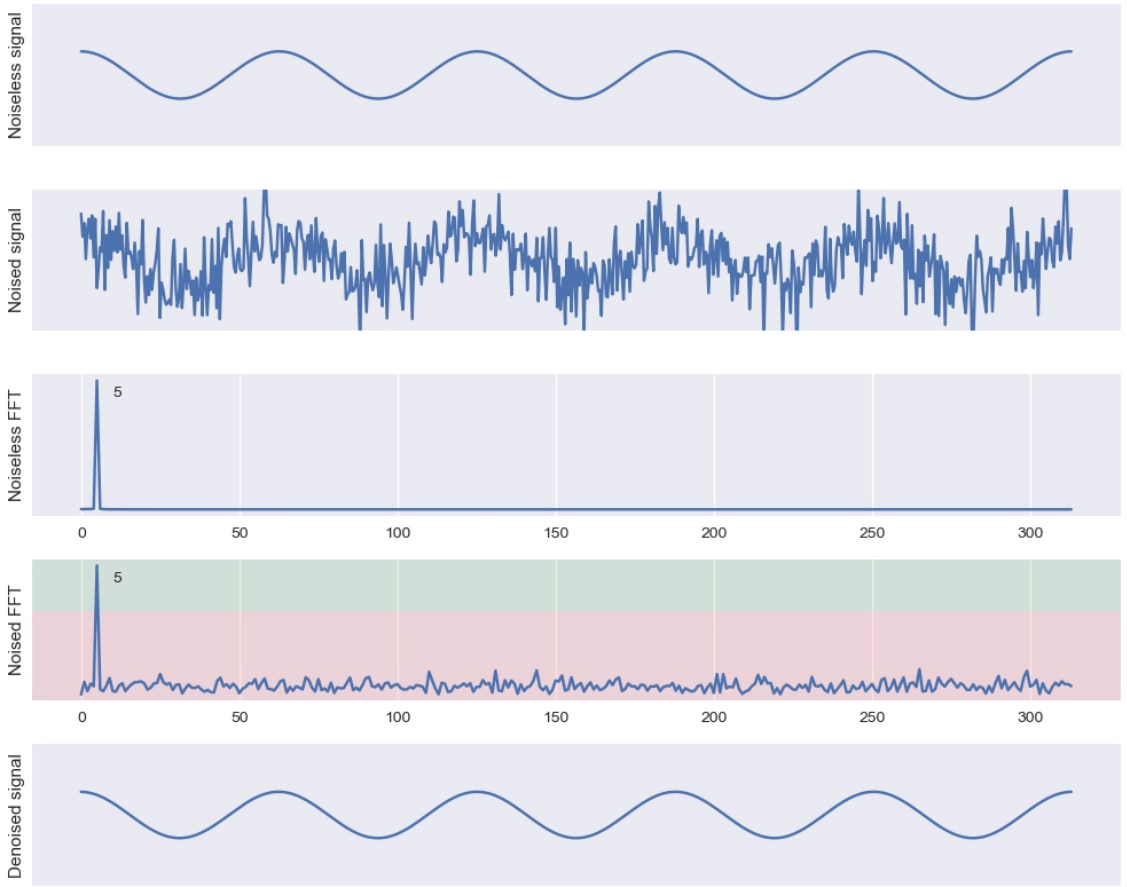
Why do we get different, distance-dependent interpretations of hybrid images?

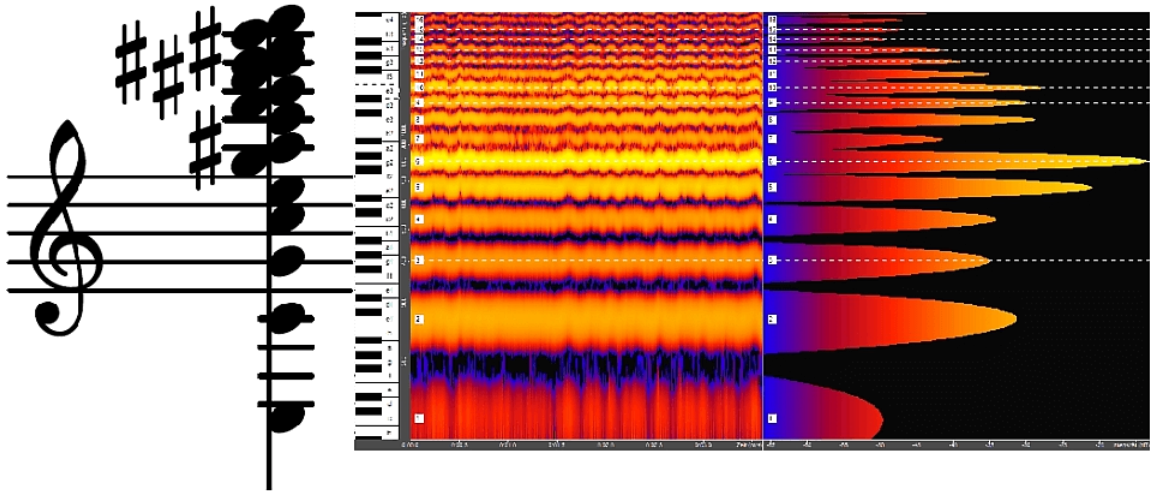


Slide: Hoiem

Applications: Filtering 1D Audio Signals

- Filtering/denoising audio 1D signals (frequential vs spatial domains)





Applications: Filtering and Blending Signals

- Filtering and blending images (frequential vs spatial domains)
- How to combine and make “smooth” transitions between two signals?

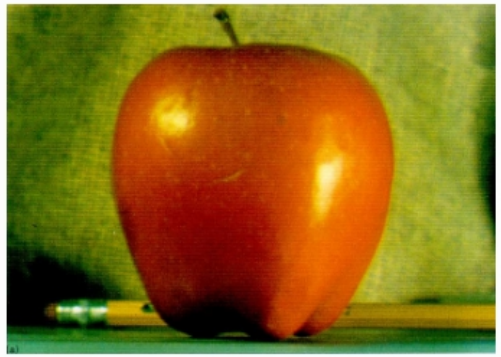


Fig 3. Apple (with scanned paper texture), from Burt and Adelson 1983.

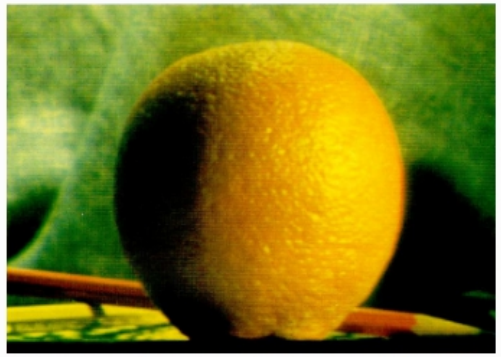
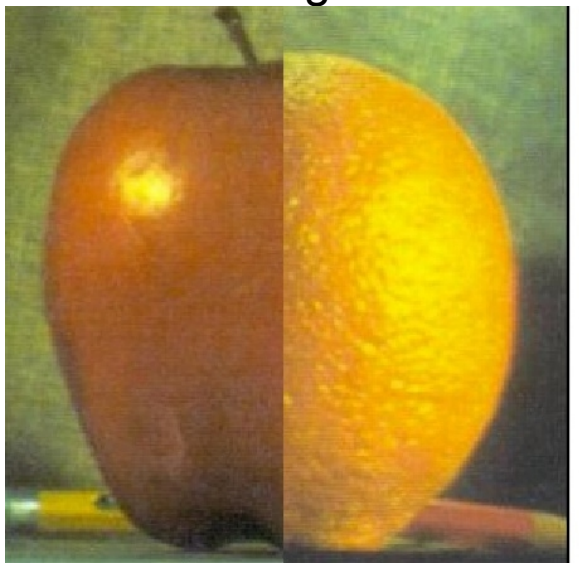
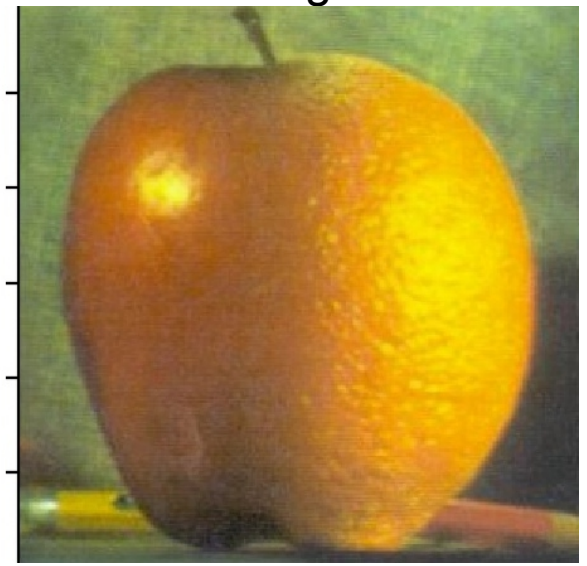


Fig 4. Orange (with scanned paper texture), from Burt and Adelson 1983.

Blending result 1



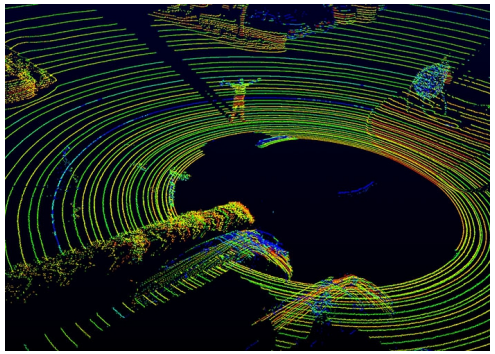
Blending result 2

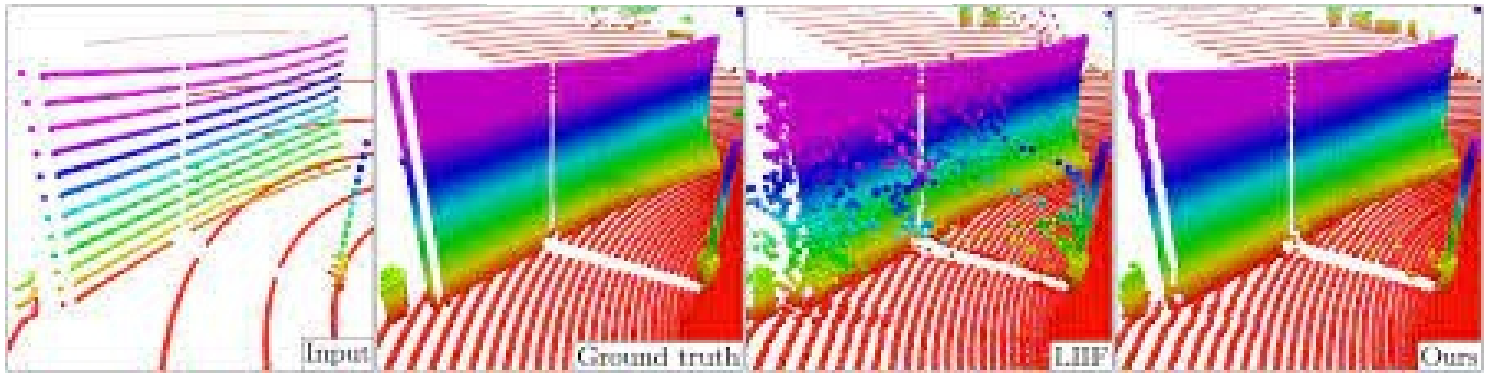


Applications: Filtering and Blending Signals

- Filtering and interpolation of 3D data (LIDAR)
- How to interpolate smooth 3D signals? How to handle missing values?

Depth sensors :





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Main covered topics:

- Description and representation of signals
- Filtering in spatial domain
  - Convolution
  - Typical kernels and applications

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- Description and representation of signals
- Filtering in spatial domain
  - Convolution
  - Typical kernels and applications
- Sampling and quantization
  - Interpolation
  - Signal reconstruction and synthesis
- Fourier Series and Fourier Transform
- Filtering in frequentual domain

Requirements & Skills

- A working knowledge of Matlab/python is desirable for the practical courses.

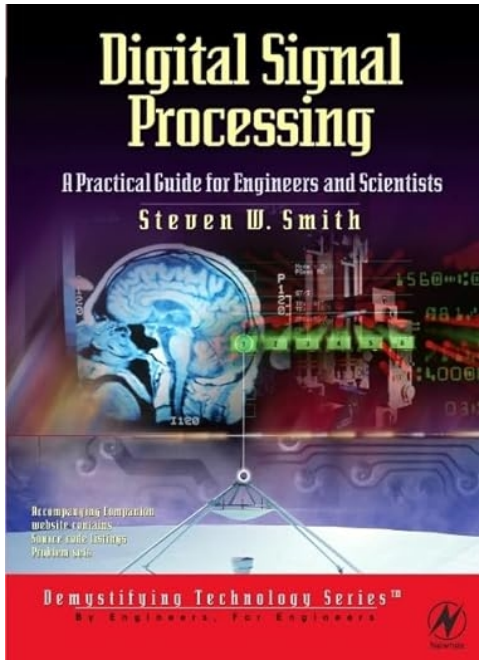
- This course has some math that you need to know:
  - Linear algebra, linear systems, vector calculus, derivate and integrals
  - Probability and statistics
  - We will provide helpers and reminders during the lectures 

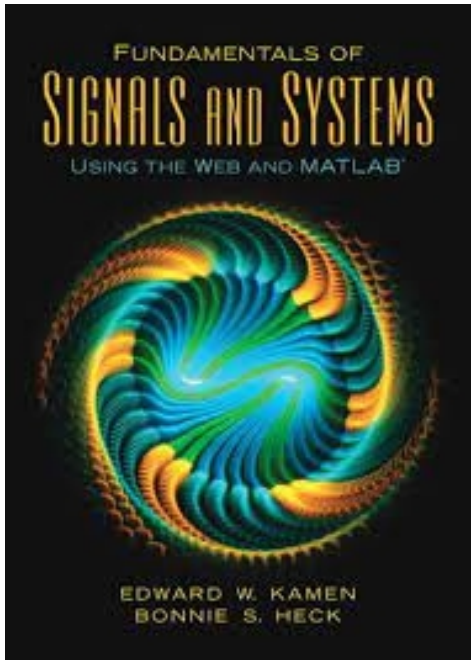
- No strong prior knowledge on systems/signals is assumed. However some experience with programming with images and sensor data is helpful.

Course Materials

- Many books on SP online with nice content:
  - https://www.doradolist.com/signal.html
- “Fundamentals of Signals and Systems: Using the Web and MATLAB”
- Courses in French

The books are in the course channel files





Grading/Evaluation

- [Practical] **4 practical** assignments **(~15 pts each): 60 pts**
  - Practical sessions for developing the assignements **(don’t miss them!)**
- [Exam 1] **Midterm exam: 60 pts**
- [Exam 2] **Final exam: 80 pts**
- Mini project?

Academic Integrity

- You can discuss assignments/projects, but don’t share it.
- Don’t look up code or copy assignments from a friend (it is easy to catch :( ).
- If you’re not sure if it’s allowed, ask.
- Acknowledge any inspirations.
- If you get stuck, come talk to me.

I hope you will enjoy the course!

Pourquoi ce cours vous interesse?

Questions?