Image Processing on Line

http://www.ipol.im

A new way to publish algorithms?
A new way to organize research in an image analysis lab?
A new way to establish a state of the art?

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Project partially funded by ERC, CNES, ONR N00014-97-1-0839

IPOL: http://www.ipol.im

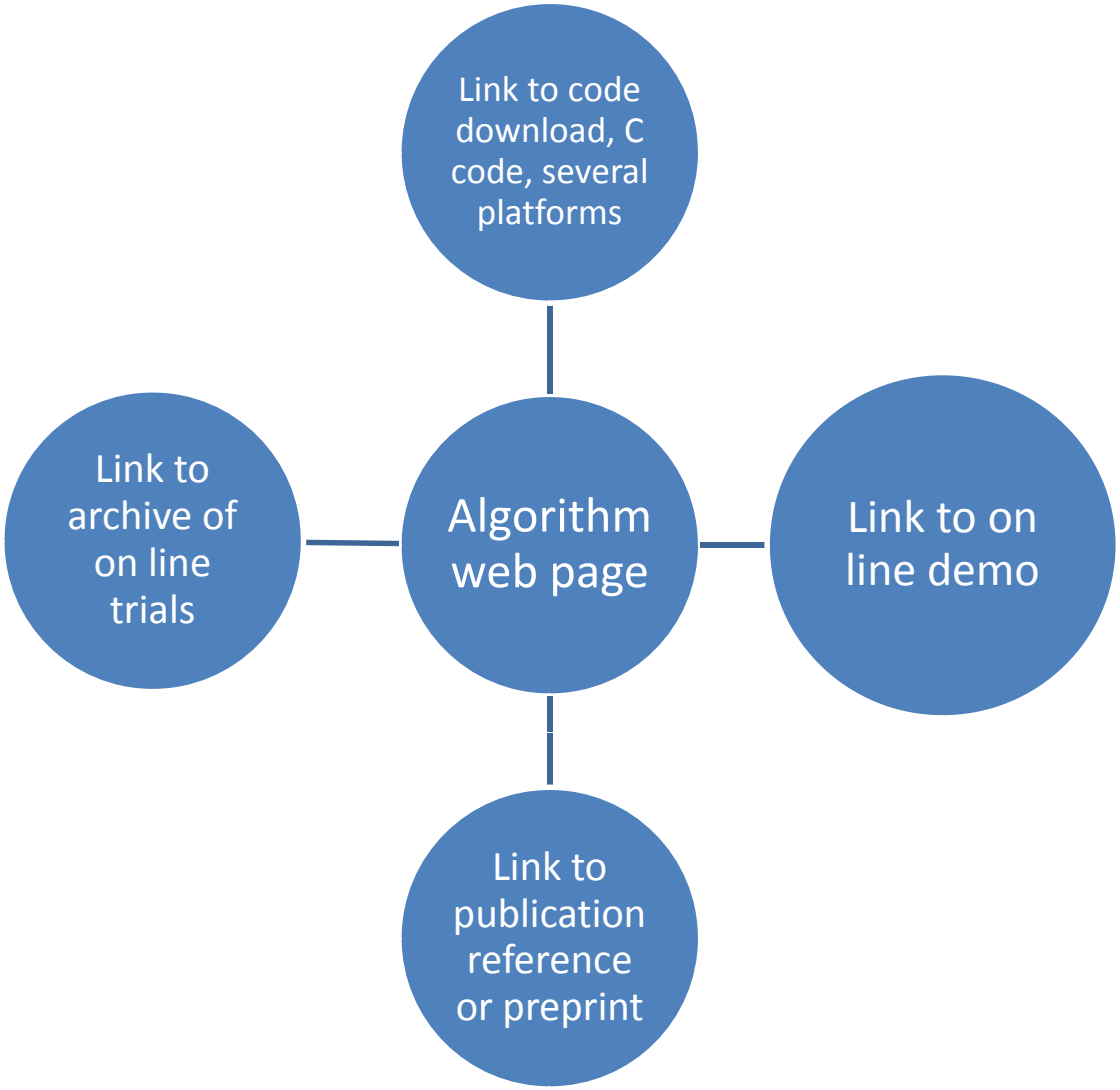
The goal is to achieve « reproducible research » and therefore to publish:

Litterary but complete and accurate description of each algorithm
Downloadable code (certified by refeerees to correspond to the description)
On line demo (also tested and certified by referees)
An open archive for each article with all on line experiments results

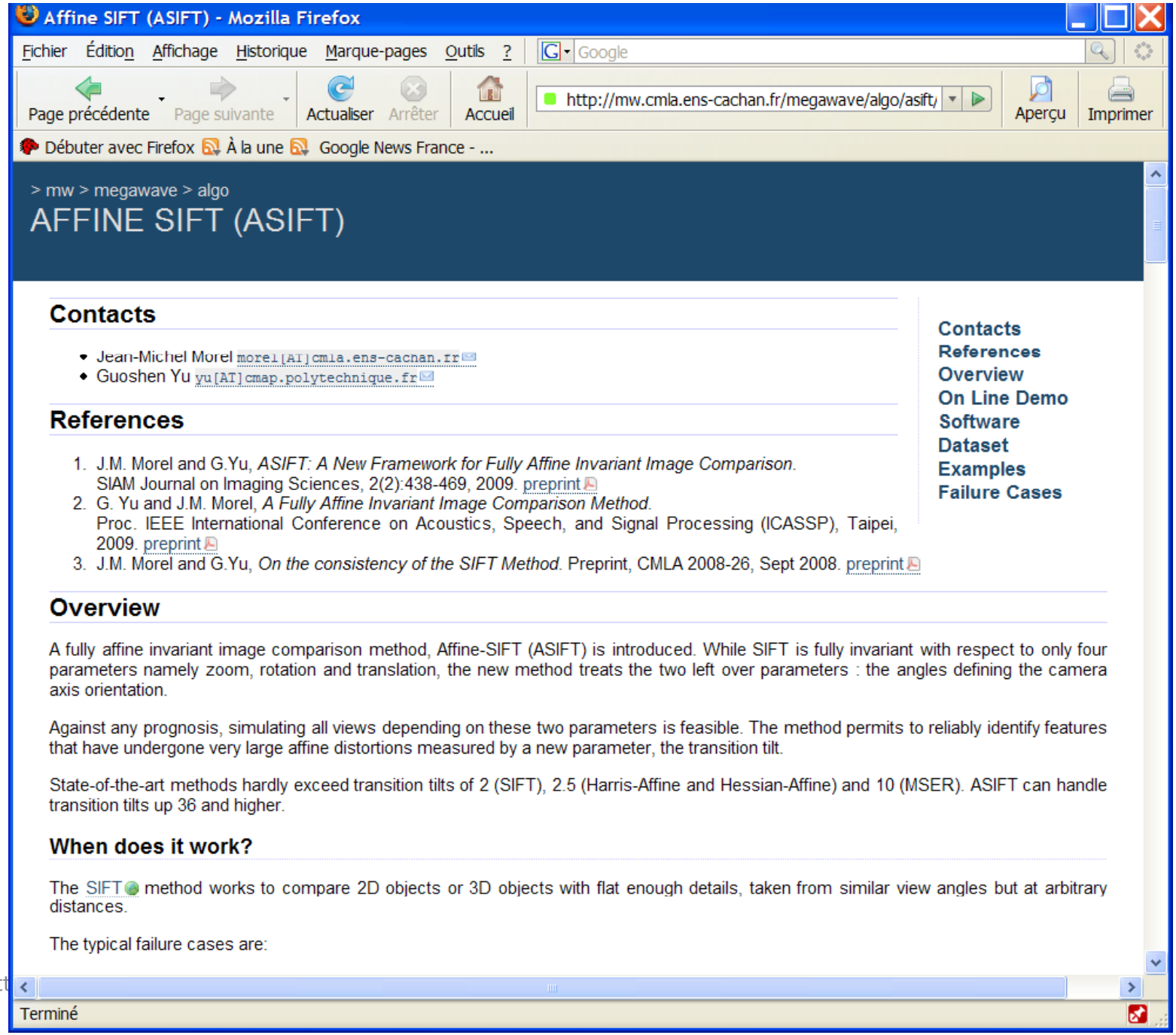
Advantages
Experiment sharing
Testing independent of any platform (no code download, no system requirement…)
Authors rewarded by a peer reviewed publication, complementary to a classic « paper »

Online execution is particularly adapted to image processing because images and video have standard formats and can be uploaded.

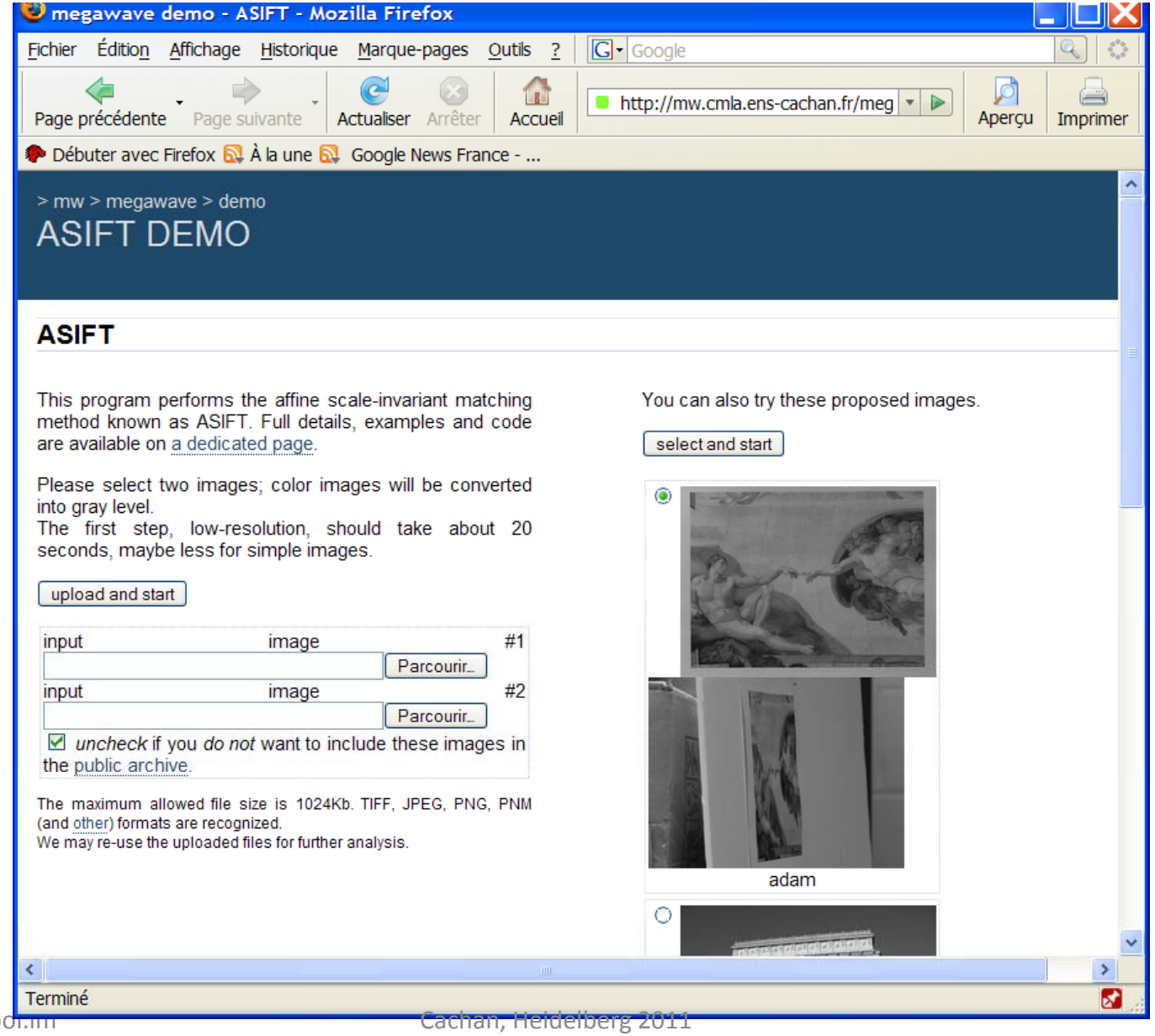
For each algorithm: a fourfold publication



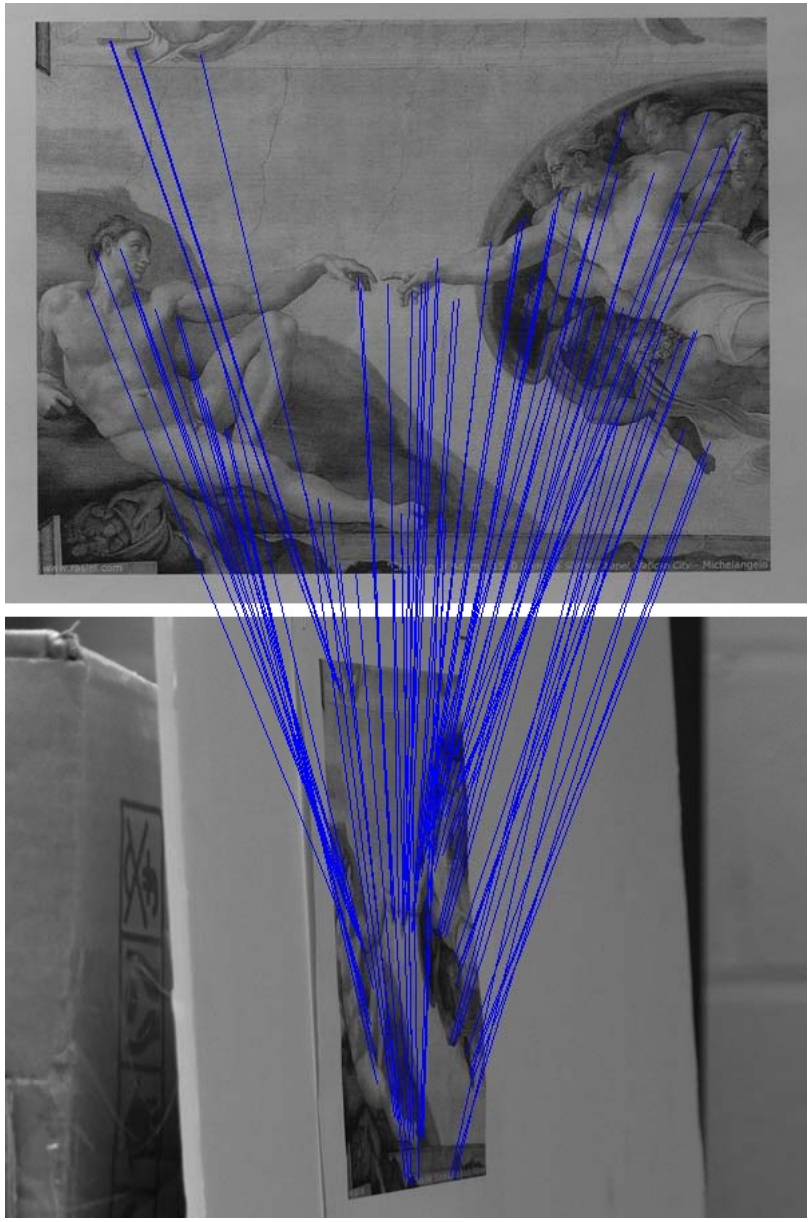
Article = Web page + Online demo + Archive + Code



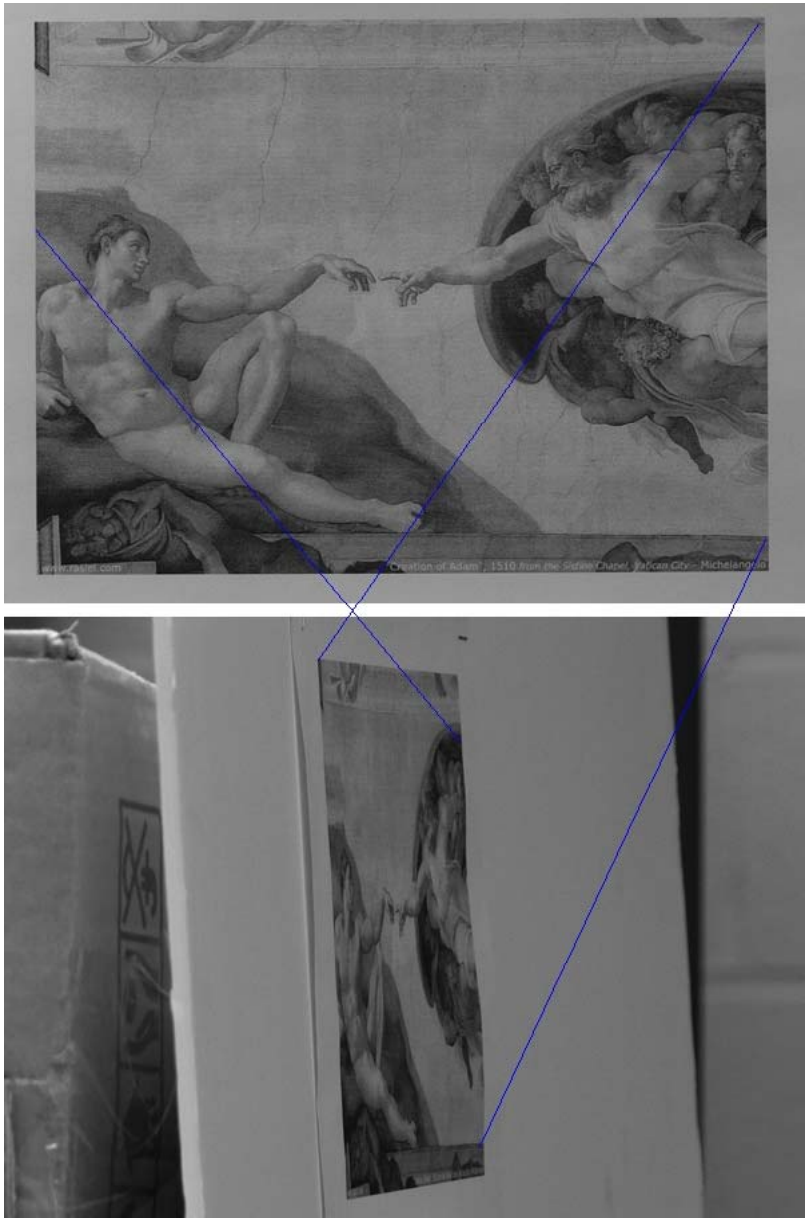
Example : ASIFT: affine invariant image, SIFT scale invariant image comparison (tools : heat equation, differential invariants), a contrario methods



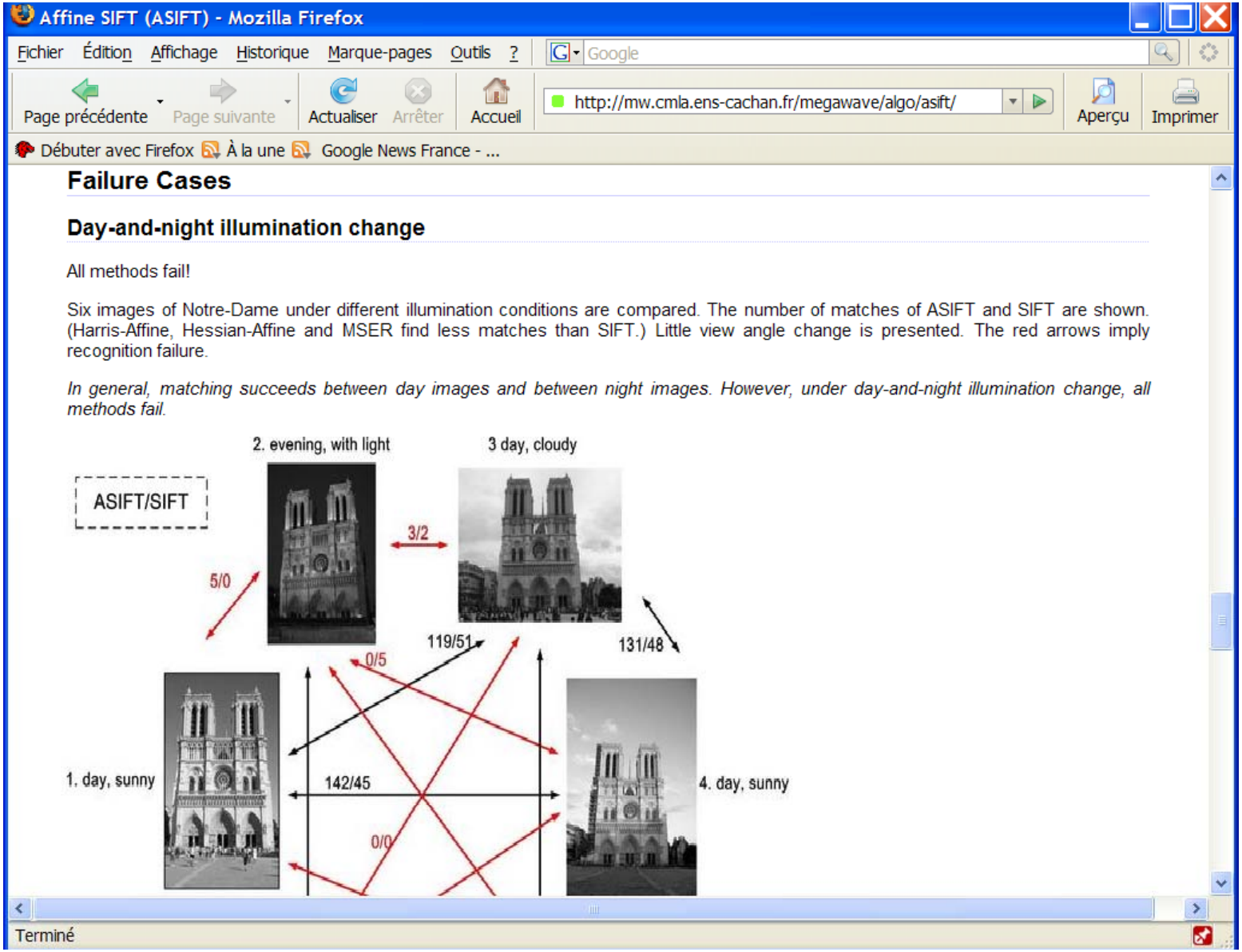
Result of ASIFT:



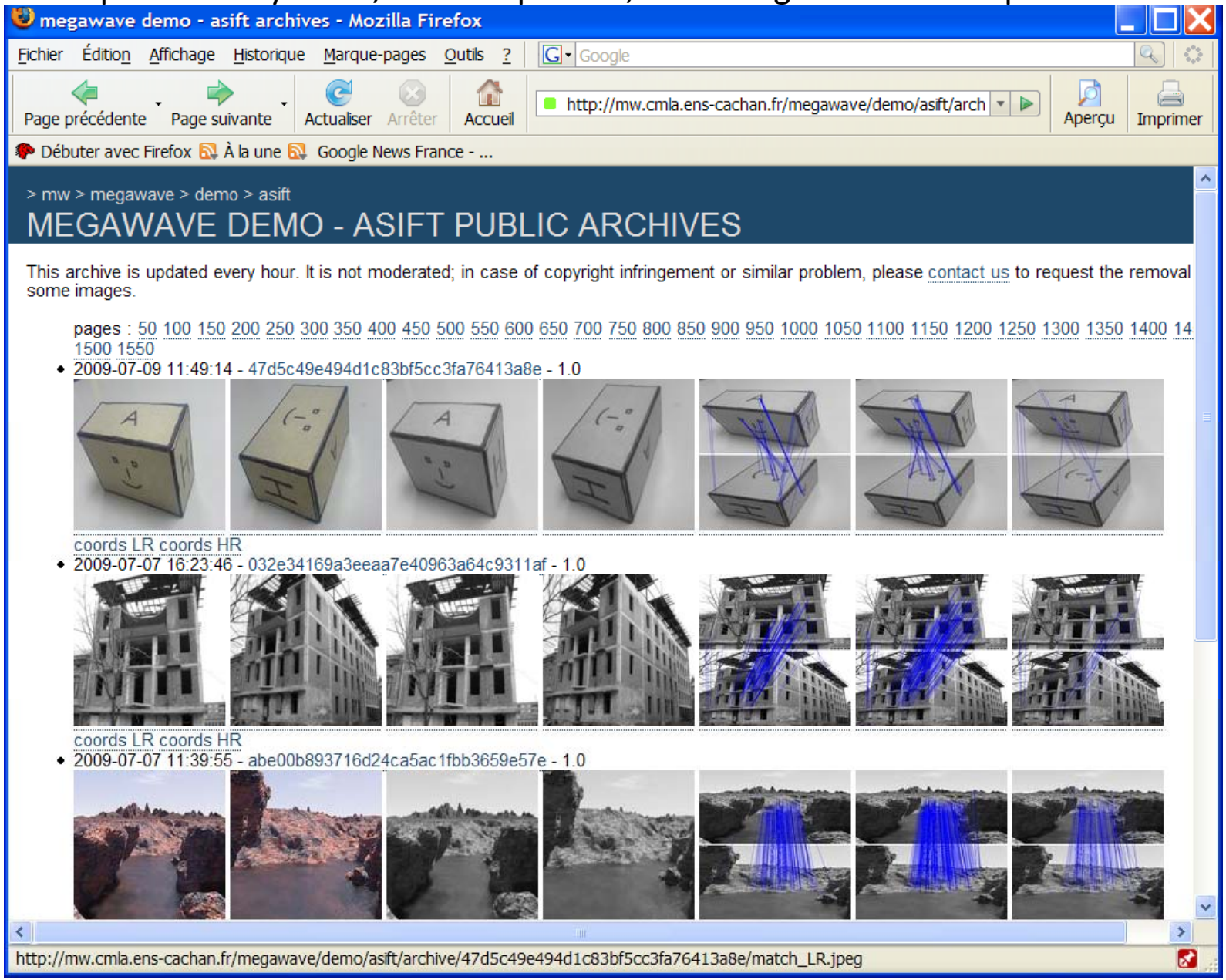
Compared with SIFT:



The page of each algorithm shows and explains the failure cases. For instance for SIFT and ASIFT, failure comparing objects with night and day illumination

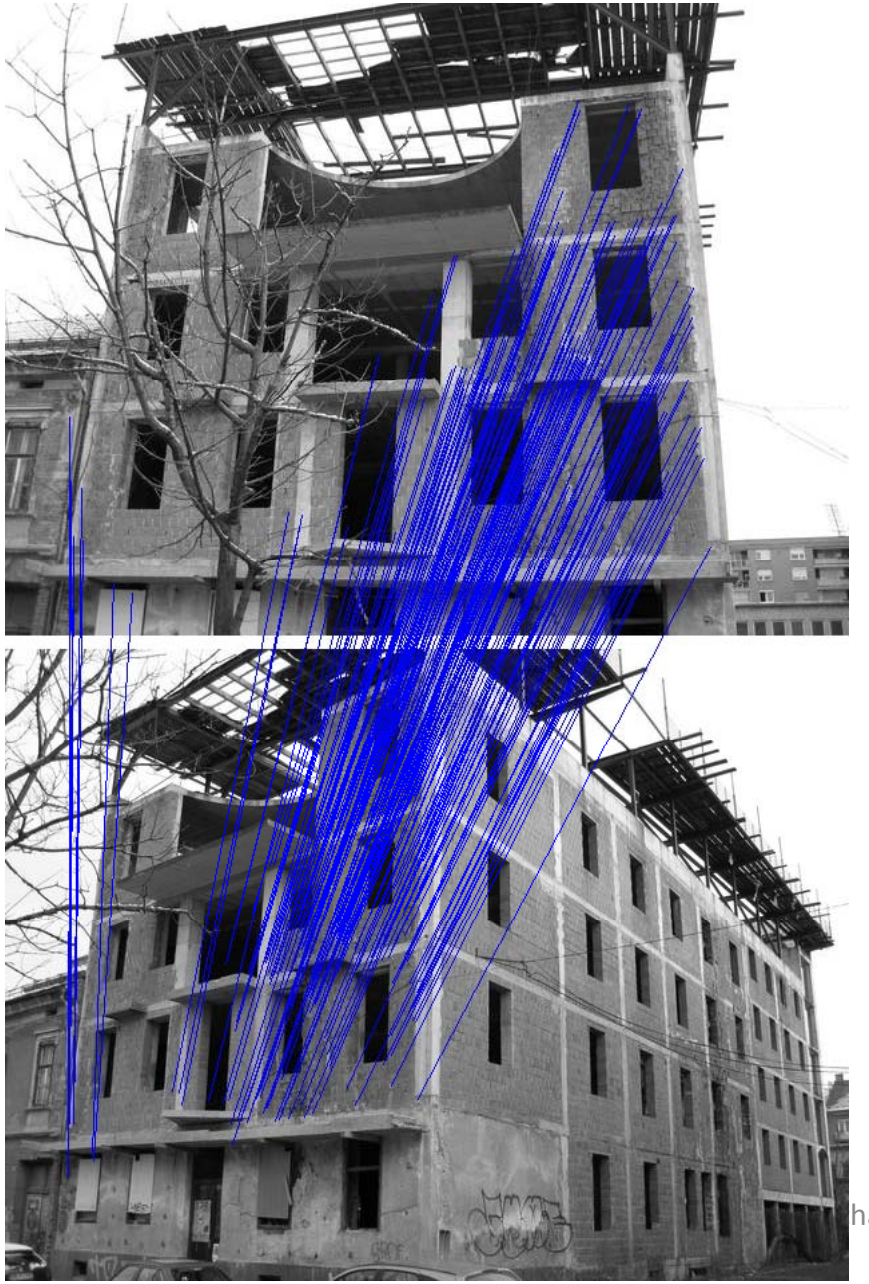


The online demo gives also access to the online archive. More than 8550 different images have been so far tried by on line users. They are grouped in pages of 20. Here are three examples tried by users, on a simple box, a building and a landscape.

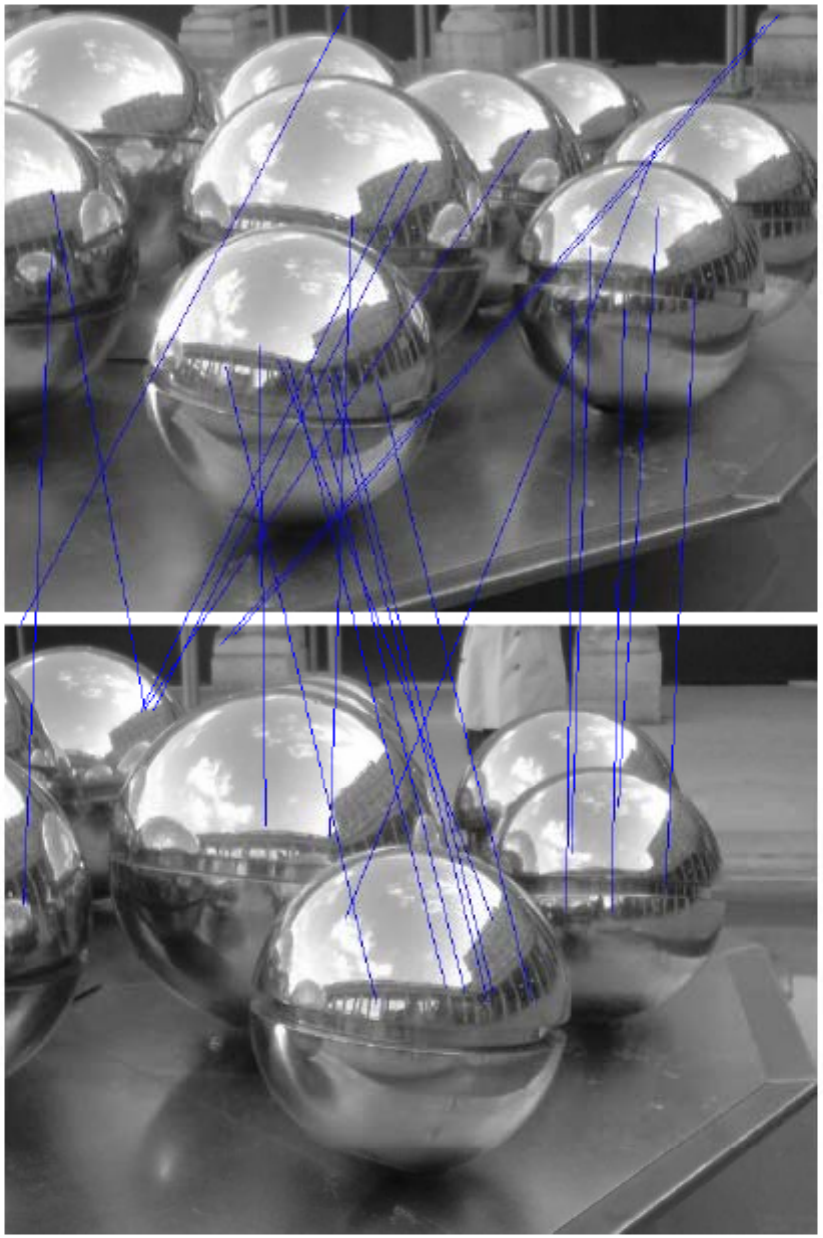


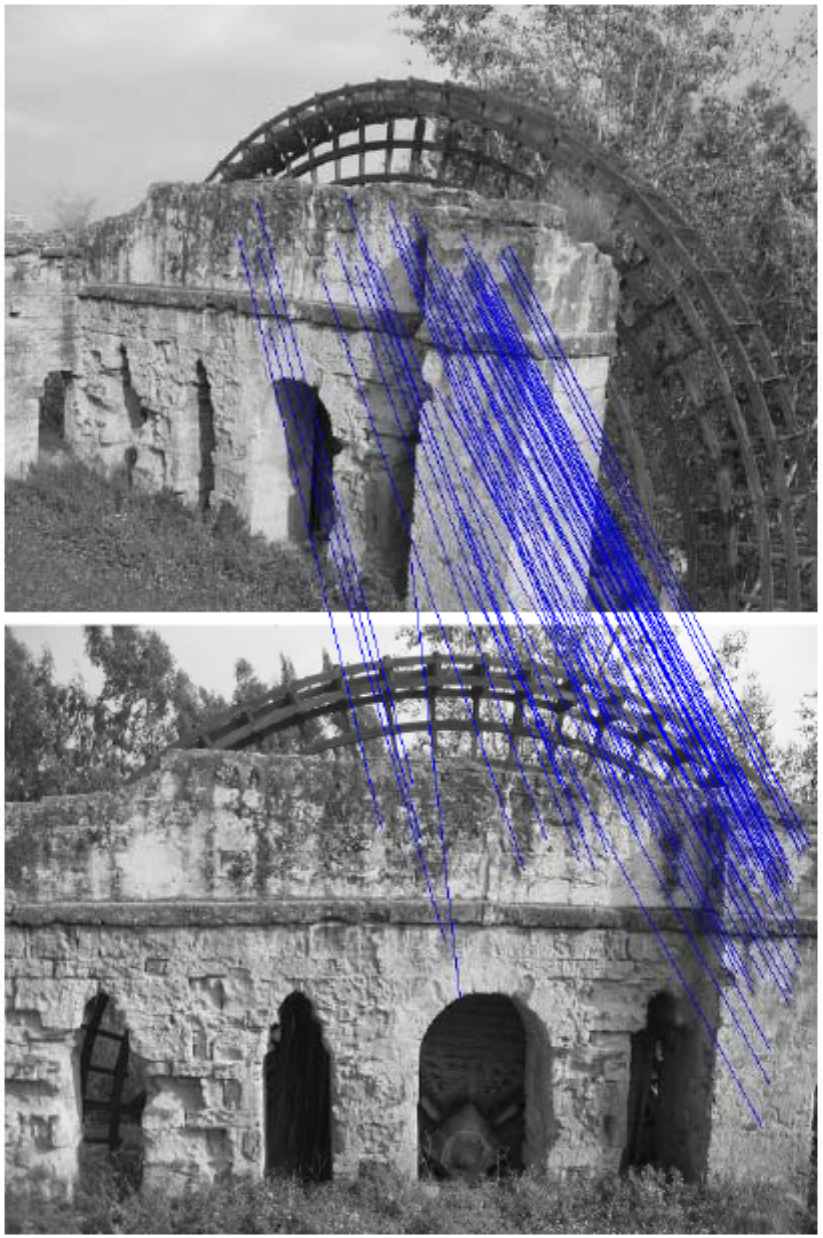
By a simple click a closer view of each experiment is available:

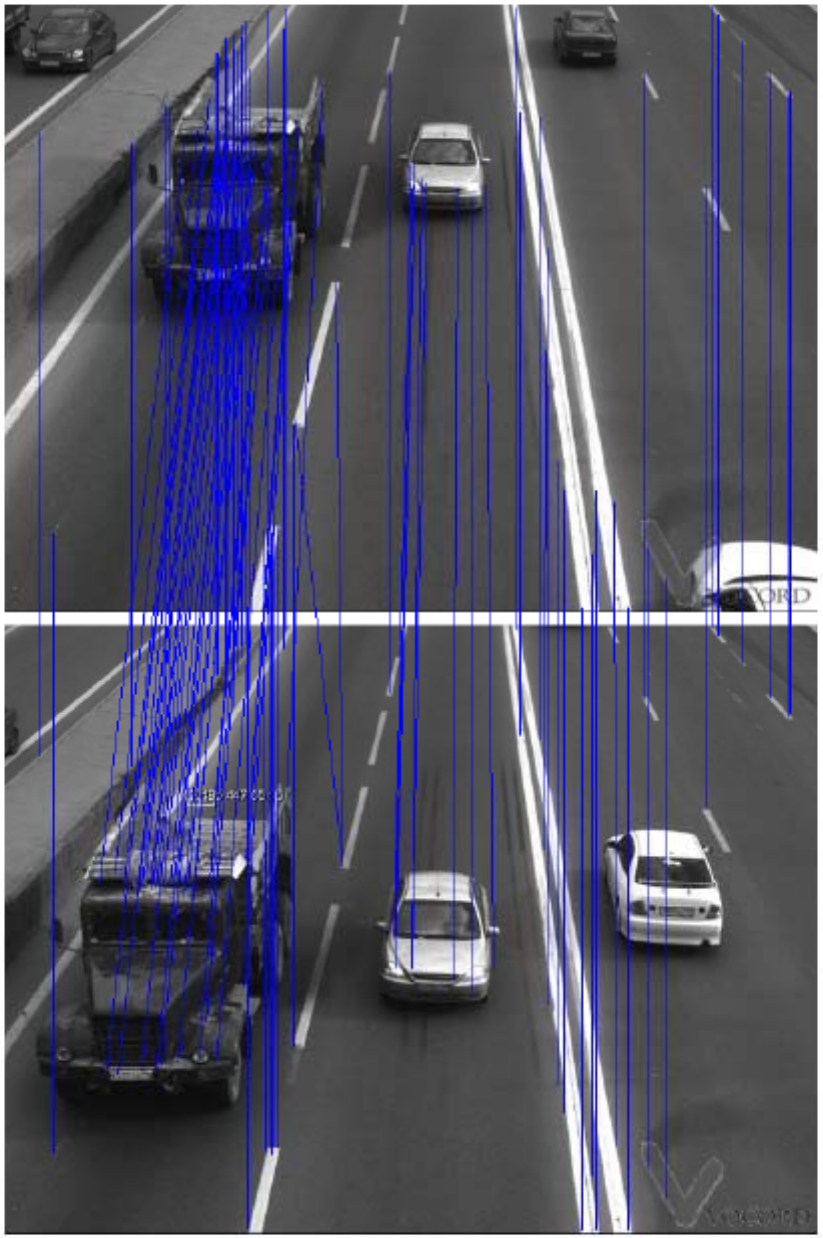
ASIFT result :

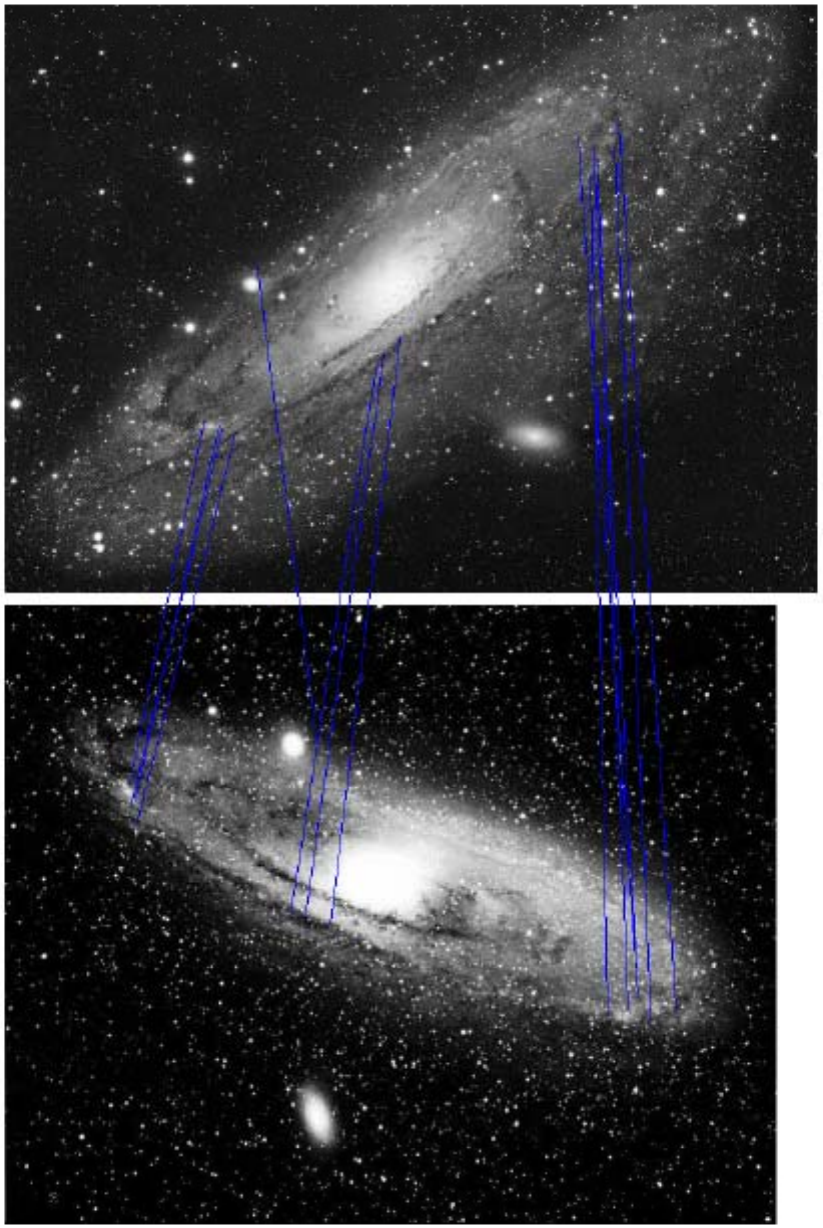


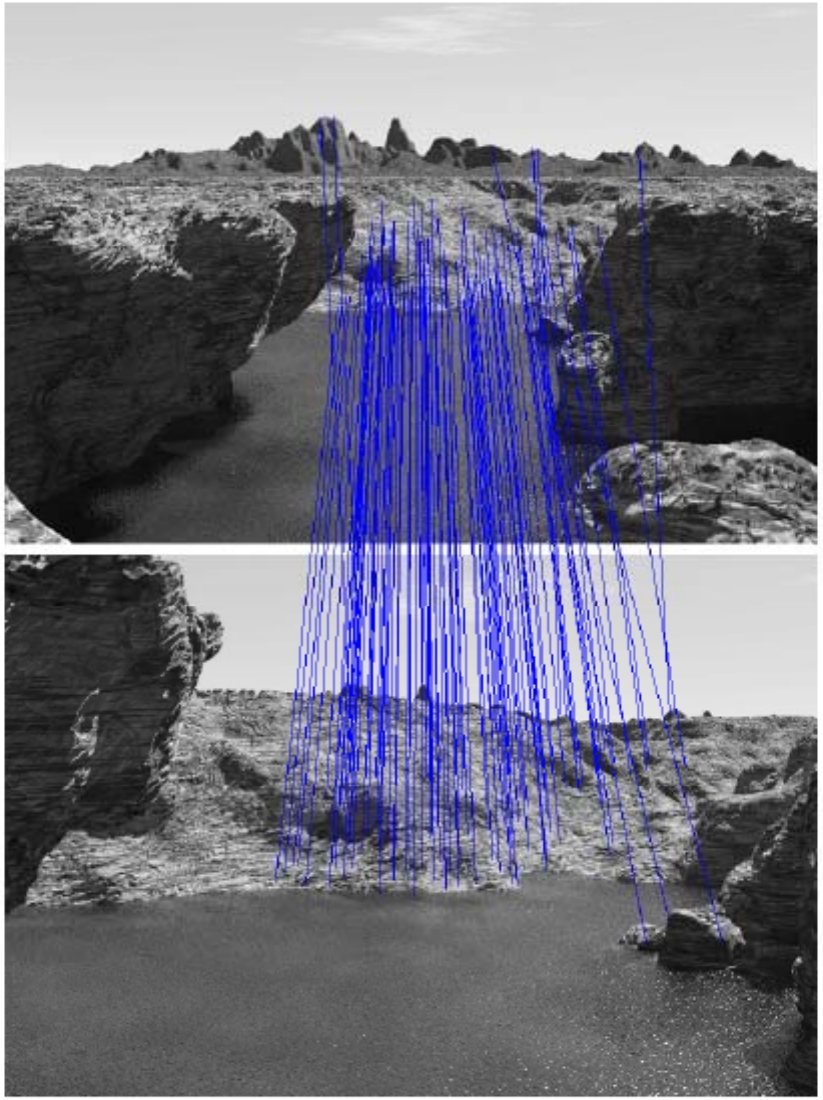
SIFT result :

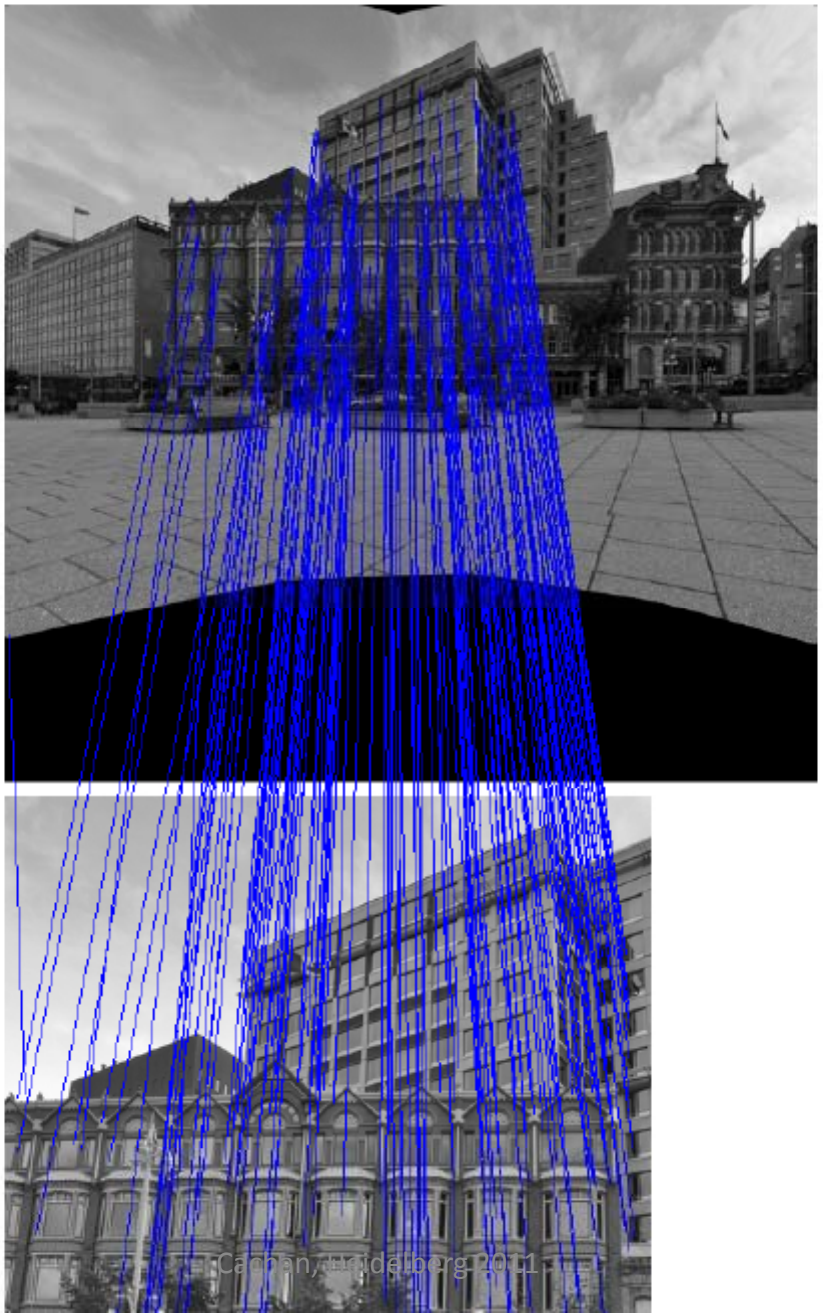


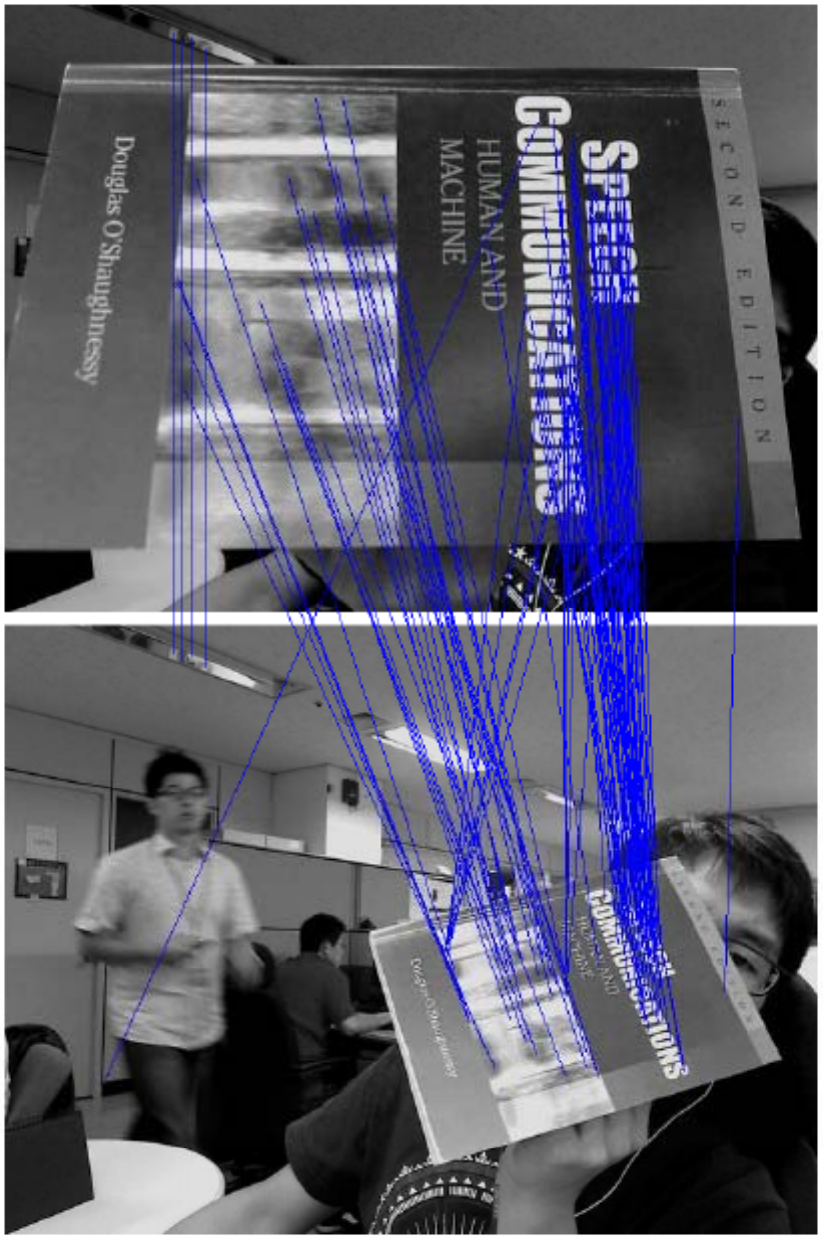








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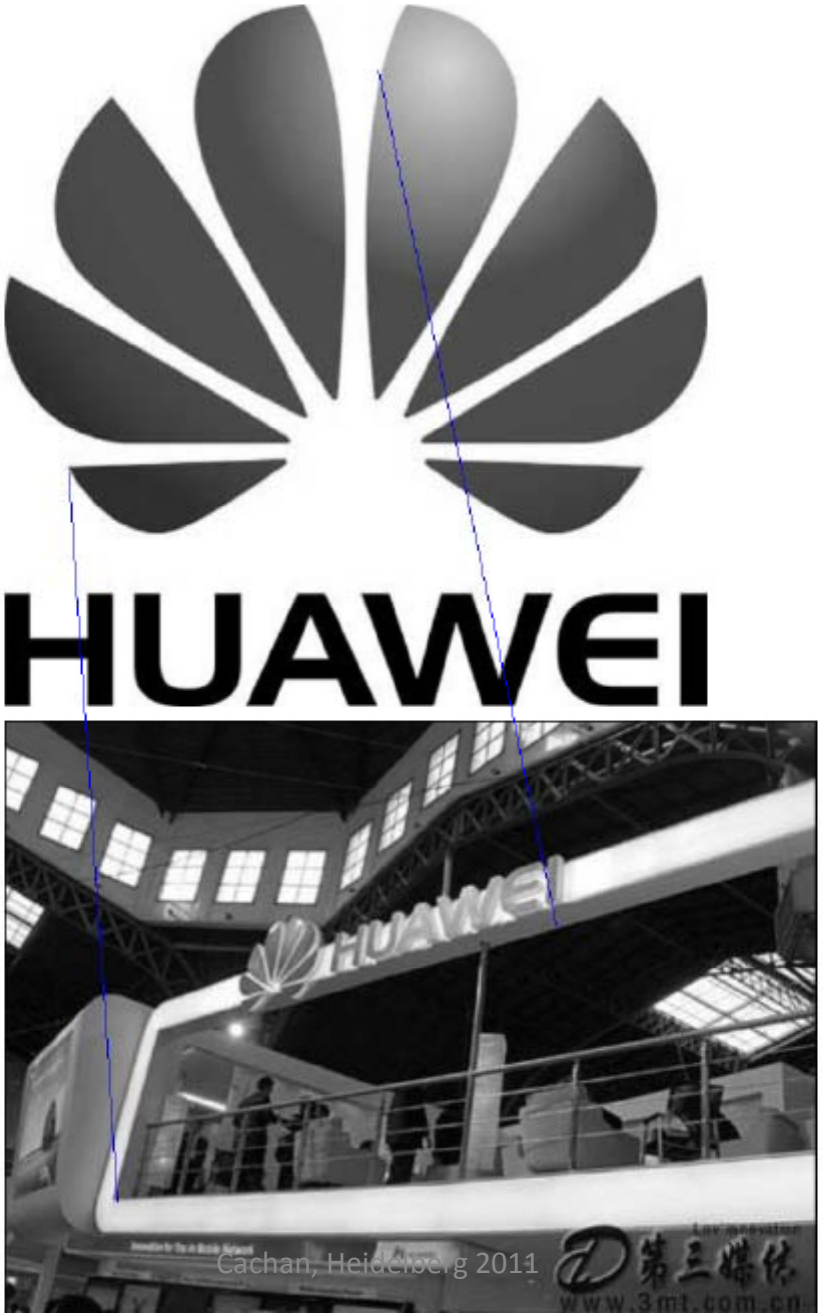
MACHINE
Douglas O'Shaughnessy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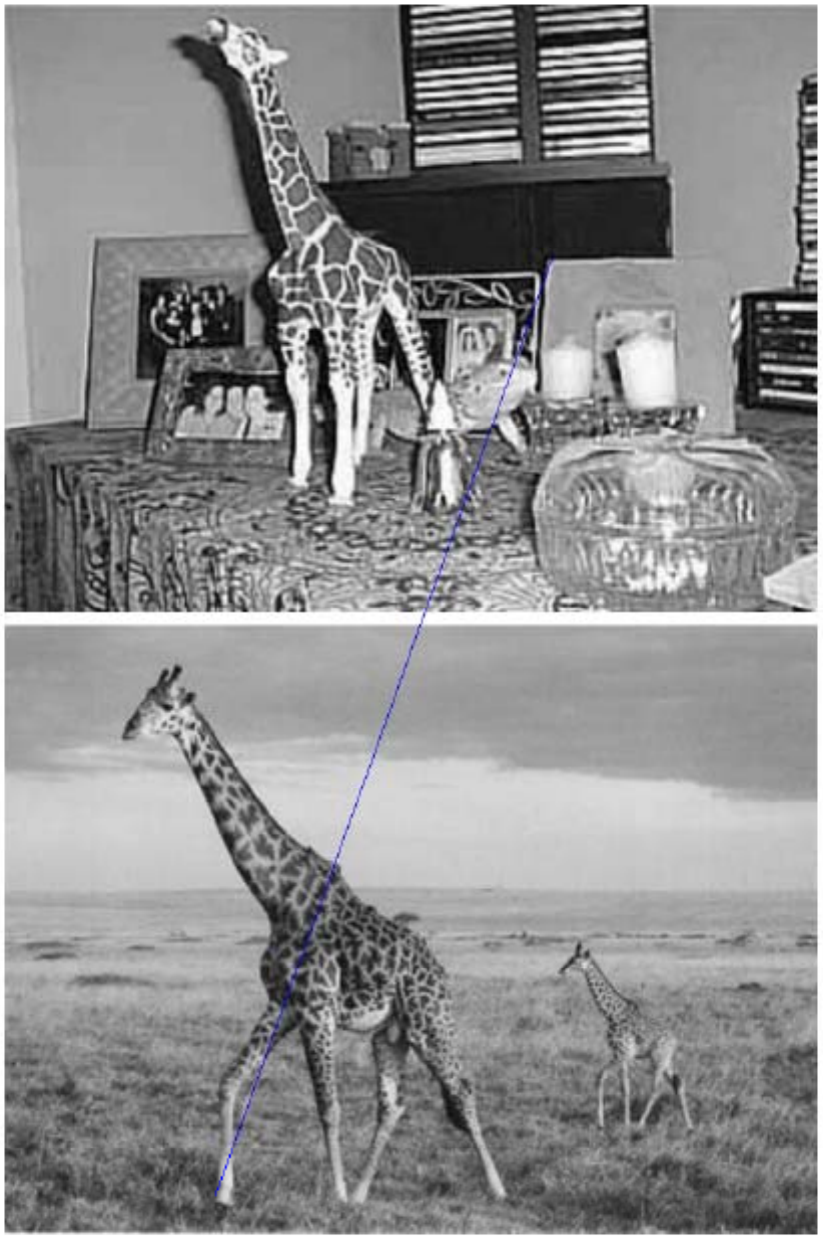
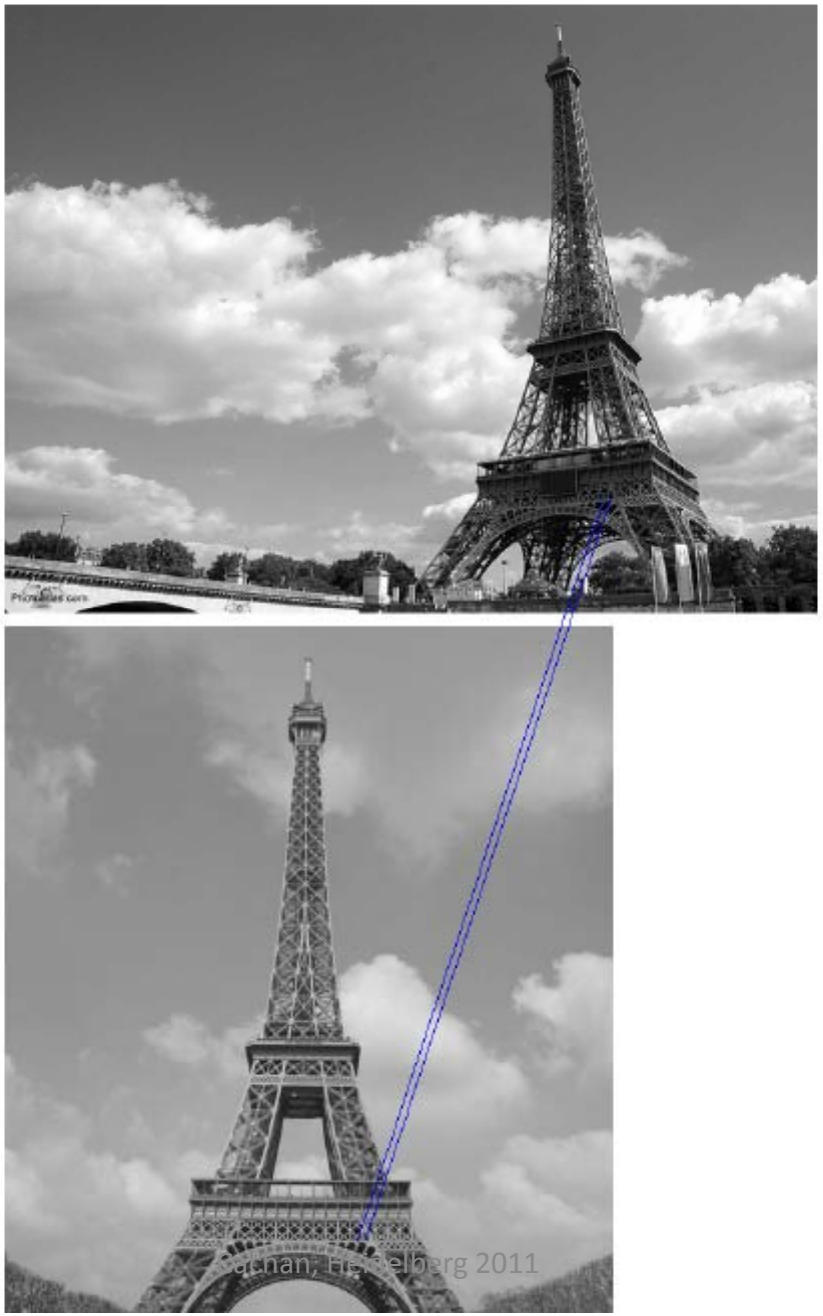


Panorama (Caposele)



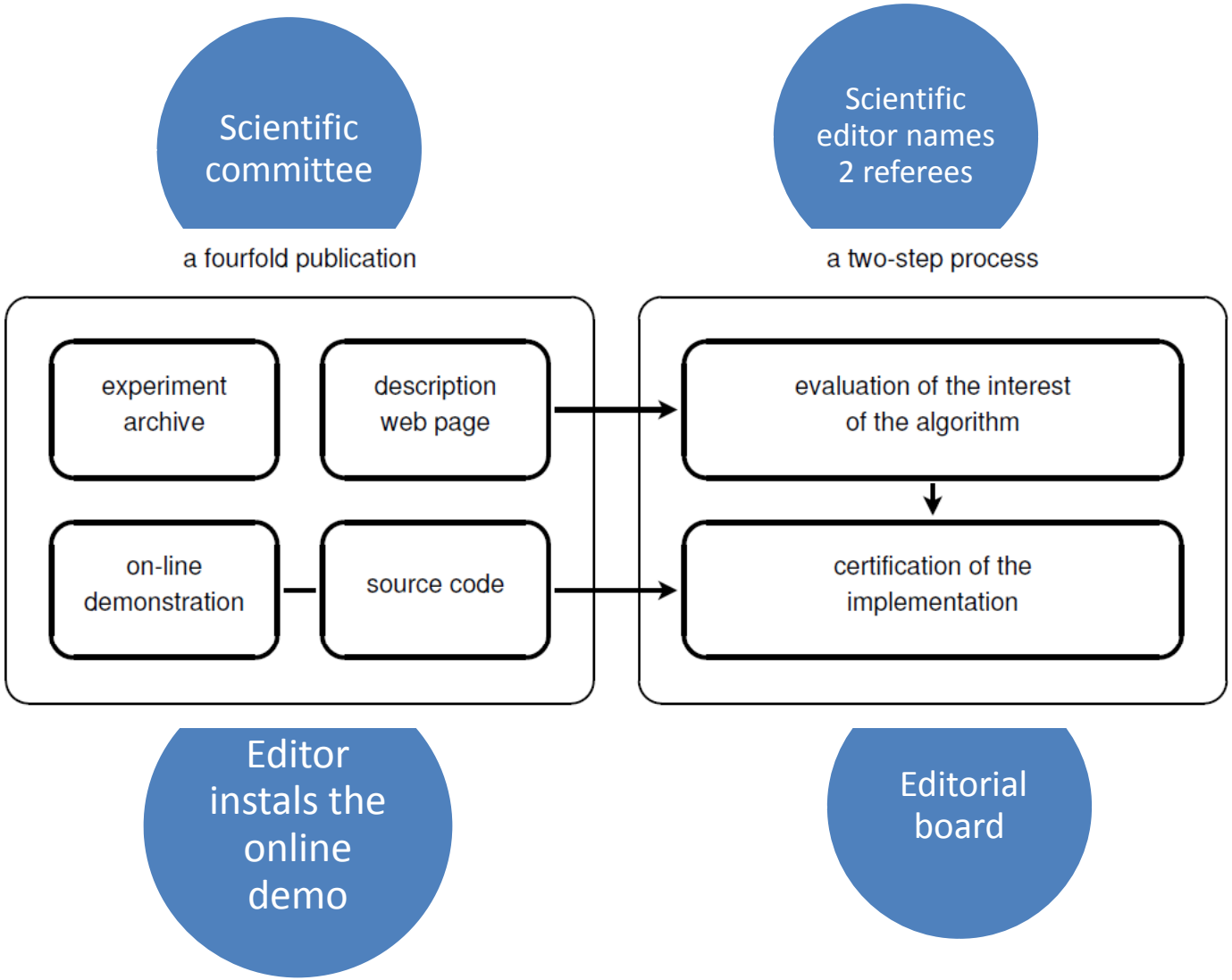
Online experiments: statistics on 14 articles

	Number of online experiments	Google Scholar
SIFT + ASIFT :	**8295** experiments since 2009/04/27	52
LSD Linear Segment detector:	**3966** experiments since 2009/04/27	13
Retinex Poisson Equation:	**1189** experiments since 2009/04/27	3
Micro-texture synthesis:	**1541** experiments since 2009/07/01	2
Simplest color balance:	**851** experiments since 2009/08/28	0
Cartoon + texture :	**873** experiments since 2009/09/07	1
NL-means denoising :	**1800** experiments since 2009/11/28	473
Image Curvature Microscope:	**513** experiments since 2010/01/15	2
Lens distortion correction:	**700** experiments since 2010/05/06	5
Self-similarity demosaiciking:	**220** experiments since 2010/05/11	9
Image interpolation with contour stencils :	**54** experiments since 2010/11/12	0
Quasi-Euclidean Epipolar Rectification:	**39** experiments since 2010/11/30	17
Image color cube dimensional filtering:	**36** experiments since 2010/12/07	0
Finite difference schemes for MCM and AMSS:	**7** experiments since 2010/12/08	0

The archive contains more or less half of these experiments (the others are intentionally hidden by users)

Number of papers in preparation: 38

Publication submission and evaluation workflow



Means of the online journal

One online server, multicore (32), one test server for submissions (8 cores)
Editorial board (distinct from scientific commitee): 15 experienced researchers with solid computer background.
Each paper signed by authors and an editor

Requirements on authors:

Execution in real/interactive time (less than 20 seconds)
Some (easy) parallel computing recommended (help provided by editors)
Writing in very standard code ANSI C, C++, free of any environment
A minimal number of libraries authorized (libtiff, libpng, fftw)
Additional workload on authors: two months (acceleration, code comments, demo design, testing)

A toolkit is provided to editors to program online demos.
Authors have deliver their algorithm along with a specification of its input, output.

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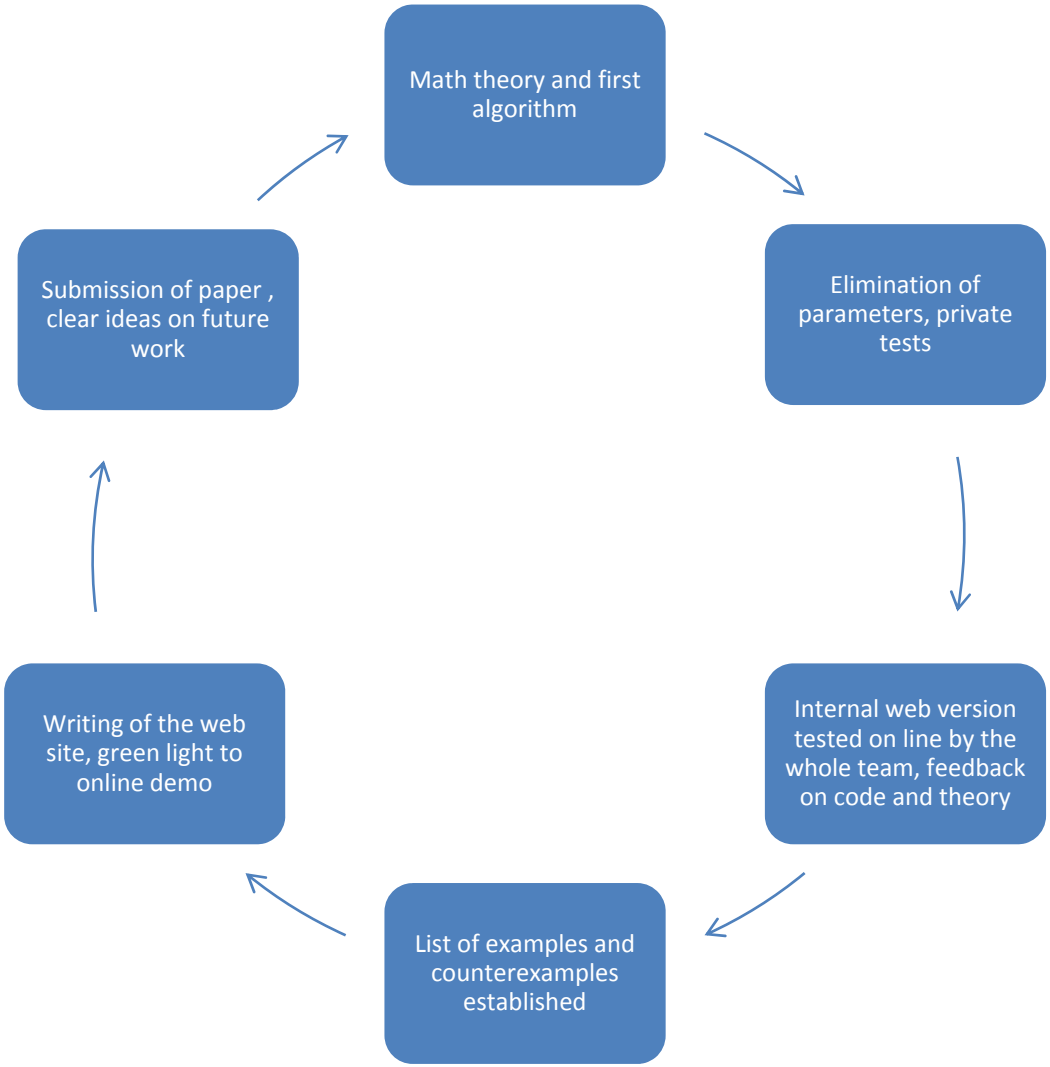
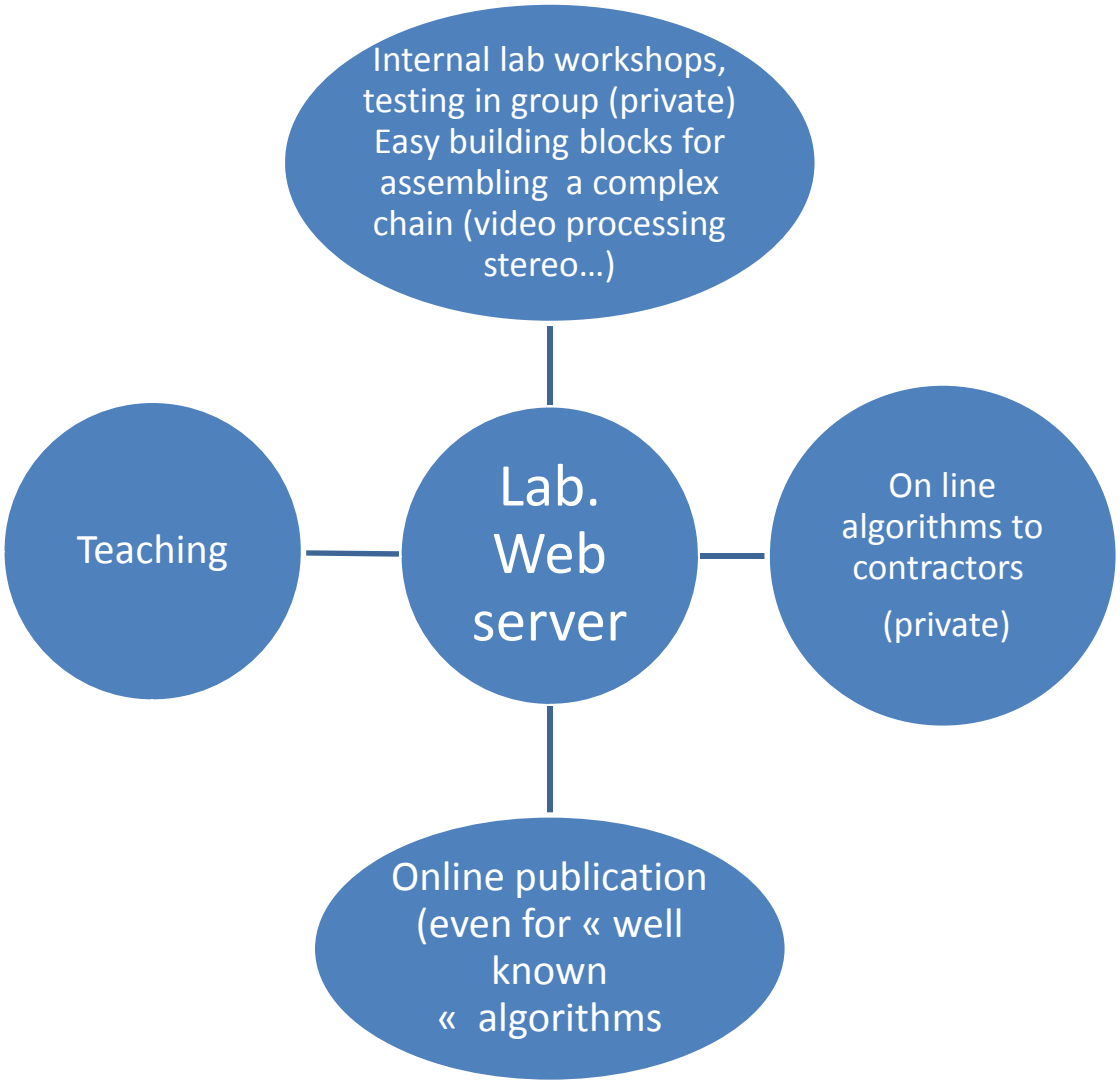
Reorganization of the work flow in a research team



Four functions for a Web server



Plans and problems

Problem 1: the atom/molecule egg and hen problem

Submitted articles are atoms, but online demos are molecules because they must display some kind of end result

. For example ASIFT uses SIFT and ORSA. Only the submitted atom is evaluated the

. The rest of the routines must be at some point submitted, evaluated too:
(ORSA is currently submitted)

. Stereo=calibration+ stereorectification + matching + reconstruction…

. Image processing (noise, blur, color, contrast: requires reliable estimates)

Problem 2: Can a publication become two fold: journal paper + IPOL ?

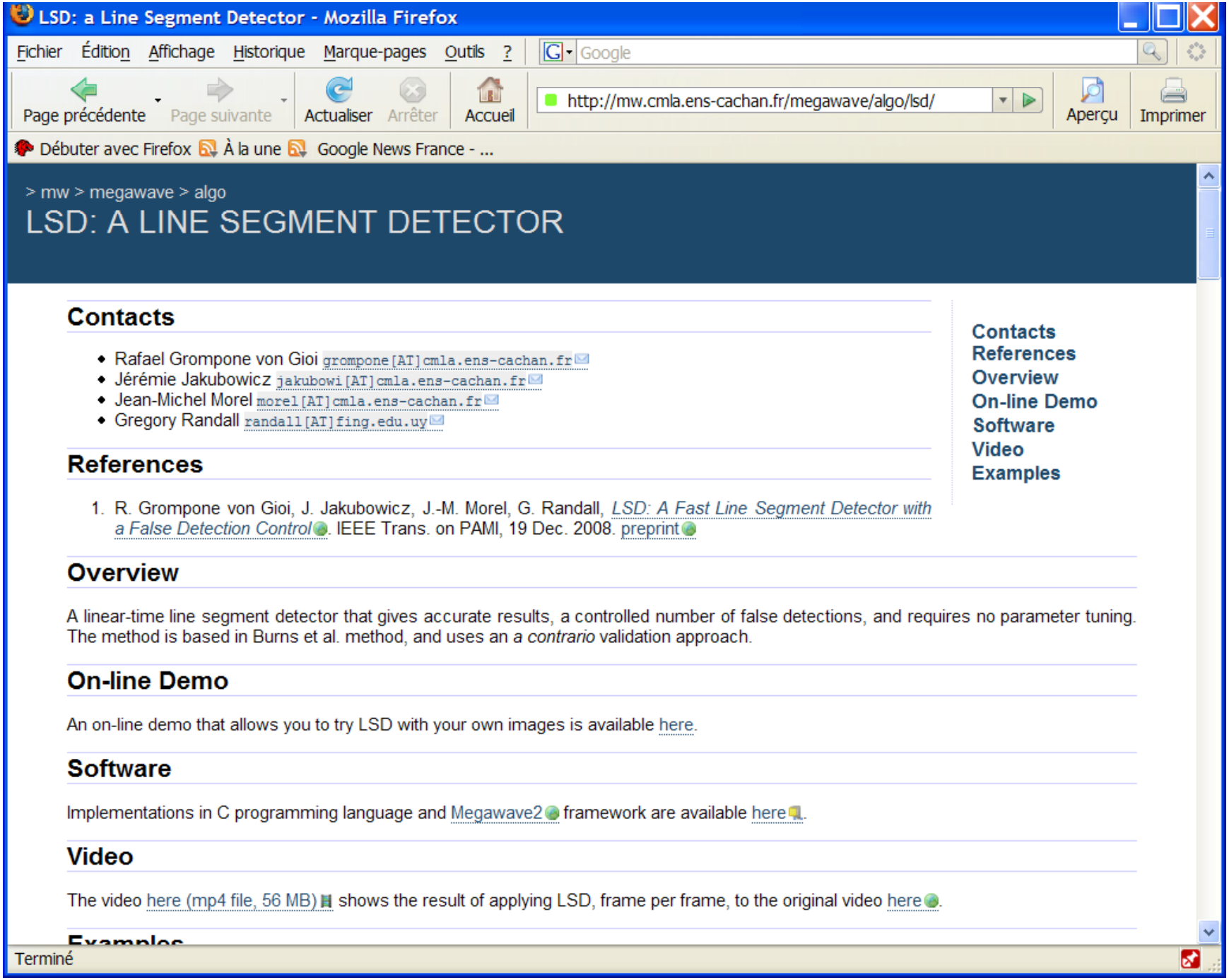
-YES (1st agreement with SIAM J. of Image Science)

Problem 3: Already published algorithms can become research level IPOL articles?

-YES. An IPOL publication of a « know » algorithm + conception of the demo turns out to be substantial research

Problem 4: Licence GPL, others: If authors also want to sell licenses to industry, compatible?

-YES, you can see private licences along with a public licence


LSD: a Line Segment Detector - Mozilla Firefox
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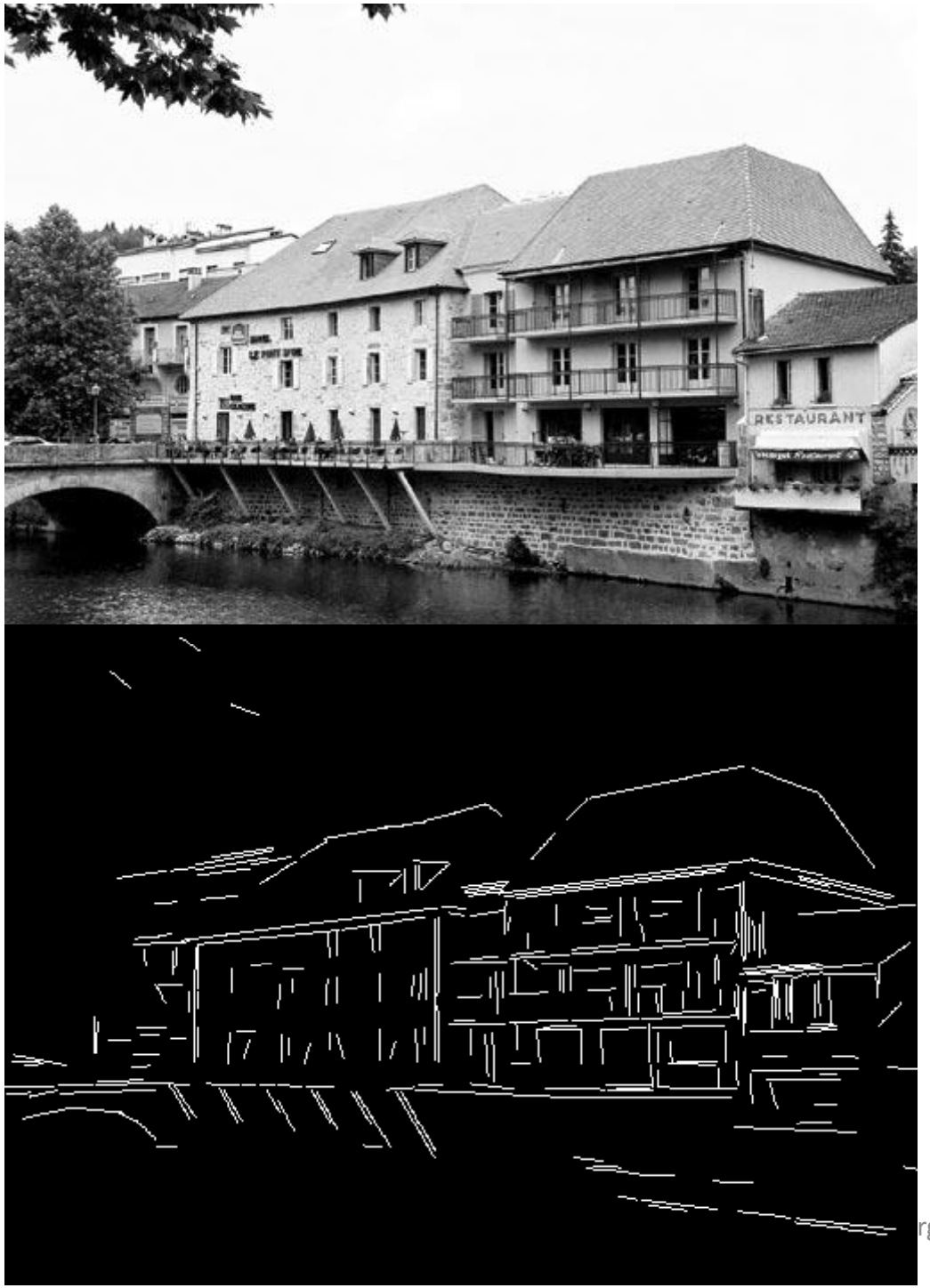
Jérémie Jakubowicz jakubowi[AT]cmla.ens-cachan.fr
Jean-Michel Morel morel[AT]cmla.ens-cachan.fr
Gregory Randall randall[AT]fing.edu.uy
References
1. R. Grompone von Gioi, J. Jakubowicz, J.-M. Morel, G. Randall, LSD: A Fast Line Segment Detector with a False Detection Control. IEEE Trans. on PAMI, 19 Dec. 2008. preprint
Overview
A linear-time line segment detector that gives accurate results, a controlled number of false detections, and requires no parameter tuning. The method is based in Burns et al. method, and uses an a contrario validation approach.
On-line Demo
An on-line demo that allows you to try LSD with your own images is available here.
Software
Implementations in C programming language and Megawave2 framework are available here.
Video
The video here (mp4 file, 56 MB) shows the result of applying LSD, frame per frame, to the original video here.
Examples
Terminé

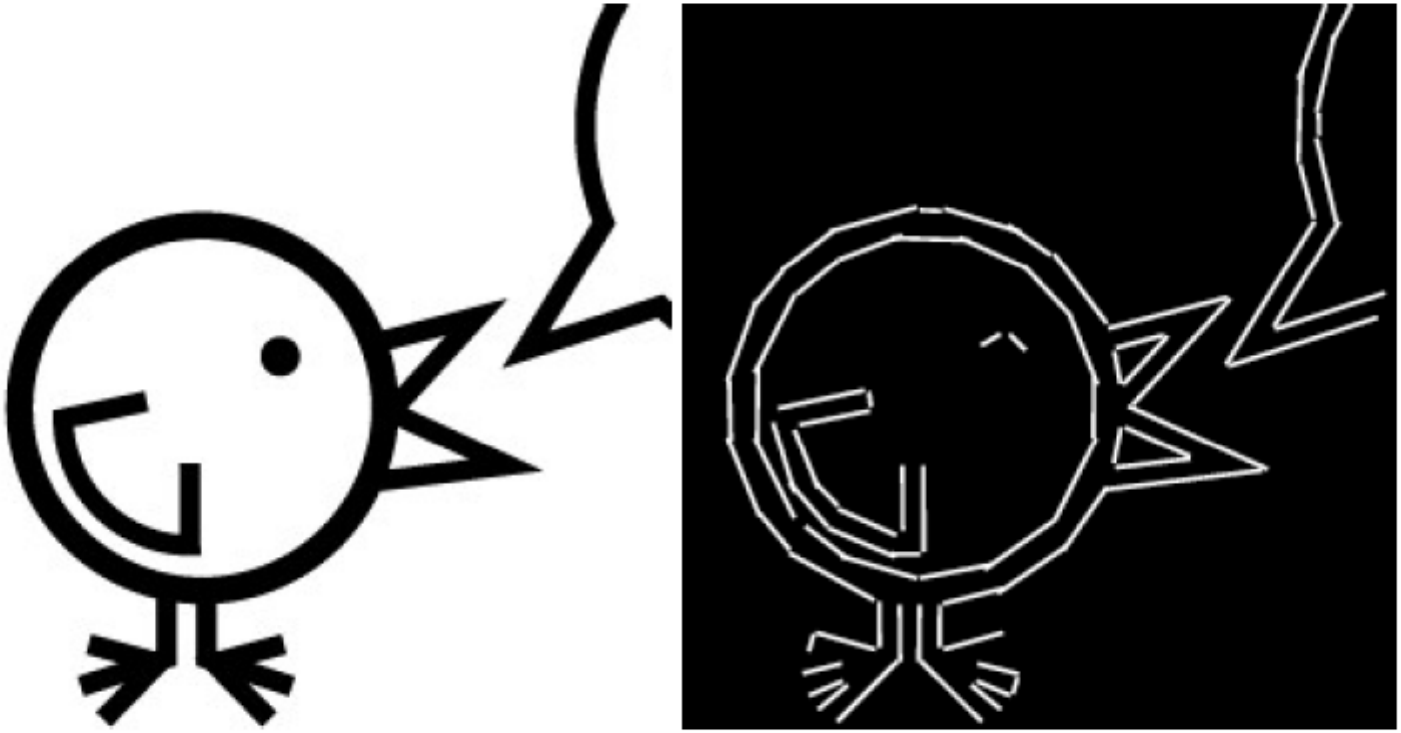
Line segment detector (LSD), no parameter. More than 3500 images on line trials in the archive. Tools: A contrario statistical method, level line analysis

Examples

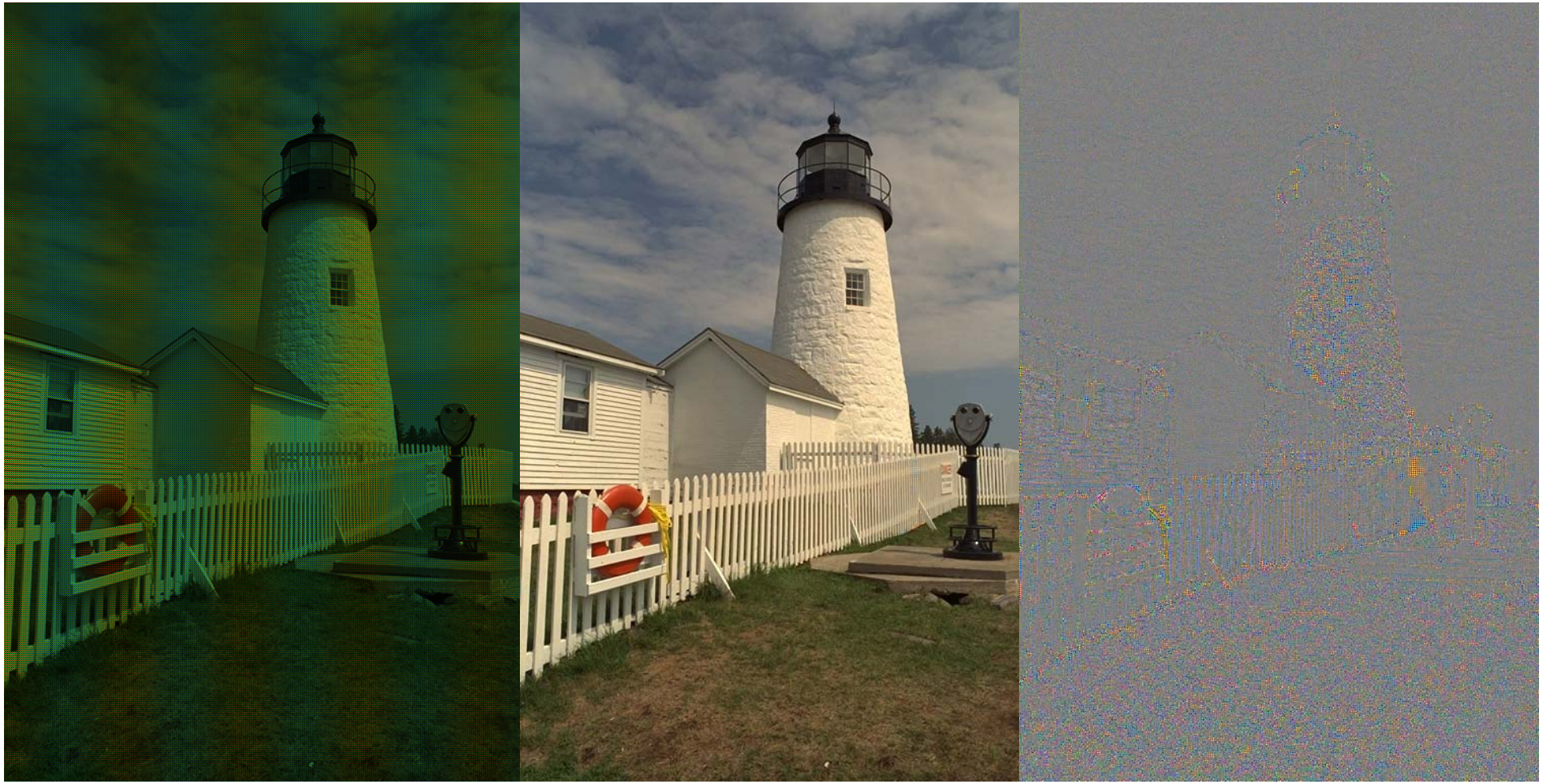


LSD: Some results in the online archive

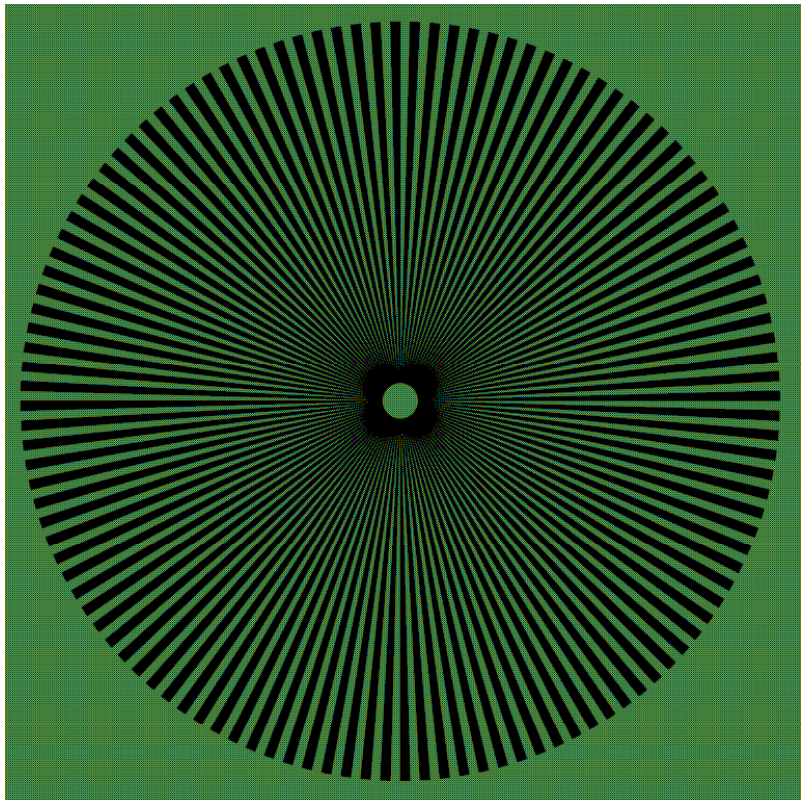
Examples

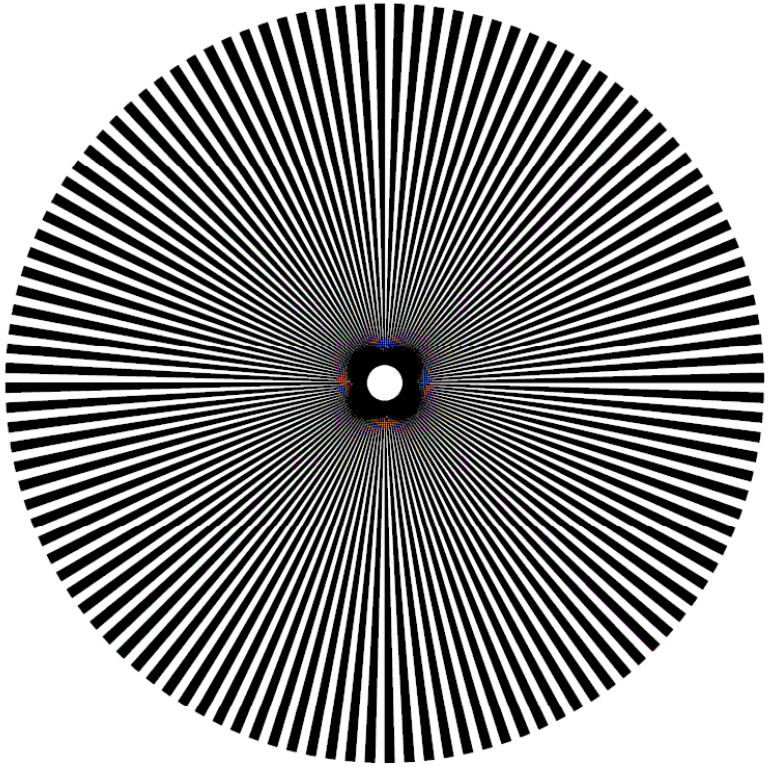


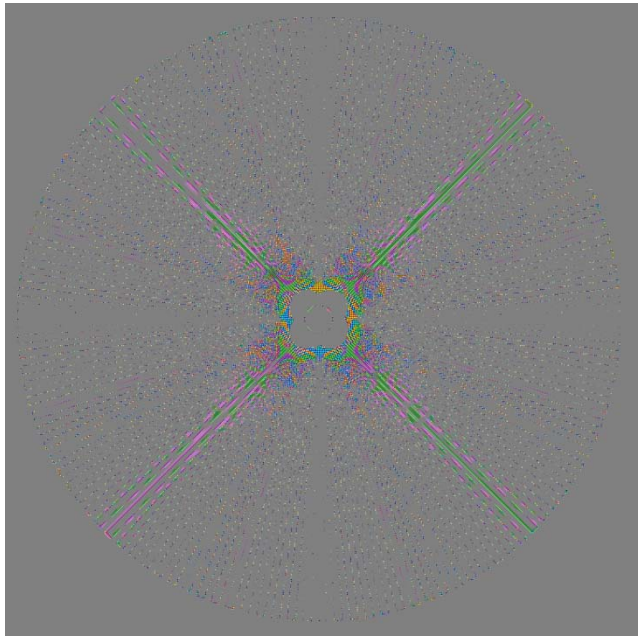
NL-means, archive on line. Tools: non linear partial differential equation, non local filters. Noise is automatically estimated.



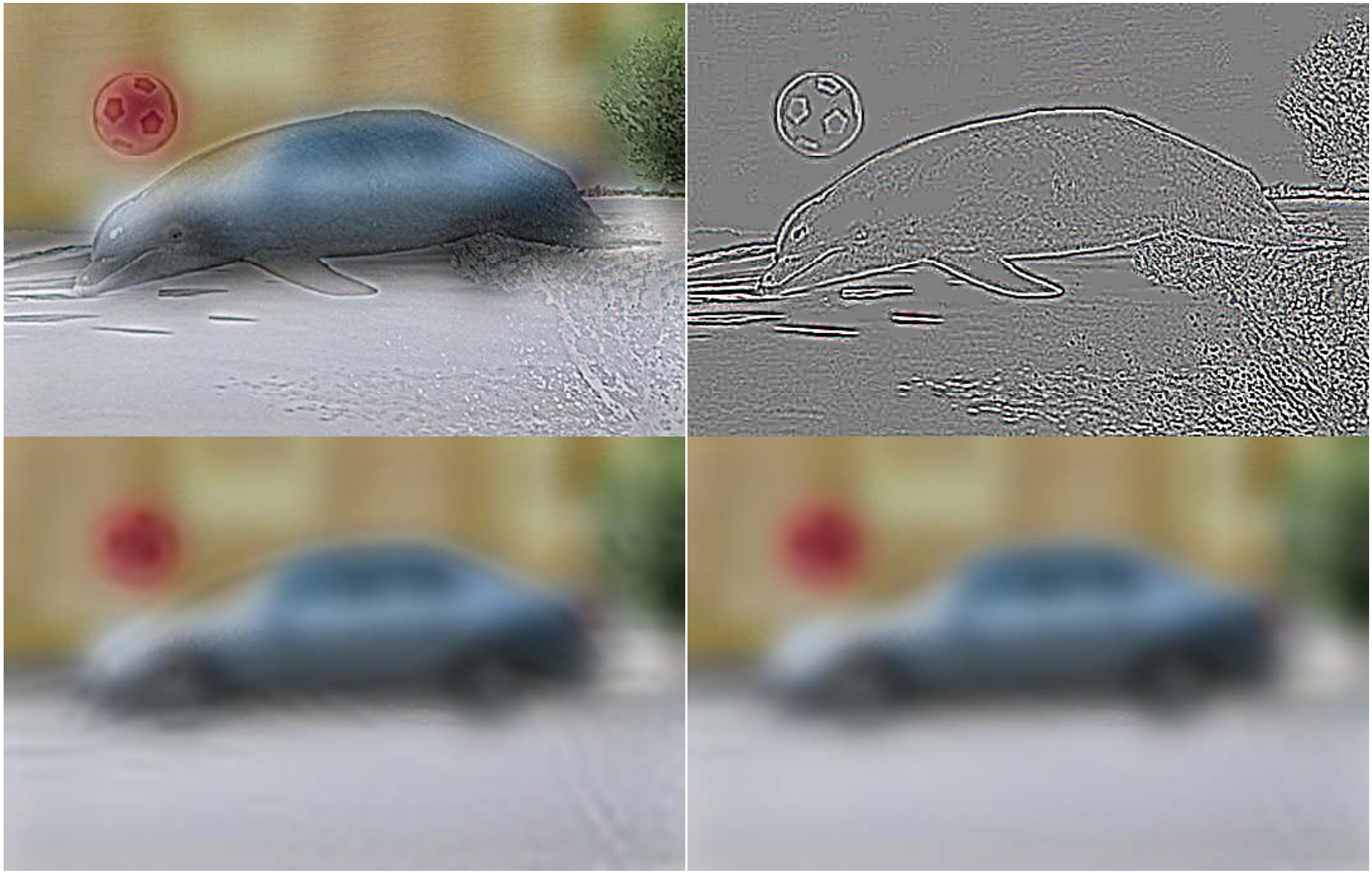
Demosaicking (zero parameter method) Tools: nonlocal methods, Fourier analysis, partial differential operators. From Archive on line



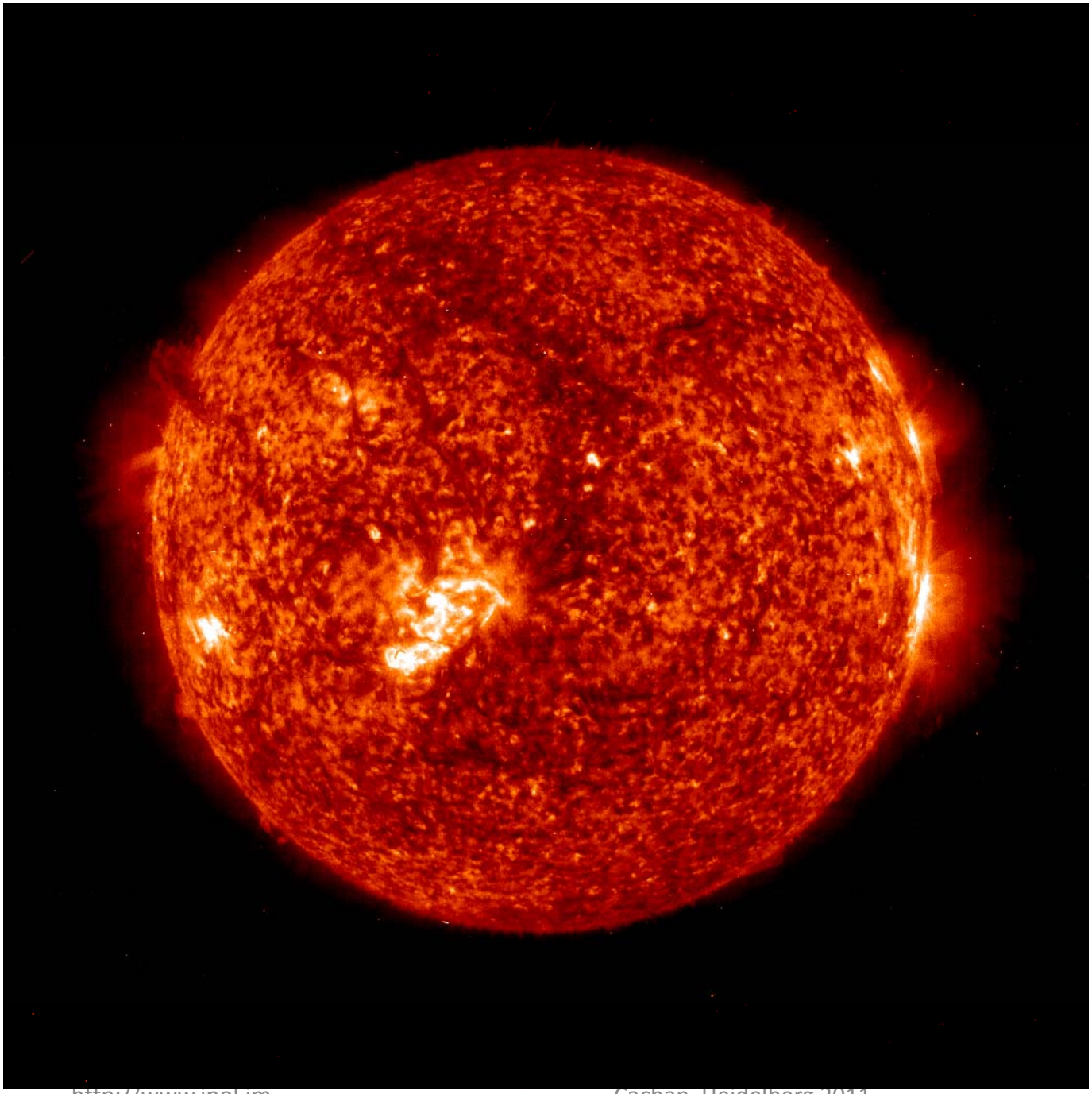




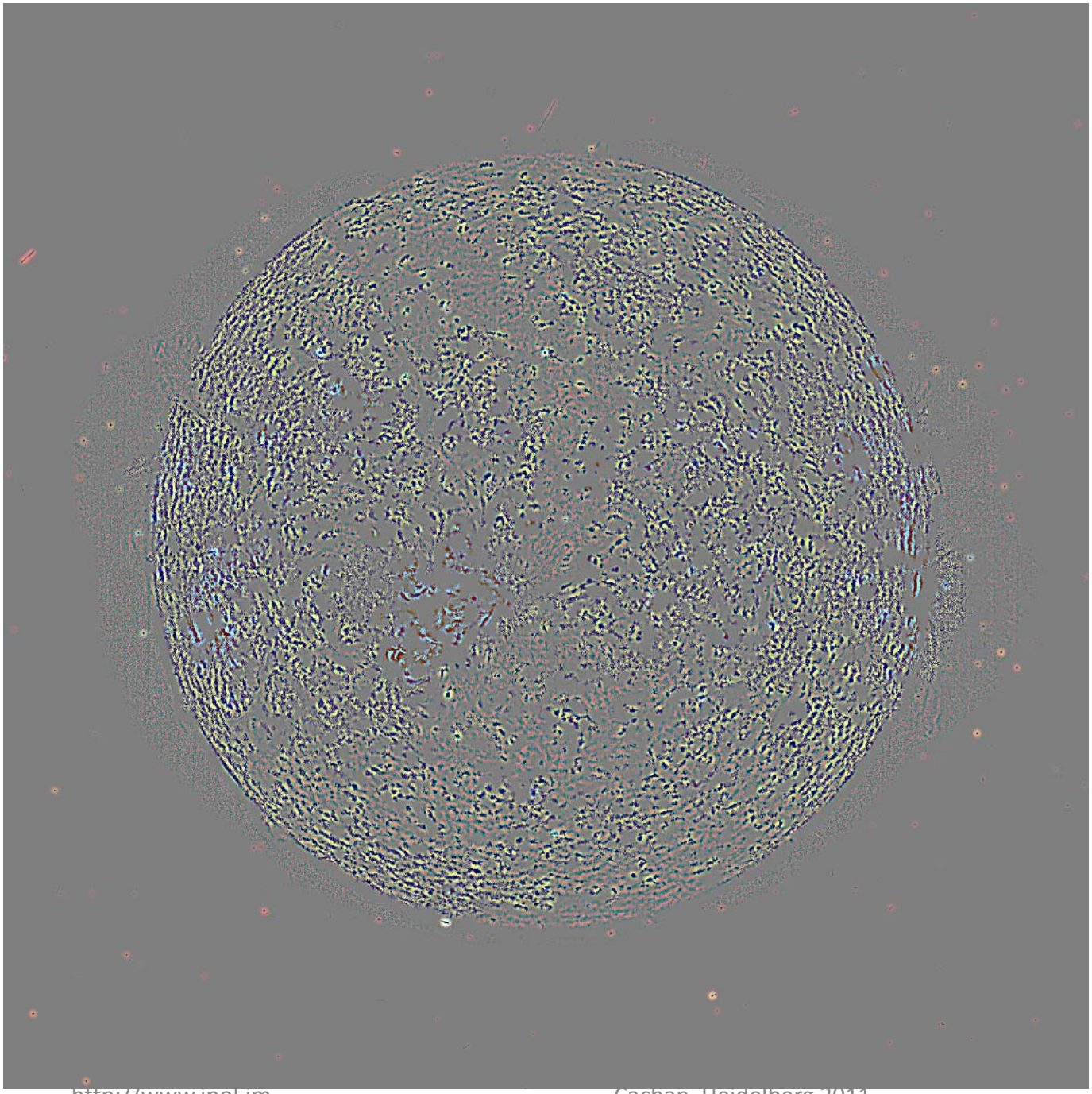
LSD: Some results in the online archive



Cartoon+texture (IPOL Archive): method invented by Yves Meyer to decompose any image. One scale parameter. Tools : Fourier + functions with bounded variation



Cartoon+texture (IPOL Archive)



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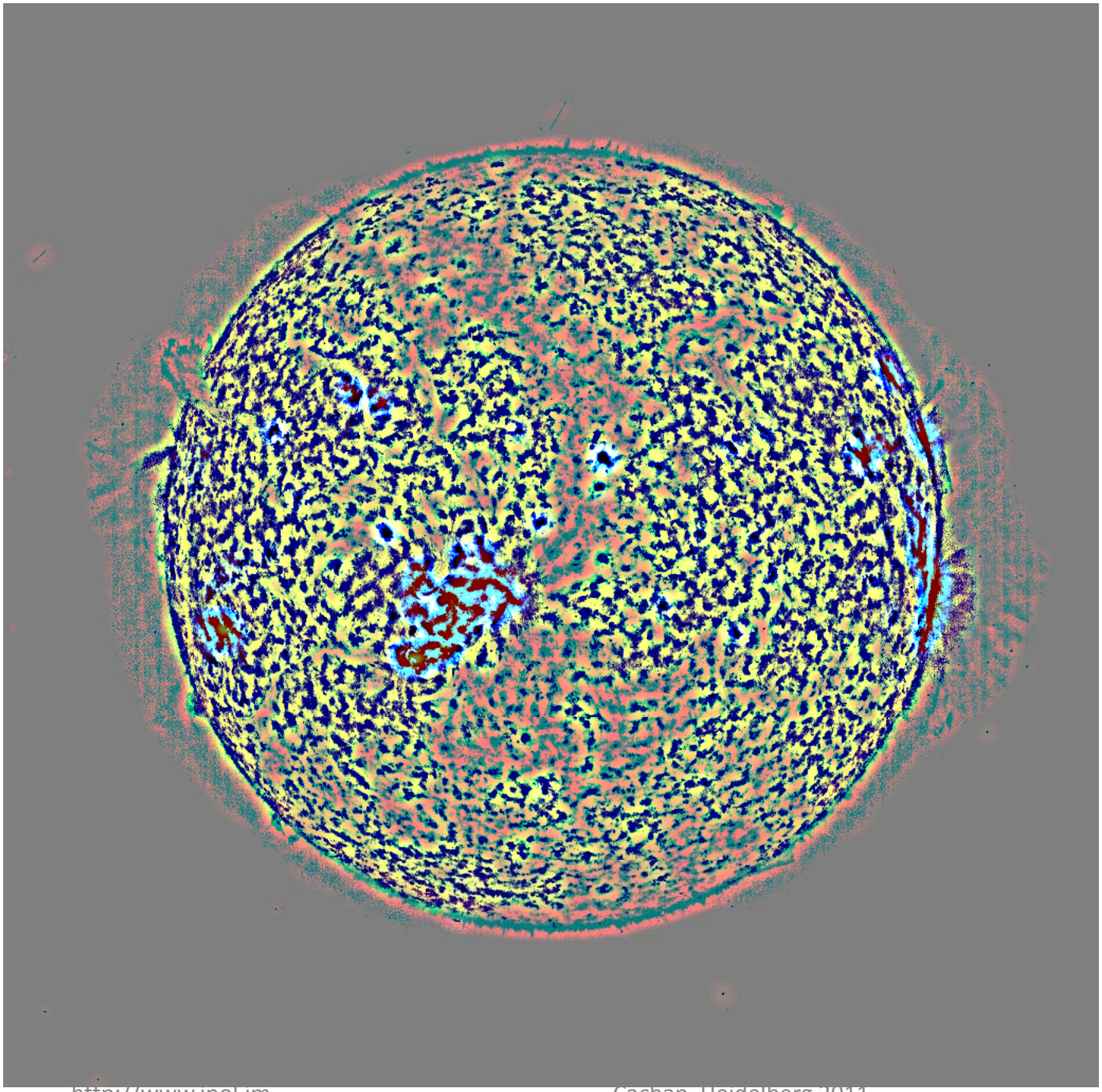
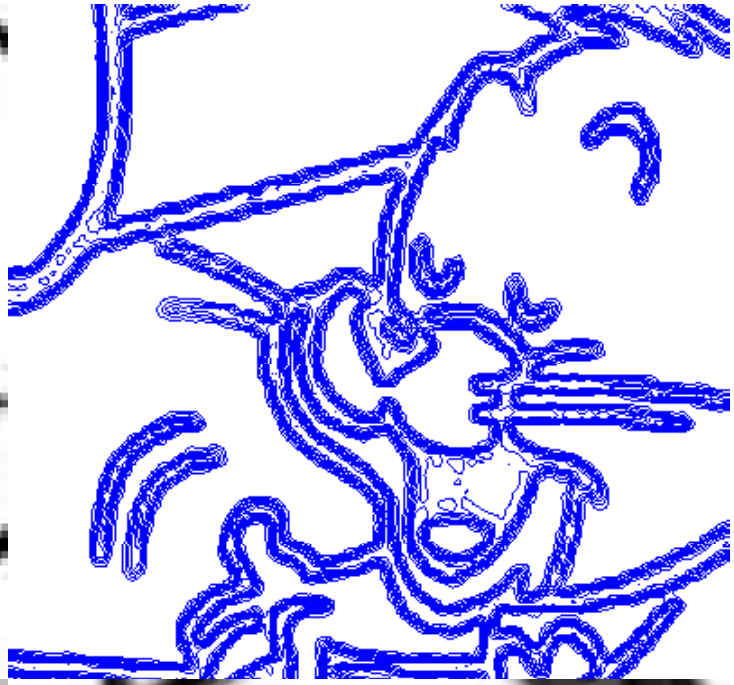


Cartoon+texture (IPOL Archive)



Mean curvature motion (IPOL Archive). Tools: Morse theory, geometric partial differential equations


Micro-Texture Synthesis by Phase Randomization - Mozilla Firefox
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MICRO-TEXTURE SYNTHESIS BY PHASE RANDOMIZATION
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Jean-Michel Morel morel@cmla.ens-cachan.fr
References
1. B. Galerne, Y. Gousseau and J.-M. Morel, Random Phase Textures: Theory and Synthesis, preprint CMLA N°2009-24, 2009.
Abstract and pdf file on CMLA preprint webpage.
Contacts
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Overview
On Line Demo: Try It!
Source Code
Algorithm
Implementation
Micro-textures
Examples
Overview
The Random Phase Noise (RPN) algorithm synthesizes a texture from any original image by randomizing its Fourier phase. The RPN algorithm is able to reproduce the textures which are characterized by their Fourier modulus, namely the phase invariant textures.
The presented algorithm deals with color images and it is able to synthesize output textures having a larger size than the input samples.
Even though this texture synthesis algorithm only reproduce a limited class of textures, it has several good properties:
It produces a micro-texture given any input image, and thus can be used to produce micro-texture versions of some macro-textures, or can also be used to design textures.
The algorithm is perceptually stable: all the textures synthesized from the same input image look similar.
The algorithm is fast.
On Line Demo: Try It!
An on-line demo of this algorithm is available.
The demo permits to upload a color texture sample and to replicate it in arbitrary size. Texture samples can be taken from existing databases, but to have still more realistic samples, you can extract them as homogeneous regions of a photograph, as shown below in What are micro-textures?
Données transférées depuis mw.cmla.ens-cachan.fr

Micro-Texture Synthesis by Phase Randomization - Mozilla Firefox

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Examples

Below are some examples of satisfyingly well reproduced textures.

Original image	*RPN*
	
stone	stone simulated
	
wood	wood simulated
	

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Micro-Texture Synthesis by Phase Randomization - Mozilla Firefox

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Wood

Wood samples must be homogeneous in direction to be correctly emulated by RPN. Wood samples with knots or other conspicuous patterns fall logically in the failure catalog.

Wood sample

RPN simulation

Show/hide **more wood examples**

Fabric

These fabric samples were picked from several web sites. Only homogeneous fabrics, with no printed on patterns are treated. RPN turns

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Micro-Texture Synthesis by Phase Randomization - Mozilla Firefox

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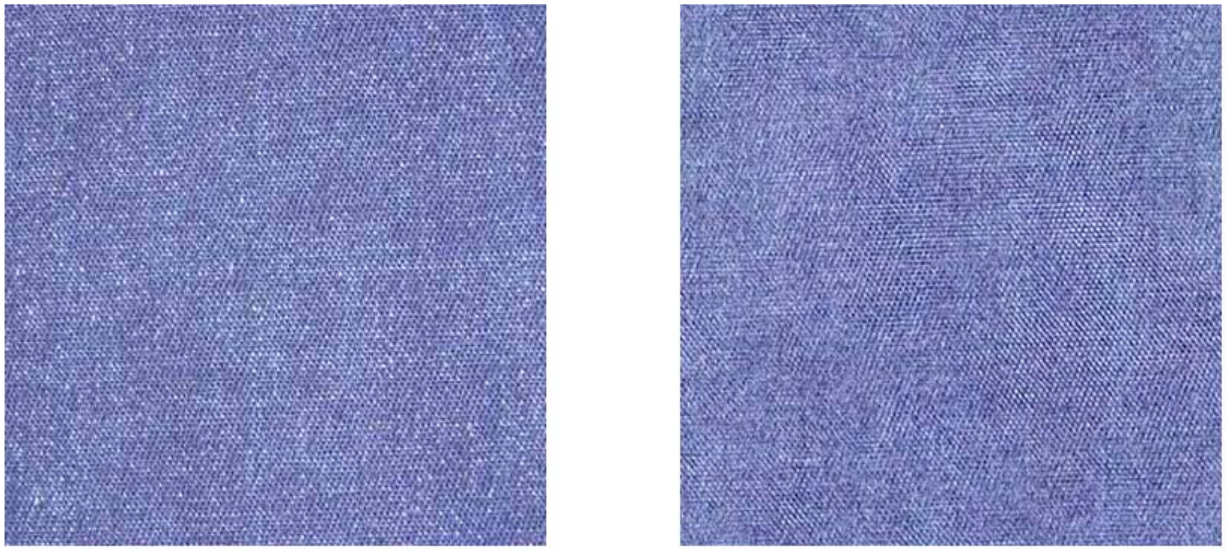
These fabric samples were picked from several web sites. Only homogeneous fabrics, with no printed on patterns are treated. RPN turns out to work remarkably on jeans fabrics.

Fabric sample *RPN simulation*



Show/hide **more fabric examples**

carpet

These carpet samples are taken from a singe commercial website. Those with big patterns will be found in the **failure catalog**.

Carpet sample *RPN simulation*

Terminé

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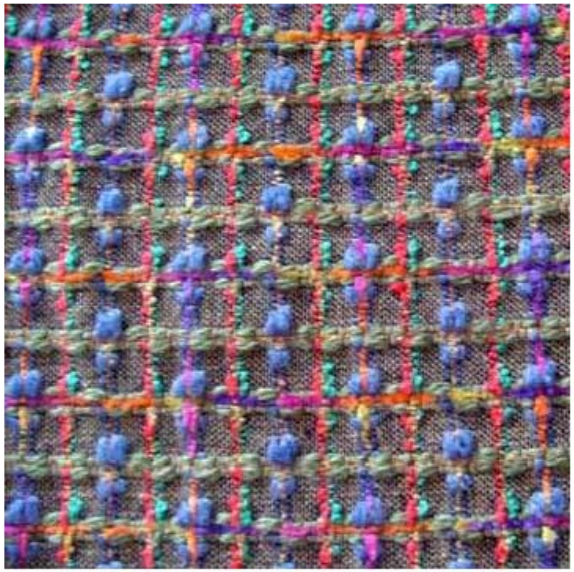
failure catalog

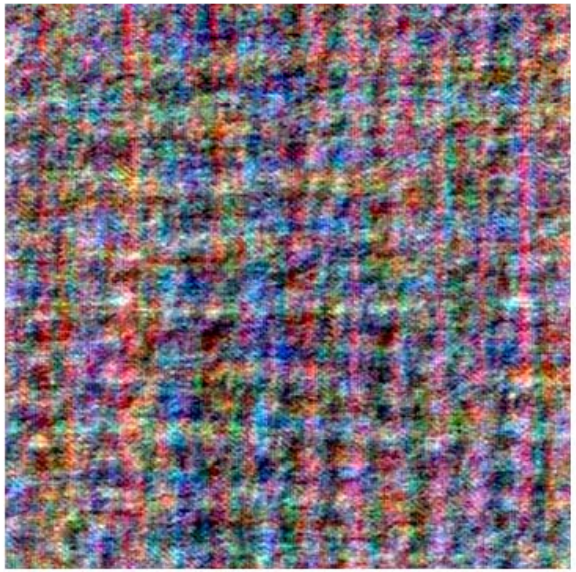
Most failures are **macro**-textures. For instance:

- textures containing periodic geometric patterns with large period,
- textures containing strong edges, such as veins in marble or cracks in bark
- textures containing definite shapes, such as knots in wood or fruit or visible leaves in foliage
- strictly periodic patterns, even with small period, where phase shifts cause aliasing effects
- failure also occurs when the sample texture contains different dominant directions in different areas. Then these directions are mixed by the random sampler.

Macro-texture sample



RPN simulation



Show/hide **more failure examples (macro-textures)**

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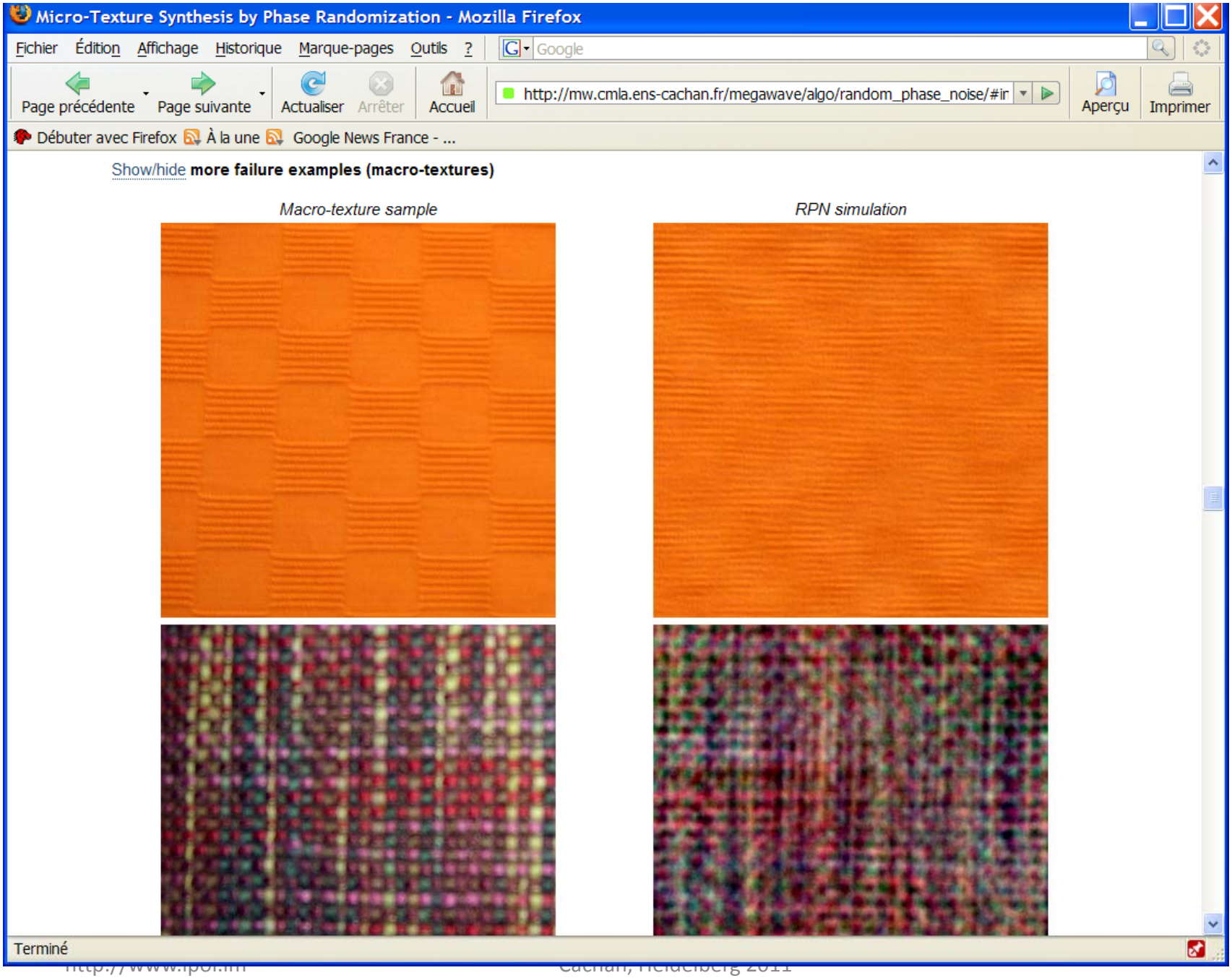
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Macro-texture sample
RPN simulation
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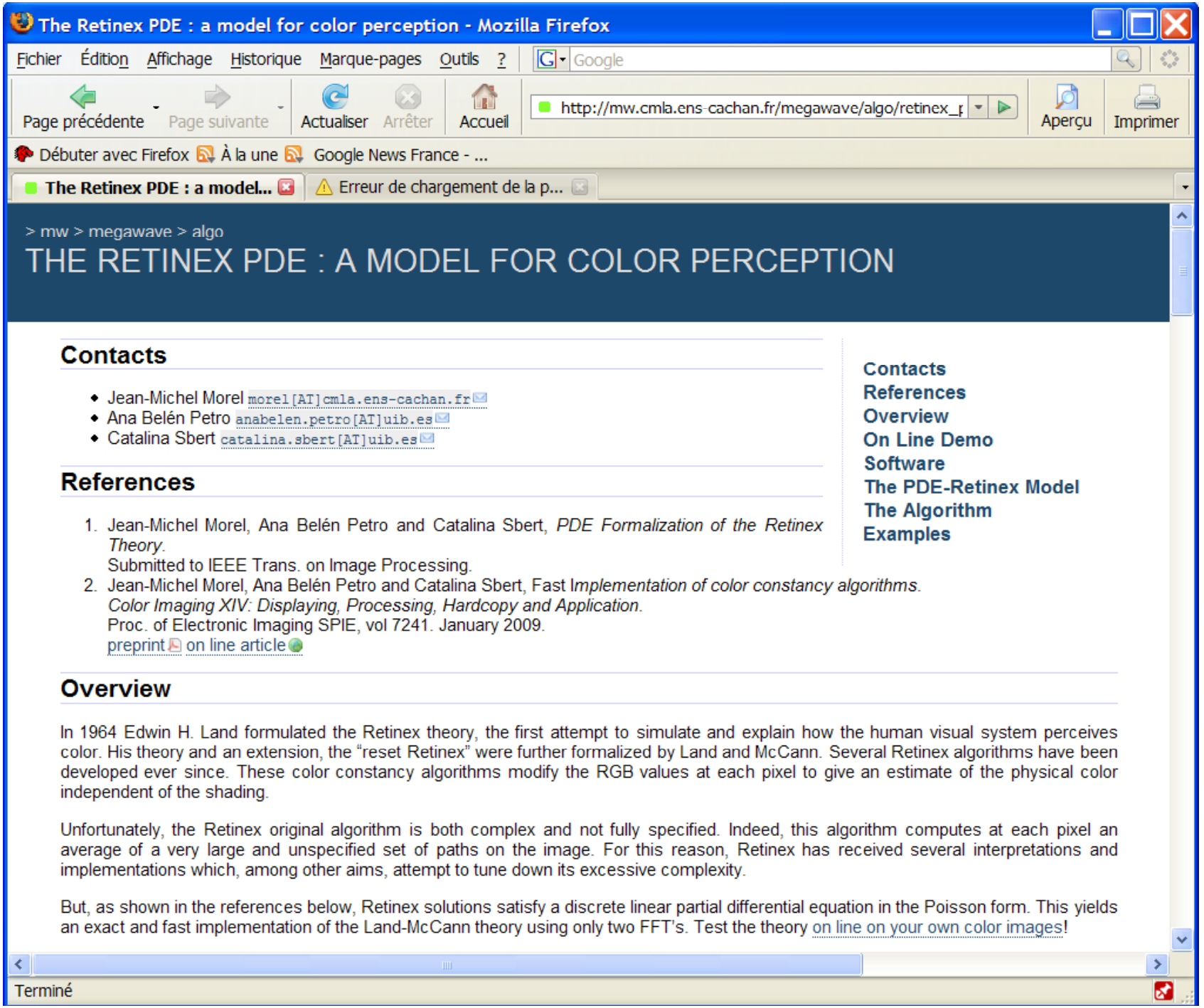
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THE RETINEX PDE : A MODEL FOR COLOR PERCEPTION
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Catalina Sbert catalina.sbert[AT]uib.es
References
1. Jean-Michel Morel, Ana Belén Petro and Catalina Sbert, PDE Formalization of the Retinex Theory.
Submitted to IEEE Trans. on Image Processing.
2. Jean-Michel Morel, Ana Belén Petro and Catalina Sbert, Fast Implementation of color constancy algorithms.
Color Imaging XIV: Displaying, Processing, Hardcopy and Application.
Proc. of Electronic Imaging SPIE, vol 7241. January 2009.
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Overview
In 1964 Edwin H. Land formulated the Retinex theory, the first attempt to simulate and explain how the human visual system perceives color. His theory and an extension, the "reset Retinex" were further formalized by Land and McCann. Several Retinex algorithms have been developed ever since. These color constancy algorithms modify the RGB values at each pixel to give an estimate of the physical color independent of the shading.
Unfortunately, the Retinex original algorithm is both complex and not fully specified. Indeed, this algorithm computes at each pixel an average of a very large and unspecified set of paths on the image. For this reason, Retinex has received several interpretations and implementations which, among other aims, attempt to tune down its excessive complexity.
But, as shown in the references below, Retinex solutions satisfy a discrete linear partial differential equation in the Poisson form. This yields an exact and fast implementation of the Land-McCann theory using only two FFT's. Test the theory on line on your own color images!
Terminé

The Retinex PDE : a model for color perception - Mozilla Firefox

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The Retinex PDE : a model... Erreur de chargement de la p...

The PDE-Retinex Model

In the IEEE article it is proven that the output of the retinex algorithm proposed by Land and McCann is the solution of the discrete partial differential equation with Neumann boundary conditions

$$-\Delta_d u(i,j) + \frac{4}{\dim -1} u(i,j) = F(i,j)$$

where

$$-\Delta_d u(i,j) = u(i+1,j) + u(i-1,j) + u(i,j+1) + u(i,j-1) - 4u(i,j)$$

is the discrete Laplacian, *dim* = *N M* is the size of the image,

$$F(i,j) = f(I(i,j)-I(i+1,j))+f(I(i,j)-I(i-1,j))+f(I(i,j)-I(i,j+1))+f(I(i,j)-I(i,j-1))$$

and *f(x)* is a threshold function, whose value is zero if |*x*| < *t* and the identity in other case and *I* is the image to process. This function *f* eliminates the small variations of the intensity image *I*.

The parameter *t* (the threshold) is by default *t* = *3* but you can choose the value depending of the variations you want to eliminate.

The Algorithm

The output of the algorithm are two images: the first one is the white balance of the original color image (on each channel the darkest pixels are put to zero and the brightest ones are put to 255); the second image is the result of the Retinex PDE applied to the white balanced image.

The discrete partial differential equation is easily solved by fast Fourier transform. Applying the Fourier transform to the discrete partial differential equation yields

$$\hat{u}(k,l) \cdot \left(4 + \frac{4}{\dim -1} - 2\cos\left(\frac{2k\pi}{N}\right) - 2\cos\left(\frac{2l\pi}{M}\right)\right) = \hat{F}(k,l)$$

The algorithm is

1. Compute F(i,j);
2. Compute Fourier transform of F by FFT;
3. Deduce the Fourier transform of u using the formula above;
4. Compute the final solution u using the inverse FFT.

Terminé

megawave demo - retinex_pde archives - Mozilla Firefox

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MEGAWAVE DEMO - RETINEX_PDE PUBLIC ARCHIVES

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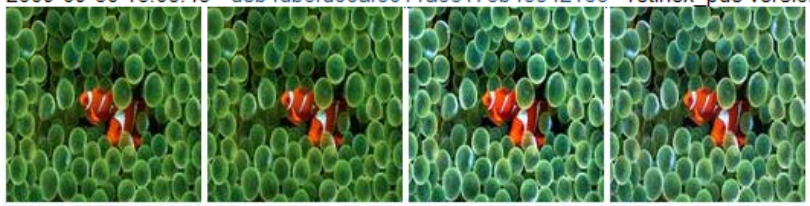
- 2009-09-30 13:06:46 - deb4db3fd0caf6011a63173b46542166 - retinex_pde version 2.04.20090613



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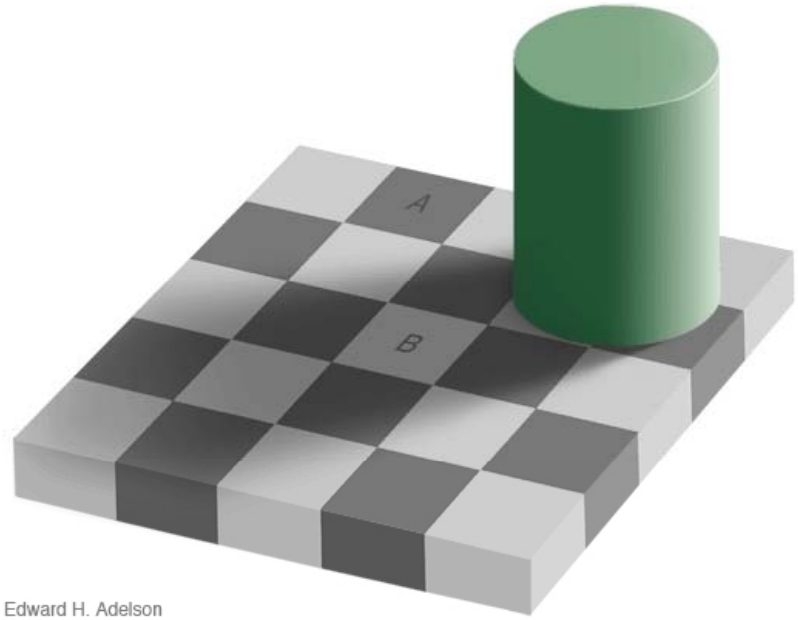
- 2009-08-28 06:23:12 - 1fabe644068a2fa7ebef1fbe93265e1e - retinex_pde version 2.04.20090613

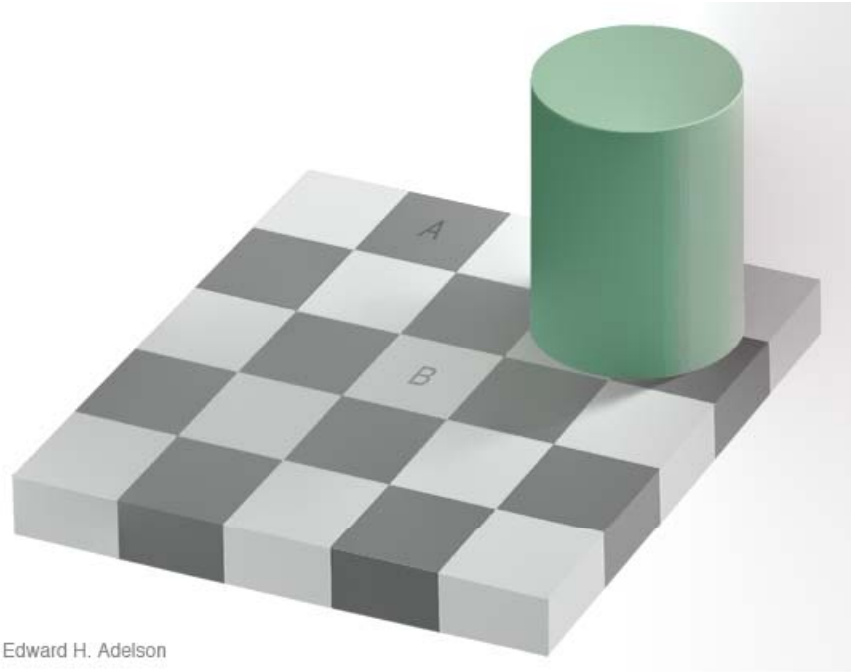
Terminé

Some Results

The gray level of A and B is 120



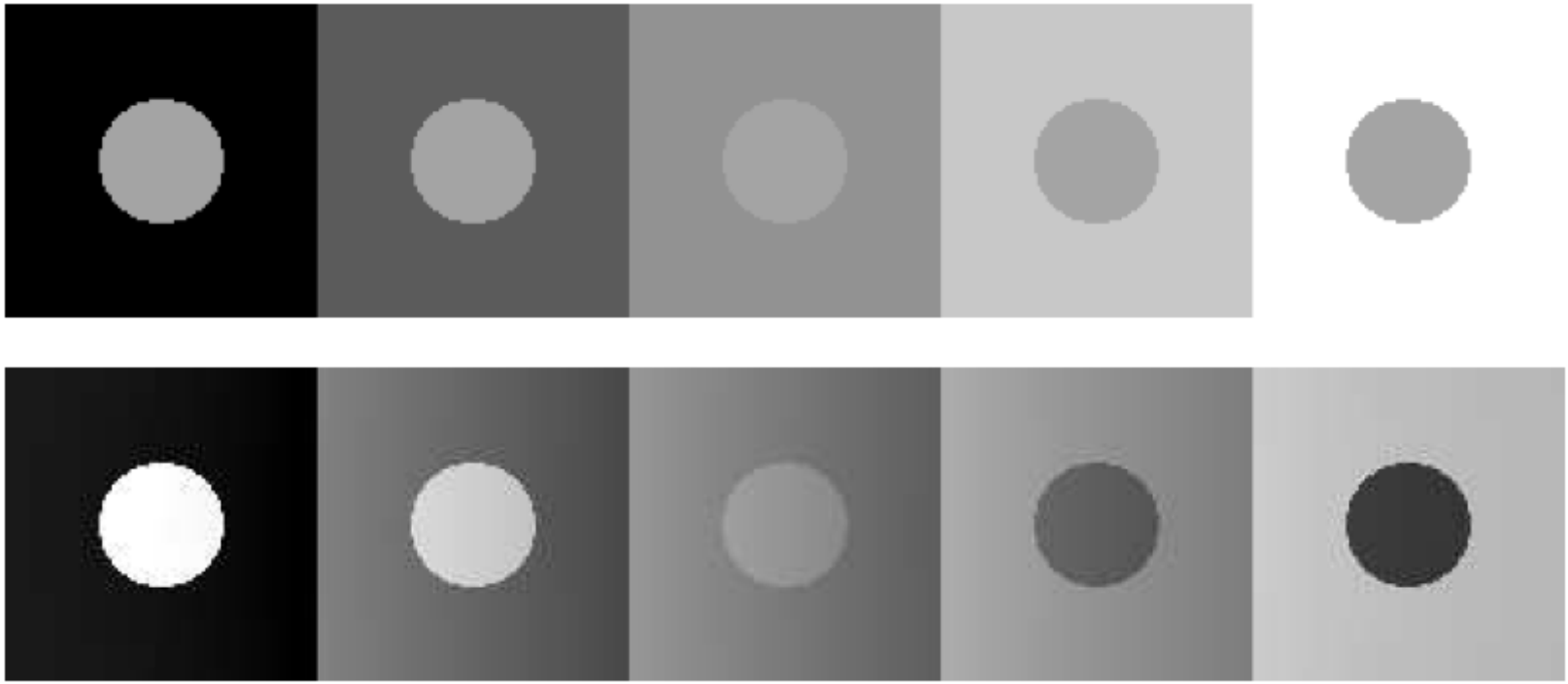
The gray level of A is 145 and B is 190



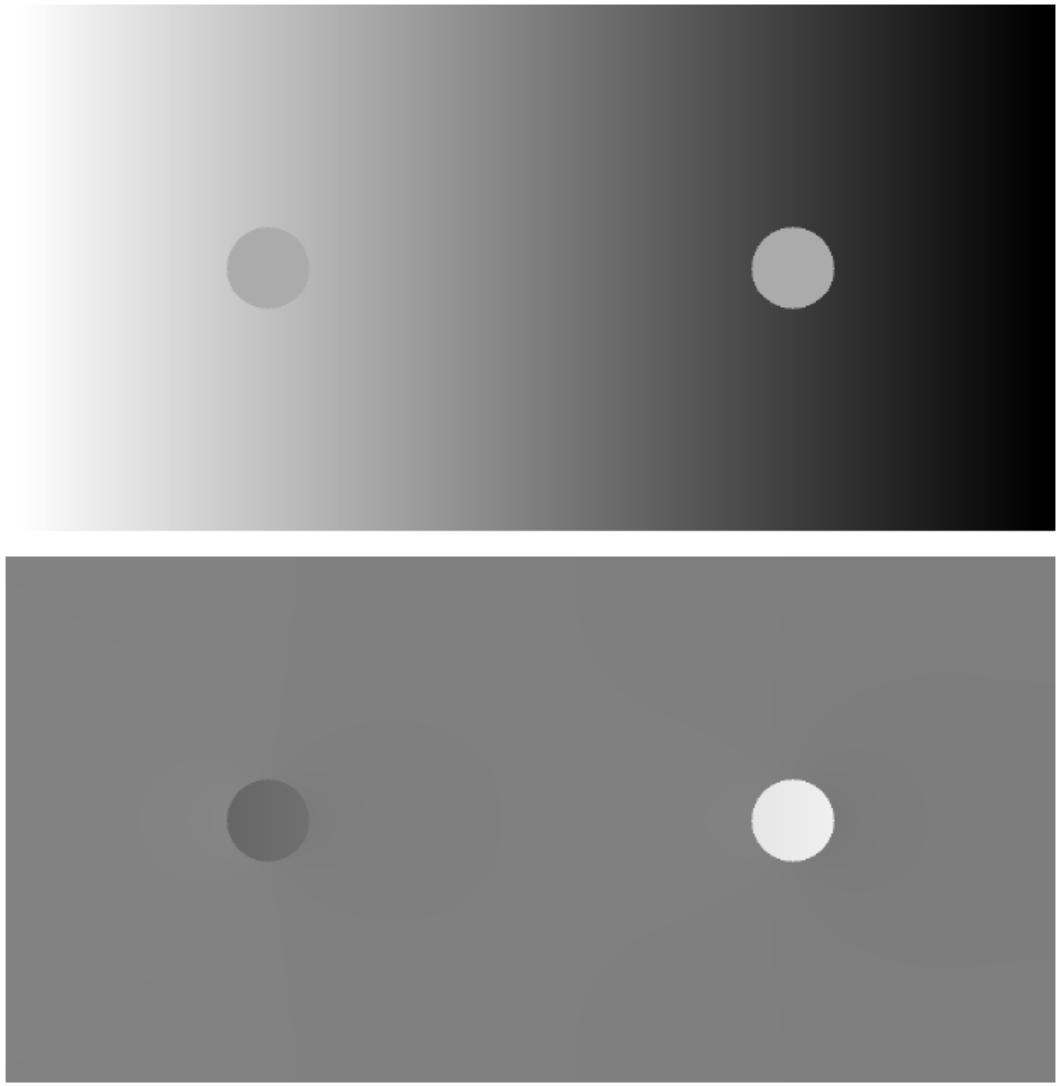
EI 2009

Retinex: color constancy ignoring shadows

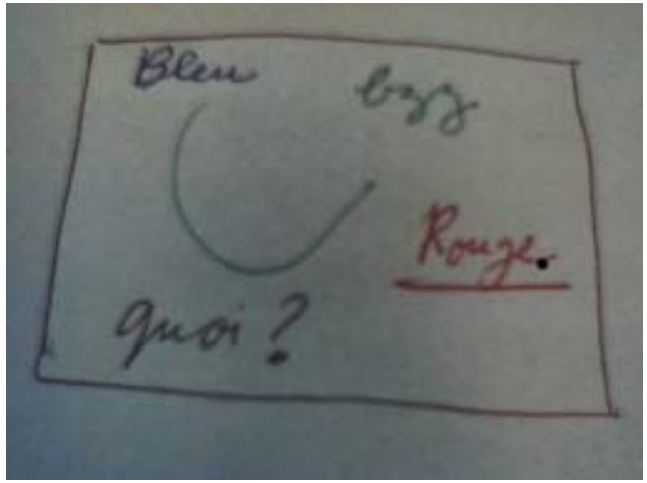
Retinex Theory



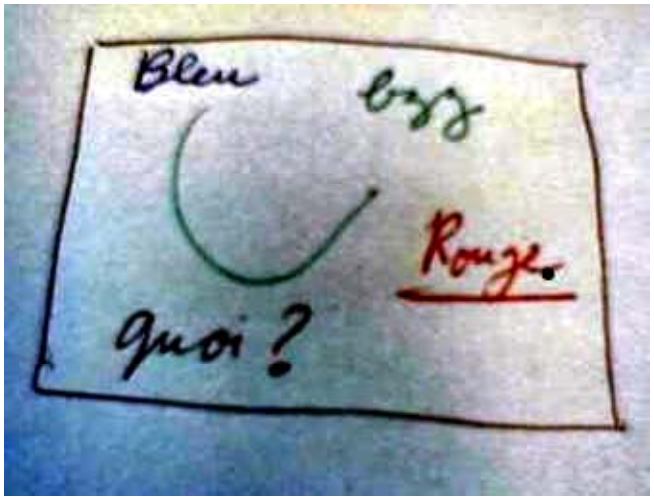
Retinex Theory



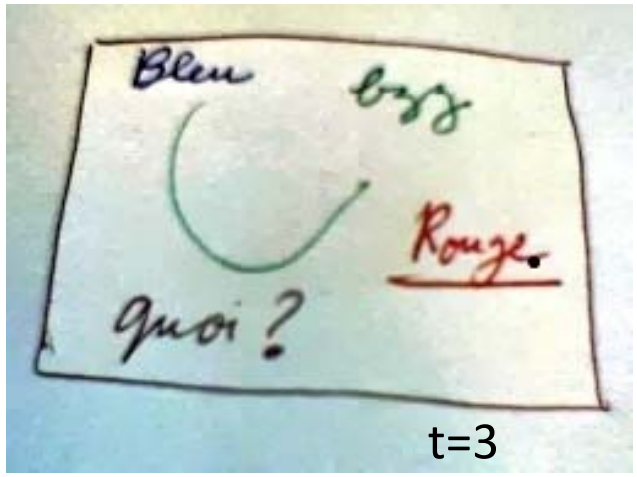
Retinex results



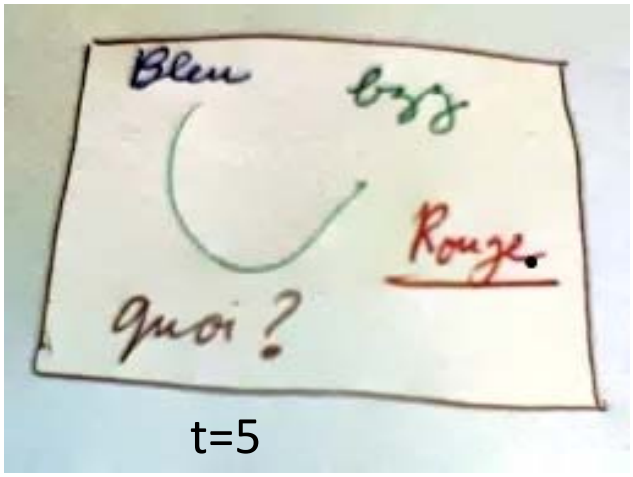
Original



Color balanced



t=3



t=5

EI 2009

Local contrast adjustment. Algorithm

Given an image f and with the values for T and α the proposed algorithm is fully automatic:

- Select the dark region Ω by the threshold T.
- Define the guidance vector field by

$$\mathbf{V} = \begin{cases} \nabla f & in\ R \setminus \Omega \\ \alpha \nabla f & in\ \Omega \end{cases}$$

  where $\alpha \in [2, 3]$ and in the experiment we have took $\alpha = 2.5$.
- Solve the Poisson equation with Neumann boundary conditions using the Fourier transform as explained in a posterior section.

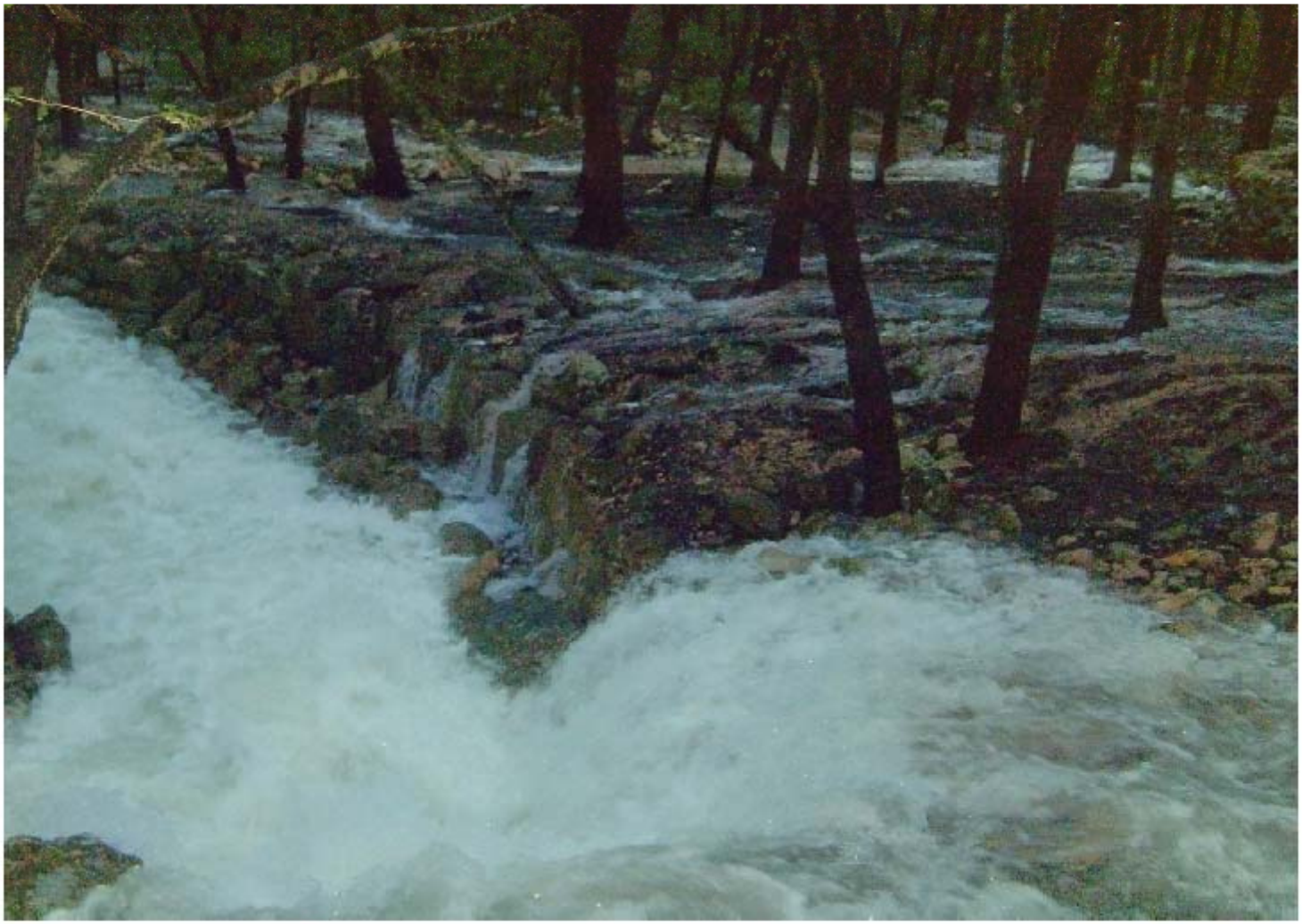
$$\Delta u = \operatorname{div} \mathbf{V}, \quad \text{over } R, \quad \frac{\partial u}{\partial \mathbf{n}} = 0 \quad \text{over } \partial R,$$

Local contrast adjustment. Examples

Local contrast adjustment. Examples

Local contrast adjustment. Examples

Local contrast adjustment. Examples



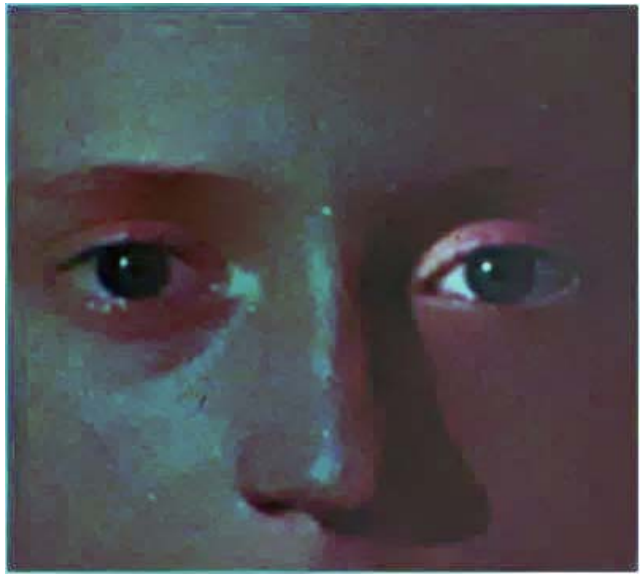
Local contrast adjustment. Examples

Local contrast adjustment. Examples

Experimental Results

Original Image

Colour balanced



Retinex t=10

Retinex t=20

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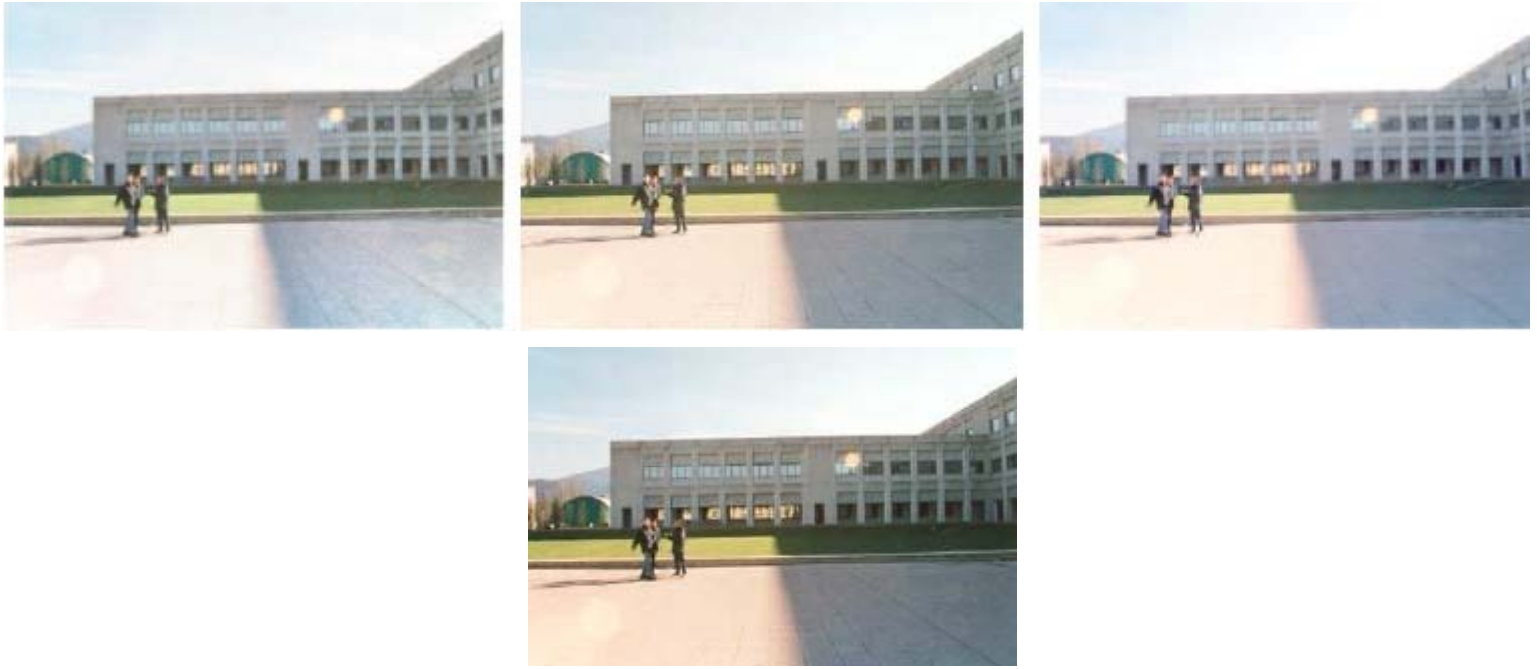
Original, Color-Balanced, Beltramio-Caselles-Provenzi, Retinex_t=4



Beltramio-Caselles-Provenzi 1, 2, and 3

Original

Retinex t=2, Retinex t=10, Retinex t=20