Image Processing on Line

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

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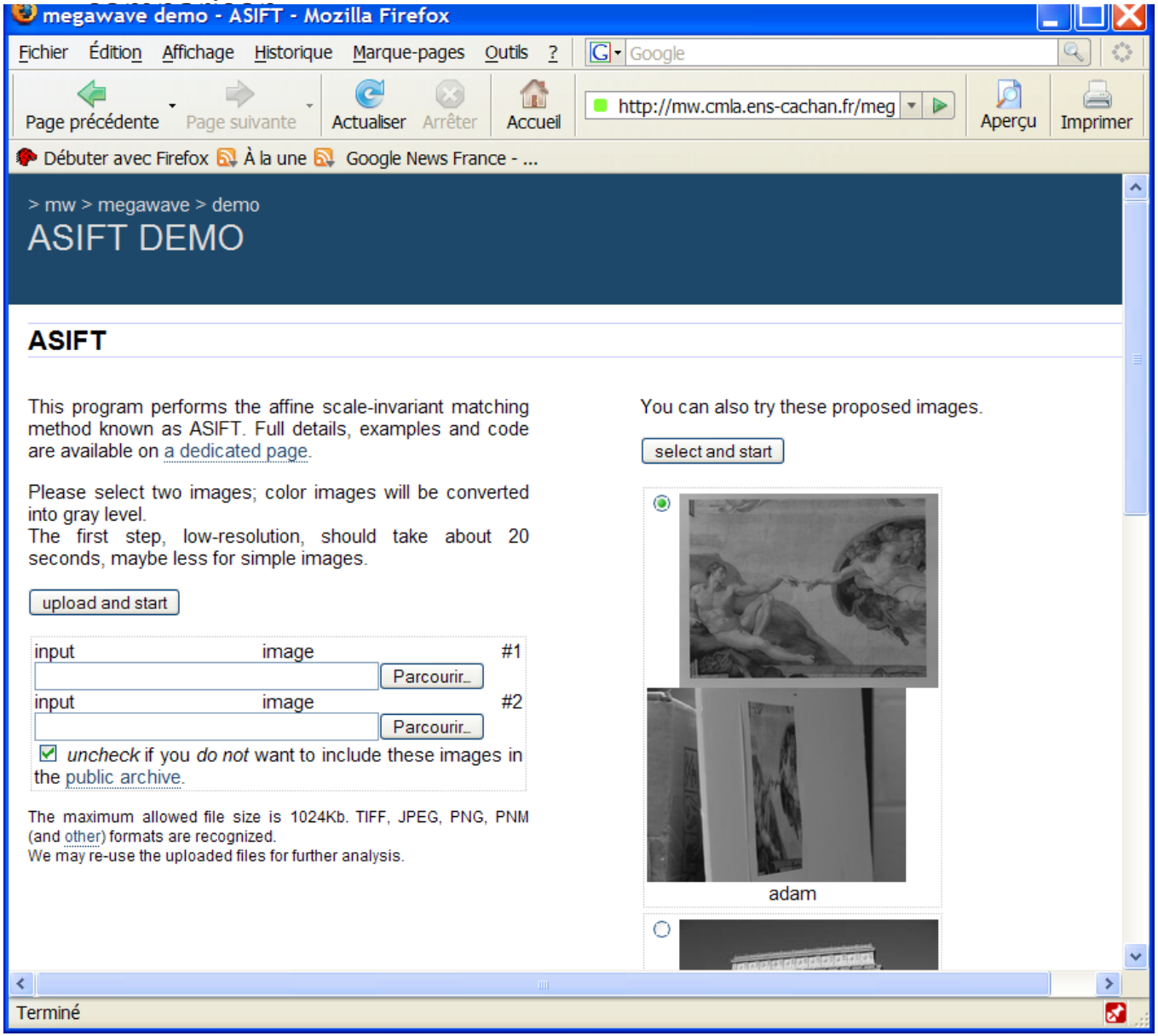
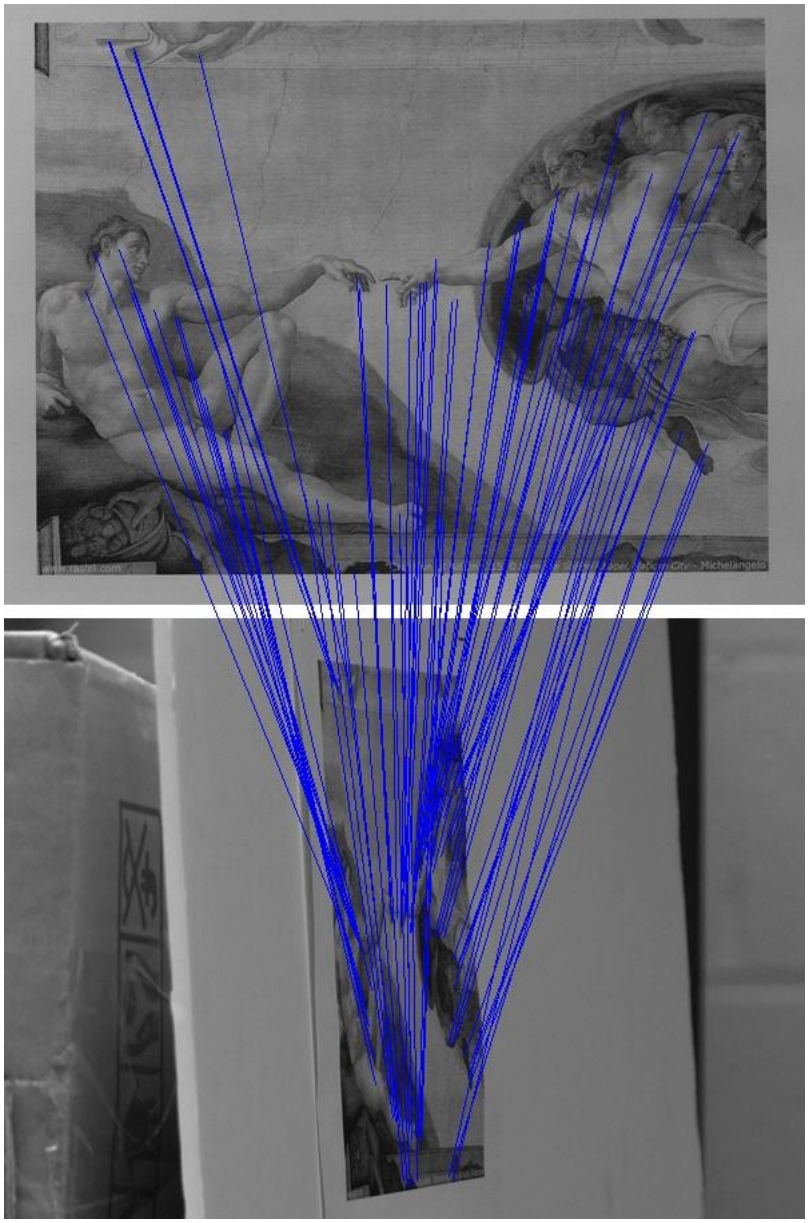
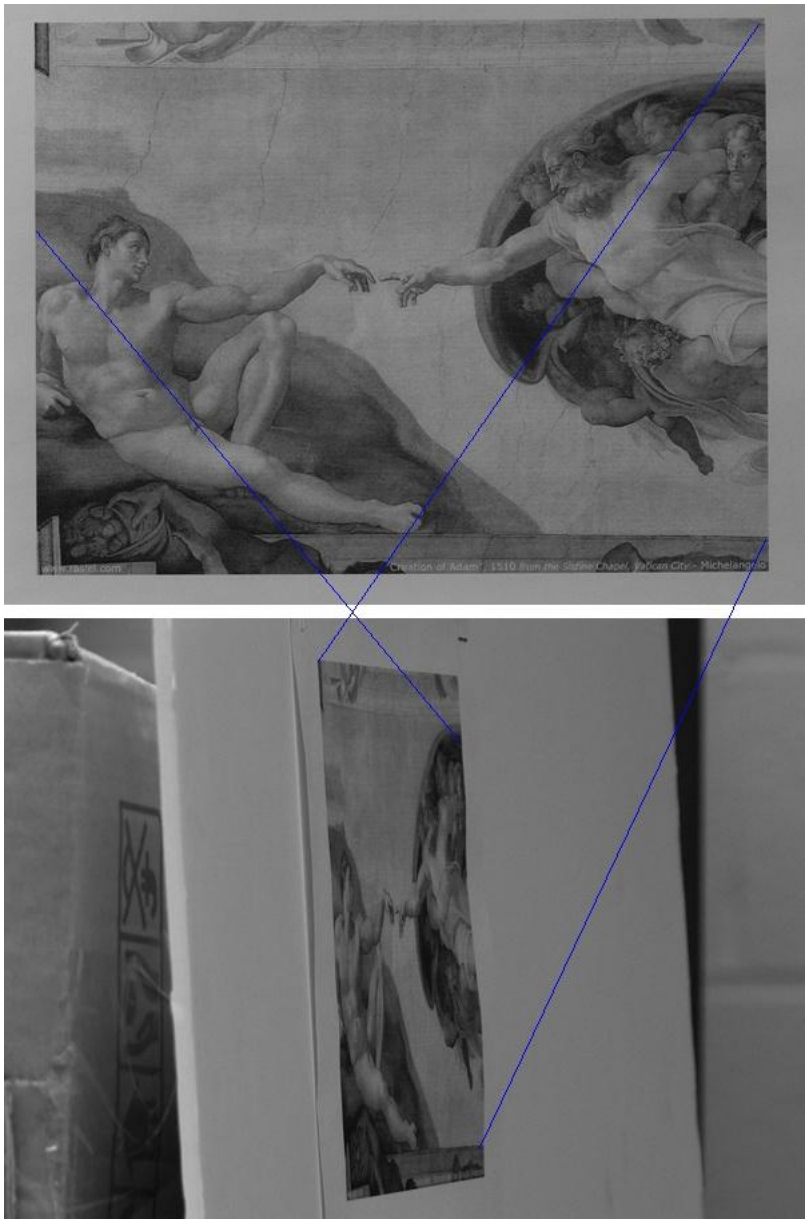
Example : ASIFT: affine invariant image comparison



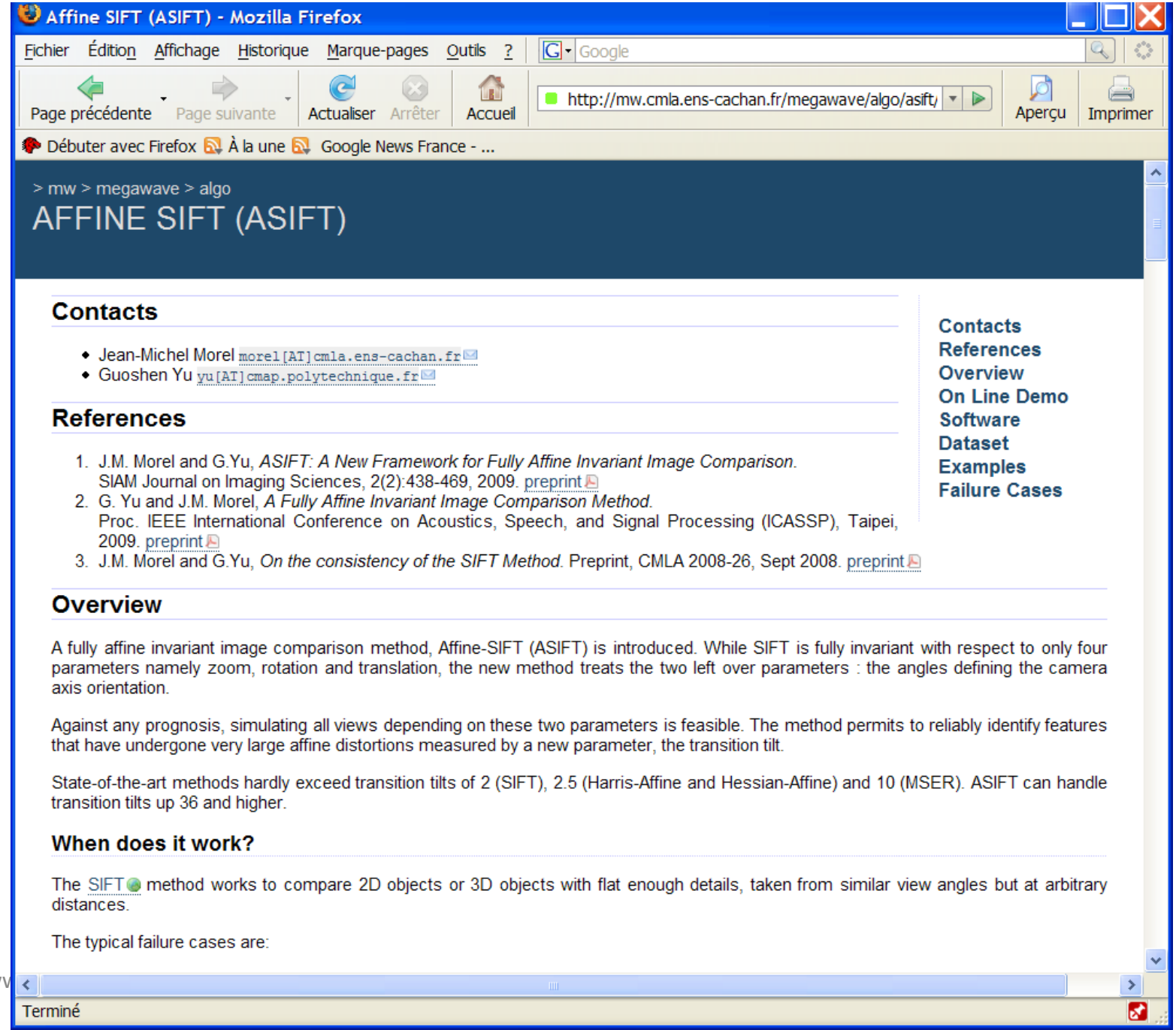
Result of ASIFT:



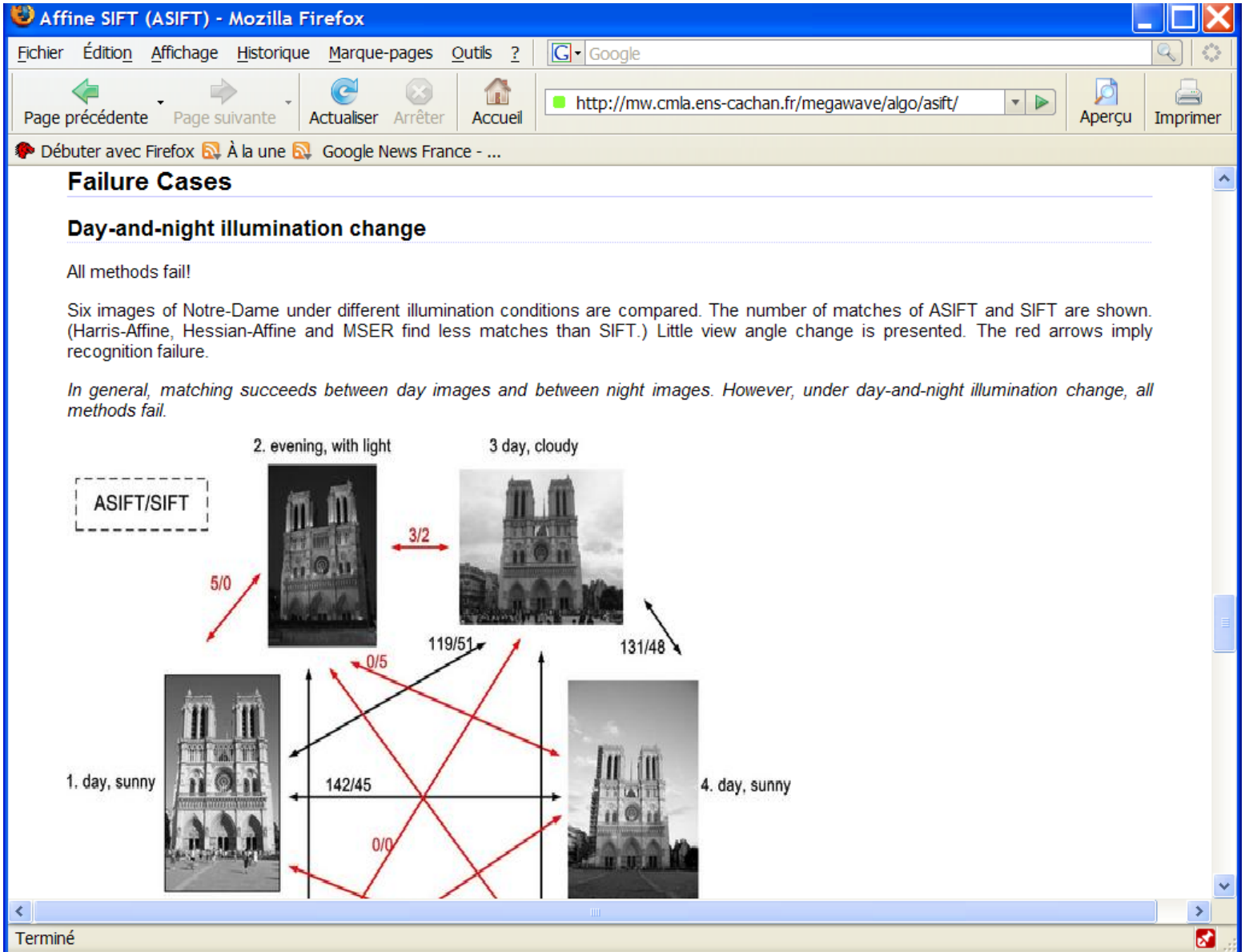
Compared with SIFT:



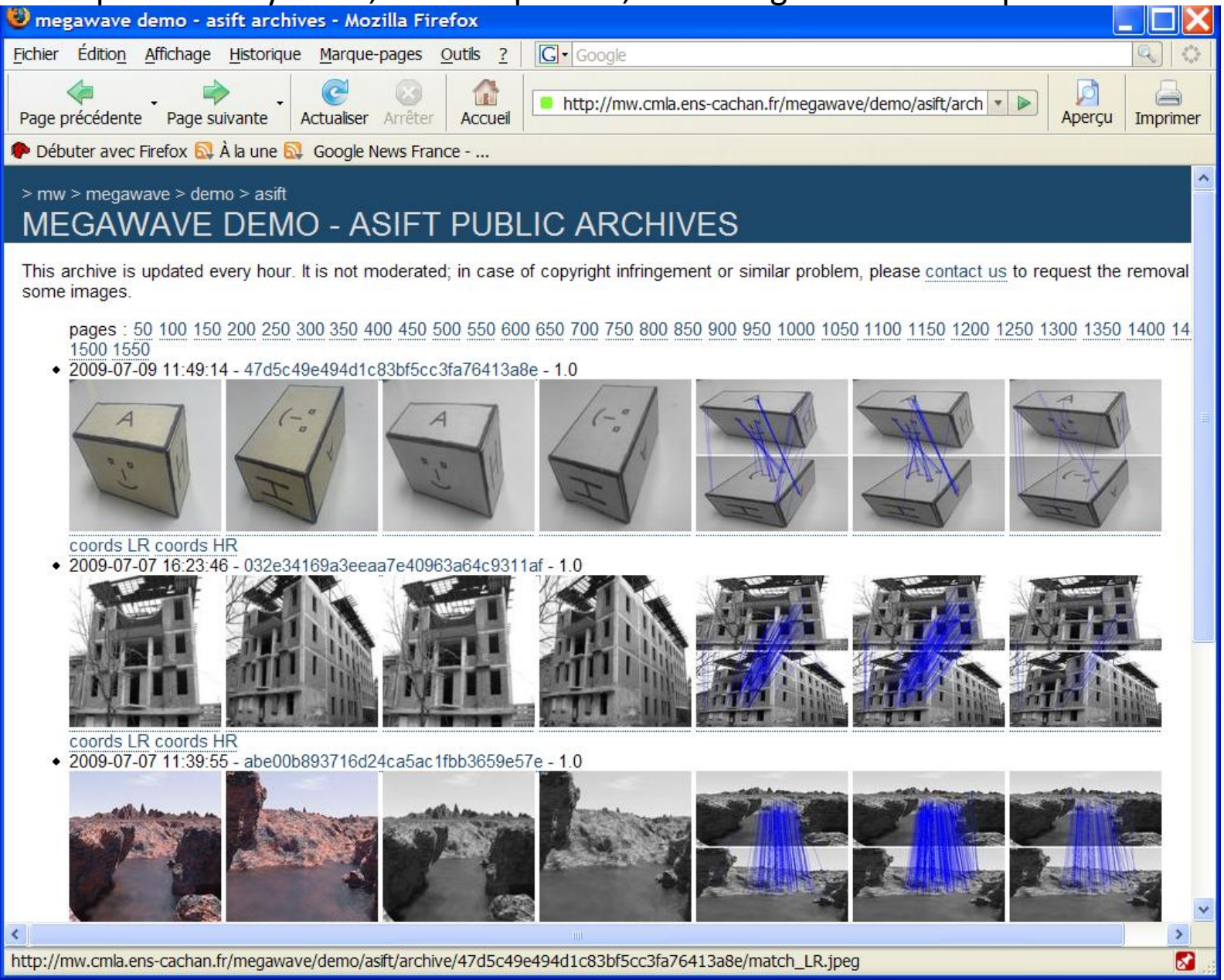
Algorithm Website



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

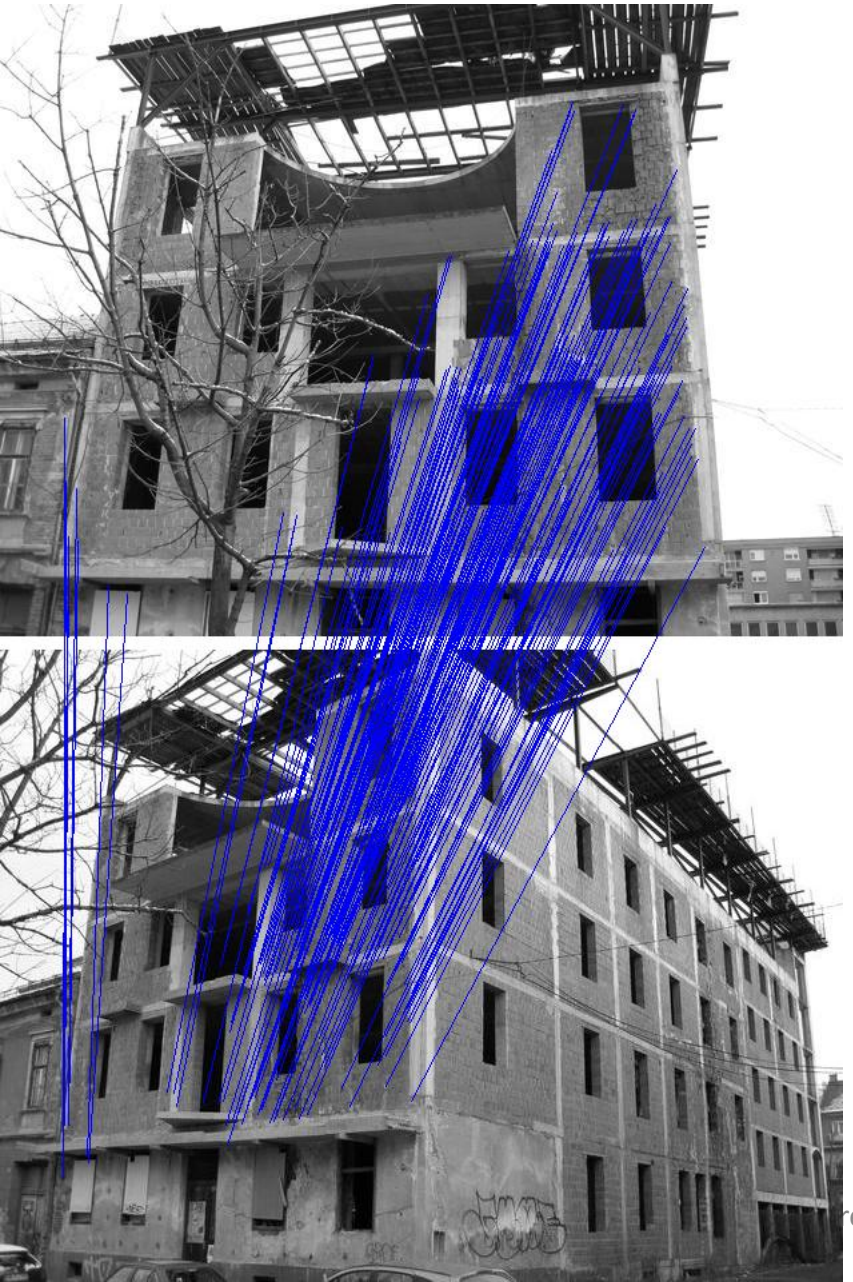


The online demo gives also access to the online archive. More than 8550 different images have been so far tried by on line users. They are grouped in pages of 50. Here are three examples tried by users, on a simple box, a building and a landscape.



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

ASIFT result :



SIFT result :

LSD: A LINE SEGMENT DETECTOR

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- Jean-Michel Morel morel[AT]cmla.ens-cachan.fr
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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

Line segment detector (LSD), no parameter. More than 3500 images on line trials in the archive

megawave demo - lsd archives - Mozilla Firefox

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> mw > megawave > demo > lsd

MEGAWAVE DEMO - LSD PUBLIC ARCHIVES

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pages : 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850

- 2009-09-30 11:34:20 - 95be8a74889a75a6ab137b38c581c8f7 - 1.0

coords

- 2009-09-30 11:33:47 - 59c3d5663a82b971d0ba8bcc00fdbcc6 - 1.0

coords

- 2009-09-30 11:10:44 - f73d5a6fb7b9c94d22cad8ca01590867 - 1.0

coords

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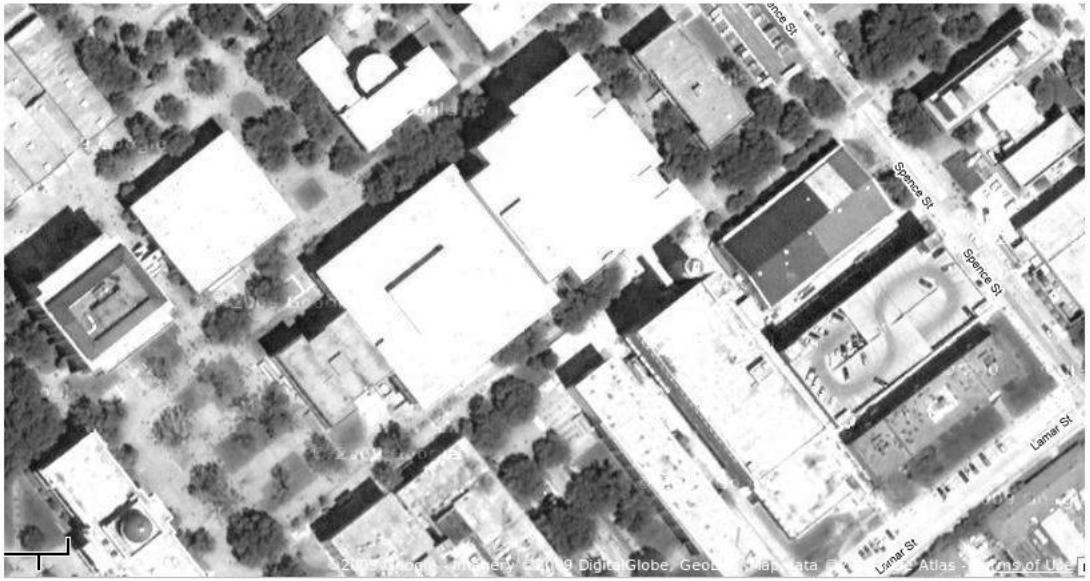
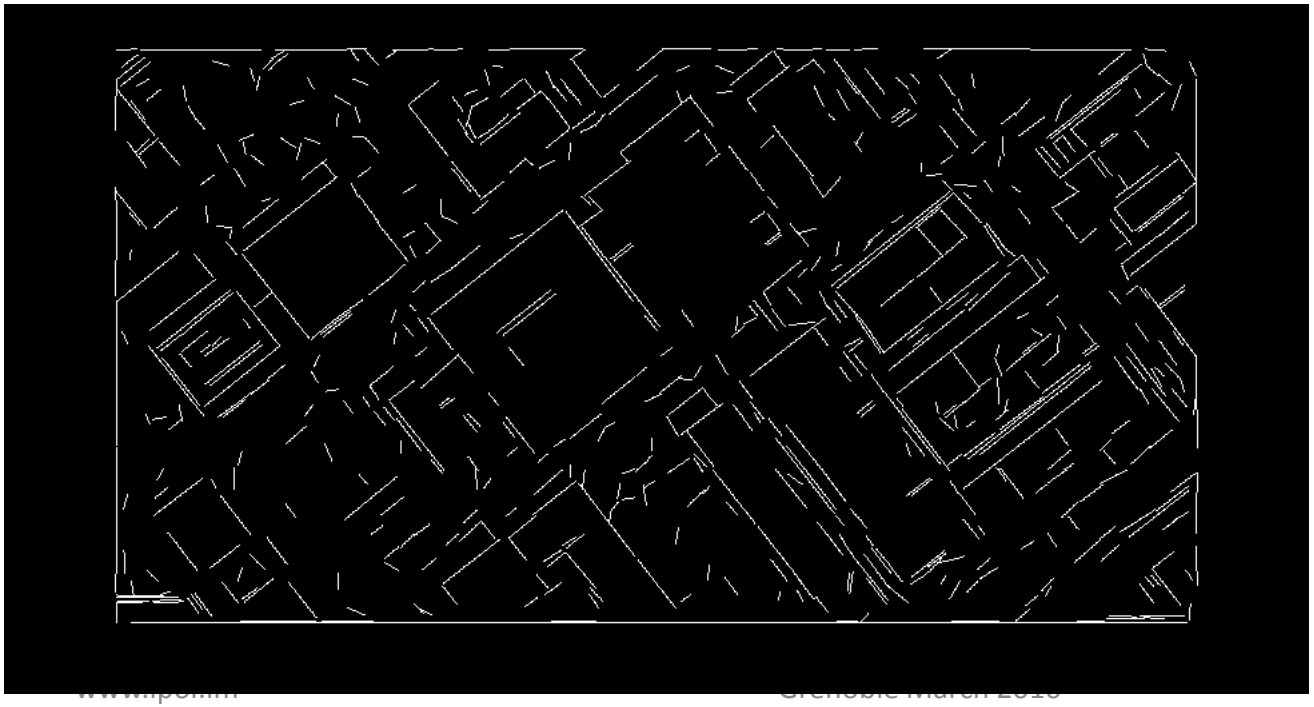


Some results

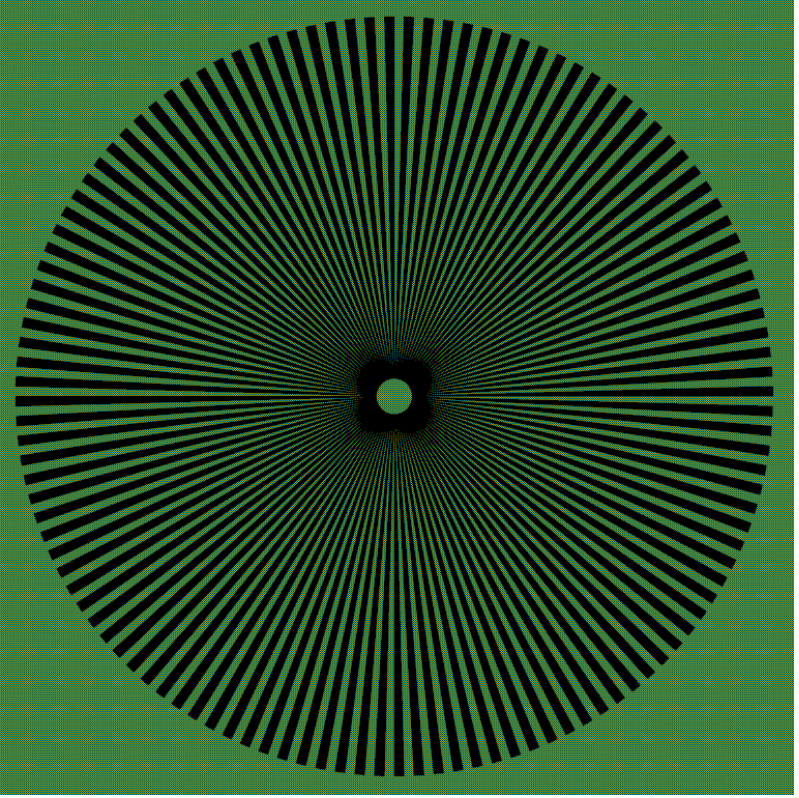


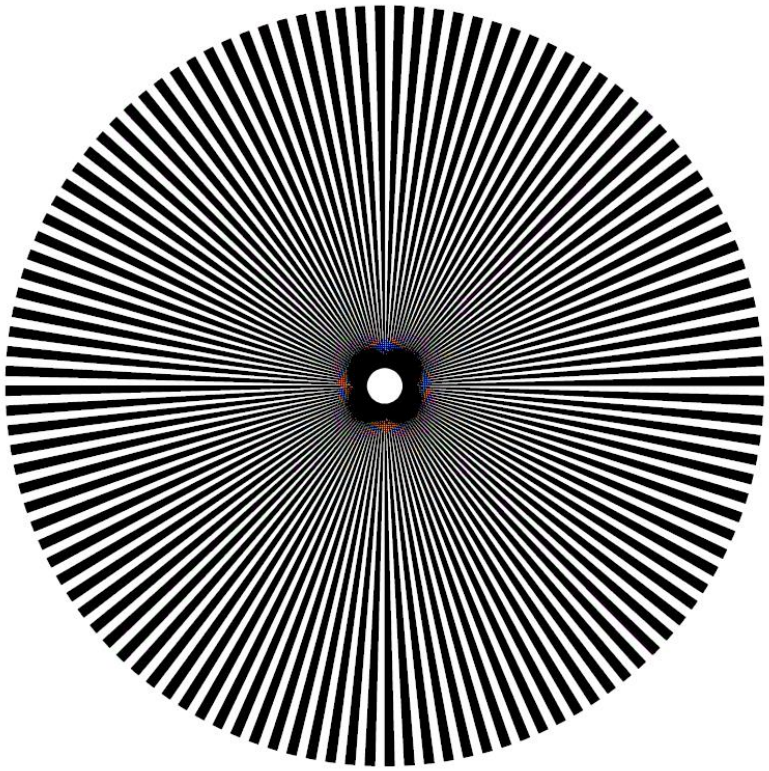
LSD: Some results in the online archive

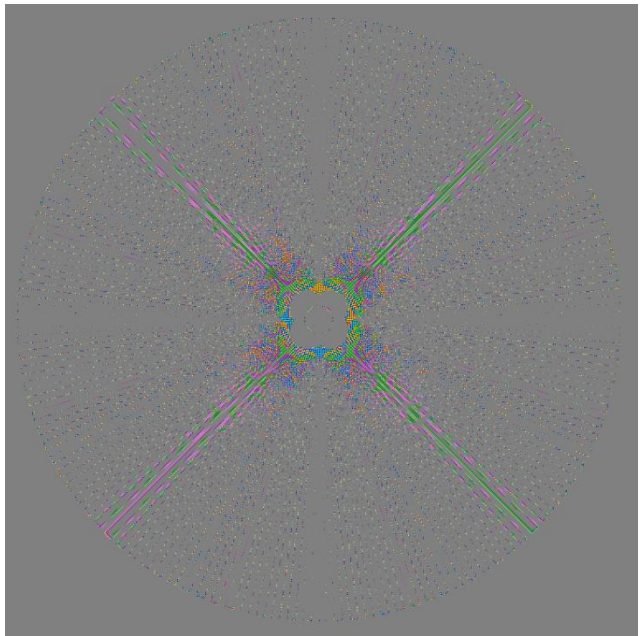
NL-means, archive on line



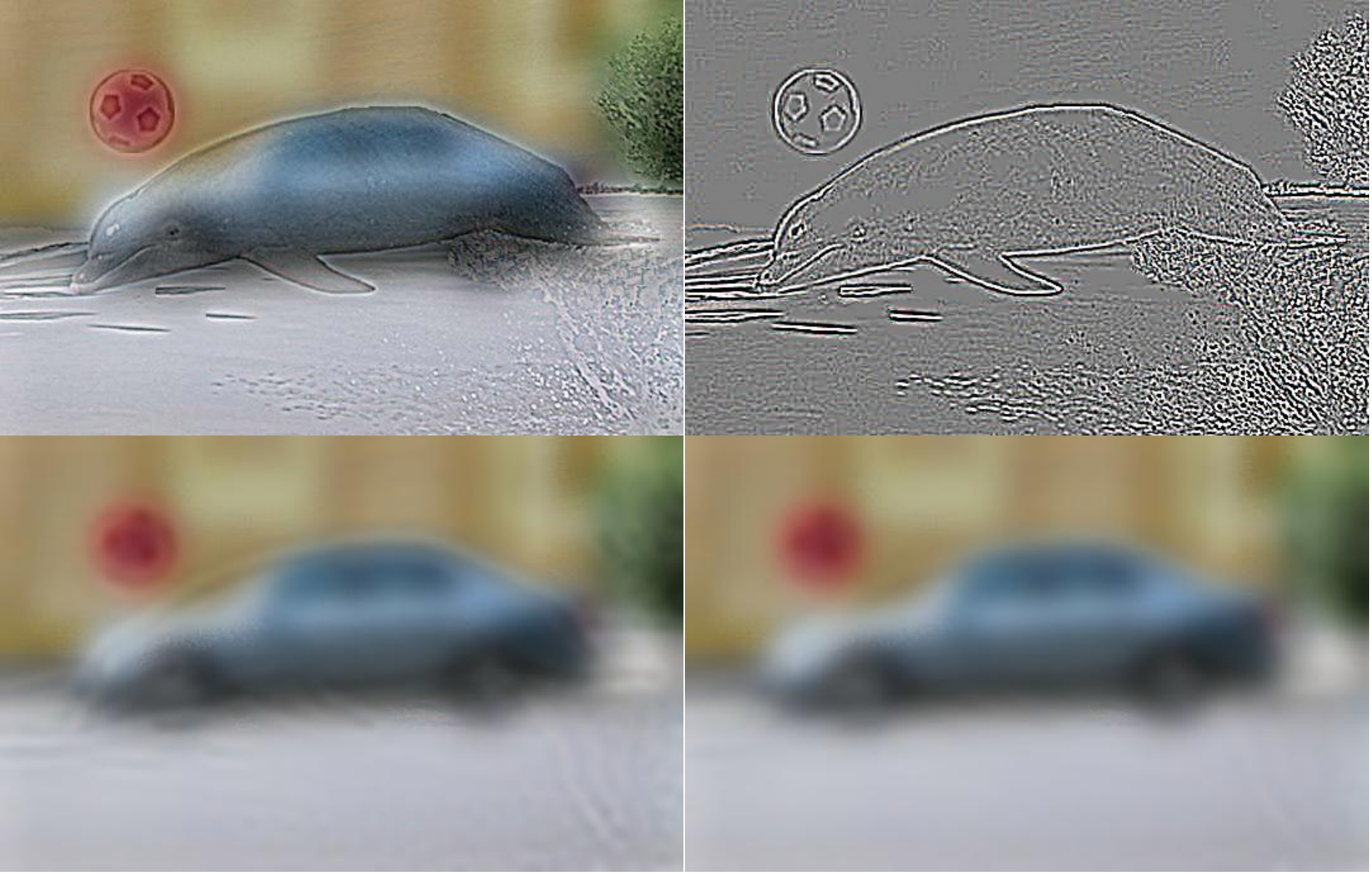
Demosaicking (DxO)
From Archive on line



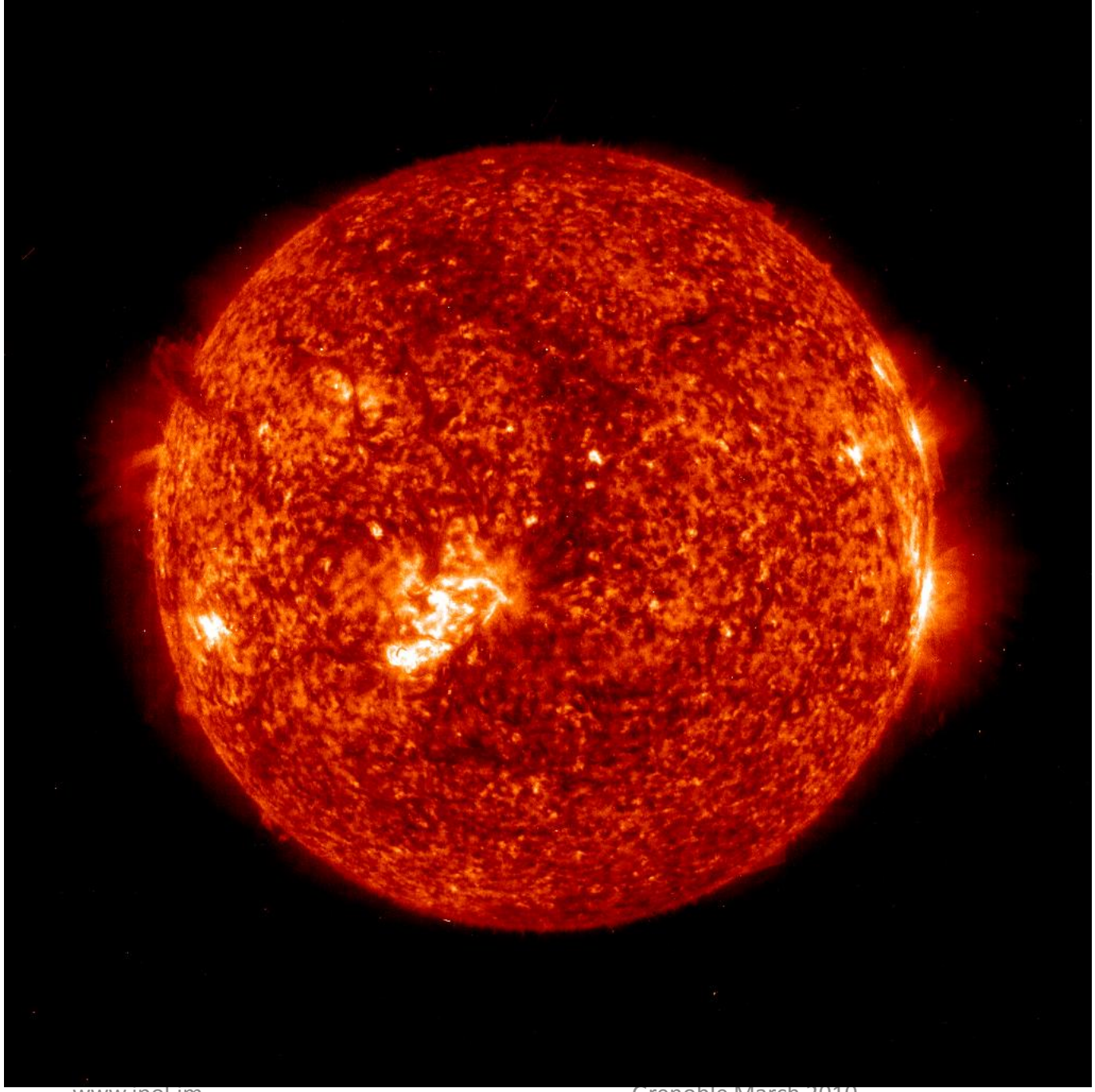




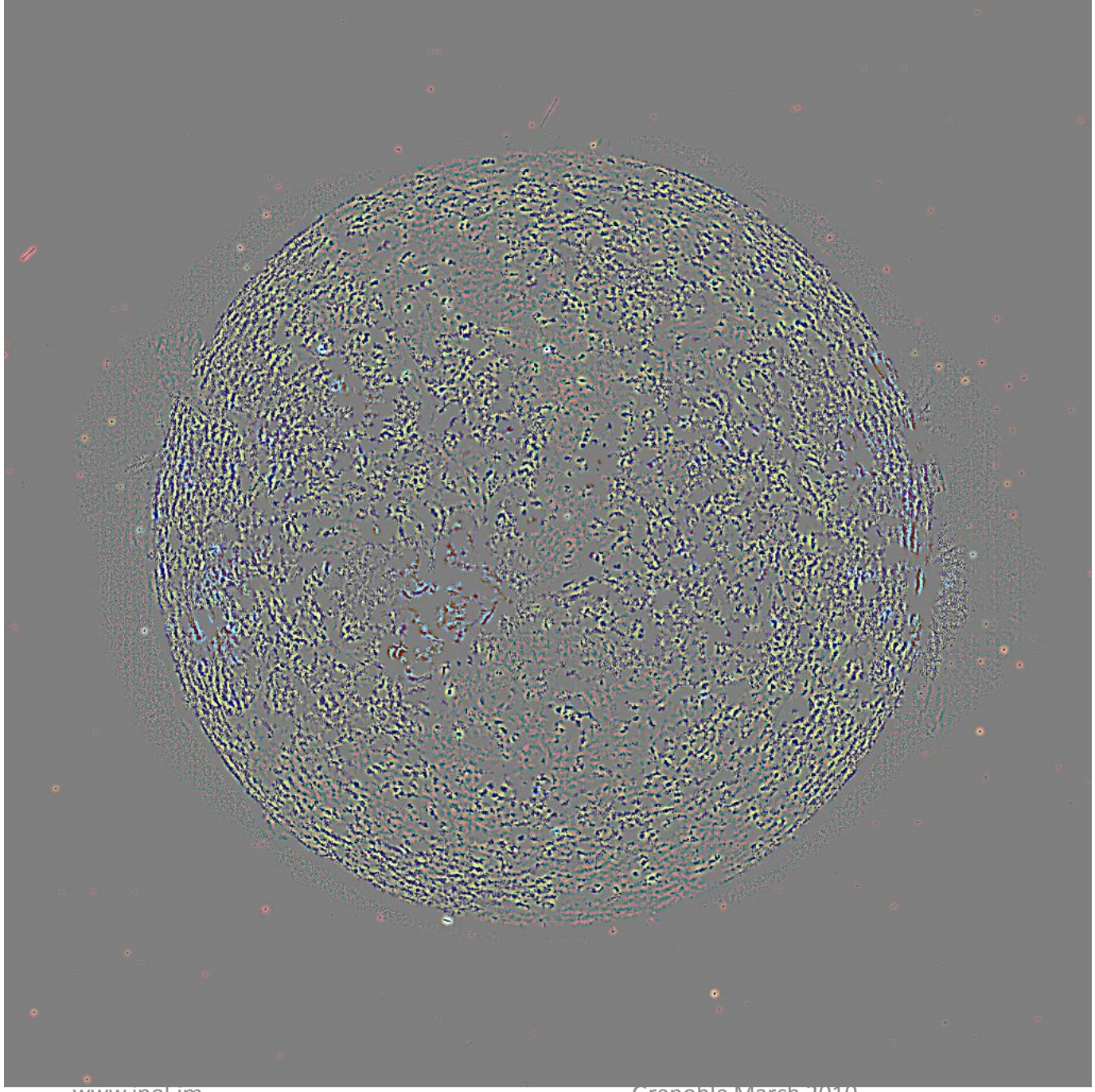
LSD: Some results in the online archive



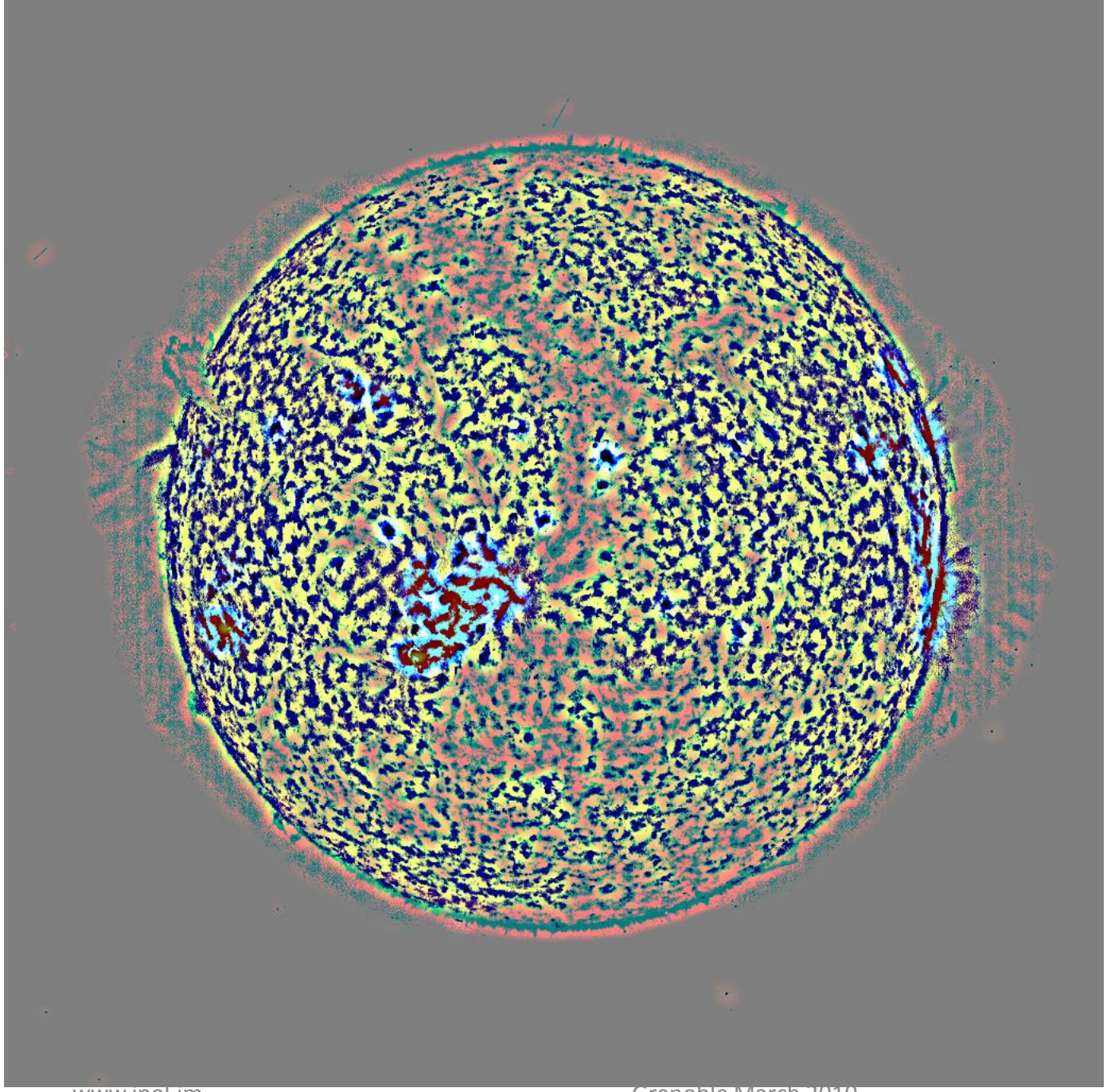
Cartoon+texture (IPOL Archive)



Cartoon+texture (IPOL Archive)



Cartoon+texture (IPOL Archive)



Cartoon+texture (IPOL Archive)

Cartoon+texture (IPOL Archive)

Micro-Texture Synthesis by Phase Randomization - Mozilla Firefox

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> mw > megawave > algo

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.

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

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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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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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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

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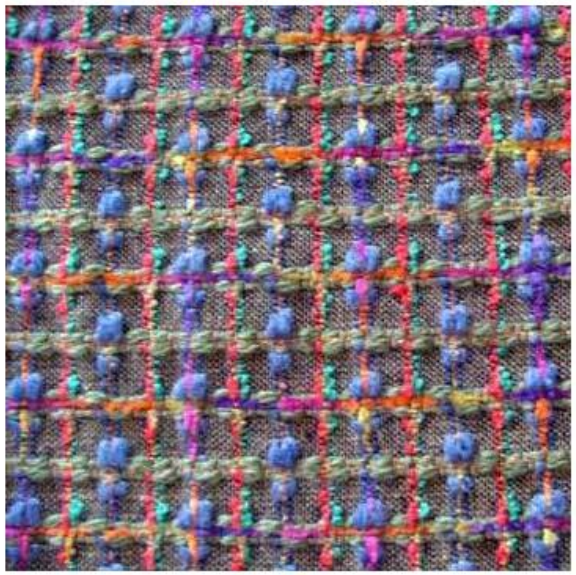
failure catalog

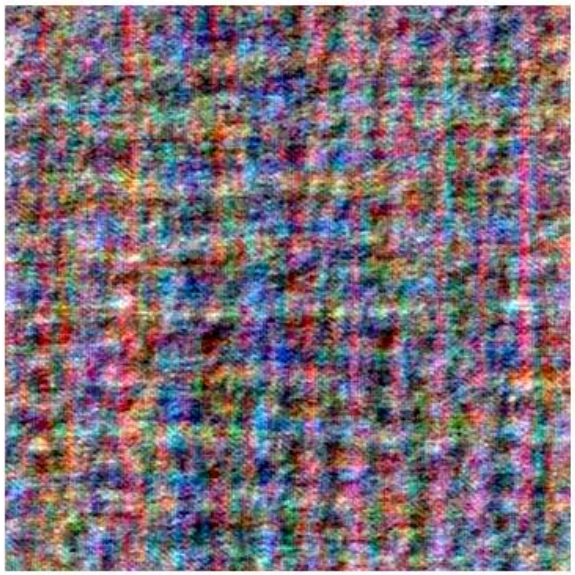
Most failures are **macro**-textures. For instance:

- 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)**

Micro-Texture Synthesis by Phase Randomization - Mozilla Firefox

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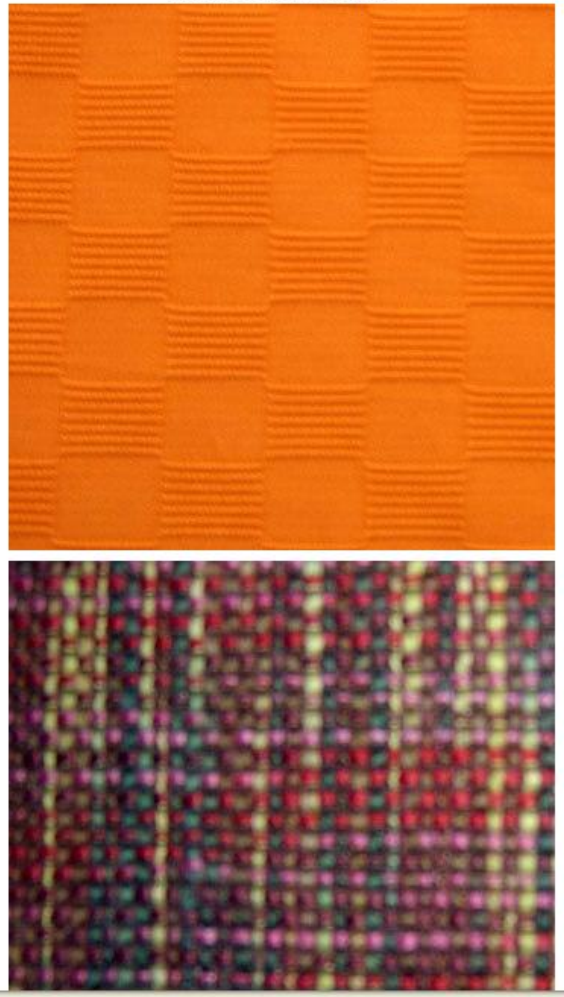
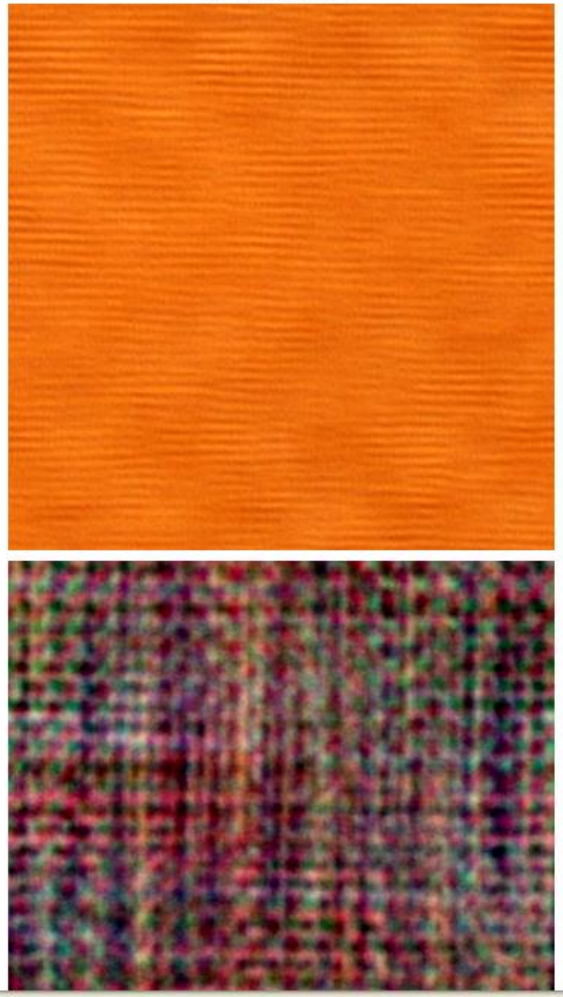
Show/hide **more failure examples (macro-textures)**

Macro-texture sample



RPN simulation



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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...

> mw > megawave > algo

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 I*mplementation of color constancy algorithms*.
   Color Imaging XIV: Displaying, Processing, Hardcopy and Application.
   Proc. of Electronic Imaging SPIE, vol 7241. January 2009.
   preprint on line article

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!

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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.

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megawave demo - retinex_pde archives - Mozilla Firefox

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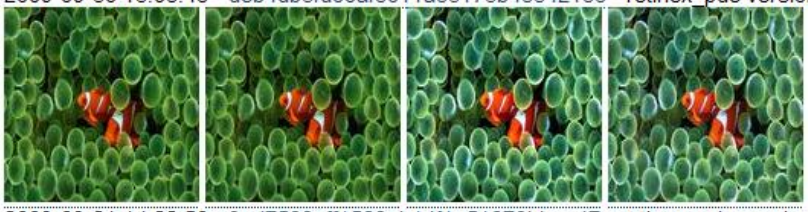

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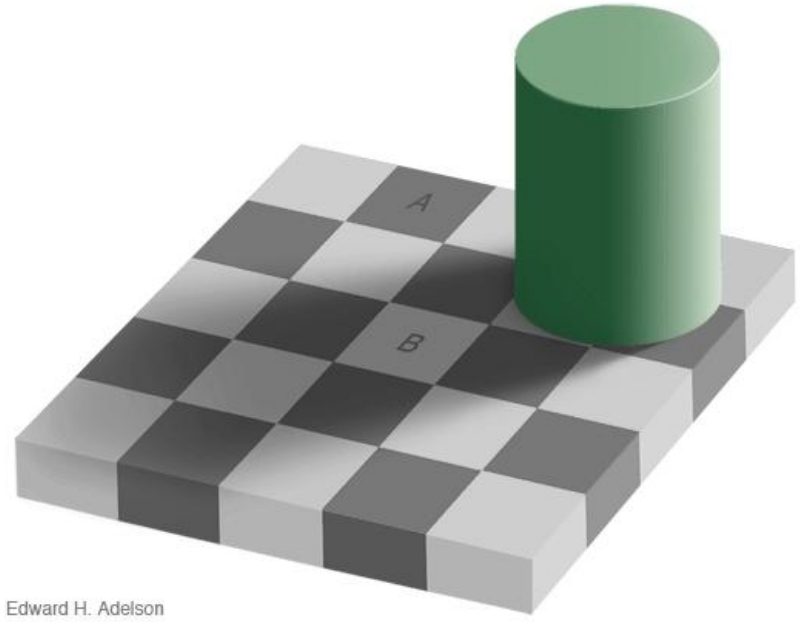
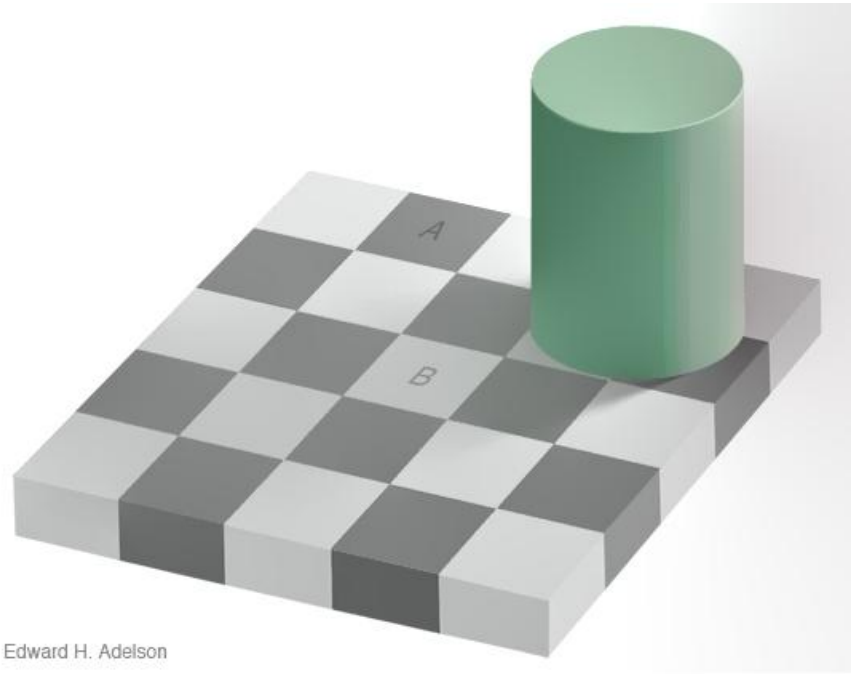
Some Results

The gray level of A and B is 120



The gray level of A is 145 and B is 190



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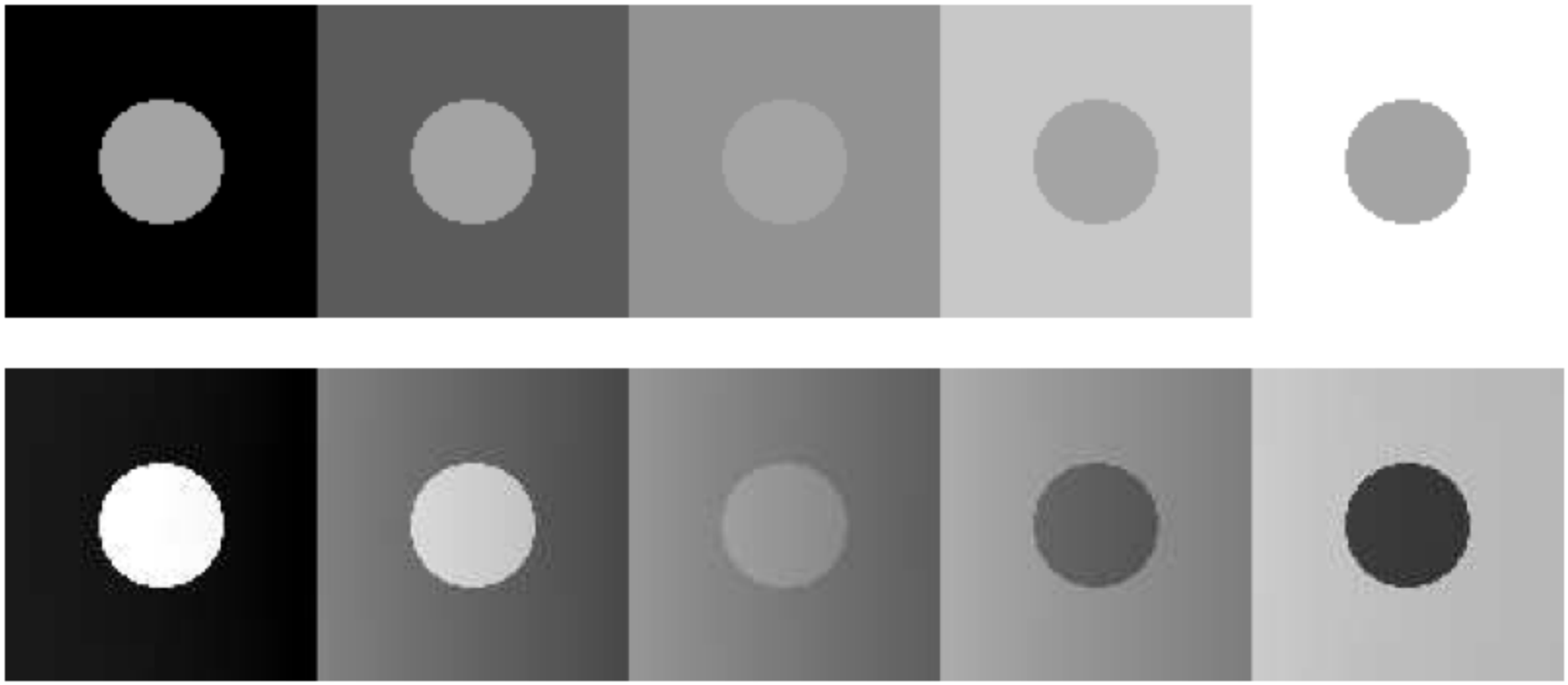
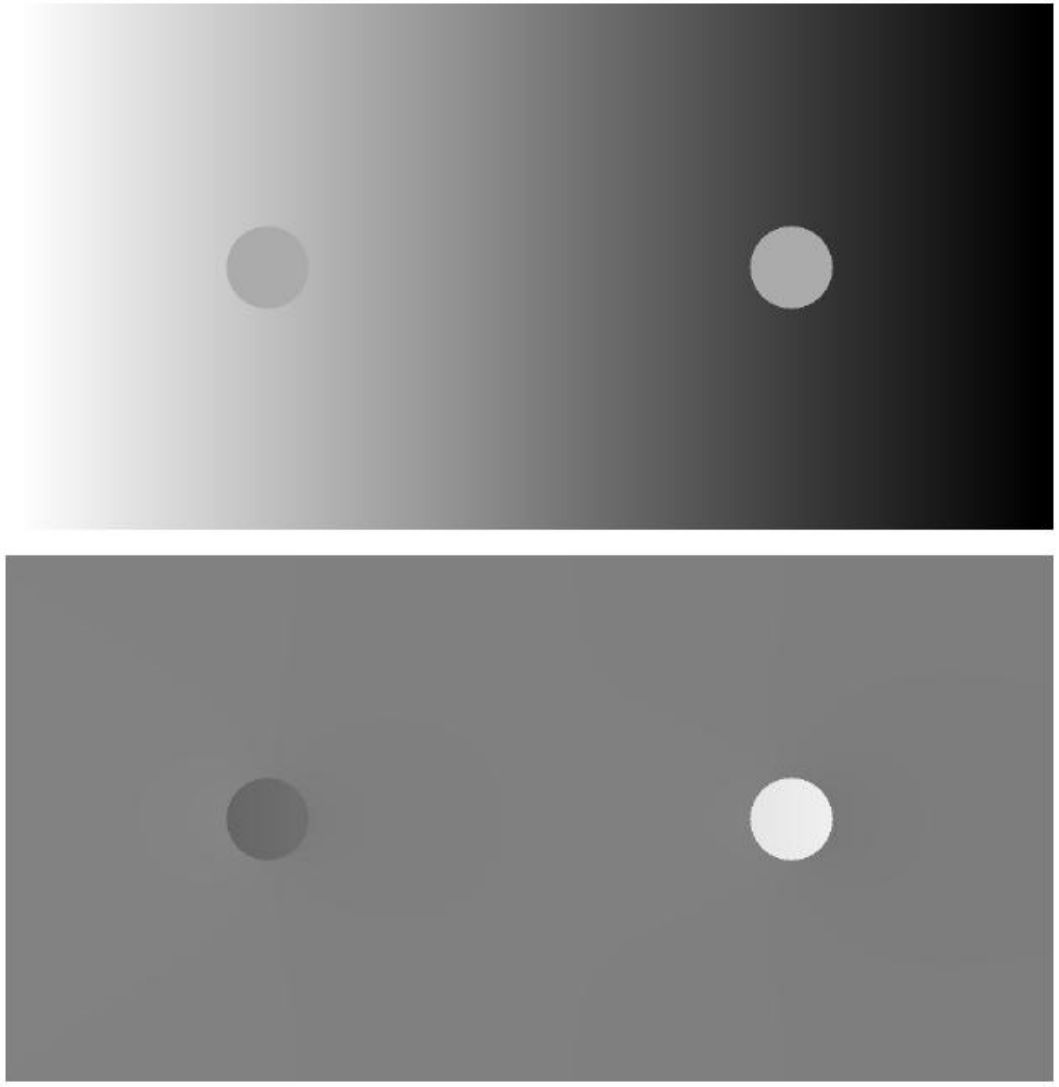
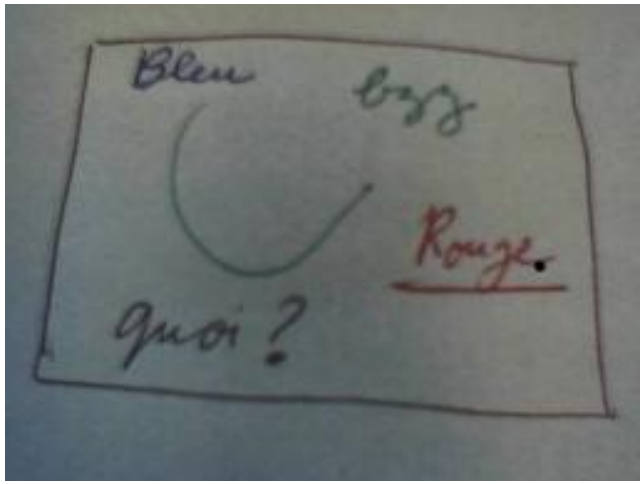
Retinex Theory



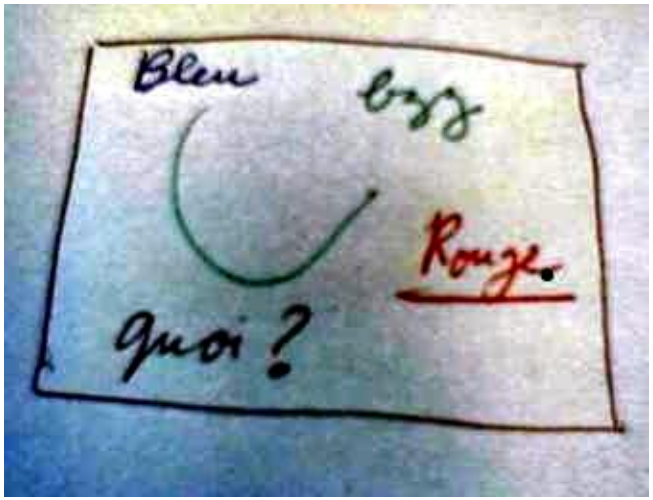
Retinex Theory



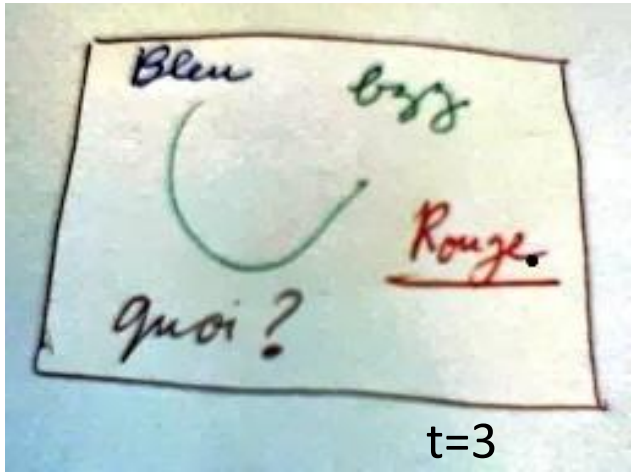
Retinex results



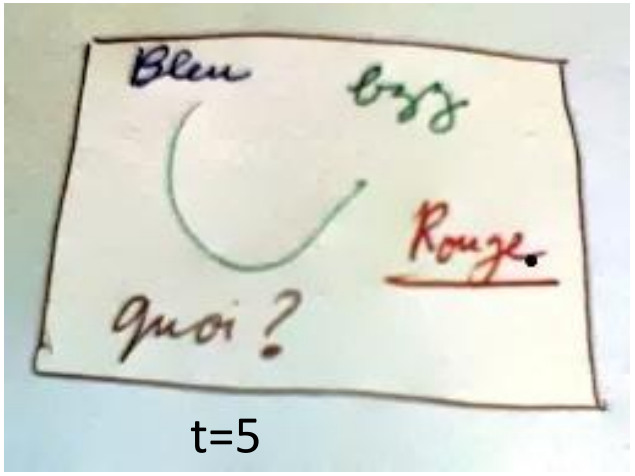
Original



Color balanced

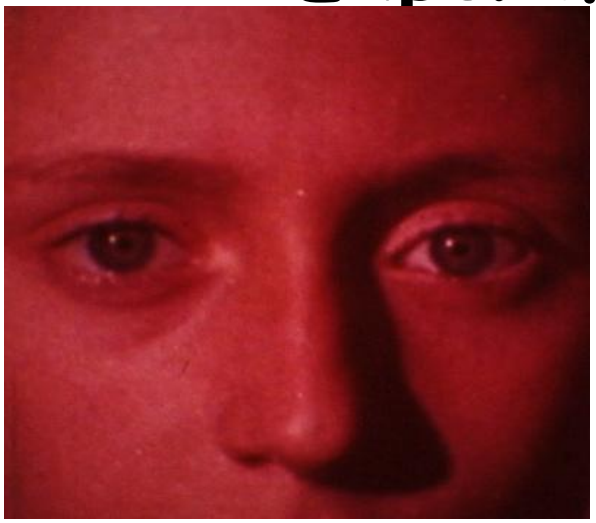


t=3



t=5

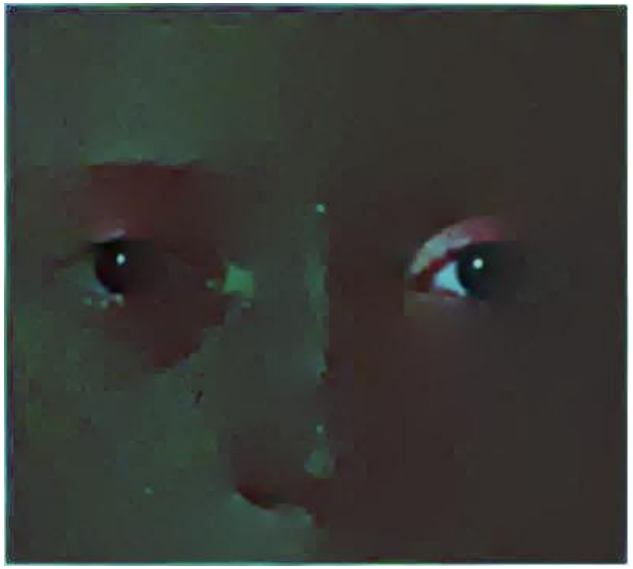
Experimental Results



Original Image

Colour balanced

Retinex t=10



Retinex t=20

EI 2009

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

Image Processing on Line (IPOL): main goals

Achieve « reproducible research » and therefore:

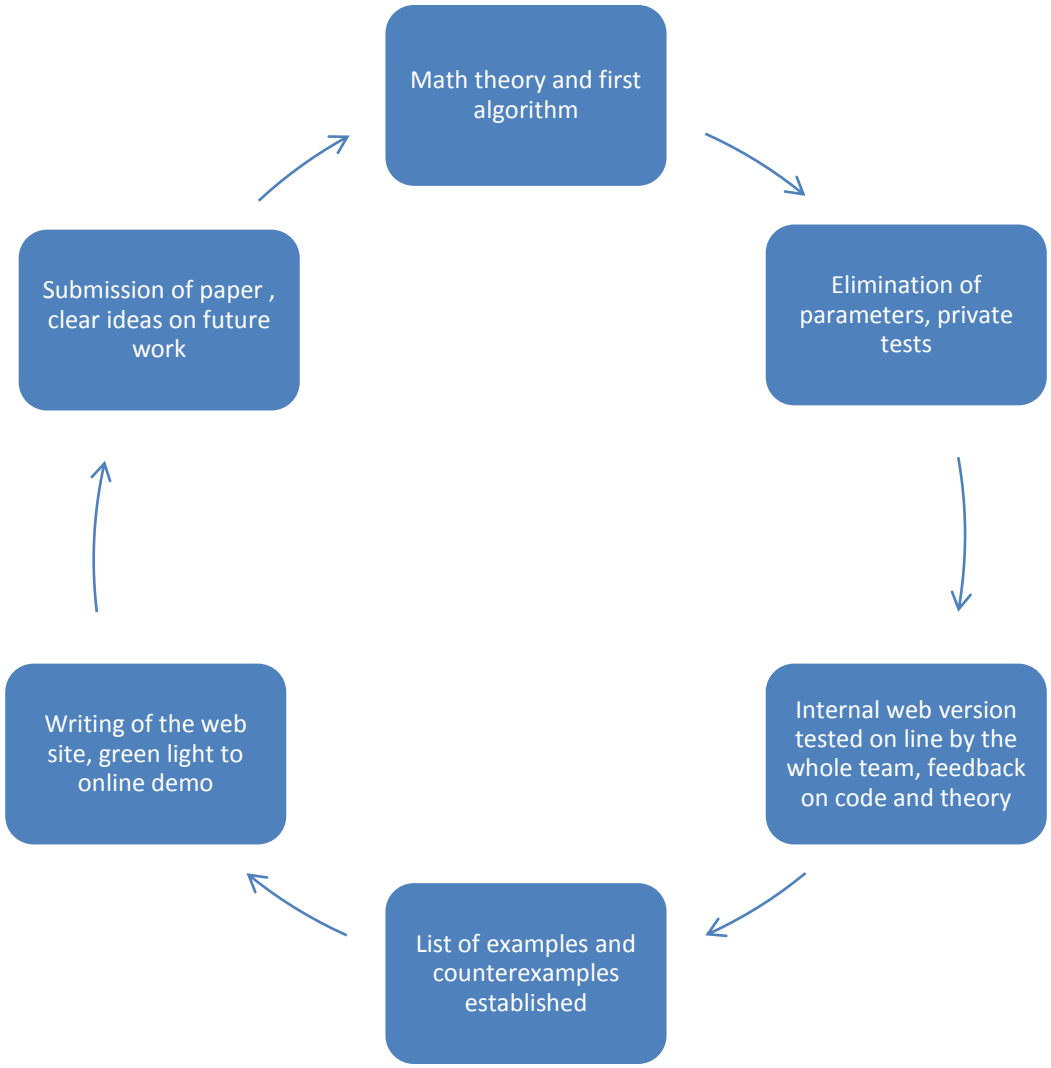
Allow EVERYBODY to try the algorithms on their own images (including deciders who DO NOT program)
Make all results of trials accessible in a Web archive (experiment sharing)
Downloadable code
Give a list of examples AND counterexamples, and explain them
Describe the algorithms carefully (pseudocode+comments)
Testing independent of any platform (no code download, no system requirement…)
Reward by a publication authors who deliver clear and autonomous codes and algorithms

ONLINE execution: this is particularly adapted to image processing because images and video have standard formats and can be uploaded

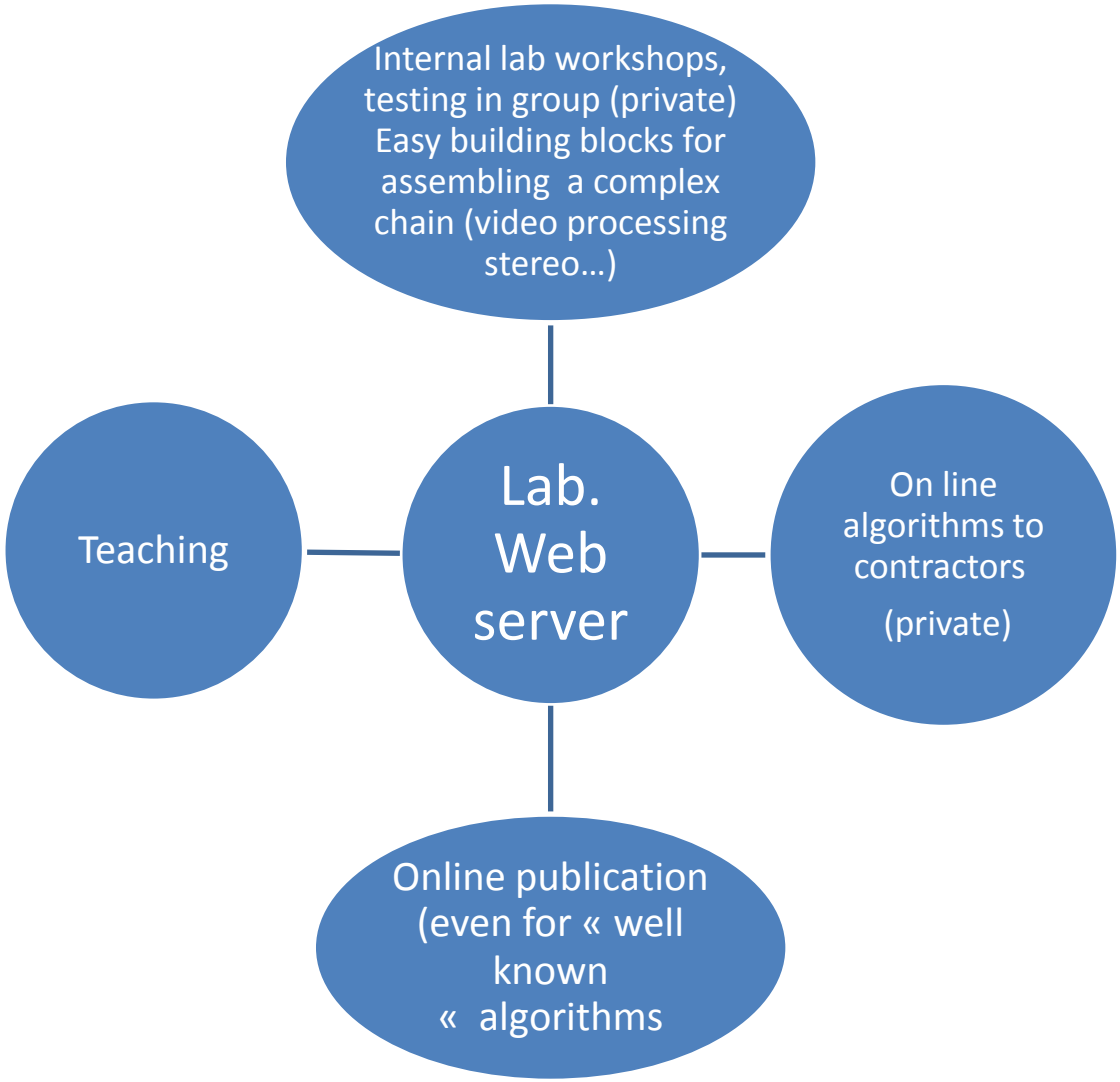
Means of the project

One online server, multicore
Execution in real/interactive time (less than 20 seconds)
Research team on online web tools
Some (easy) parallel computing
Reorganization of the work flow in a team
One researcher with computer science background fully dedicated (Nicolas Limare)
PhD students dedicate part of their time to rewrite and rething their algorithms and codes (estimated time 15%)

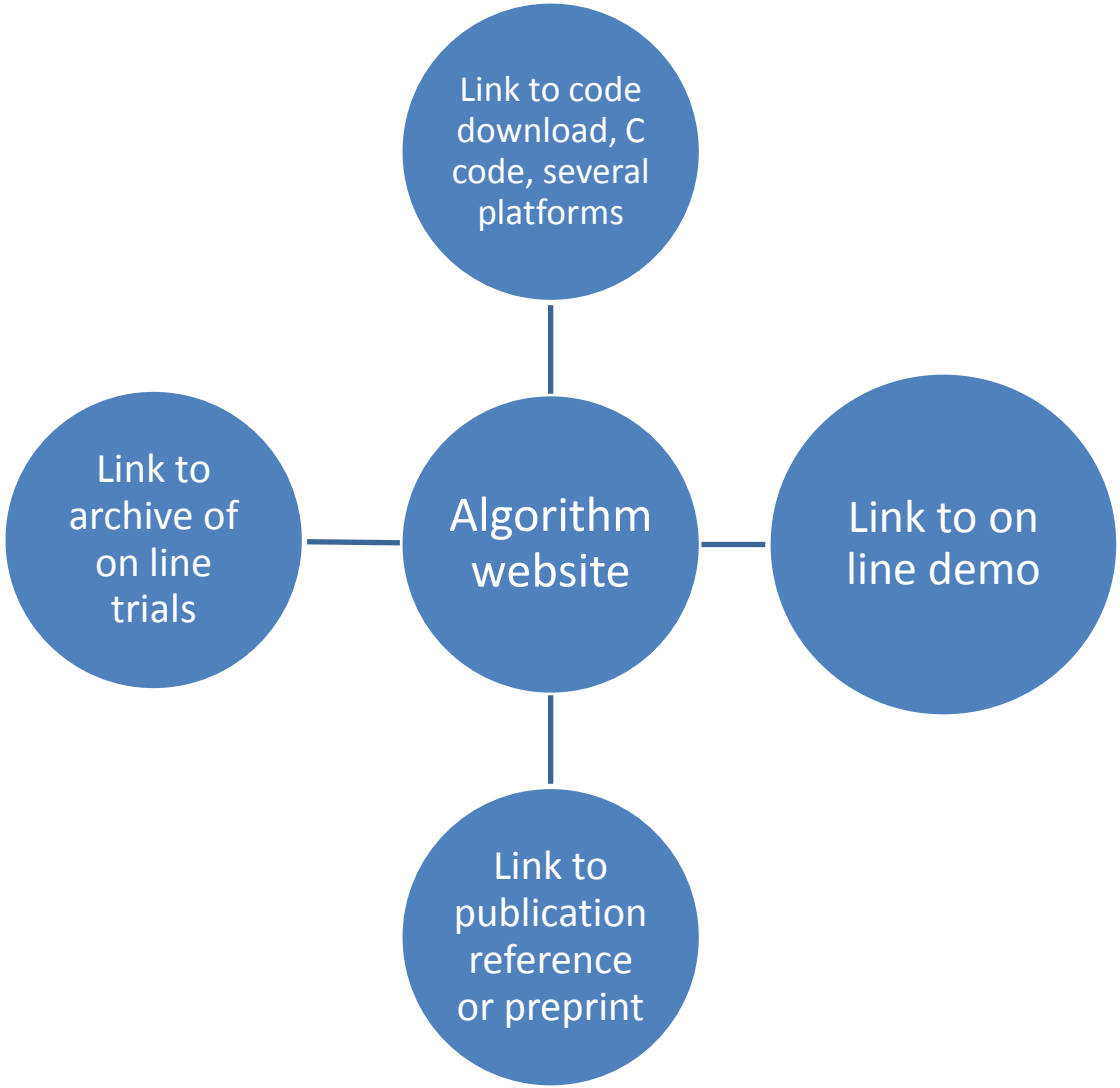
Reorganization of the work flow in a research team



Four functions for a Web server



For each algorithm: a fourfold publication



Current state of the site

PUBLIC ONLINE (Website and demos): http://www.ipol.im

ASIFT : Affine Invariant Image Matching, an extension of the SIFT method to all angles of view
LSD : Line Segment Detection
Random Phase Noise : Microtexture Synthesis
Cartoon+Texture Image Decomposition (Meyer's BV+texture algorithm)
Retinex PDE (the Land McCann theory of color perception translated into a Poisson equation)
Color Balance (the simplest color refresh algorithm)
Level line curvature motion (applies a curvature shortening to all image level lines), calculates and visualizes curvatures
NL-means (image denoising + estimation of the noise)
Raw image demosaicking (synthesis of missing colors in CCD or CMOS Bayer arrays)

INTERNAL WORKSHOPS:
Color contrast enhancement by PDE (three algorithms compared)

Plans

-Make a substantial database of algorithms

. New ones

. But many classic ones

-Pass from atoms to molecules :

. Stereo (calibration, stereorectification, matching, reconstruction

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

-Official publication?

. A scientific AND technical committee

. Needs a union of labs to start (currently 9 labs)

. Needs to fix very carefully the rules for code description, examples, etc.

. Currently: online demos written in C/C++ and downloadable code in C, matlab, Megawave,..

VISIT US: http://www.ipol.im

Problems

-Licence: GPL, others? If authors also want to sell licenses to industry, is it compatible? (Yes)

-Submission is a complex process that must be made standard: how to pass from code to online demo smoothly? It demands a manual translation. The interface operating the online demo and calling the submitted code is manual and written by the ipol staff . Each demo has a different setting.

-Official publication? Yes, but:

- -Papers are not « original » : the ideas and algorithms were or are published elsewhere.
- -The authors are only authors of the page and online demo.
- -The authors of the initial algorithms are not necessarily authors of the online demo
- -The authors of the initial used code are not necessarily authors of the online demo
- -Role of referees specific: they check the code.

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