

# 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?

Nicolas Limare (ENS Cachan),  
Jean-Michel Morel (ENS Cachan)

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# Example : ASIFT: affine invariant image

megawave demo - ASIFT - Mozilla Firefox

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http://mw.cmla.ens-cachan.fr/meg Aperçu Imprimer

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> mw > megawave > demo

## ASIFT DEMO

### ASIFT

This program performs the affine scale-invariant matching method known as ASIFT. Full details, examples and code are available on a [dedicated page](#).

Please select two images; color images will be converted into gray level.  
The first step, low-resolution, should take about 20 seconds, maybe less for simple images.


input image #1

input image #2


*unchecked if you do not want to include these images in the public archive.*

The maximum allowed file size is 1024Kb. TIFF, JPEG, PNG, PNM (and other) formats are recognized.  
We may re-use the uploaded files for further analysis.

You can also try these proposed images.

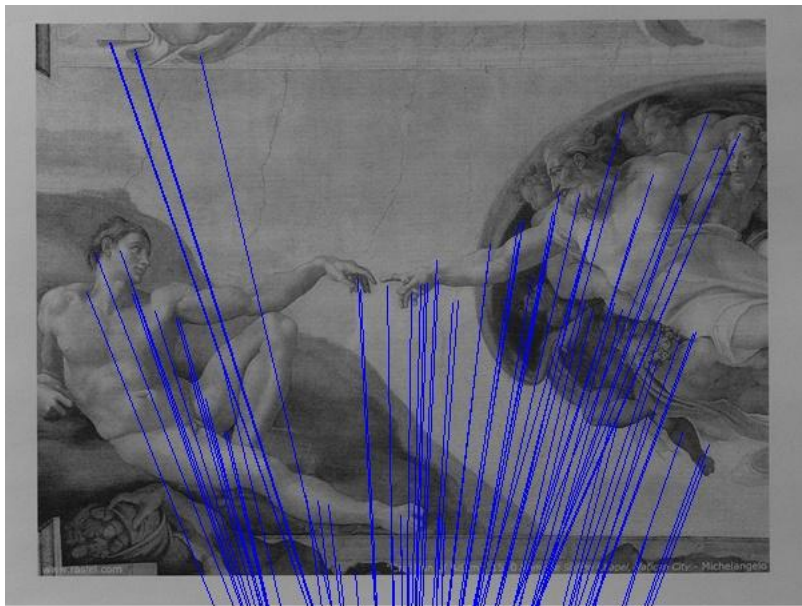


adam

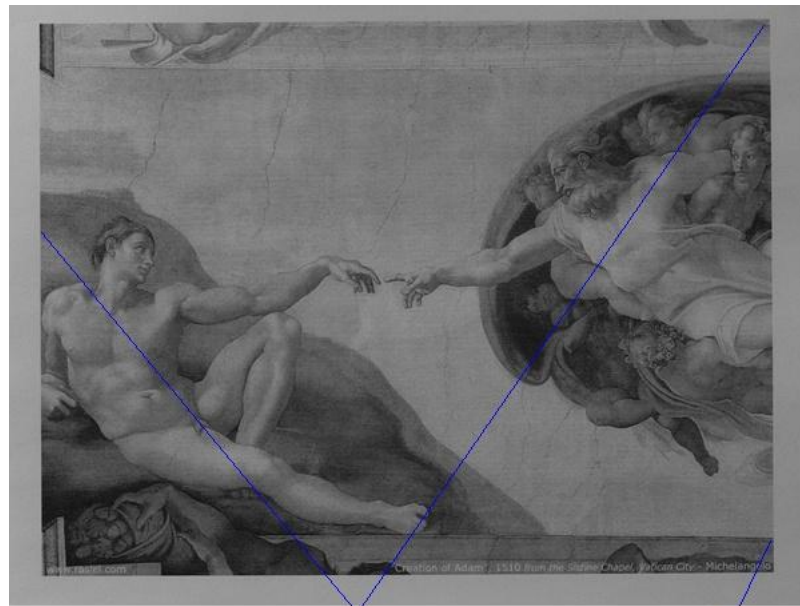


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Result of ASIFT:



Compared with SIFT:



# Algorithm Website

Affine SIFT (ASIFT) - Mozilla Firefox

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Page précédente Page suivante Actualiser Arrêter Accueil <http://mw.cmla.ens-cachan.fr/megawave/algo/asift/> Aperçu Imprimer

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## AFFINE SIFT (ASIFT)

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### Contacts

- Jean-Michel Morel [morel\[AT\]cmla.ens-cachan.fr](mailto:morel@cmla.ens-cachan.fr)
- Guoshen Yu [yu\[AT\]cmap.polytechnique.fr](mailto:yu@cmap.polytechnique.fr)

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### References

- J.M. Morel and G.Yu, *ASIFT: A New Framework for Fully Affine Invariant Image Comparison*. SIAM Journal on Imaging Sciences, 2(2):438-469, 2009. [preprint](#)
- G. Yu and J.M. Morel, *A Fully Affine Invariant Image Comparison Method*. Proc. IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), Taipei, 2009. [preprint](#)
- J.M. Morel and G.Yu, *On the consistency of the SIFT Method*. Preprint, CMLA 2008-26, Sept 2008. [preprint](#)

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### Overview

A fully affine invariant image comparison method, Affine-SIFT (ASIFT) is introduced. While SIFT is fully invariant with respect to only four parameters namely zoom, rotation and translation, the new method treats the two left over parameters : the angles defining the camera axis orientation.

Against any prognosis, simulating all views depending on these two parameters is feasible. The method permits to reliably identify features that have undergone very large affine distortions measured by a new parameter, the transition tilt.

State-of-the-art methods hardly exceed transition tilts of 2 (SIFT), 2.5 (Harris-Affine and Hessian-Affine) and 10 (MSER). ASIFT can handle transition tilts up 36 and higher.

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### When does it work?

The [SIFT](#) method works to compare 2D objects or 3D objects with flat enough details, taken from similar view angles but at arbitrary distances.

The typical failure cases are:

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**Dataset**

**Examples**

**Failure Cases**

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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

Affine SIFT (ASIFT) - Mozilla Firefox

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Page précédente Page suivante Actualiser Arrêter Accueil <http://mw.cmla.ens-cachan.fr/megawave/algo/asift/> Aperçu Imprimer

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## Failure Cases

### Day-and-night illumination change

All methods fail!

Six images of Notre-Dame under different illumination conditions are compared. The number of matches of ASIFT and SIFT are shown. (Harris-Affine, Hessian-Affine and MSER find less matches than SIFT.) Little view angle change is presented. The red arrows imply recognition failure.

*In general, matching succeeds between day images and between night images. However, under day-and-night illumination change, all methods fail.*

Image 1	Image 2	Image 3	Image 4
1. day, sunny	2. evening, with light	3. day, cloudy	4. day, sunny
ASIFT/SIFT	ASIFT/SIFT	ASIFT/SIFT	ASIFT/SIFT
5/0	3/2	119/51	131/48
0/5	0/0	142/45	0/5

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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.

megawave demo - asift archives - Mozilla Firefox

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Page précédente Page suivante Actualiser Arrêter Accueil

http://mw.cmla.ens-cachan.fr/megawave/demo/asift/arch Aperçu Imprimer

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> mw > megawave > demo > asift

## MEGAWAVE DEMO - ASIFT PUBLIC ARCHIVES

This archive is updated every hour. It is not moderated; in case of copyright infringement or similar problem, please [contact us](#) to request the removal some images.


pages : 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400 14 1500 1550

- 2009-07-09 11:49:14 - 47d5c49e494d1c83bf5cc3fa76413a8e - 1.0




[coords LR](#) [coords HR](#)

- 2009-07-07 16:23:46 - 032e34169a3eeaa7e40963a64c9311af - 1.0



[coords LR](#) [coords HR](#)

- 2009-07-07 11:39:55 - abe00b893716d24ca5ac1fbb3659e57e - 1.0



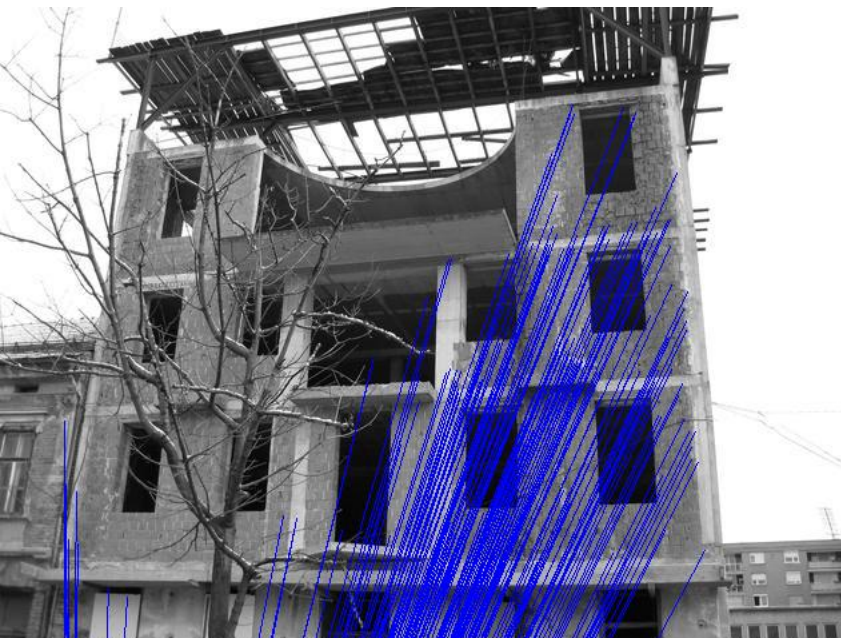
http://mw.cmla.ens-cachan.fr/megawave/demo/asift/archive/47d5c49e494d1c83bf5cc3fa76413a8e/match\_LR.jpeg



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

ASIFT result :

SIFT result :



LSD: a Line Segment Detector - Mozilla Firefox

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Google

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http://mw.cmla.ens-cachan.fr/megawave/algo/lsd/ Aperçu Imprimer

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> mw > megawave > algo

# LSD: A LINE SEGMENT DETECTOR



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## Contacts

- ♦ Rafael Grompone von Gioi [grompone\[AT\]cmla.ens-cachan.fr](mailto:grompone@cmla.ens-cachan.fr) ✉
- ♦ Jérémie Jakubowicz [jakubowi\[AT\]cmla.ens-cachan.fr](mailto:jakubowi@cmla.ens-cachan.fr) ✉
- ♦ Jean-Michel Morel [moral\[AT\]cmla.ens-cachan.fr](mailto:moral@cmla.ens-cachan.fr) ✉
- ♦ Gregory Randall [randall\[AT\]fing.edu.uy](mailto:randall@fing.edu.uy) ✉

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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](#) 

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## 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.



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## On-line Demo

An on-line demo that allows you to try LSD with your own images is available [here](#).



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## Software

Implementations in C programming language and [Megawave2](#)  framework are available [here](#) .

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## Video

The video [here](#) (mp4 file, 56 MB)  shows the result of applying LSD, frame per frame, to the original video [here](#) .

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## Examples

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Video  
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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http://mw.cmla.ens-cachan.fr/megawave/demo/lsd/archiv Aperçu Imprimer




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> mw > megawave > demo > lsd

## MEGAWAVE DEMO - LSD PUBLIC ARCHIVES

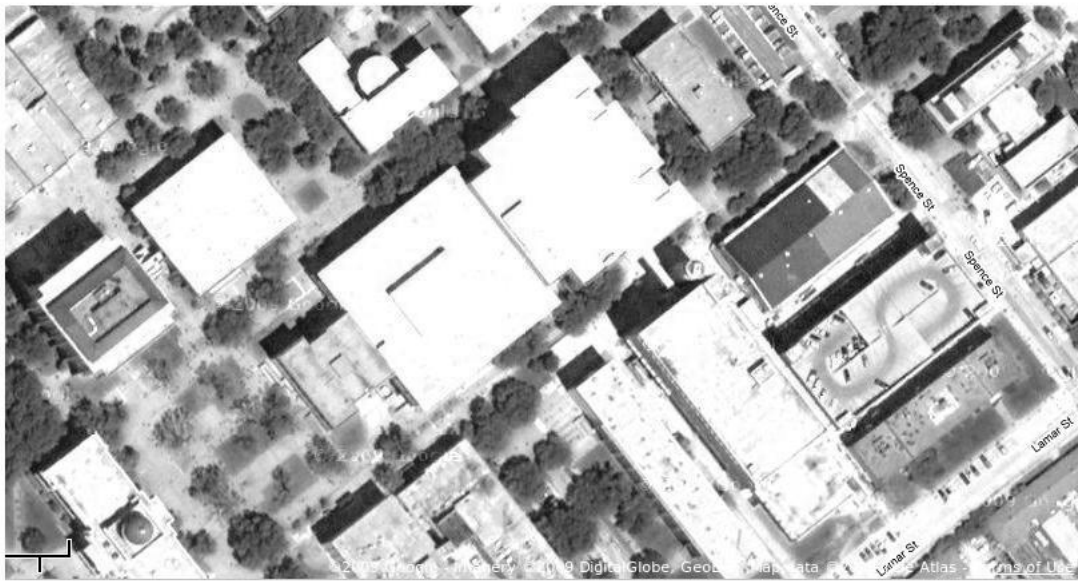
This archive is updated every hour. It is not moderated; in case of copyright infringement or similar problem, please [contact us](#) to request the removal some images.

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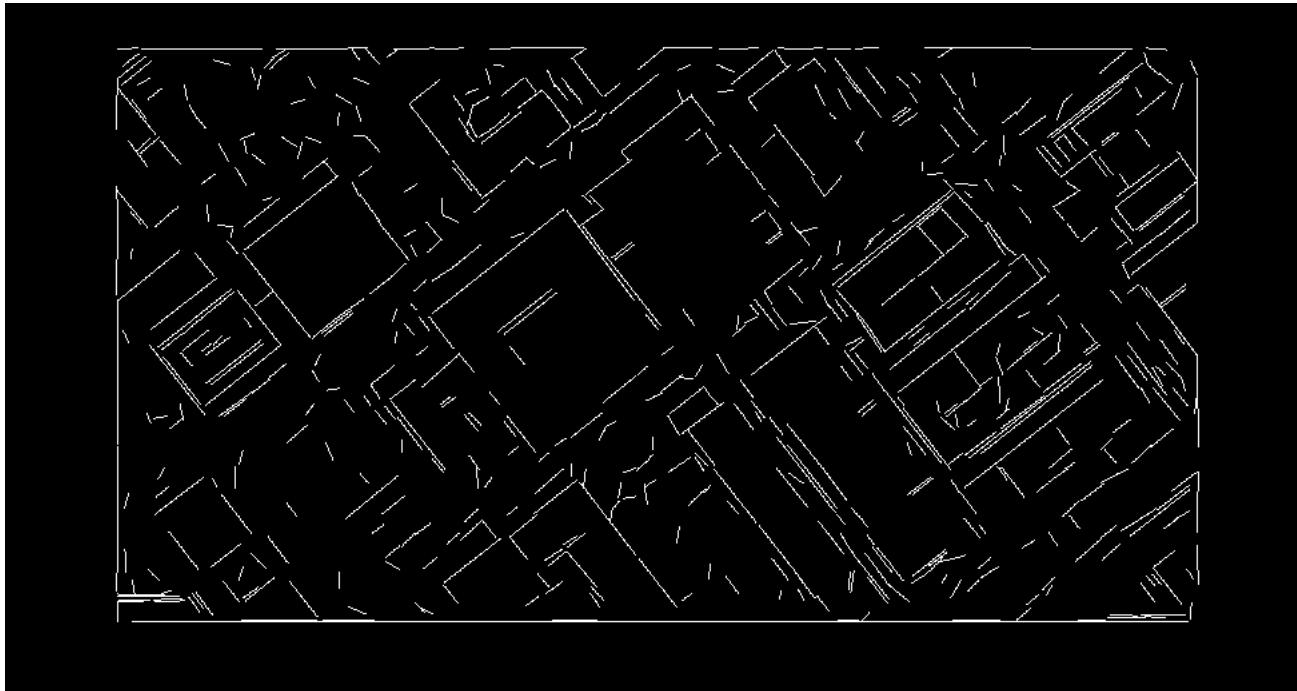
- 2009-09-30 11:34:20 - 95be8a74889a75a6ab137b38c581c8f7 - 1.0  

- [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





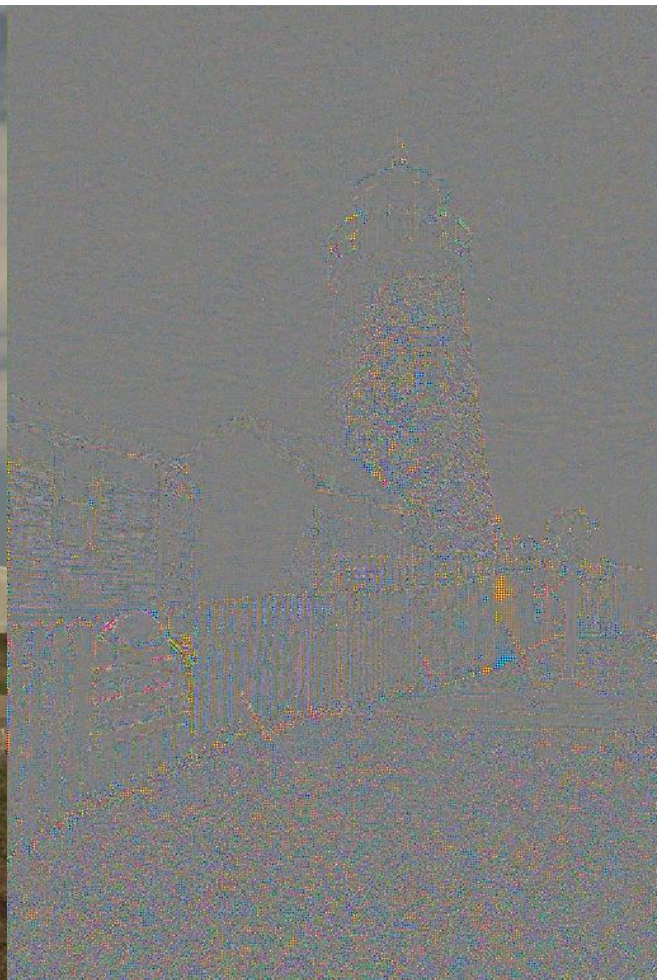
LSD: Some results in the online archive



# NL-means, archive on line

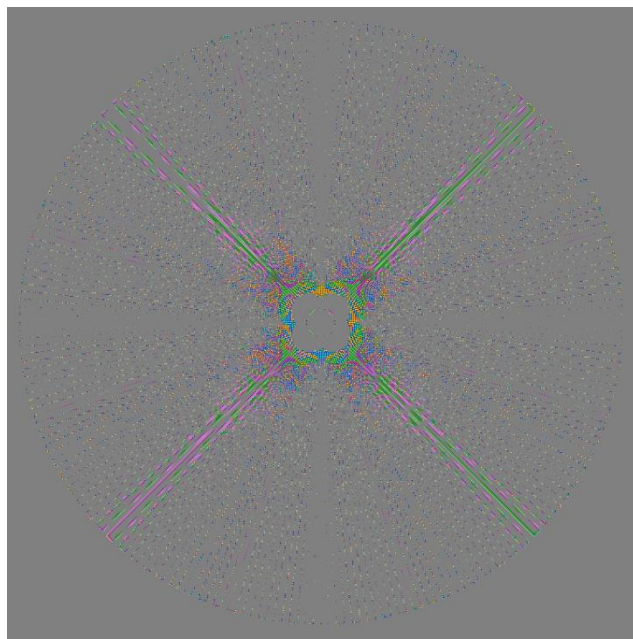
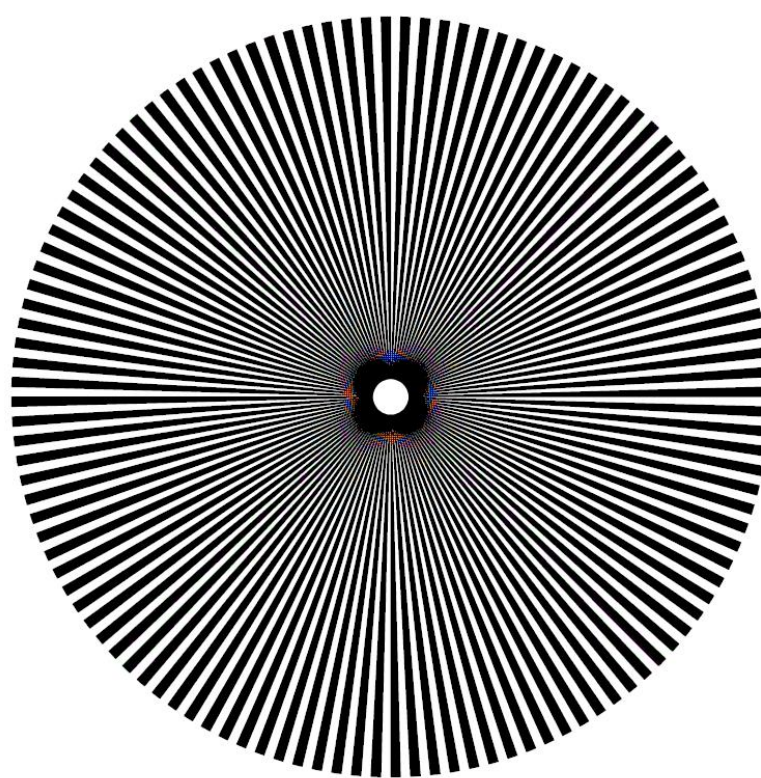
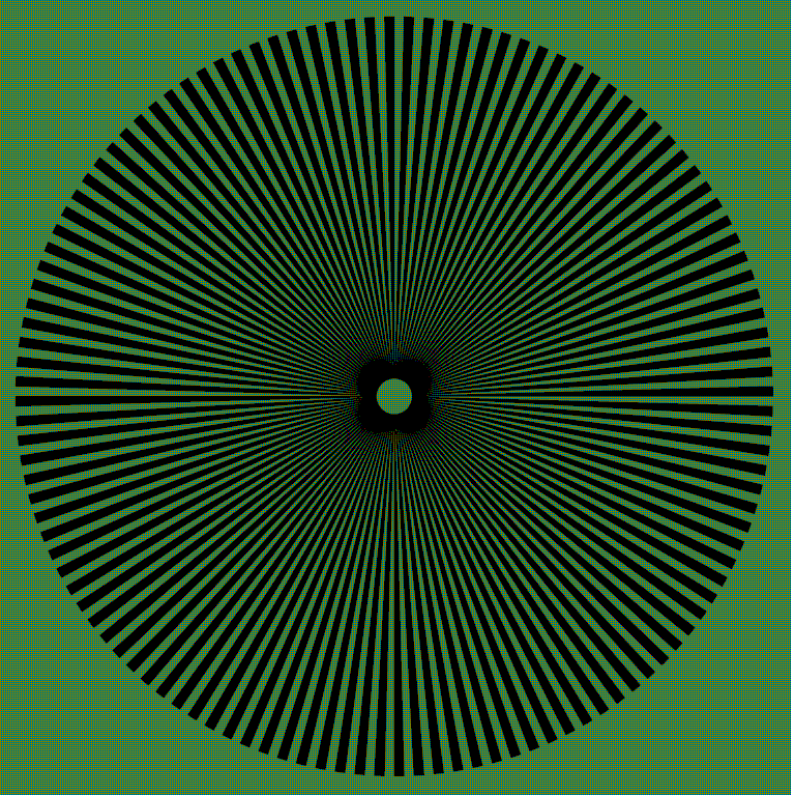






## Demosaicking (DxO) From Archive on line

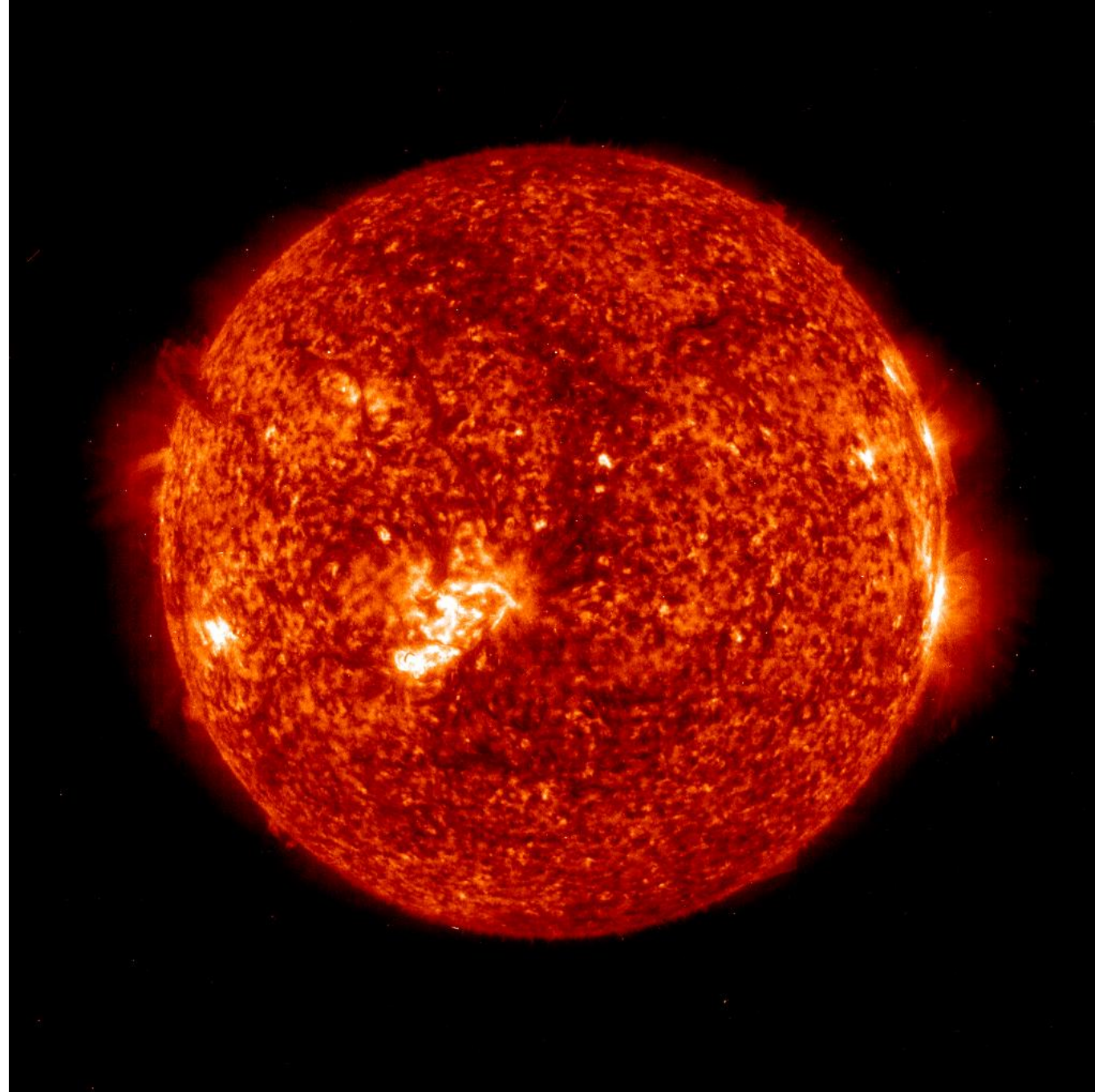






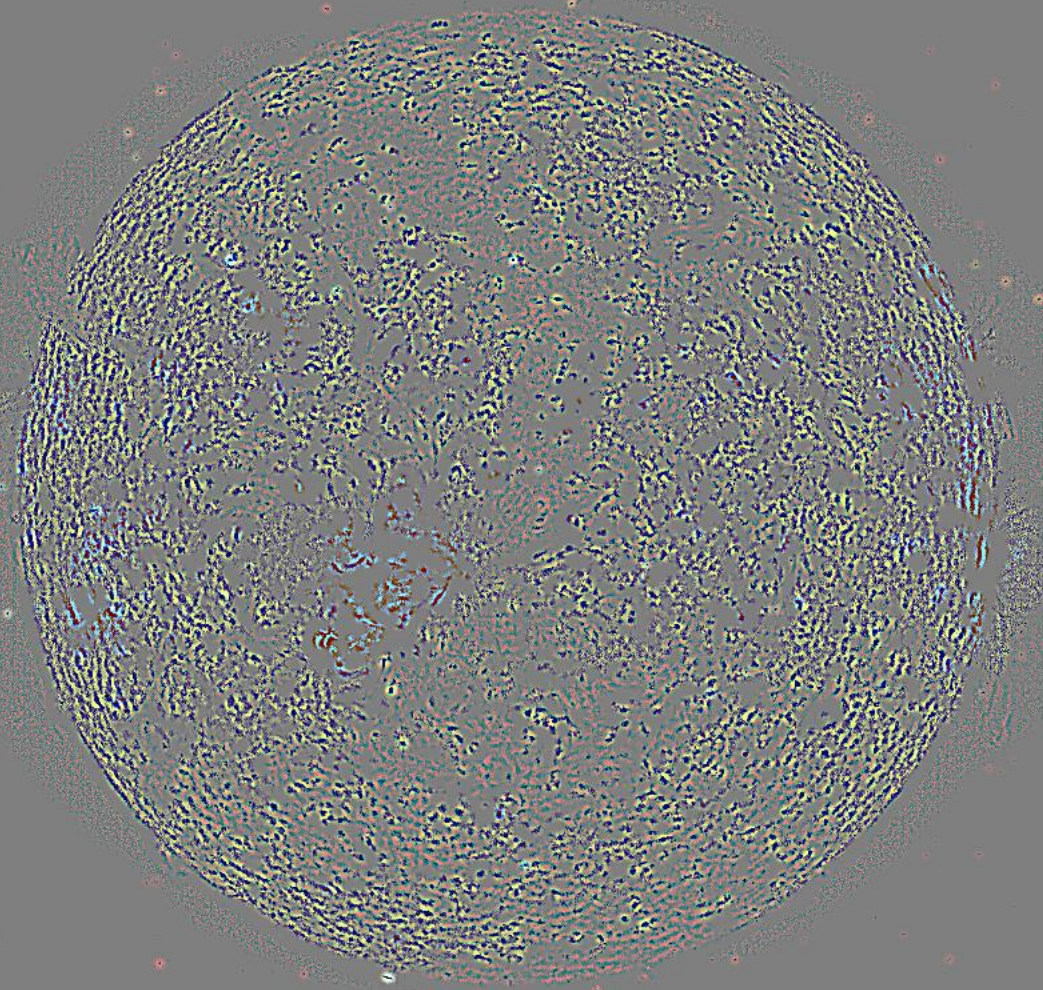


Cartoon+texture (IPOL Archive)



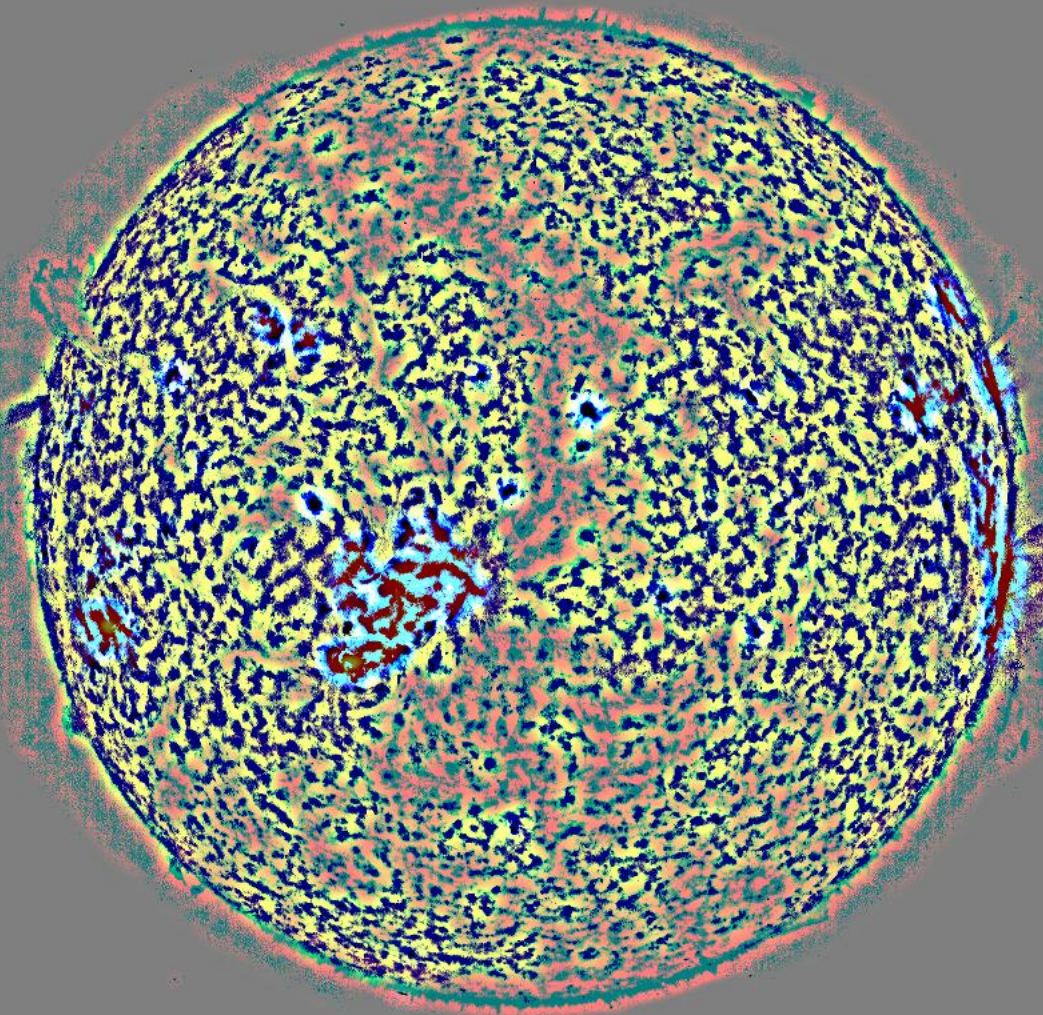
Cartoon+texture (IPOL  
Archive)





Cartoon+texture (IPOL  
Archive)





Cartoon+texture (IPOL  
Archive)



Cartoon+texture (IPOL Archive)



&gt; mw &gt; megawave &gt; algo

# MICRO-TEXTURE SYNTHESIS BY PHASE RANDOMIZATION

## Contacts

- Bruno Galerne [galerie@cmla.ens-cachan.fr](mailto:galerie@cmla.ens-cachan.fr)
- Yann Gousseau [gousseau@tsi.enst.fr](mailto:gousseau@tsi.enst.fr)
- Jean-Michel Morel [more1@cmla.ens-cachan.fr](mailto:more1@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?](#)

[Contacts](#)[References](#)[Overview](#)[On Line Demo: Try It!](#)[Source Code](#)[Algorithm](#)[Implementation](#)[Micro-textures](#)[Examples](#)



## Examples

Below are some examples of satisfyingly well reproduced textures.

*Original image*

*RPN*



stone

stone simulated



wood

wood simulated



### 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



Micro-Texture Synthesis by Phase Randomization - Mozilla Firefox

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http://mw.cmla.ens-cachan.fr/megawave/algo/random\_phase\_noise/#ir


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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 single commercial website. Those with big patterns will be found in the **failure catalog**.

*Carpet sample*



*RPN simulation*



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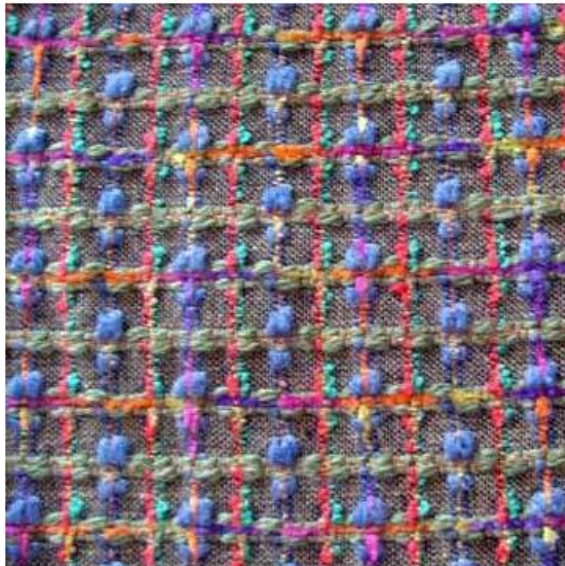


## failure catalog

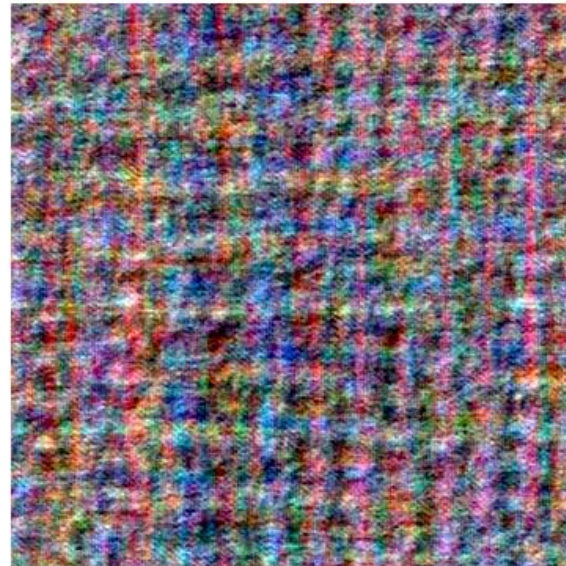
Most failures are **macro**-textures. For instance:

- 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



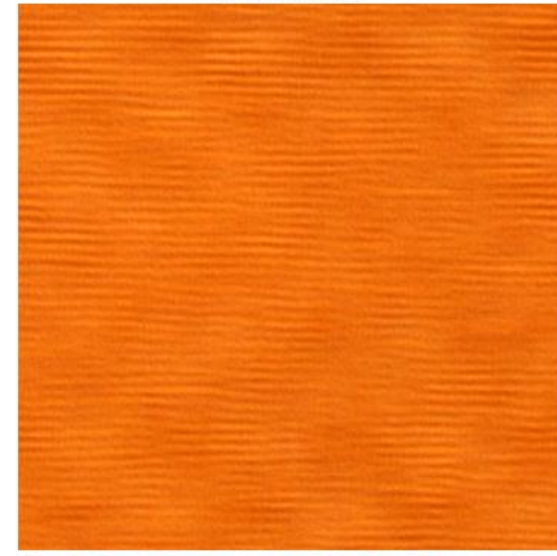
[Show/hide more failure examples \(macro-textures\)](#)

Show/hide more failure examples (macro-textures)

Macro-texture sample



RPN simulation





> mw > megawave > algo

# THE RETINEX PDE : A MODEL FOR COLOR PERCEPTION

## Contacts

- Jean-Michel Morel [morel\[at\]cmla.ens-cachan.fr](mailto:morel@cmla.ens-cachan.fr)
- Ana Belén Petro [anabelen.petro\[at\]uib.es](mailto:anabelen.petro@uib.es)
- Catalina Sbert [catalina.sbert\[at\]uib.es](mailto:catalina.sbert@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.  
[preprint](#) [on line article](#)

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- The PDE-Retinex Model
- The Algorithm
- Examples

## 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!](#)



## 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,  $\dim = NM$  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.

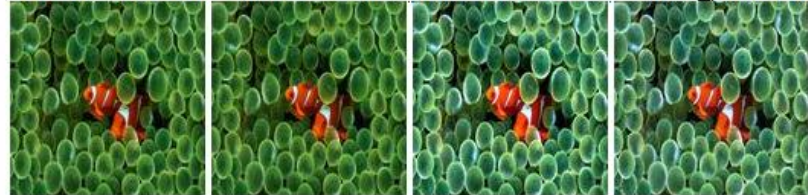
> mw > megawave > demo > retinex\_pde

# MEGAWAVE DEMO - RETINEX\_PDE PUBLIC ARCHIVES

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pages : [50](#) [100](#) [150](#) [200](#) [250](#) [300](#)

- 2009-09-30 13:06:46 - deb4db3fd0caf6011a63173b46542166 - retinex\_pde version 2.04.20090613



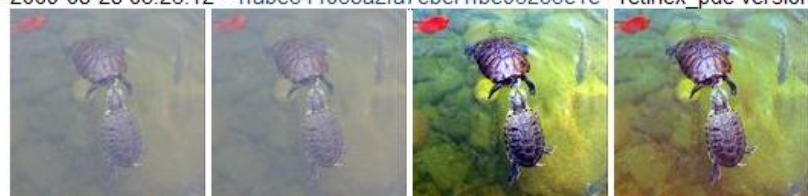
- 2009-09-21 14:22:56 - 3ed7539eff1589eb14f1a51073bbcc47 - retinex\_pde version 2.04.20090613



- 2009-09-14 11:49:03 - ce2cc1566bbfae101ffaed2494a4972 - retinex\_pde version 2.04.20090613



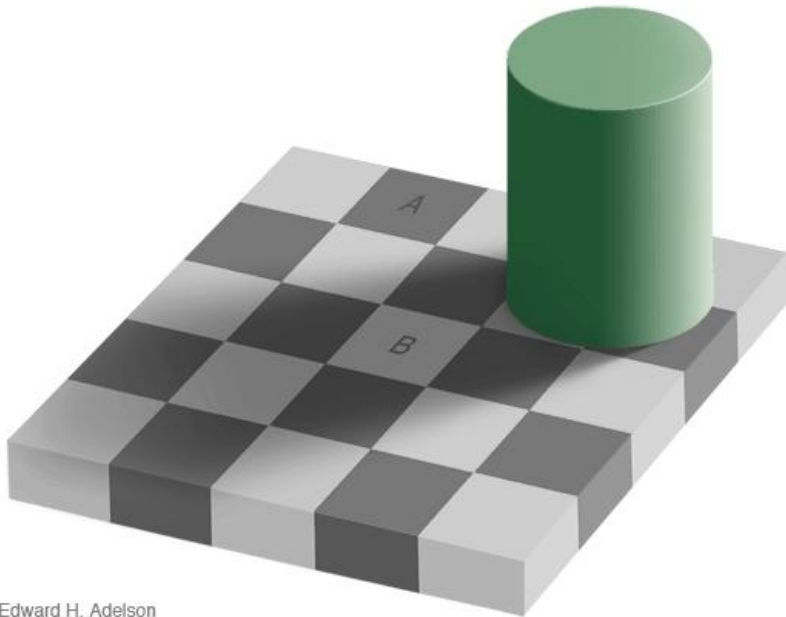
- 2009-08-28 06:23:12 - 1fabe644068a2fa7ebef1fbe93265e1e - retinex\_pde version 2.04.20090613



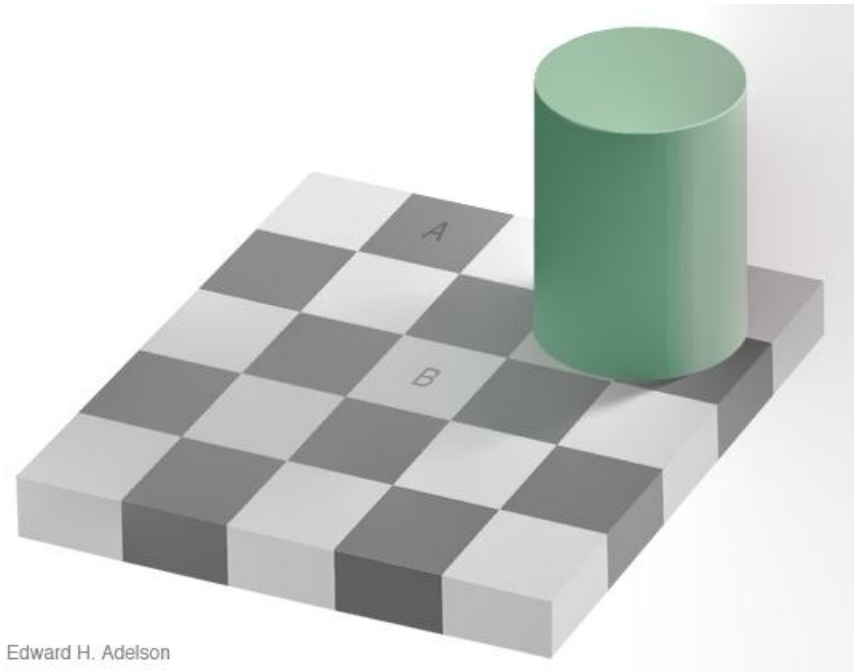
# Some Results

The gray level of A and B is 120

The gray level of A is 145 and B is 190



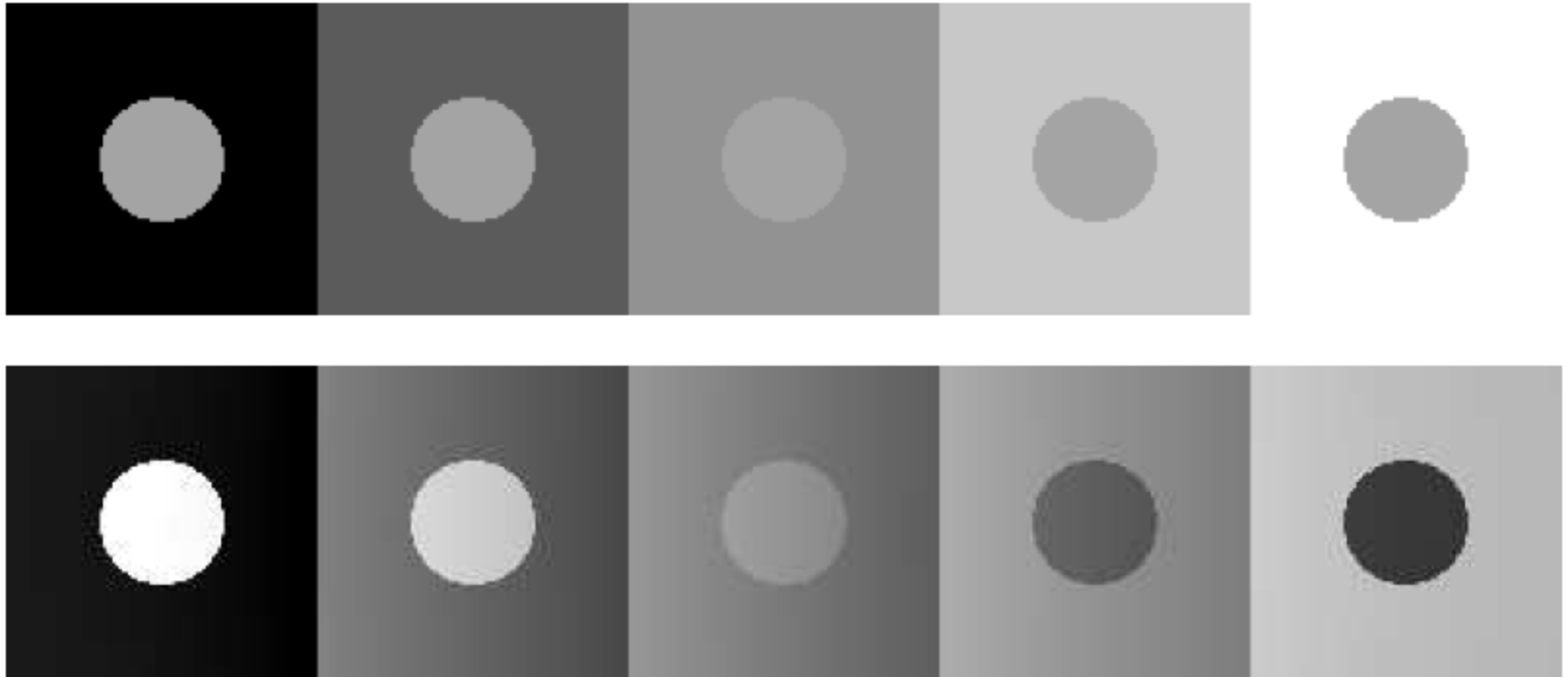
Edward H. Adelson



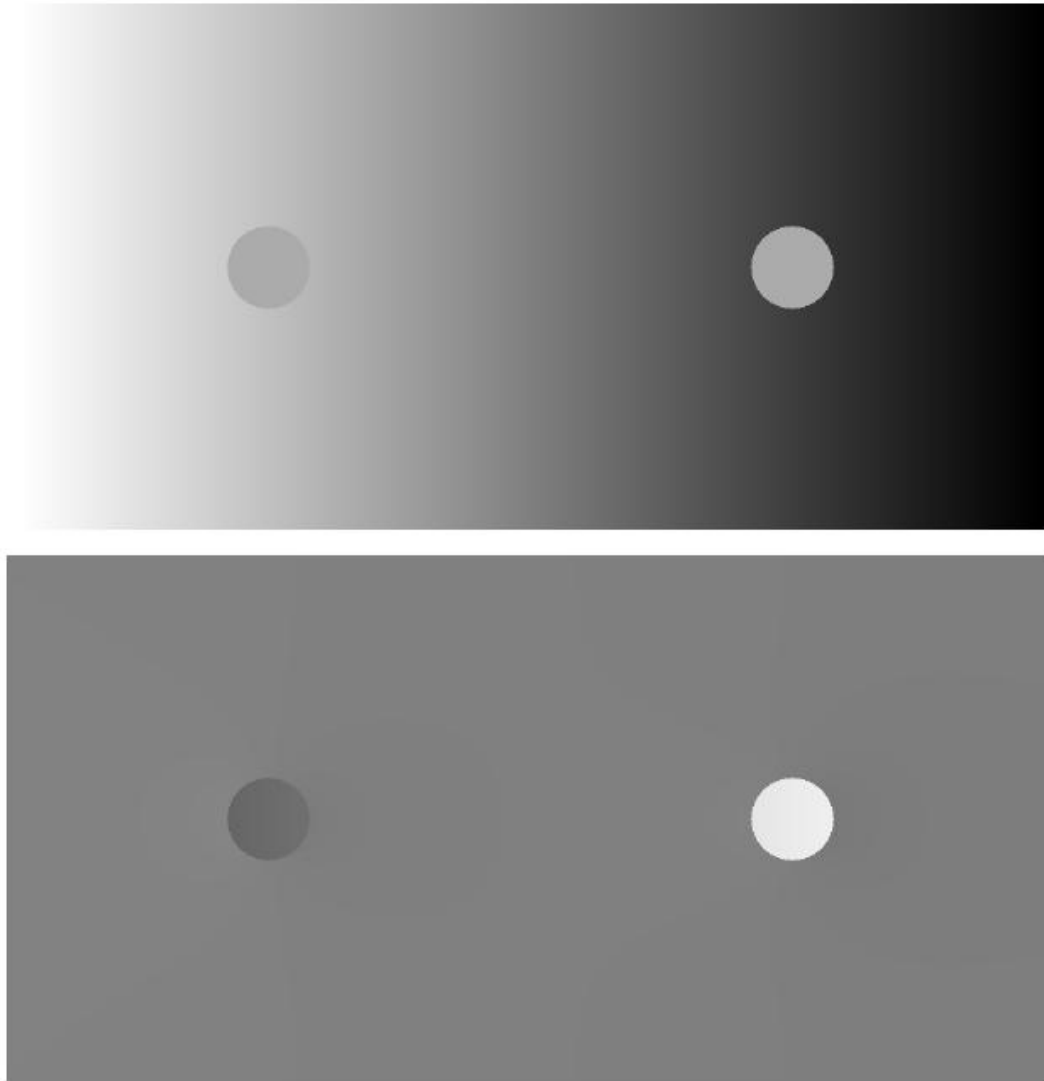
Edward H. Adelson



# Retinex Theory

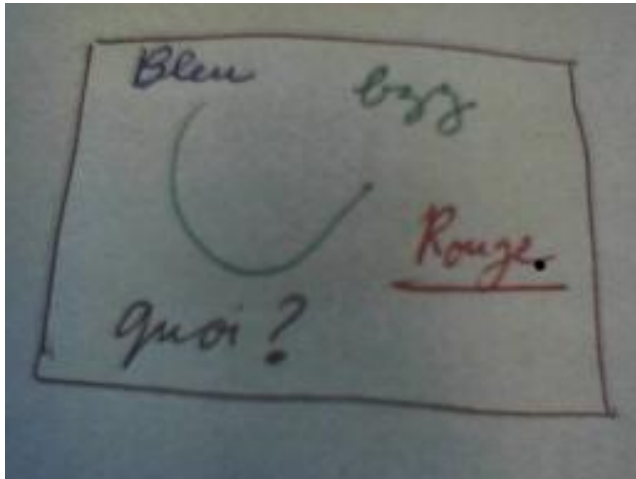


# Retinex Theory

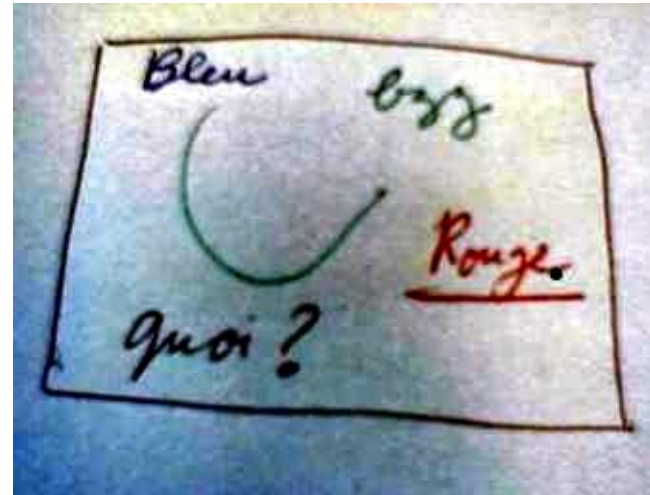




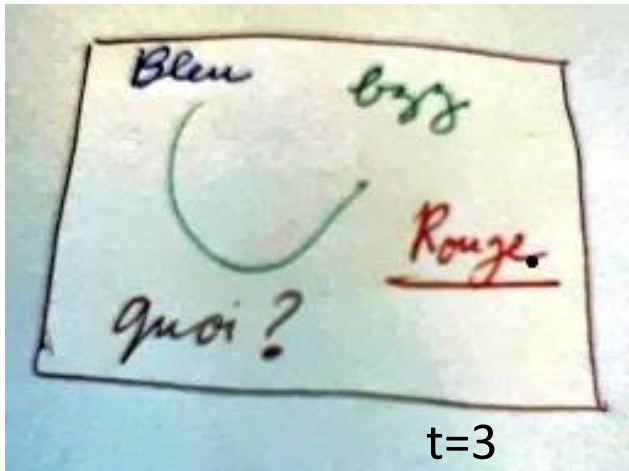
# Retinex results



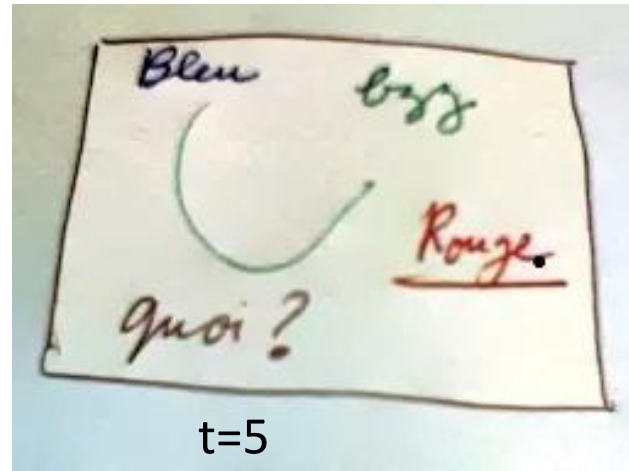
Original



Color balanced



$t=3$



$t=5$

# Experimental Results



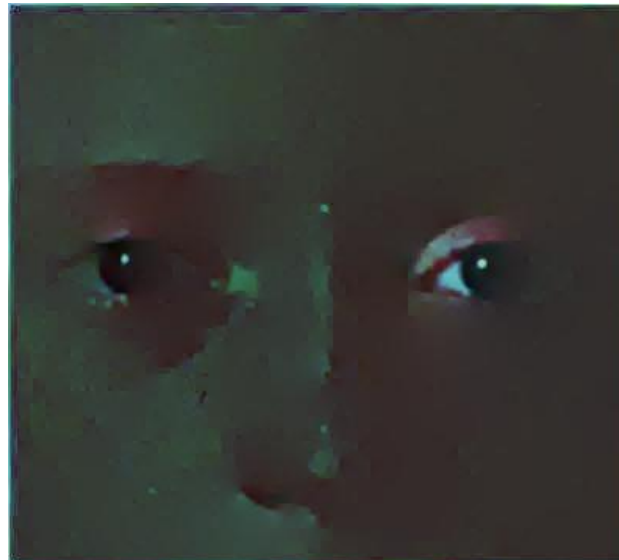
Original Image



Colour balanced



Retinex  $t=10$



Retinex  $t=20$



Original,  
Color-Balanced,

Beltramio-Caselles-Provenzi,  
Retinex\_t=4





Beltramo-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

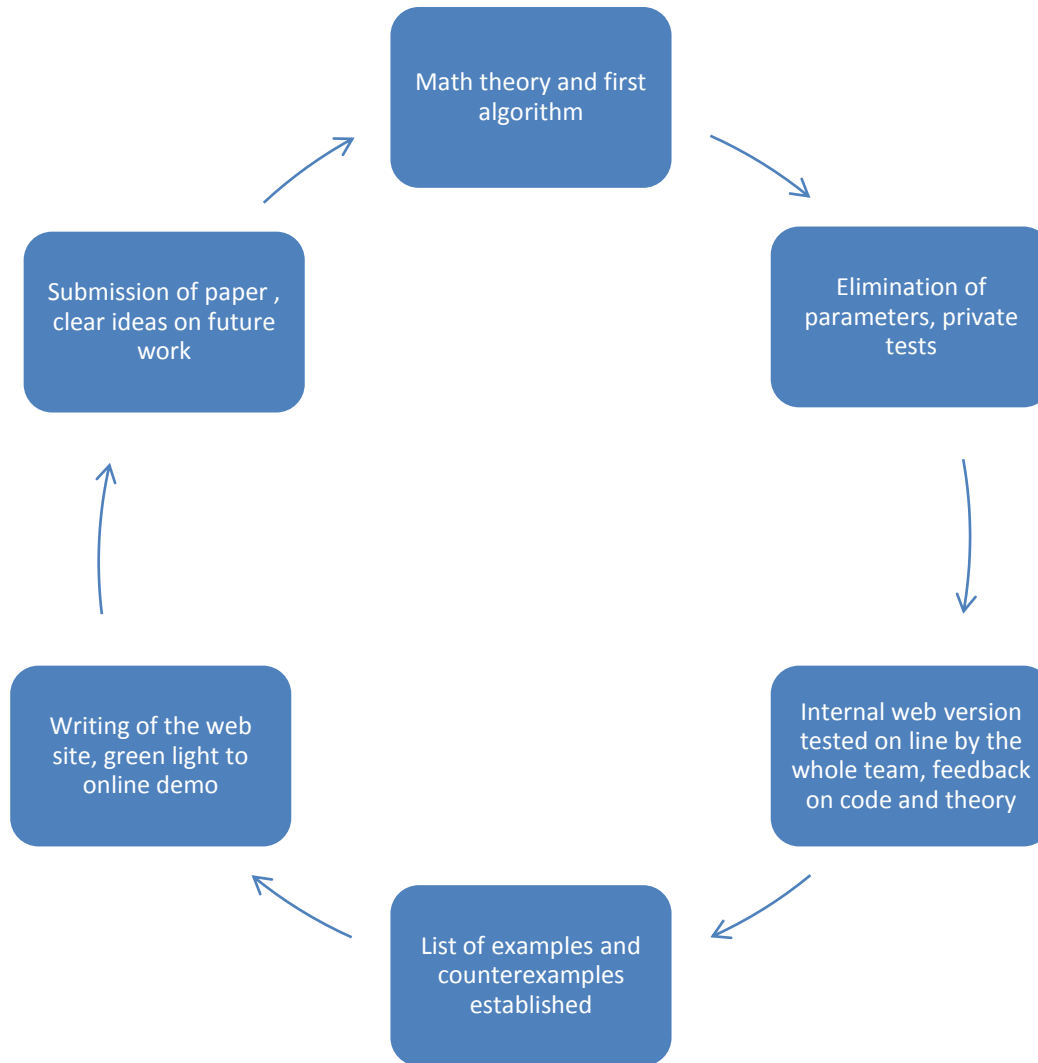
Reorganization of the work flow in a team

One researcher with computer science background fully dedicated (Nicolas Limare)

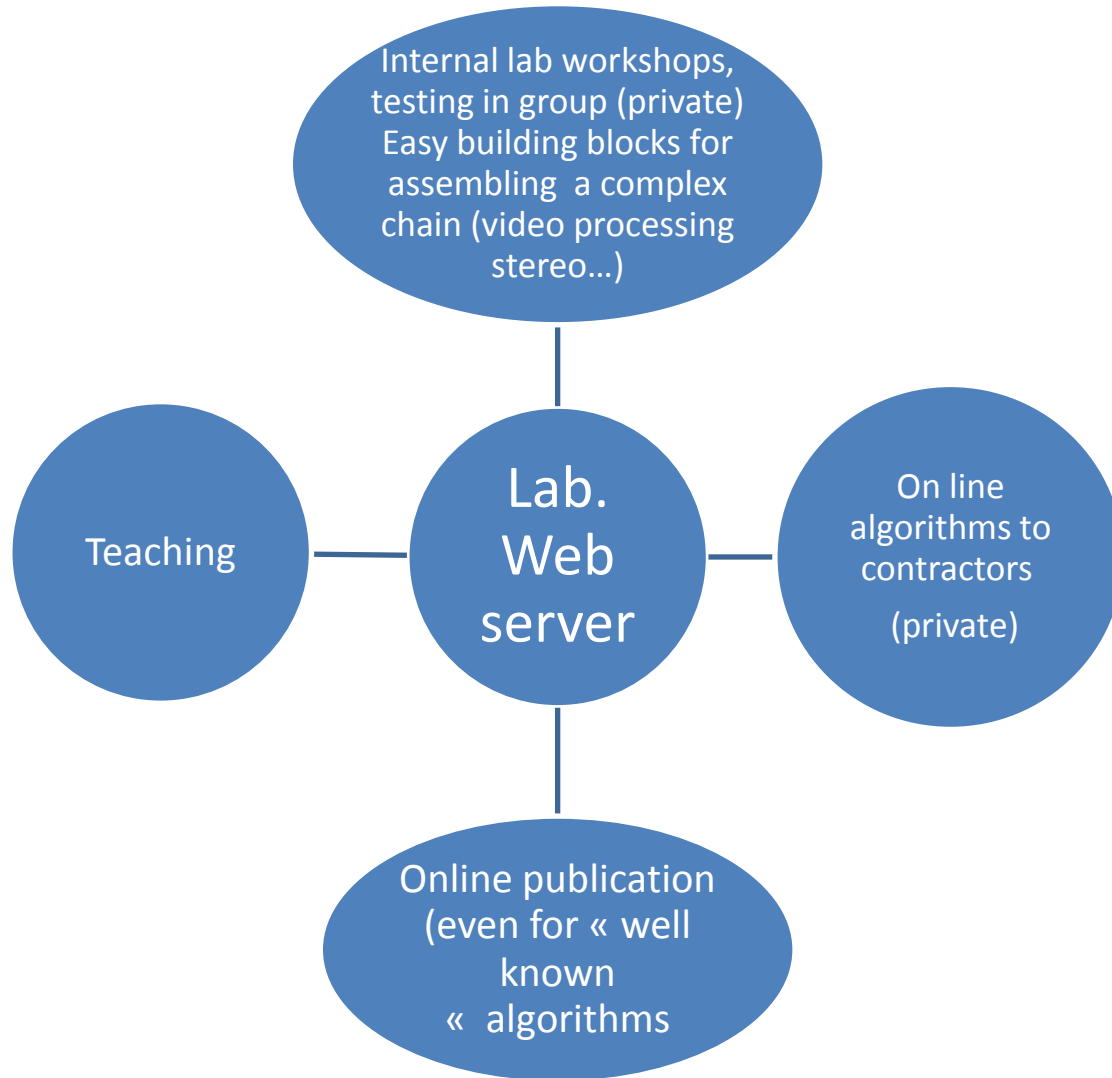
PhD students dedicate part of their time to rewrite and rething their algorithms and codes ( estimated time 15%)



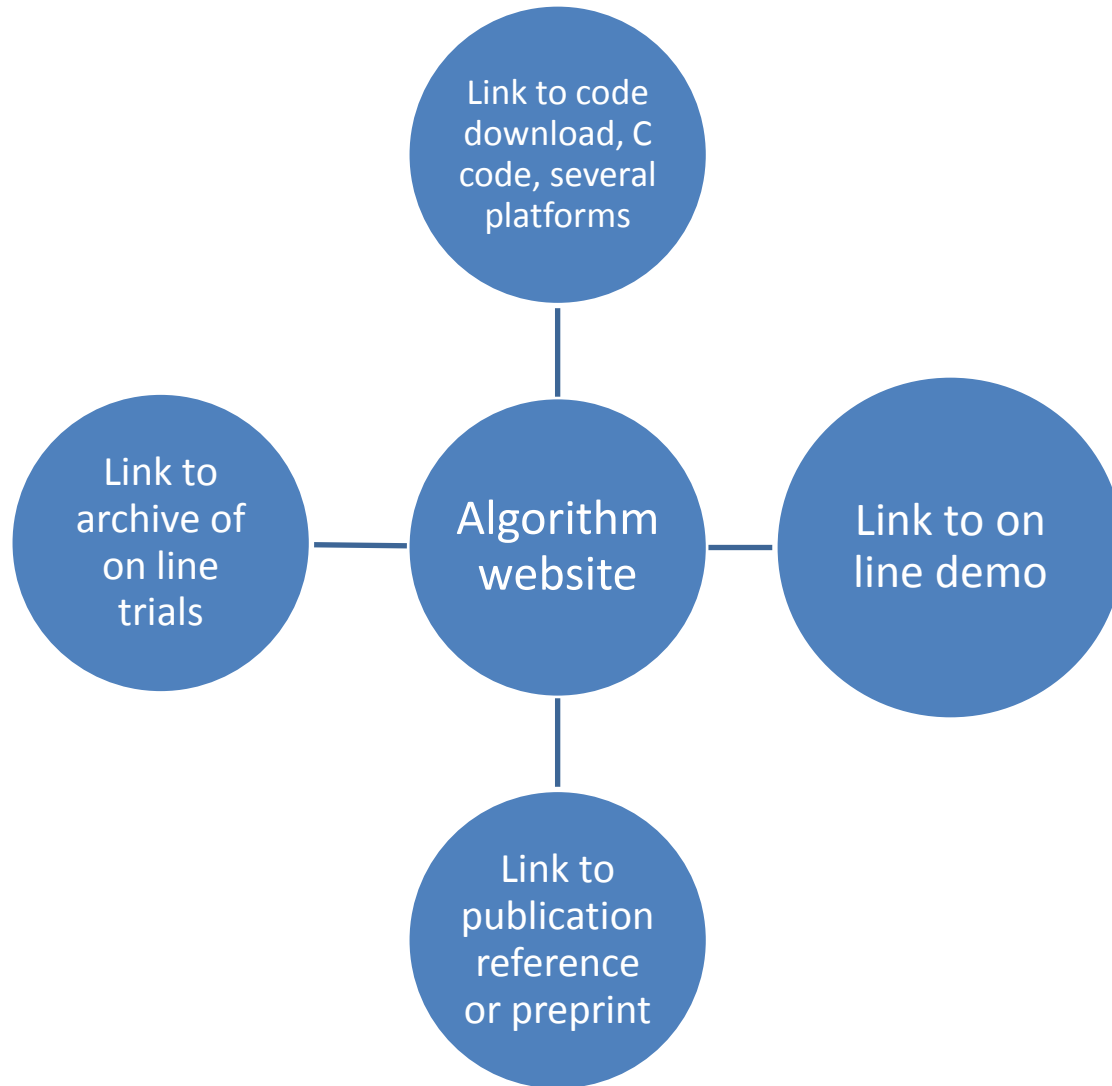
# Reorganization of the work flow in a research team



# 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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- 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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