# Mathematicians – Companies Interactions

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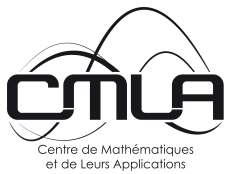
# My Experience

- Master 2 **M***athématiques,* **V***ision et* **A***pprentissage* (ENS Cachan),


- Internship at the **C***entre d'***E***nergie* **A***tomique* (3 months),


- Internship at *DxO Labs.* (10 months),

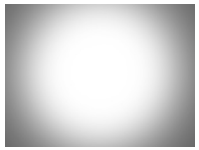

- PhD at the **CMLA** in collaboration with *DxO* (3 years),

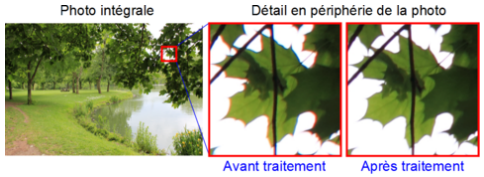



- Post-doc at *Technicolor* (since the 1st of october, 2014).

# Subjects studied

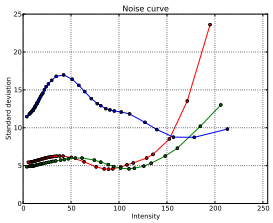
- Vignetting, chromatic aberrations (DxO),



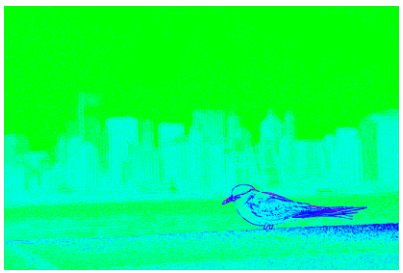


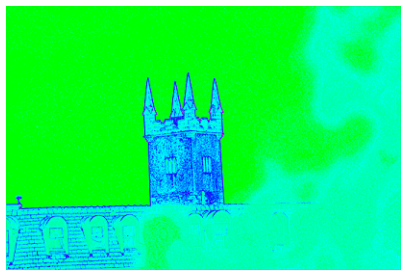

- **Denoising** (DxO, CMLA),

- Noise estimation (CMLA),




- Blur metric, deblurring (Technicolor).





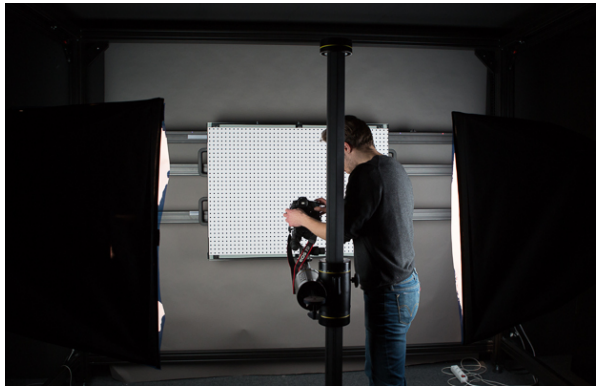
# DxO – Main focus

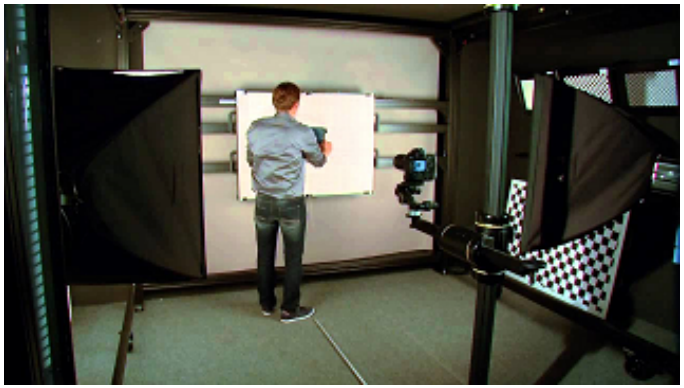

DxO Labs is a french company, world first in its category:

- About **100** employees (*),
- Two sophisticated lab,
- About **20** engineers (*),
- About **1** scientist (*),
- Two main domains: **embedded** and **Optics Pro**,
- One main idea: **calibration**.

(*) When I was working with them.

# Advantage of the calibration





- Small need of huge and difficult theories,
- A lot of optic default may be calibrated,
- DxO were the first to do that [1],
- Tabulated corrections are simple to use,
- Give objective tools for measurement[2].

[1] They own a patent on it, which is joyfully violated by Adobe.
[2] Used by *FNAC and some major magazine on photography.*

# Drawback of the calibration

- Expensive cost,
- Time consuming (especially for per-unit calibration),
- Need a model to fit the data,
- Too much camera/optic to calibrate every year,

# Embedded

Two main problems. **Physical constraints:**

- operation per pixel,

  NI-means: $\sim 10^3$ op. per pixel

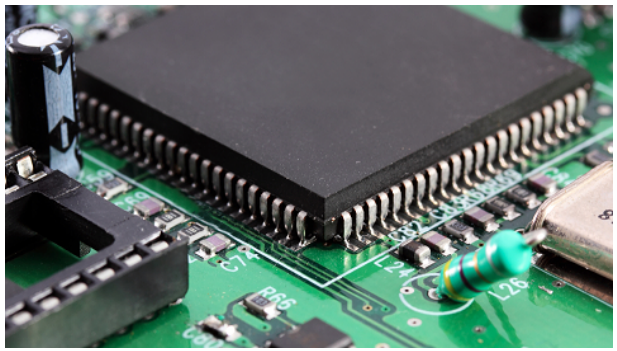
  NI-Bayes: $\sim 10^6$ op. per pixel.

- memory (read, write),

  reachable lines: 3
  NI-means neighbourhood: up to $35 \times 35$

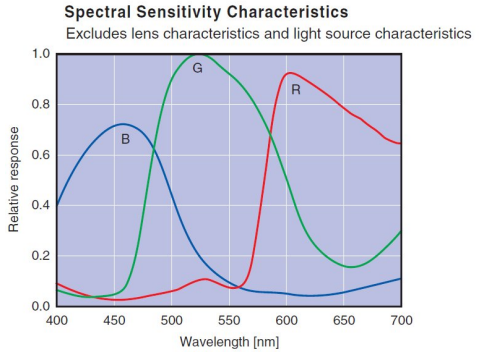
  NI-Bayes neighbourhood: up to $45 \times 45$

- image acquisition (line by line),



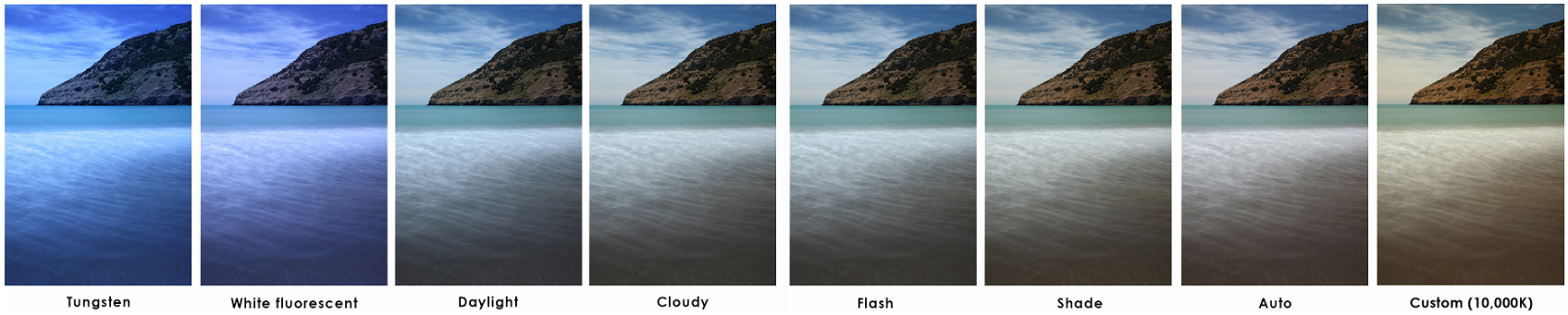
## New optical defaults:

- Vignetting (luminance, chrominance),

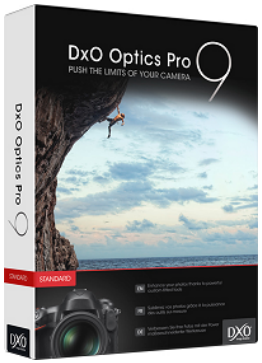



- Depth of Focus, autofocus.

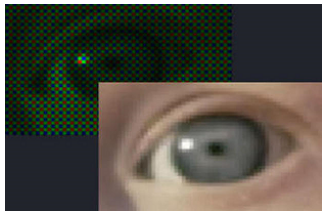
- White balance,



# Optics Pro



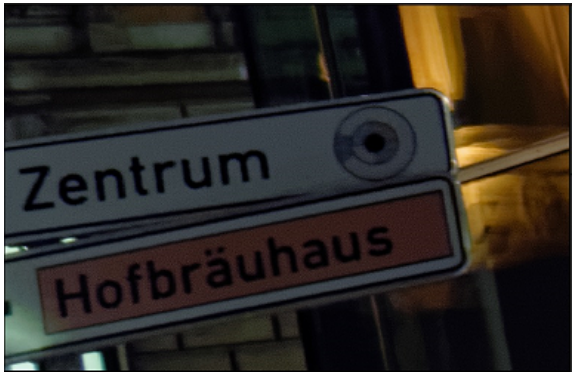

- **show room** of the expertise of DxO,
- Commercial **software** designed for pro and semi-pro photographs,
- From one **raw image**, gives the **best jpeg result**



# Optics Pro

**Correct all optic defaults:**

- denoising,



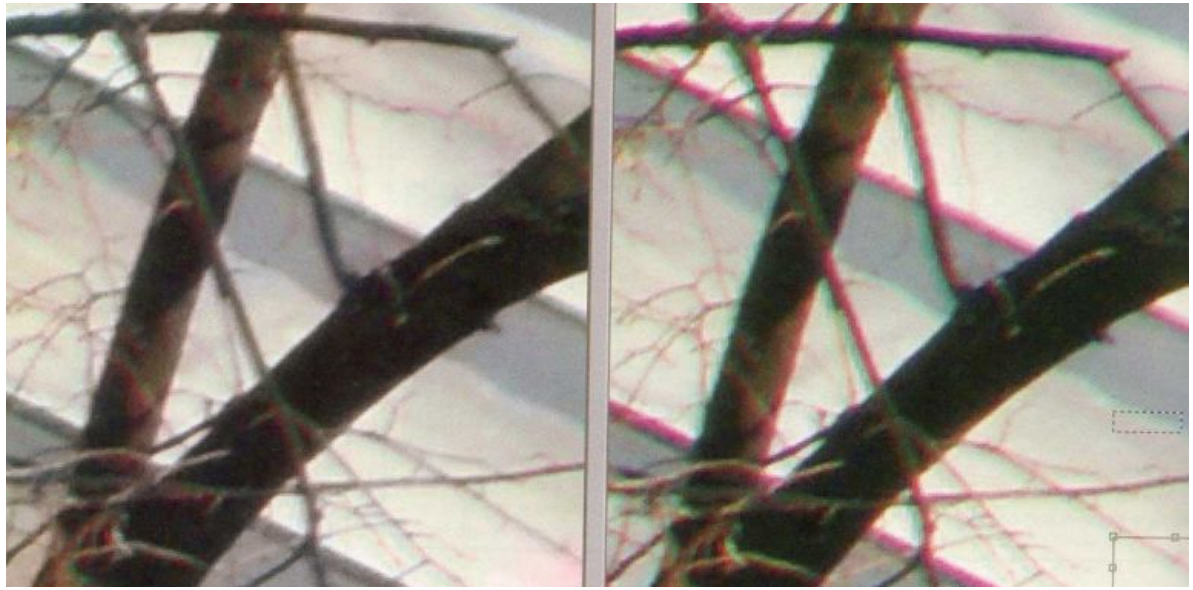

- contrast enhancement,

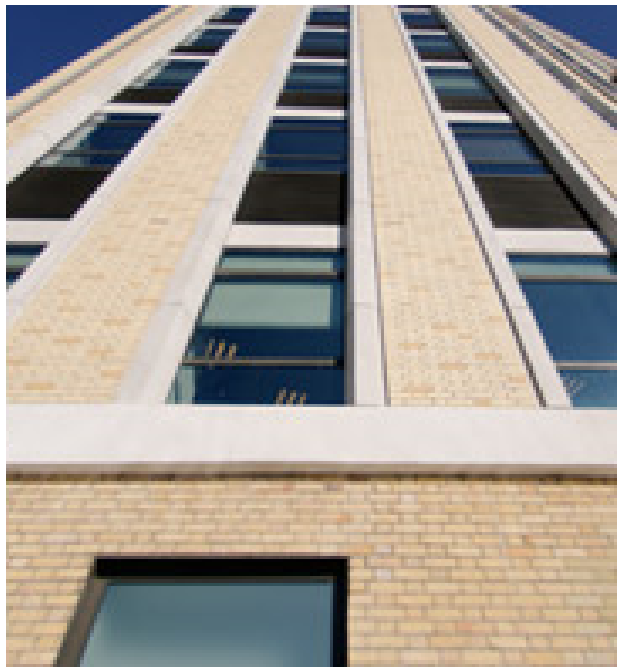
- dehazing,

# Optics Pro

**Correct all optic defaults:**

- chromatic aberration,



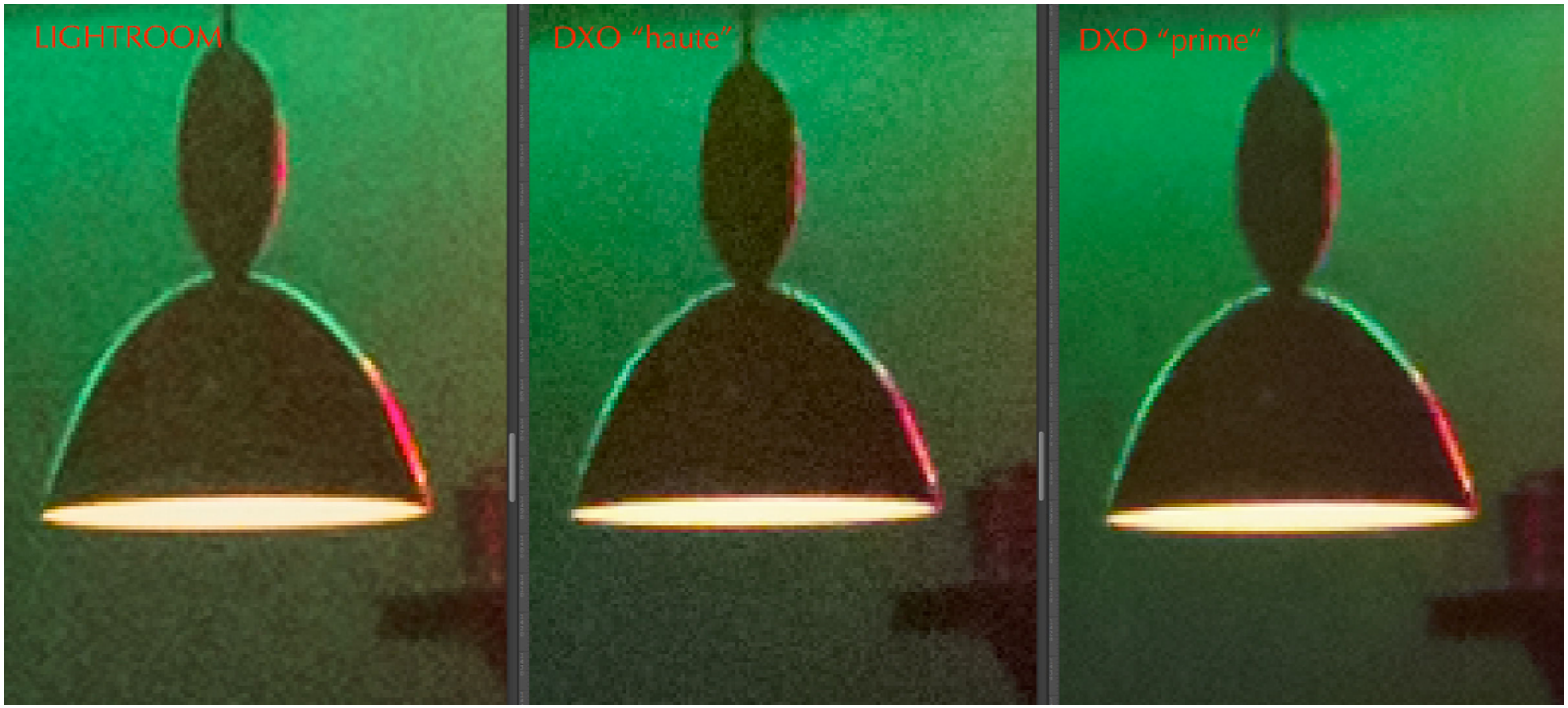


- optic distorsion.

# Special case of the denoising

Were among **the first** to propose a denoising of raw images.

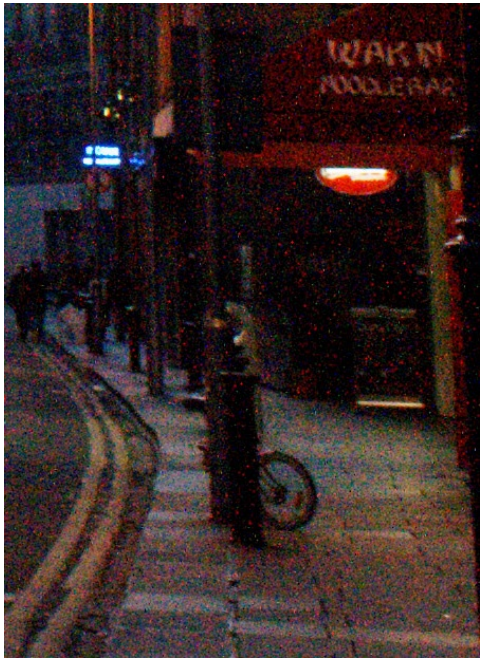
- **Calibration** of the noise curves,
- Collaboration with the CMLA **to adapt NL-means to raw images**,
- **Multi-scale** approach,
- Very fast [3]
- Obtained the best results on the market.



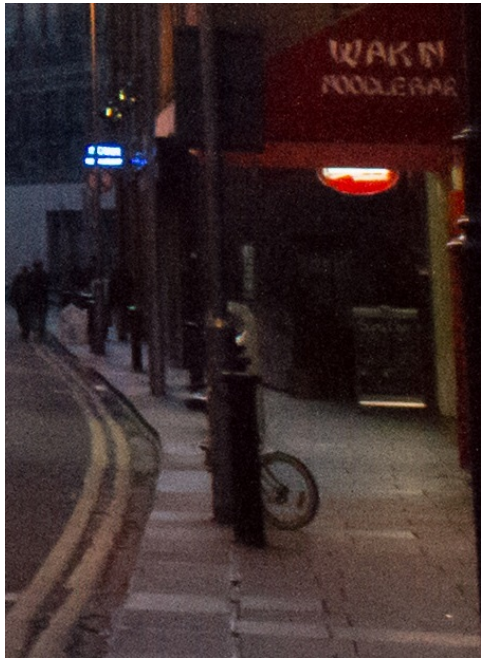

[3] A lighter solution of the same algorithm has been embedded

# Limitations

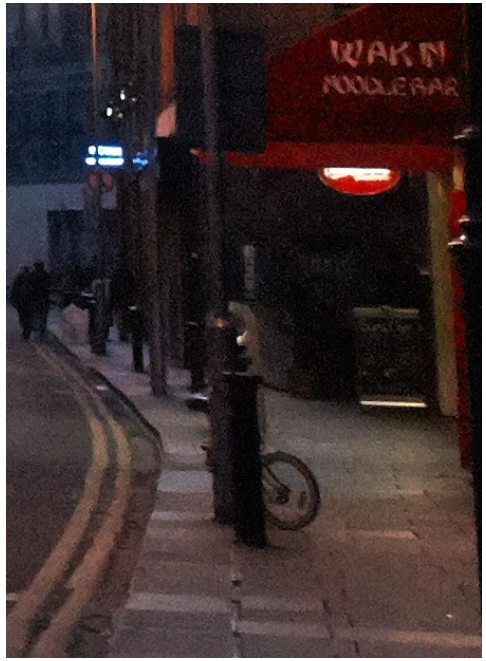
- Rival products achieved comparable and even **better solution**,



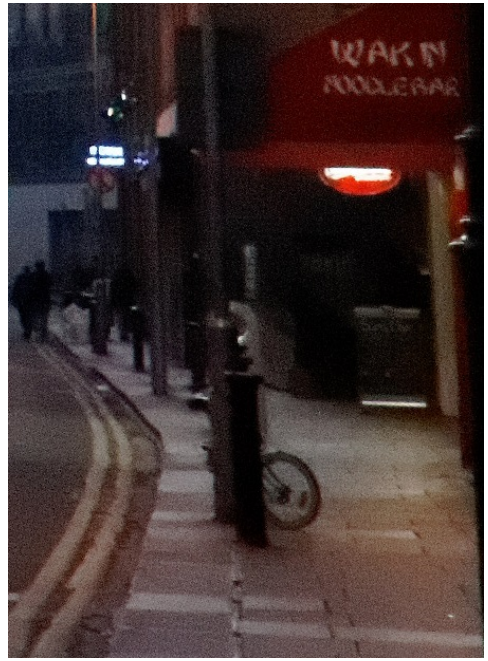

Original image




Lightroom




Capture One




Optics Pro 8

# Limitations

- Source code became **really complex**, no one knows what exactly this is about [4]
- Slightly becomes **inefficient** due to complex upgrades,
- Need of a **new** theory...
- ...but no time/engineer to do that...
- ...solution: **academic research** with a PhD student.

[4] Typical of (this) company.

# Cifre PhD – How it works?

1. **Specification** of the problem (company),
2. **Study** of the state-of-the-art (lab),
3. **Test** state-of-the-art algorithms [5](lab/company),
4. **Develop** a new theory/algorithm to solve the problem (lab),
5. **Adapt** it to the specific use-case of the company (lab/company),
6. Intense **test** of the algorithm (company),
7. Modification and **adaptation** (lab/company),
8. **Validation** of the algorithm (company),
9. Final **implementation** of the solution (company).

[5] In my case, no source code were available, so I had to analyse and implement the alorithms.

# Academic work $\neq$ real life (caricatural)

| | **Academic** | **Company** |
|---|---|---|
| **Specification** | Gaussien noise<br>Model for the noise<br>Can be implemented in<br>matlab, C++, python... | Signal-dependent noise<br>Noise curve calibrated<br>Must be efficient<br>(C++), parallelized |
| **Theory development** | Look state-of-the-art<br>Try to improve existing theory<br>or create a new one | Look on what we have<br>Try to upgrade by<br>small steps |
| **Evaluation** | PSNR<br>$\sim$ 10 images<br>mostly 1 channel<br>up to $512 \times 512$ | Visually<br>$>$100 images<br>4 channels<br>$>$15 Mp |
| **Case of failure** | Very ugly result | Too slow<br>One tiny detail on<br>one image looks weird |

# Advantages of both sides

**Academic**

- Knowledge of the **state-of-the-art**,
- Understand it quite easily,
- Build **breakthrough** theories,
- Can **adapt** the theory,
- Knows **theoretically** what/why it would/should (not) work.

**Company**

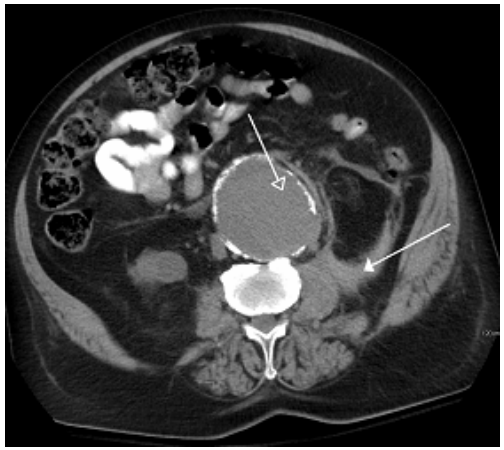
- Bring **specific** problems to solve,
- Interesting set of test images,
- Really good **intuitions**,
- Remains **practical**,
- The final solution/product will be **effectively used**.

# Today's issues in numerical images

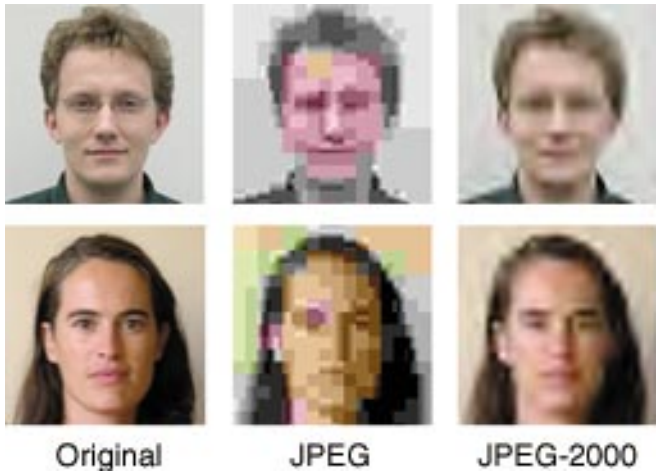
Small overview of what today's companies are working on:

**Professional content:**

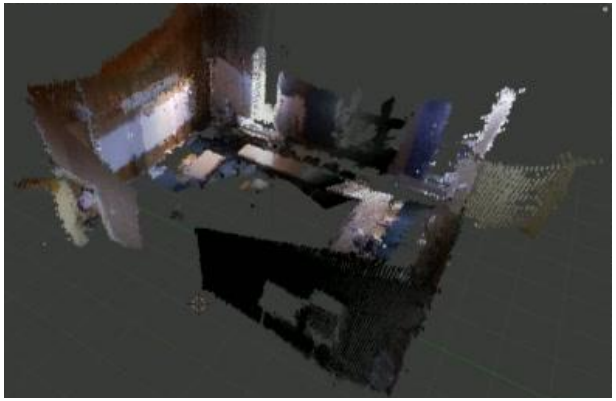
- Medical images,



- Compression (video and still images),




- Drone, 3D reconstruction,



- Satellite images,

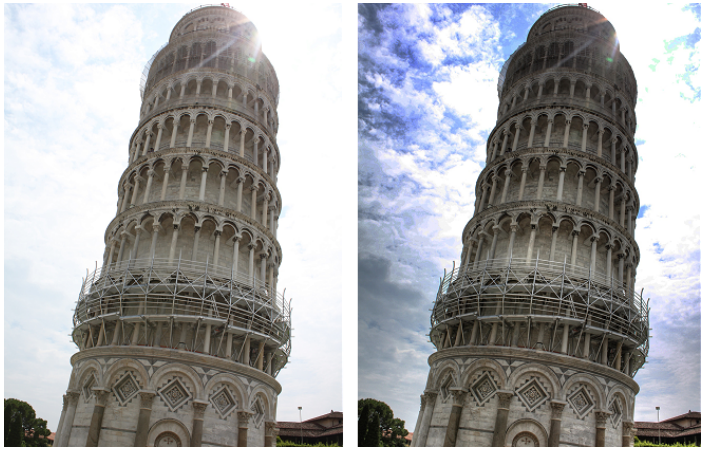
# Today's issues in numerical images

Small overview of what today's companies are working on:

**Professional content:**

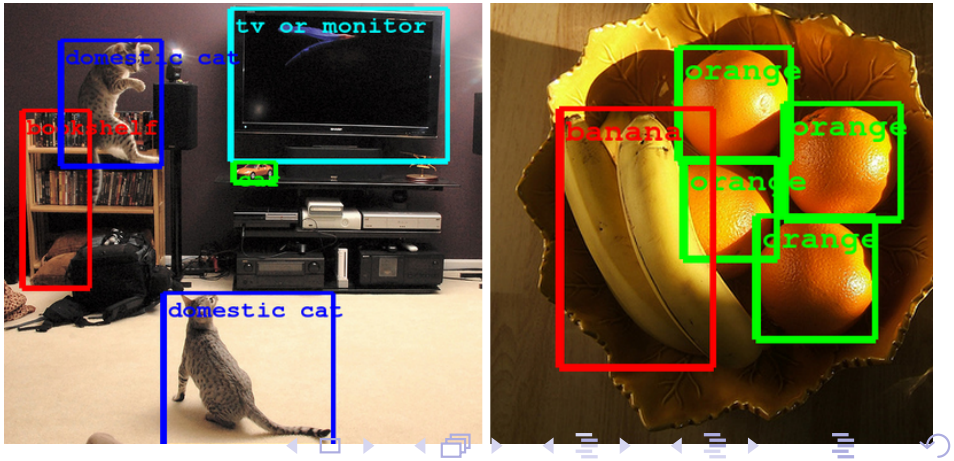
- Video surveillance,

- HDR,



- 4K movies (reframing),

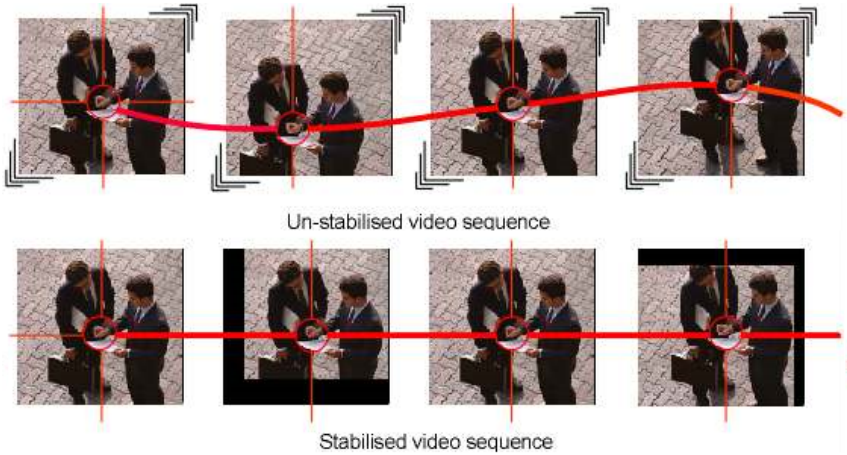
- Detection, content understanding



# Today's issues in numerical images

**User Generic Content:**

- video stabilization,




- denoising,

- deblurring,

- contrast enhancement,

# Today's issues in numerical images

**User Generic Content:**

- upscaling,

- smart rescaling,


- smart sort of content,


- smartphone

# Conclusion

Without academic research, a company dies:

- Out-of-date solutions,
- Need to understand the state-of-the-art,
- No breakthrough with small upgrades,
- Google research, Microsoft research, Technicolor, ...

Without real-life interactions, the pure academic research is doomed to get lost:

- Companies have really interesting problems,
- Need to look at the result, and not only to the theory (PSNR),
- Solutions are used by mankind, not abandoned after the PhD.