

ACPR 19 Tutorial

Digital Geometry in Pattern Recognition: Extracting Geometric Features with DGtal and Applications

– Part II –

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Overview of the presentation - Part II -

1. Digital Surfaces

Digital surface tracking and algebraic topology

Duality with isosurfaces

2. Discrete Exterior Calculus

Foundations of discrete calculus

Discrete calculus model of Ambrosio-Tortorelli functional

Some applications of AT functional

3. Reproducible Research

4. Practical session: Hands on the IPOL Demonstration System

<https://kerautret.github.io/ACPR19-DGPTutorial>

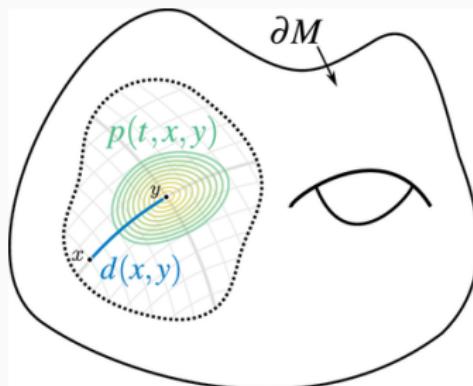


1. Digital Surfaces

Digital Surfaces

Sound definition for digital surfaces

- boundary of volumes must be digital surfaces
- closed connected digital surfaces have a connected interior
- valid in arbitrary dimension
- open digital surfaces are orientable
- analogous to $d - 1$ -manifold in \mathbb{R}^d : locally $d - 1$ directions

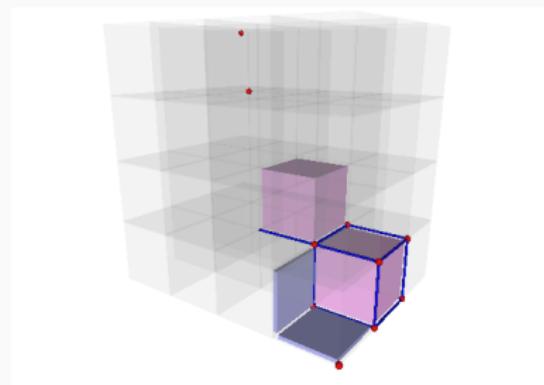


Digital Surfaces

Sound definition for digital surfaces

Digital surfaces require cell/interpixel topology

- volume elements (**voxel**) are d -cells
- surface elements (**surfel**) are $d - 1$ -cells

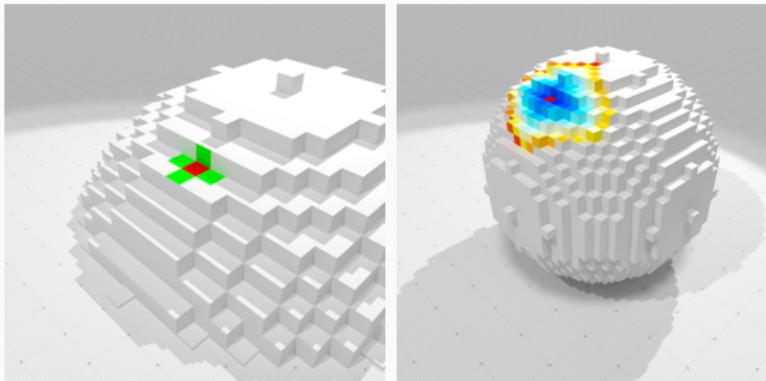


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- surfels have adjacent surfels; surfels + adjacencies form a graph

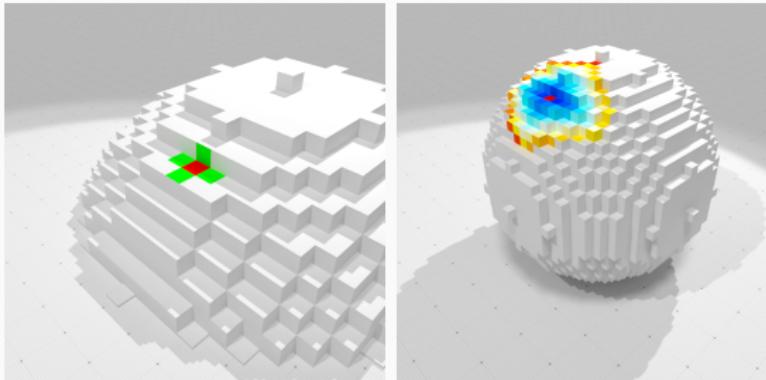


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- surfels have $2d - 2$ neighbor surfels, two per dimension

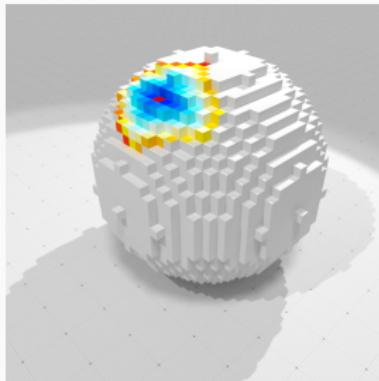
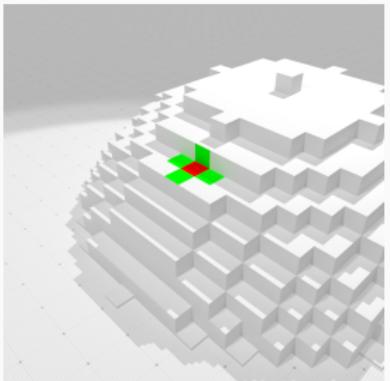


Digital Surfaces

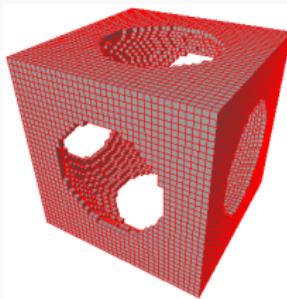
Sound definition for digital surfaces

Digital surfaces require cell/interpixel topology

- volume elements (**voxel**) are d -cells
- surface elements (**surfel**) are $d - 1$ -cells
- surfels have **adjacent** surfels; surfels + adjacencies form a graph
- surfels have $2d - 2$ **neighbor** surfels, two per dimension
- surfel adjacency graph depends on chosen **connectednesses** for interior/exterior.



Topology on digital surfaces ? i



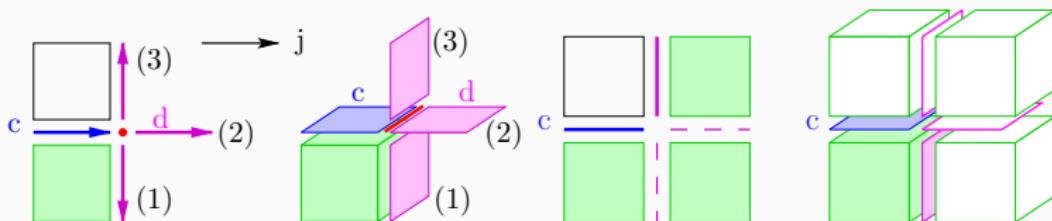
- For now, a surface is a set of surfels

Questions ?

Can we define local neighborhood relations so that

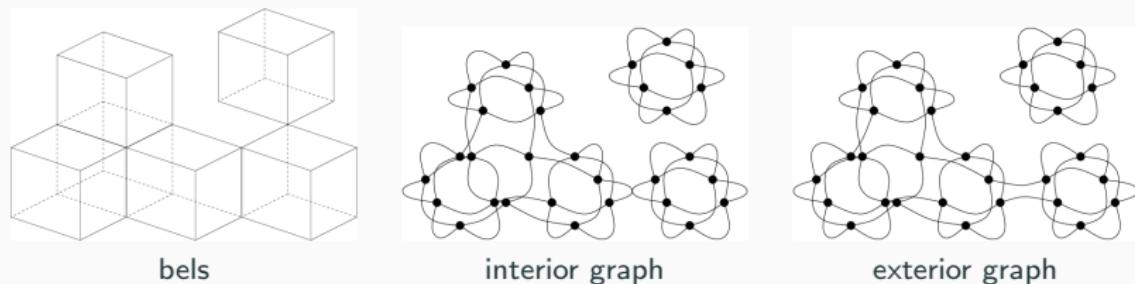
- a whole connected surface can be extracted by their **tracking**,
- **Jordan separation** property is satisfied

Bel adjacency in a picture i



- shape / binary picture I : finite subset X of \mathbb{Z}^n
- boundary element or *bel* in I = surfel between X and X^c
- For each direction j ($n - 1$ directions for each bel)
 - **interior** bel-adjacency from c along j = first follower of c which is a bel
 - **exterior** bel-adjacency from c along j = last follower of c which is a bel

Bel adjacency graph i



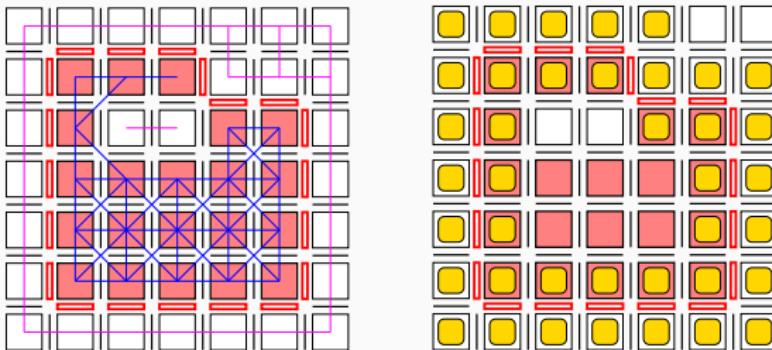
- For each direction, choose interior/exterior $\Rightarrow 2^{\frac{n(n-1)}{2}}$ bel-adjacencies

Theorem (3D [Herman,Webster83])

Let $O \subset X$ 6-connected, $Q \subset X^c$ 18-connected. c any bel.

The **all-interior** bel-adjacency graph component containing c is the boundary surface between O and Q .

Bel adjacency graph ii



Theorem (nD , $n \geq 2$, [Udupa94])

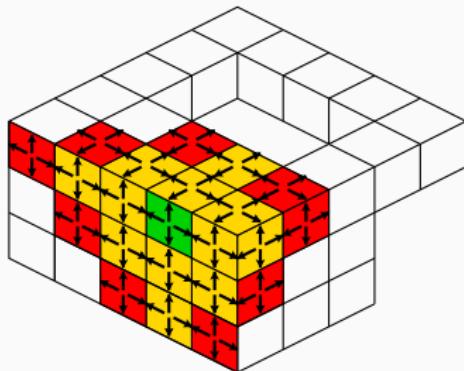
Let $O \subset X$ $2n$ -connected, $Q \subset X^c$ $2n^2$ -connected. c a bel.

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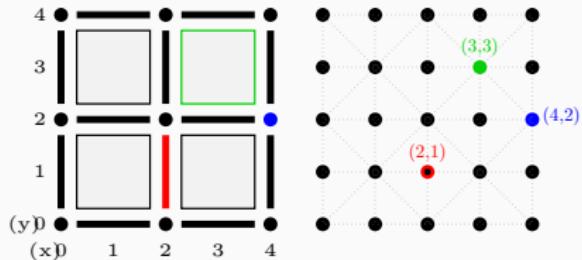
- To extract a boundary component \Rightarrow track it.

Tracking digital boundaries i

- boundary in parallelepiped N^n
- number of bels is $V = O(N^{n-1})$
- degree of each vertex is $2n - 2$
- breadth-first traversal of bel-adjacency graph
- each bel is visited $2n - 2$ times
- time complexity $\approx (2n - 2)V$



Cubical chain complex i

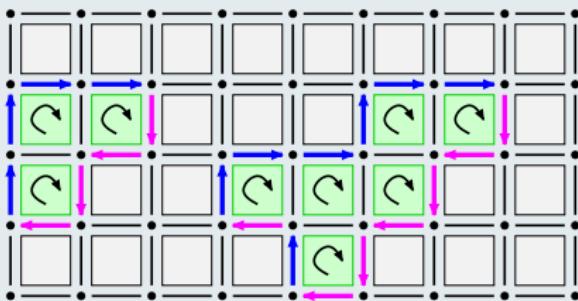


Classical trick for representing cell space

- isomorphism “grid” and “Khalimsky’s space”
- cells can be represented by integer points
- a cell is an element of \mathbb{Z}^n , parities = topology
- pixels, voxels, n -cells have odd parities

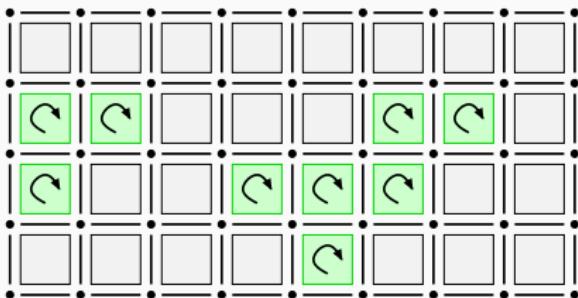
Cubical chain complex ii

Construction of a chain complex



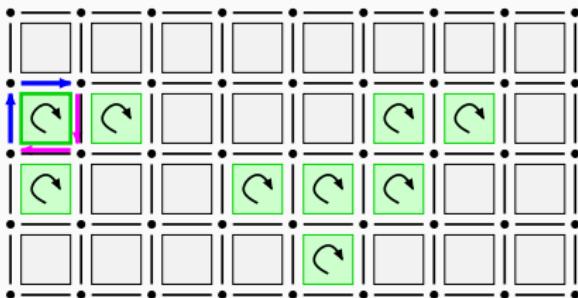
- oriented k -cells form k -dimensional bases
- k -chains are formal sums of k -cells (coefficient \mathbb{Z})
 $[\sum_i +o_i^n]$ is a digital shape
 $\sum [+s_j^{n-1}] + \sum [-s_{j'}^{n-1}]$ is a digital surface
- boundary operator Δ , with $\Delta\Delta = 0$, based on cell parities

Application to digital boundaries



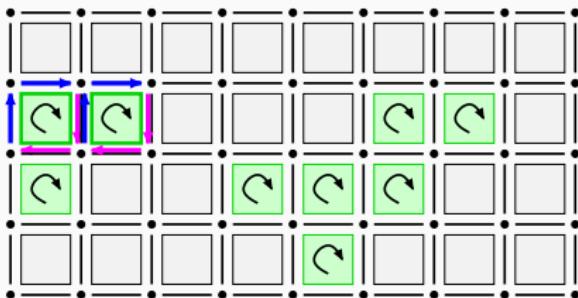
- digital shape is a subset X of \mathbb{Z}^n (odd parities)
- its boundary = $n - 1$ -chain $\Delta \sum_{x \in X} +x$
- it is a cycle since $\Delta\Delta = 0$

Application to digital boundaries



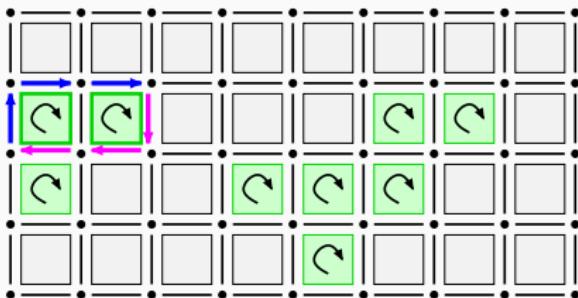
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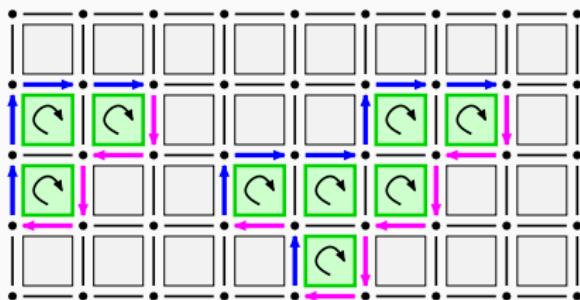
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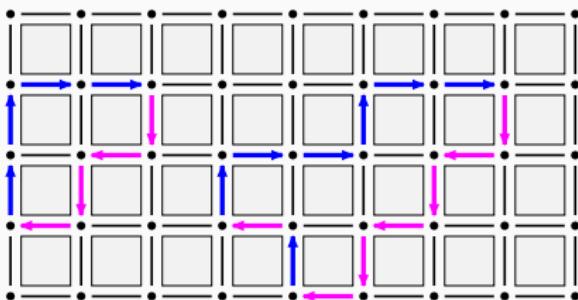
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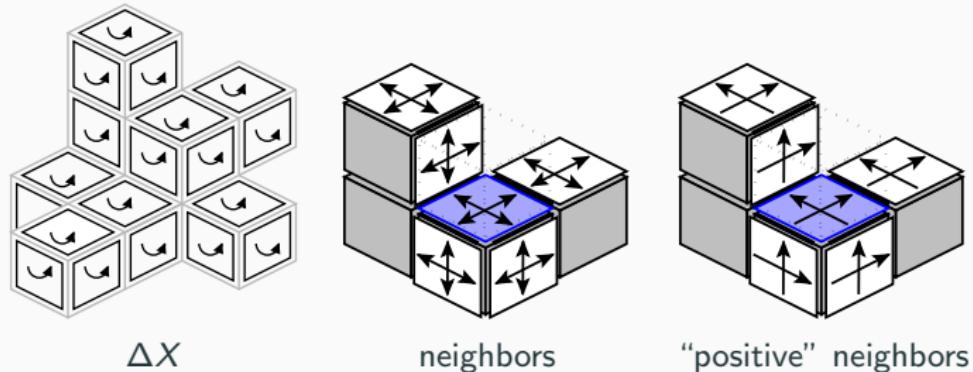


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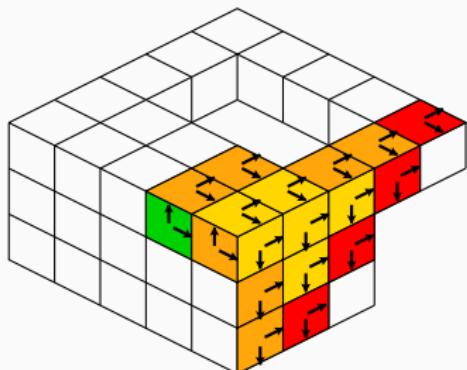
Theorem

The boundary of a volume is a closed digital surface

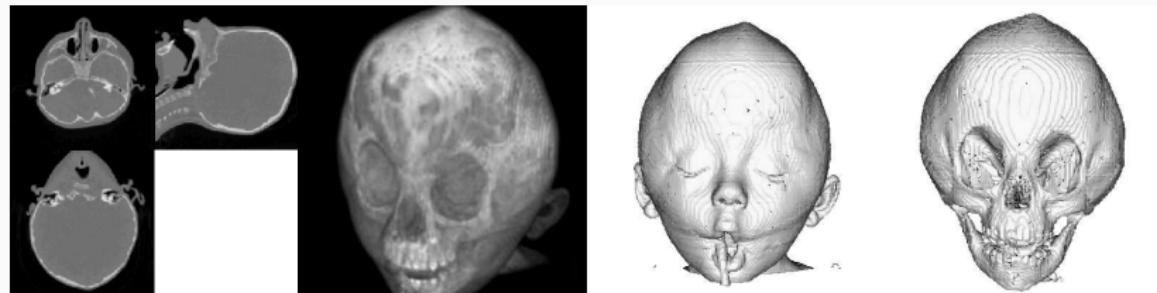
Oriented boundary tracking i



- since $\Delta\Delta X = 0$
- breadth-first traversal of **directed** bel-adjacency graph
- each bel is visited $\frac{2n-2}{2}$ times
- time complexity $\approx (n-1)V$



Isosurfaces i



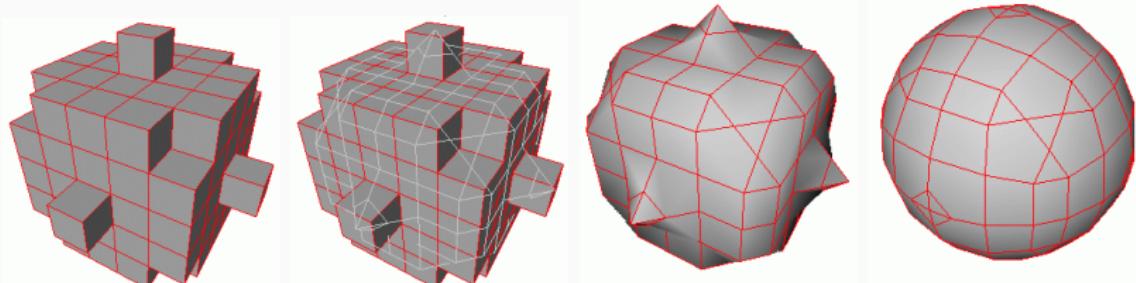
Definition (Isosurface)

Let $I : \mathbb{R}^3 \rightarrow \mathbb{R}$.

Isosurface of value s in $I = \{(x, y, z) \in \mathbb{R}^3, I(x, y, z) = s\}$.

- *marching-cubes* [Lorensen,Cline87], by scanning

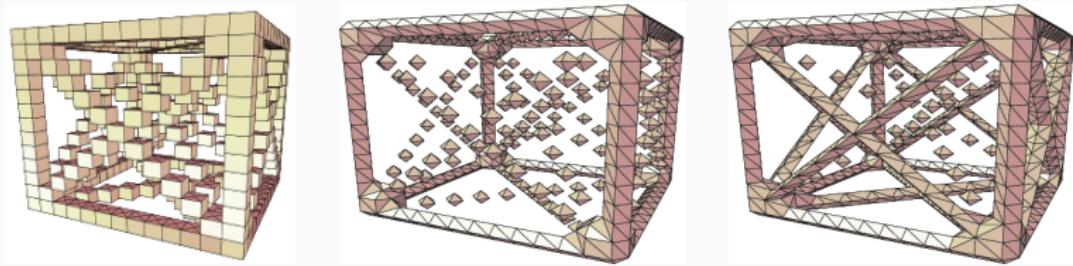
Duality isosurfaces / digital surface



$$X = \{\vec{x} \in \mathbb{Z}^3, I(\vec{x}) \geq s\}$$

Theorem [L. Montanvert 2000]

bel-adjacency complex defines a $n - 1$ -pseudomanifold without boundary

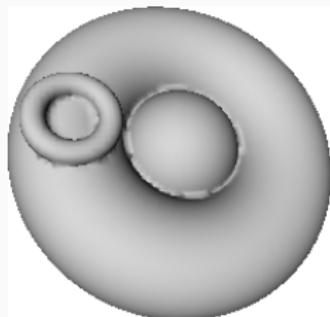
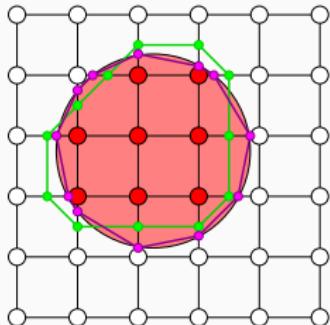
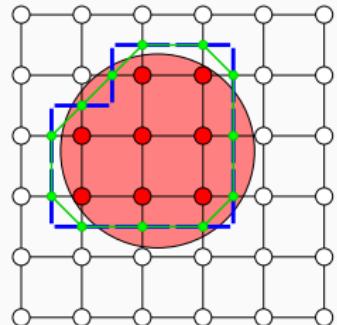


shape

interior

exterior

Making isosurfaces nice



1. $X = \{\vec{x} \in \mathbb{Z}^3, I(\vec{x}) \geq s\}$
2. track $\Delta \sum_{x \in X} +x$
3. local triangulation
4. move vertices

Digital surfaces in DGtal

Generic representation of digital surfaces

- One interface `DigitalSurface`, many implementations
 - `DigitalSetBoundary` implicit boundary of volumes
 - `SetOfSurfels` explicit set of surfels
 - `LightImplicitDigitalSurface` implicit digital surface from interior/exterior predicate
 - `ImplicitDigitalSurface` same as above with boundary precomputation
 - `LightExplicitDigitalSurface` explicit digital surface from surfel predicate
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 - `ExplicitDigitalSurface` same as above with boundary precomputation
- everything generic, arbitrary dimensional
- In 3D, one interface `IndexedDigitalSurface`, same many implementations
 - all cells are numbered from 0,
 - based on half-edge data structure,
 - faster if process requires several pass, many neighborhood comput.

Digital surfaces in DGtal

Usual usages: use **Shortcuts module**

```
1 #include "DGtal/helpers/Shortcuts.h"
...
3 typedef Shortcuts<Z3i::KSpace> SH3;
4 auto params = SH3::defaultParameters();
5 params("surfaceTraversal", "BreadthFirst") // specifies breadth-first traversal
     ("colormap", "Jet"); // specifies the colormap
6 auto vol      = SH3::makeBinaryImage( "samples/A1.100.vol", params ); //load vol file
7 auto K        = SH3::getKSpace( vol );                                // define grid cell space
8 auto surface  = SH3::makeLightDigitalSurface( vol, K, params );//define digital surface
9 auto surfels  = SH3::getSurfelRange( surface, params );           //track surfels with BFT
10 auto cmap     = SH3::getColorMap( 0, surfels.size(), params );//paint surfels from rank
    SH3::Colors colors( surfels.size() );
11 for ( int i = 0; i < surfels.size(); ++i ) colors[ i ] = cmap( i );
12 bool ok     = SH3::saveOBJ( surface, SH3::RealVectors(), colors, "al-primal-bft.obj" );
```



Digital surfaces in DGtal

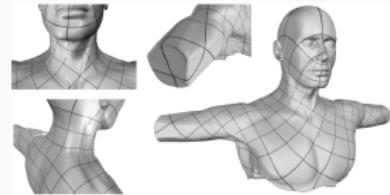
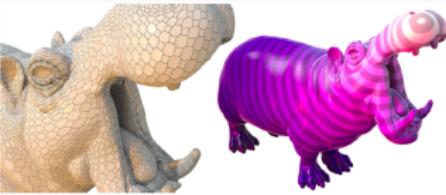
Usual usages: use **Shortcuts module**

- image → digital surface / indexed digital surface
- extraction of connected components / main component
- polynomial shape → digital surface / indexed surface
- digital surface ↔ indexed digital surface
- (indexed) digital surface → dual triangulated surface (MC)
- (indexed) digital surface → primal polygonal surface
- (indexed) digital surface → dual polygonal surface
- traversals/visitors: breadth-first, depth-first
- many export to OBJ
- many geometric estimation: area, normals, curvatures

2. Discrete Exterior Calculus

II.2 Discrete (exterior) Calculus

Computer graphics, geometry processing, shape optimization



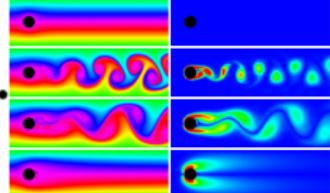
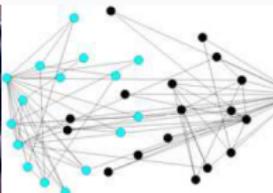
(Images: Knöppel et al. 2015, Crane et al. 2013, Springborn et al. 2010)

Discrete exterior calculus [[Desbrun, Hirani, Leok, ...](#)]

Discrete differential calculus [[Polthier, Pinkall, Bobenko, ...](#)]

Discrete calculus [[Grady, Polimeni, ...](#)]

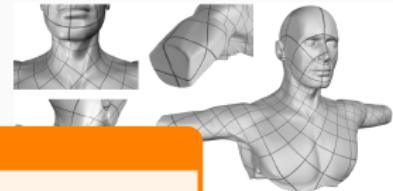
Graph and network analysis, image processing, fluid simul.



(Images: Bugeau et al. 2014, couprie et al. 2014, Elcott et al. 2006)

II.2 Discrete (exterior) Calculus

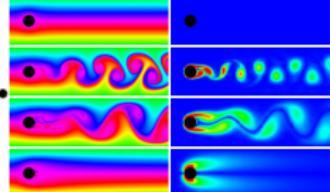
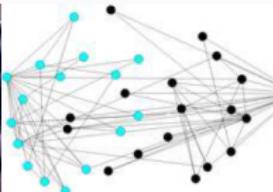
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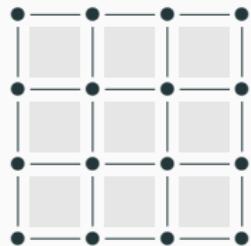
Discrete exterior calculus (DEC)

- no discretization, discrete by nature
- keep algebraic properties of calculus, exact Stokes' theorem
- reduces to matrix/vectors
- works without embedding, just metric
- “any” cell complex, arbitrary dimension

Graph and network analysis, image processing, fluid simul.

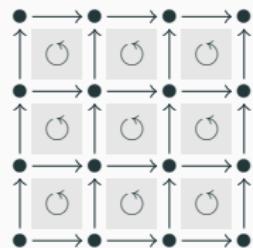


Cell complex, chains, boundary, forms



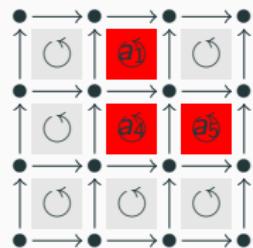
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Cell complex, chains, boundary, forms



- *cell complex K :* vertices, edges, faces (pixels/surfels) with orientation

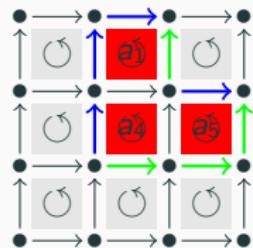
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$$\sigma := a_1 + a_4 + a_5 \in C_2(K)$$

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Cell complex, chains, boundary, forms



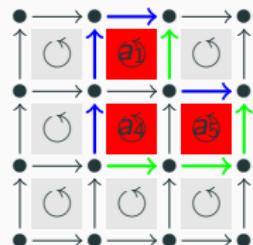
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$$\eta := \sum e_i - \sum e_j \in C_1(K)$$

$$\eta = \partial_2 \sigma$$

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- *k -chains*: $C_k(K)$ are integral formal sums of oriented cells
- *boundary operators*: $\cdots C_2(K) \xrightarrow{\partial_2} C_1(K) \xrightarrow{\partial_1} C_0(K) \xrightarrow{\partial_0} 0$

Cell complex, chains, boundary, forms



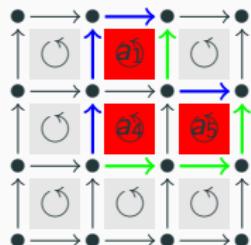
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- *discrete k -forms*: elements of $C^k(K) := \text{Hom}(C_k(K), \mathbb{R})$
 - 0-forms: functions, i.e. a value per vertex
 - 1-forms: differential forms/vector field, i.e. a value per edge
 - 2-forms: area forms, i.e. a value per face

Cell complex, chains, boundary, forms



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 - 1-forms: differential forms/vector field, i.e. a value per edge
 - 2-forms: area forms, i.e. a value per face
- *Integral* $\int_{\sigma} \alpha =$ pairing k -form α with k -chain σ

$$\int_{\sigma} \alpha := \alpha(\sigma) = \sum_i a_i \alpha(c_i) \quad \text{if } \sigma = \sum_i a_i c_i$$

Exterior derivative, Stokes theorem

- *exterior derivative* defined by duality: $\mathbf{d}_k : C^k(K) \rightarrow C^{k+1}(K)$

$$(\mathbf{d}_k \alpha^k)(\sigma_{k+1}) := \alpha^k(\partial_{k+1} \sigma_{k+1})$$

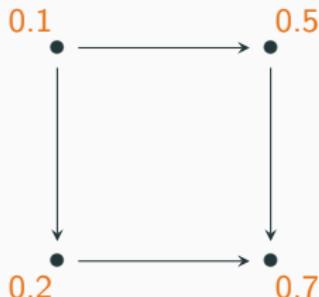
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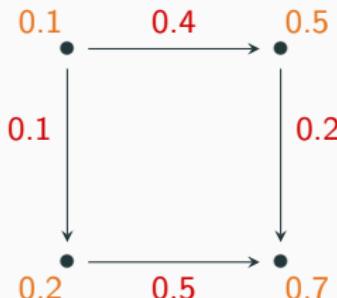
- Function or discrete 0-form : $\alpha = (0.2, 0.7, 0.1, 0.5)$

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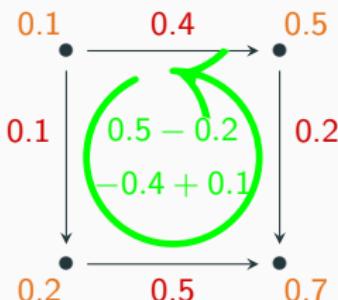
- Function or discrete 0-form : $\alpha = (0.2, 0.7, 0.1, 0.5)$
- 1-form $\mathbf{d}_0(\alpha) = \beta = (0.5, 0.1, 0.2, 0.4)$

Exterior derivative, Stokes theorem

- exterior derivative defined by duality: $\mathbf{d}_k : C^k(K) \rightarrow C^{k+1}(K)$

$$(\mathbf{d}_k \alpha^k)(\sigma_{k+1}) := \alpha^k(\partial_{k+1} \sigma_{k+1})$$

thus incidence relations define derivative by duality



- Function or discrete 0-form : $\alpha = (0.2, 0.7, 0.1, 0.5)$
- 1-form $\mathbf{d}_0(\alpha) = \beta = (0.5, 0.1, 0.2, 0.4)$
- 2-form $\mathbf{d}_1(\beta) = 0$, since $\mathbf{d}_1 \mathbf{d}_0 = 0$

Exterior derivative, Stokes theorem

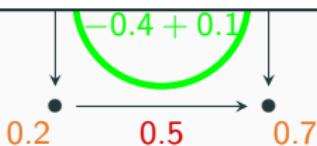
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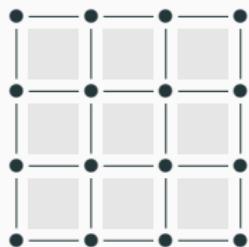
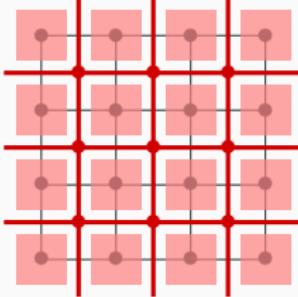
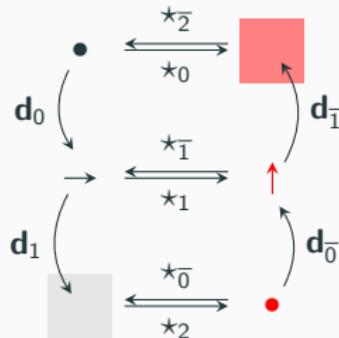
(discrete) Stokes theorem is trivial by definition

$$\int_{\sigma} \mathbf{d}\alpha = \int_{\partial\sigma} \alpha$$

for σ any k -chain and α any $k - 1$ -form

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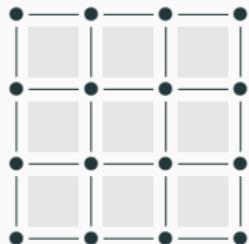
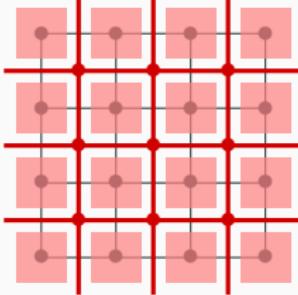
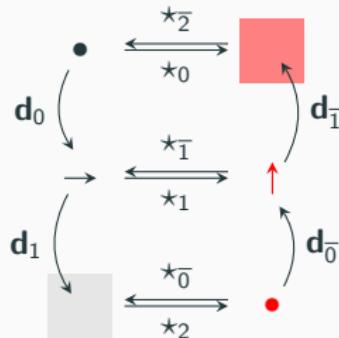
Dual cell complex, Hodge star, calculus

complex K dual complex \bar{K} 

primal dual

- Hodge duality created with dual/orthogonal structure

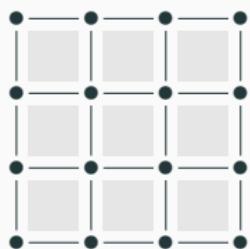
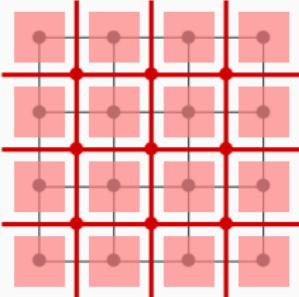
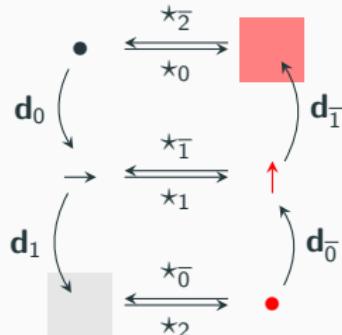
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 - in matrix form $d_{\bar{k}}^T := d_{n-1-k}$

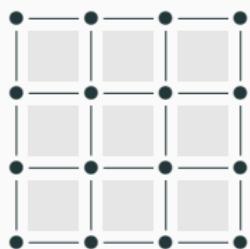
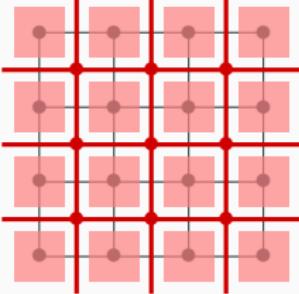
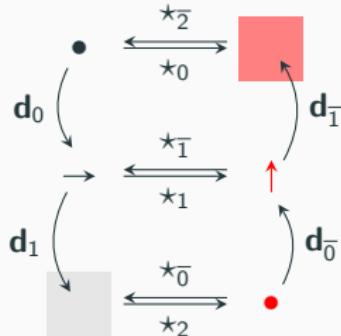
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 - diagonal matrices incorporating metric information
 - e.g. $\star_k \mathbf{1} = \alpha$ is the area 2-form dA

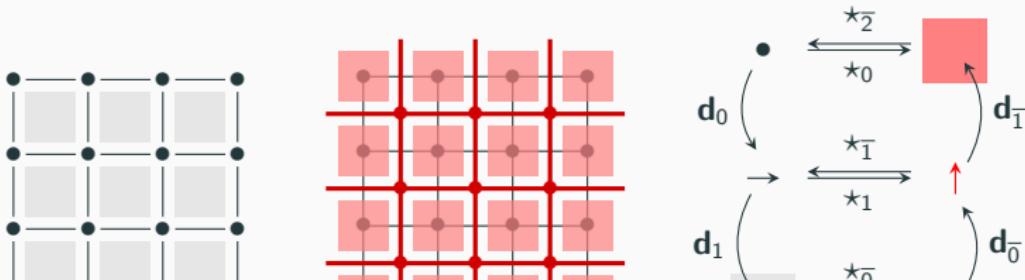
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 - e.g. $\star_k \mathbf{1} = \alpha$ is the area 2-form dA
- wedge products satisfy algebraic properties (Leibniz rules . . .)
 - $\alpha \wedge \beta := \text{diag}(\alpha)\beta$, for $\alpha \in C^k(K), \beta \in C^{2-k}(\bar{K})$,
 - $f \wedge \gamma := \text{diag}(\mathbf{M}_{01}f)\gamma$, for $f \in C^0(K), \gamma \in C^1(K)$. . .

Dual cell complex, Hodge star, calculus



Almost all the calculus is built from the previous operators

- codifferentials $\delta_1 := -\star_2 \mathbf{d}_1 \star_1$, $\delta_2 := -\star_1 \mathbf{d}_0 \star_2$,
- Laplacian $\Delta := \delta_1 \mathbf{d}_0$
- Edge Laplacian $\Delta_1 := \mathbf{d}_0 \delta_1 + \delta_2 \mathbf{d}_1$,
- musical ops : Vector field $\xrightarrow{\flat}$ 1-form $\xrightarrow{\sharp}$ Vector field
- gradient $\nabla f := (\mathbf{d}_0 f)^\sharp$
- divergence $\text{div } \mathbf{V} := \delta_1 \mathbf{V}^\flat$
- L^2 inner-product $(\alpha, \beta)_{\Omega, k} := \int_{\Omega} \alpha \wedge \star_k \beta$, for α, β k -forms
 - $t \wedge \gamma := \text{diag}(\mathbf{M}_{01} t) \gamma$, for $t \in C^0(K)$, $\gamma \in C^1(K)$...

Formulate PDE/variational problems with digital calculus

Anisotropic diffusion on image /

- $\frac{\partial u}{\partial t} = \operatorname{div}(f(\|\nabla u\|)\nabla u)$ with $u_0 = I$, f decreasing from 1 to 0.
- $\frac{u^{t+dt} - u^t}{dt} = \delta_1(F \wedge \mathbf{d}_0 u)$, with function F defined for all edge e as $F(e) = f(\|u(v_j) - u(v_i)\|)$, with $\partial_1 e = v_j - v_i$.
- in matrix form, with matrices $\mathbf{A} := \mathbf{d}_0$, $\mathbf{G}_k := \star_k$:

$$\mathbf{u}^{t+dt} = (\mathbf{Id} + dt \mathbf{G}_{\bar{2}} \mathbf{A}^T \mathbf{G}_1 \operatorname{diag}(\mathbf{f}) \mathbf{A}) \mathbf{u}^t,$$

with \mathbf{f} computed per edge from value of \mathbf{u}^t .

- exactly the “strangely stable” algorithm of Perona-Malik for rectangular domains
- more general formulation in digital calculus (any complex)

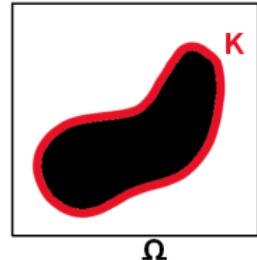
An important example: Mumford-Shah functional

Mumford-Shah functional for image restoration

We minimize

$$\mathcal{MS}(K, \textcolor{green}{u}) = \underbrace{\alpha \int_{\Omega \setminus K} |\textcolor{green}{u} - g|^2 \, dx}_{\text{fidelity term}} + \underbrace{\int_{\Omega \setminus K} |\nabla \textcolor{green}{u}|^2 \, dx}_{\text{smoothness term}} + \lambda \underbrace{\mathcal{H}^1(K \cap \Omega)}_{\text{discontinuities length}}$$

- Ω the image domain
- g the input image
- $\textcolor{green}{u}$ a piecewise smooth approximation of g
- K the set of discontinuities
- \mathcal{H}^1 the Hausdorff measure



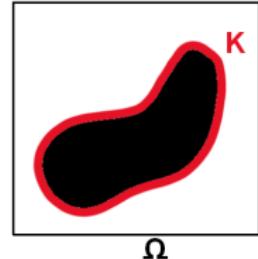
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Mumford-Shah functional

Notably difficult to minimize

Many relaxations and convexifications have been proposed.

- Total Variation [Rudin et al., 1992] and its variants
- Multi-phase level sets [Vese and Chan, 2002] and follow-ups
- Discrete graph approaches
[Boykov et al., 2001, Boykov and Funka-Lea, 2006]
- Calibration method [Alberti et al., 2003] and associated algorithms
[Pock et al., 2009, Chambolle and Pock, 2011]
- Ambrosio-Tortorelli functional [Ambrosio and Tortorelli, 1992]
- convex relaxations of AT [Kee and Kim, 2014]

Mumford-Shah functional

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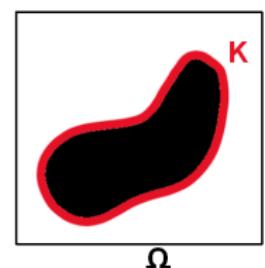
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- **Ambrosio-Tortorelli functional** [Ambrosio and Tortorelli, 1992]
- convex relaxations of AT [Kee and Kim, 2014]

Ambrosio-Tortorelli functional

$$AT_\epsilon(u, v) = \alpha \int_{\Omega} |u - g|^2 \, dx + \int_{\Omega} v^2 |\nabla u|^2 \, dx + \lambda \int_{\Omega} \epsilon |\nabla v|^2 + \frac{1}{\epsilon} \frac{(1 - v)^2}{4} \, dx$$

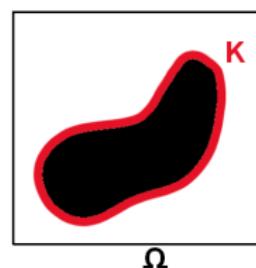
- Ω the image domain
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- u a piecewise smooth approximation of g
- v a smooth approximation of $1 - \chi_K$
- ✓ whole domain integration
- ✓ no Hausdorff measure



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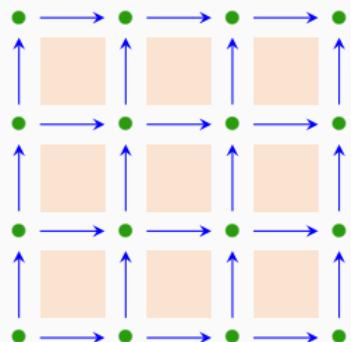
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Γ -convergence: $AT_\epsilon \xrightarrow[\epsilon \rightarrow 0]{} \mathcal{MS}$

Discrete formulation of AT

$$AT_\epsilon(u, v) = \alpha \int_{\Omega} |u - g|^2 \, dx + \int_{\Omega} v^2 |\nabla u|^2 \, dx + \lambda \int_{\Omega} \epsilon |\nabla v|^2 + \frac{1}{4\epsilon} (1 - v)^2 \, dx$$



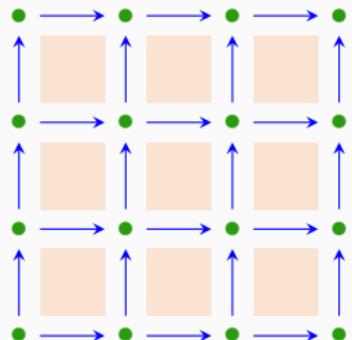
We choose :

- functions u, g to live on faces
 - u, g are 2-forms
 - equivalently dual 0-forms
- function v to live on vertices
 - v is a 0-form



Discrete formulation of AT

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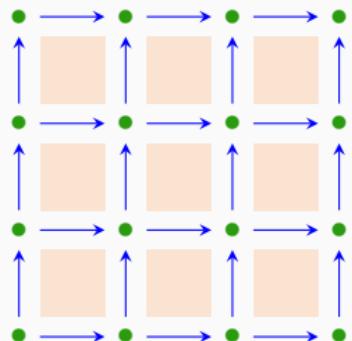
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$$AT_{\epsilon}^{2,0}(u, v) = \alpha (u - g, u - g)_{\Omega, 2}$$

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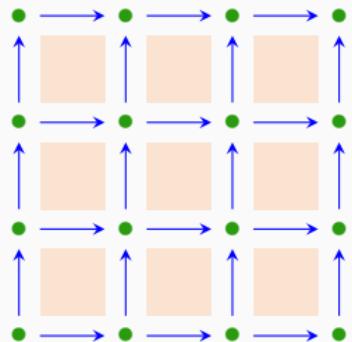
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$$AT_\epsilon^{2,0}(u, v) = \alpha (u - g, u - g)_{\Omega, 2} + \lambda \epsilon (d_0 v, d_0 v)_{\Omega, 1}$$

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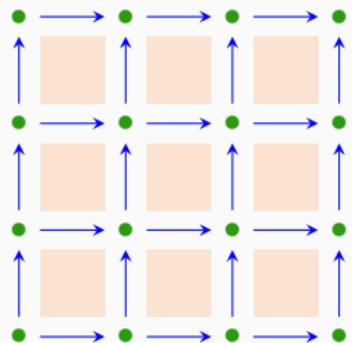
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$$\begin{aligned} AT_\epsilon^{2,0}(u, v) &= \alpha (u - g, u - g)_{\Omega, 2} \\ &\quad + \lambda \epsilon (\mathbf{d}_0 v, \mathbf{d}_0 v)_{\Omega, 1} + \frac{\lambda}{4\epsilon} (1 - v, 1 - v)_{\Omega, 0} \end{aligned}$$

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$$AT_\epsilon^{2,0}(u, v) = \alpha (u - g, u - g)_{\Omega, 2} + (?, ?)_{\Omega}$$

$$+ \lambda \epsilon (\mathbf{d}_0 v, \mathbf{d}_0 v)_{\Omega, 1} + \frac{\lambda}{4\epsilon} (1 - v, 1 - v)_{\Omega, 0}$$

Discrete formulation of AT

$$\int_{\Omega} v^2 |\nabla u|^2 \, dx = (\textcolor{green}{v} \delta_2 \textcolor{orange}{u}, \textcolor{green}{v} \delta_2 \textcolor{orange}{u})_{\Omega,1}$$

- $\textcolor{green}{v} \delta_2 \textcolor{orange}{u} = \textcolor{green}{v} \wedge \delta_2 \textcolor{orange}{u} = \text{diag}(\mathbf{M}_{01} \textcolor{green}{v}) \delta_2 \textcolor{orange}{u}$

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• 0.8 0.8 1.0

• 1.0 0.0 0.2

• 1.0 0.0 0.2

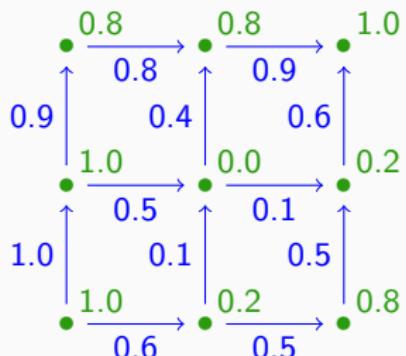
• 1.0 0.2 0.8

- 0-form \mathbf{v}

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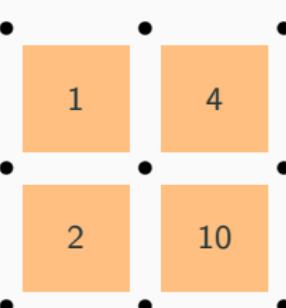
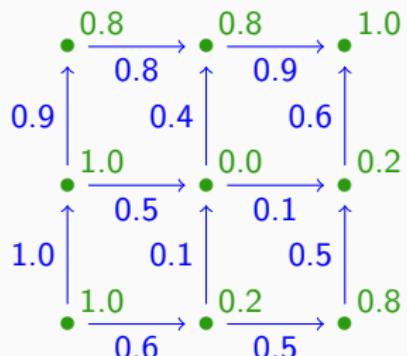


- 0-form v
- 1-form $\mathbf{M}_{01}v$

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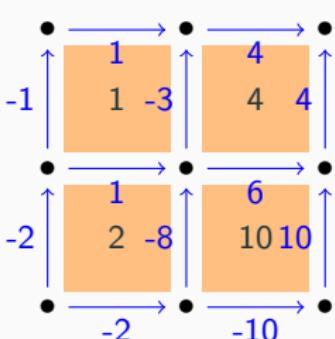
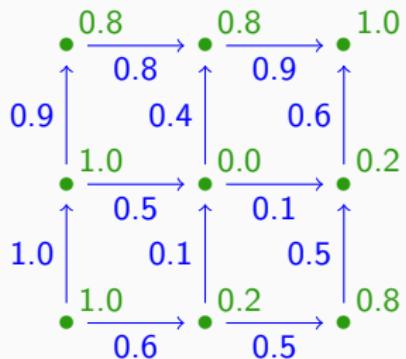
- 2-form $\textcolor{orange}{u}$

- 0-form $\textcolor{green}{v}$
- 1-form $\mathbf{M}_{01} \textcolor{green}{v}$

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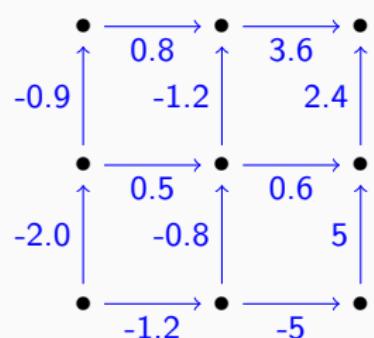
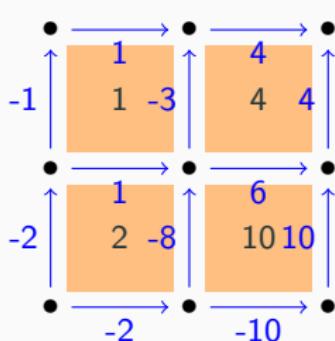
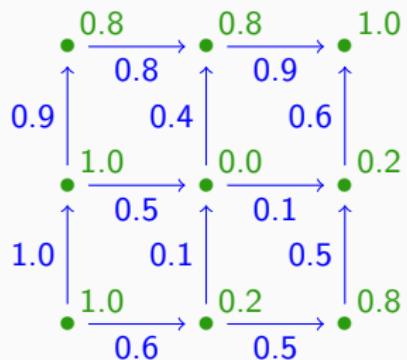


- 0-form v
- 1-form $\mathbf{M}_{01} v$
- 2-form $\textcolor{blue}{u}$
- 1-form $\delta_2 \textcolor{orange}{u}$

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- 0-form v
- 1-form $\mathbf{M}_{01} v$
- 2-form $\textcolor{blue}{u}$
- 1-form $\delta_2 \textcolor{orange}{u}$

- 1-form
 $\text{diag}(\mathbf{M}_{01} \textcolor{green}{v}) \delta_2 \textcolor{orange}{u}$

Discrete formulation of AT

$$\begin{aligned} \text{AT}_\epsilon^{2,0}(\mathbf{u}, \mathbf{v}) &= \alpha (\mathbf{u} - \mathbf{g}, \mathbf{u} - \mathbf{g})_{\Omega,2} + (\text{diag}(\mathbf{M}_{01}\mathbf{v})\delta_2\mathbf{u}, \text{diag}(\mathbf{M}_{01}\mathbf{v})\delta_2\mathbf{u})_{\Omega,1} \\ &\quad + \lambda\epsilon (\mathbf{d}_0\mathbf{v}, \mathbf{d}_0\mathbf{v})_{\Omega,1} + \frac{\lambda}{4\epsilon} (\mathbf{1} - \mathbf{v}, \mathbf{1} - \mathbf{v})_{\Omega,0} \end{aligned}$$

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- with matrices $\mathbf{A} := \mathbf{d}_0$, $\mathbf{B}' := \delta_2$, $\mathbf{G}_k := \star_k$.

$$\begin{aligned} \text{AT}_{\epsilon}^{2,0}(\mathbf{u}, \mathbf{v}) &= \alpha(\mathbf{u} - \mathbf{g})^T \mathbf{G}_2 (\mathbf{u} - \mathbf{g}) + \mathbf{u}^T \mathbf{B}'^T \text{diag}(\mathbf{M}_{01}\mathbf{v})^2 \mathbf{G}_1 \mathbf{B}' \mathbf{u} \\ &\quad + \lambda\epsilon \mathbf{v}^T \mathbf{A}^T \mathbf{G}_1 \mathbf{A} \mathbf{v} + \frac{\lambda}{4\epsilon} (\mathbf{1} - \mathbf{v})^T \mathbf{G}_0 (\mathbf{1} - \mathbf{v}) \end{aligned}$$

Discrete formulation of AT

$$\begin{aligned} \text{AT}_{\epsilon}^{2,0}(\mathbf{u}, \mathbf{v}) &= \alpha (\mathbf{u} - \mathbf{g}, \mathbf{u} - \mathbf{g})_{\Omega,2} + (\text{diag}(\mathbf{M}_{01}\mathbf{v})\delta_2\mathbf{u}, \text{diag}(\mathbf{M}_{01}\mathbf{v})\delta_2\mathbf{u})_{\Omega,1} \\ &\quad + \lambda\epsilon (\mathbf{d}_0\mathbf{v}, \mathbf{d}_0\mathbf{v})_{\Omega,1} + \frac{\lambda}{4\epsilon} (\mathbf{1} - \mathbf{v}, \mathbf{1} - \mathbf{v})_{\Omega,0} \end{aligned}$$

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$$\begin{aligned} \text{AT}_{\epsilon}^{2,0}(\mathbf{u}, \mathbf{v}) &= \alpha(\mathbf{u} - \mathbf{g})^T \mathbf{G}_2(\mathbf{u} - \mathbf{g}) + \mathbf{u}^T \mathbf{B}'^T \text{diag}(\mathbf{M}_{01}\mathbf{v})^2 \mathbf{G}_1 \mathbf{B}' \mathbf{u} \\ &\quad + \lambda\epsilon \mathbf{v}^T \mathbf{A}^T \mathbf{G}_1 \mathbf{A} \mathbf{v} + \frac{\lambda}{4\epsilon} (\mathbf{1} - \mathbf{v})^T \mathbf{G}_0 (\mathbf{1} - \mathbf{v}) \end{aligned}$$

- Euler-Lagrange: $\min_{\mathbf{u}, \mathbf{v}} \text{AT}_{\epsilon}^{2,0} \Rightarrow \frac{d\text{AT}_{\epsilon}^{2,0}}{d\mathbf{u}} = 0$ and $\frac{d\text{AT}_{\epsilon}^{2,0}}{d\mathbf{v}} = 0$
- $\text{AT}_{\epsilon}^{2,0}$ is **quadratic** in \mathbf{u} and in \mathbf{v}

Discrete formulation of AT

$$\begin{aligned} \text{AT}_{\epsilon}^{2,0}(\mathbf{u}, \mathbf{v}) &= \alpha (\mathbf{u} - \mathbf{g}, \mathbf{u} - \mathbf{g})_{\Omega,2} + (\text{diag}(\mathbf{M}_{01}\mathbf{v})\delta_2\mathbf{u}, \text{diag}(\mathbf{M}_{01}\mathbf{v})\delta_2\mathbf{u})_{\Omega,1} \\ &\quad + \lambda\epsilon (\mathbf{d}_0\mathbf{v}, \mathbf{d}_0\mathbf{v})_{\Omega,1} + \frac{\lambda}{4\epsilon} (\mathbf{1} - \mathbf{v}, \mathbf{1} - \mathbf{v})_{\Omega,0} \end{aligned}$$

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- $\text{AT}_{\epsilon}^{2,0}$ is quadratic in \mathbf{u} and in \mathbf{v}
- We solve alternatively for \mathbf{u} and \mathbf{v} the sparse linear systems:

$$\left\{ \begin{array}{l} [\alpha \mathbf{G}_2 - \mathbf{B}'^T \text{diag}(\mathbf{M}_{01}\mathbf{v})^2 \mathbf{G}_1 \mathbf{B}'] \mathbf{u} = \alpha \mathbf{G}_2 \mathbf{g}, \\ \left[\frac{\lambda}{4\epsilon} \mathbf{G}_0 + \lambda\epsilon \mathbf{A}^T \mathbf{G}_1 \mathbf{A} + \mathbf{M}_{01}^T \text{diag}(\mathbf{B}' \mathbf{u})^2 \mathbf{G}_1 \mathbf{M}_{01} \right] \mathbf{v} = \frac{\lambda}{4\epsilon} \mathbf{G}_0 \mathbf{1}. \end{array} \right.$$

Discrete formulation of AT: vectorial data

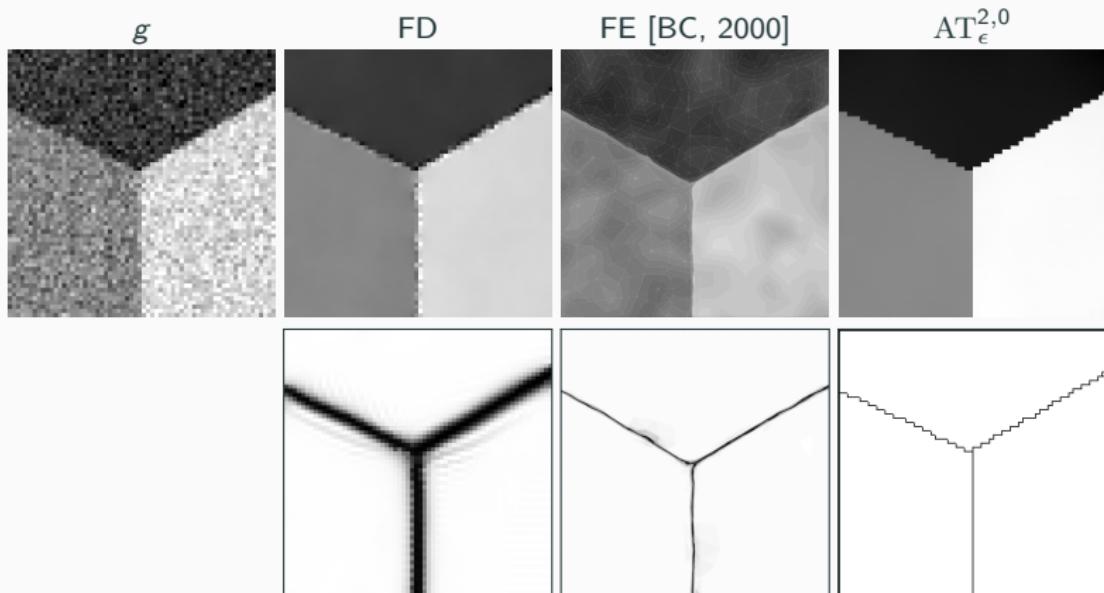
$$\begin{aligned}
 \text{AT}_{\epsilon}^{2,0}(\mathbf{u}_1, \dots, \mathbf{u}_n, \mathbf{v}) = & \alpha \sum_i (\mathbf{u}_i - \mathbf{g}_i, \mathbf{u}_i - \mathbf{g}_i)_{\Omega,2} \\
 & + \sum_i (\text{diag}(\mathbf{M}_{01}\mathbf{v})\delta_2 \mathbf{u}_i, \text{diag}(\mathbf{M}_{01}\mathbf{v})\delta_2 \mathbf{u}_i)_{\Omega,1} \\
 & + \lambda \epsilon (\mathbf{d}_0 \mathbf{v}, \mathbf{d}_0 \mathbf{v})_{\Omega,1} + \frac{\lambda}{4\epsilon} (\mathbf{1} - \mathbf{v}, \mathbf{1} - \mathbf{v})_{\Omega,0}
 \end{aligned}$$

- We solve alternatively for the \mathbf{u}_i and \mathbf{v} the sparse linear systems:

$$\left\{
 \begin{array}{lcl}
 \forall i \in \{1, \dots, n\}, [\alpha \mathbf{G}_2 - \mathbf{B}'^T \text{diag}(\mathbf{M}_{01}\mathbf{v})^2 \mathbf{G}_1 \mathbf{B}'] \mathbf{u}_i & = & \alpha \mathbf{G}_2 \mathbf{g}_i, \\
 \left[\frac{\lambda}{4\epsilon} \mathbf{G}_0 + \lambda \epsilon \mathbf{A}^T \mathbf{G}_1 \mathbf{A} + \mathbf{M}_{01}^T (\sum_i \text{diag}(\mathbf{B}' \mathbf{u}_i)^2) \mathbf{G}_1 \mathbf{M}_{01} \right] \mathbf{v} & = & \frac{\lambda}{4\epsilon} \mathbf{G}_0 \mathbf{1}.
 \end{array}
 \right.$$

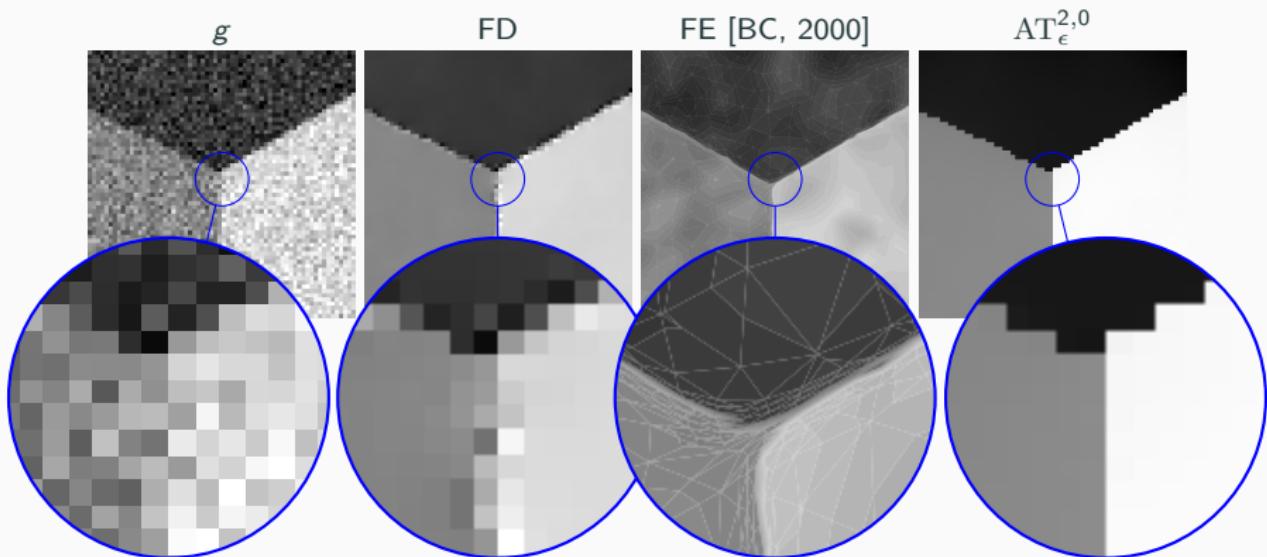
- Our algorithm progressively decreases ϵ to get a better chance of capturing the optimum
 - ϵ follows typically sequence 2, 1, 0.5, 0.25 (for $h = 1$ sampling)
 - results on \mathbf{u} and \mathbf{v} are starting point for next ϵ

Image restoration on toy examples

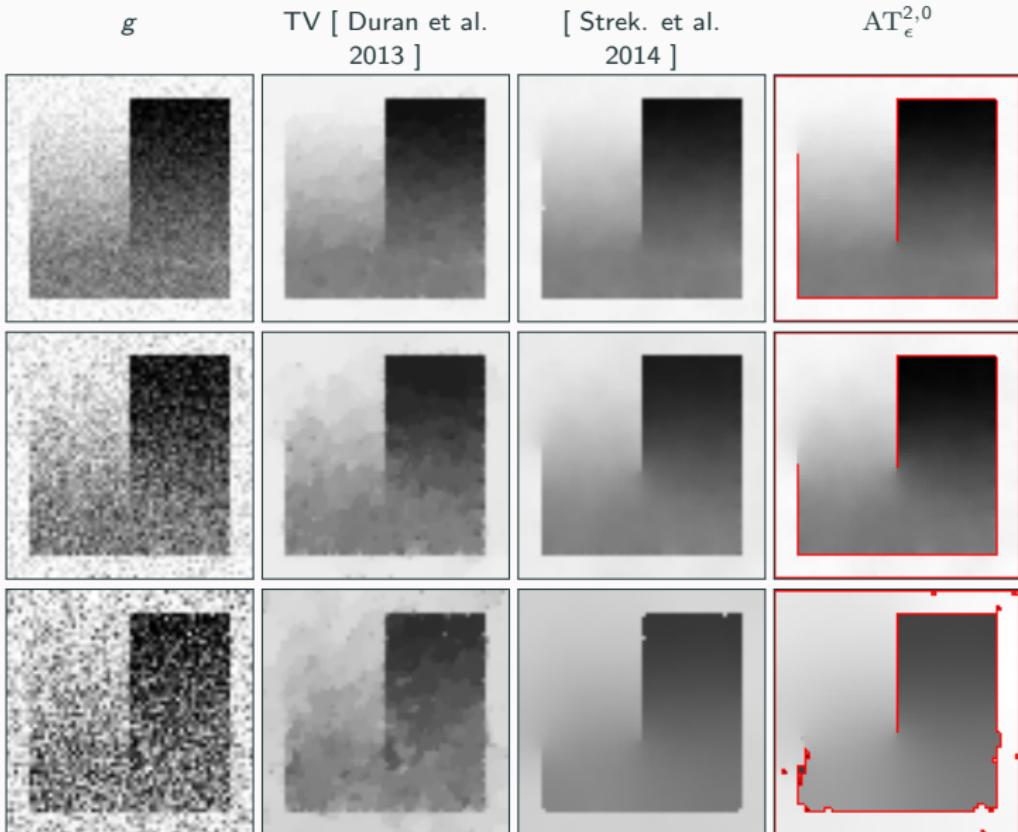


- systems are solved using Cholesky decomposition (Eigen)
- ϵ takes the successive values 2, 1, 0.5, 0.25, for sampling step $h = 1$.

Image restoration on toy examples



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Influence of parameter ϵ

$$AT_\epsilon(u, v) = \alpha \int_{\Omega} |u - g|^2 \, dx + \int_{\Omega} v^2 |\nabla u|^2 \, dx + \lambda \int_{\Omega} \epsilon |\nabla v|^2 + \frac{1}{\epsilon} \frac{(1-v)^2}{4} \, dx$$

- Γ -convergence parameter
- Controls the **thickness of the contours**
 - large ϵ convexifies AT and helps to detect the discontinuities;
 - as ϵ goes to 0, the discontinuities become thinner and thinner.

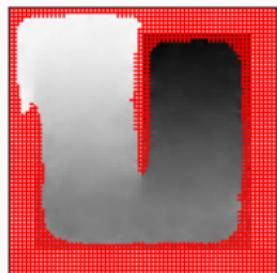
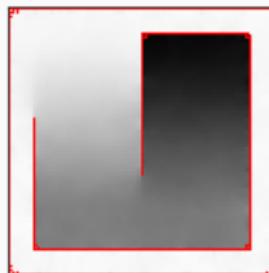
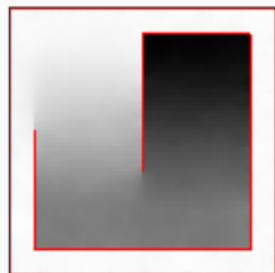
 $\epsilon = 2 \searrow 2$  $\epsilon = 2 \searrow 1$  $\epsilon = 2 \searrow 0.5$  $\epsilon = 2 \searrow 0.25$

Image restoration / denoising

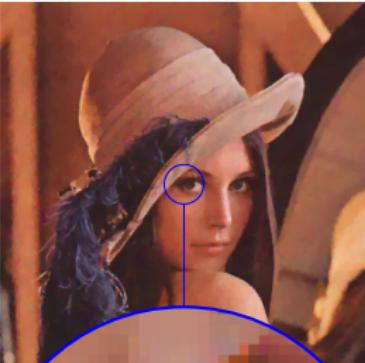
 g

(PSNR = 20.23 dB)



TV

(PSNR = 29.36 dB)

 $\text{AT}_{\epsilon}^{2,0}$

(PSNR = 29.03 dB)

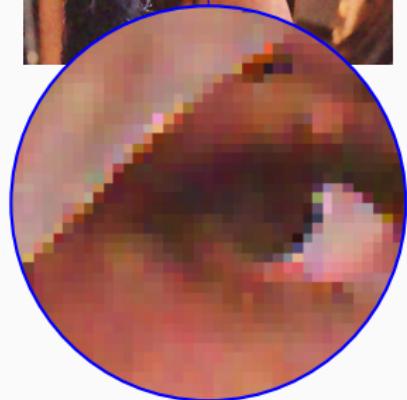
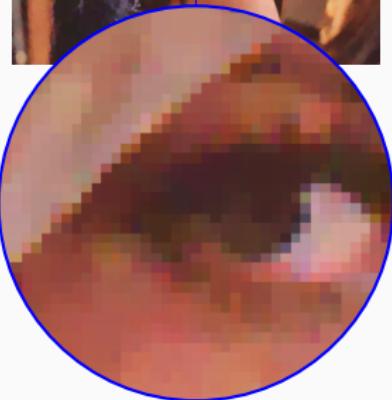
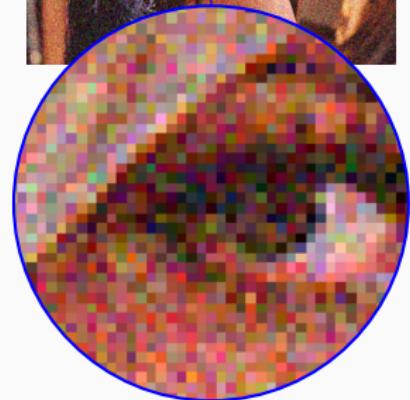


Image restoration / denoising

 g

(PSNR = 20.23 dB)

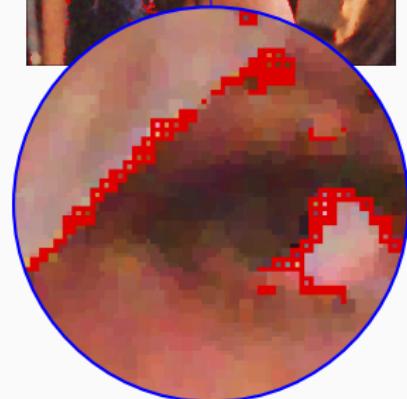
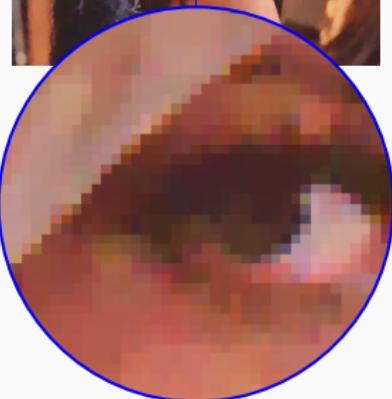
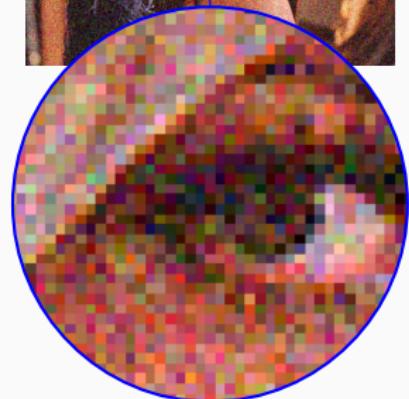


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 $\text{AT}_{\epsilon}^{2,0}$

(PSNR = 29.03 dB)



Scale-space given by α and λ and image segmentation



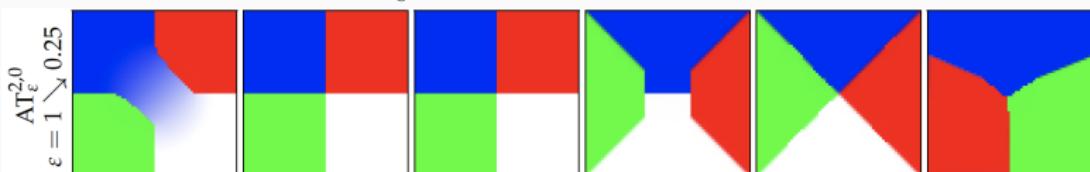
for decreasing λ

Image inpainting (on toy example)

- mask (in black) : domain M where data g (in color) is unknown
- $\alpha(x) := \{\alpha \in \Omega \setminus M, 0 \text{ elsewhere}\}$
- initialization: u random in M , $= g$ in $\Omega \setminus M$



$AT_\epsilon^{2,0}$ with ϵ from 1 to 0.25



$AT_\epsilon^{2,0}$ with ϵ from 4 to 0.25

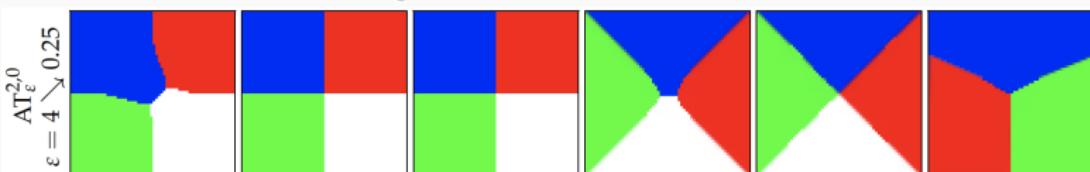
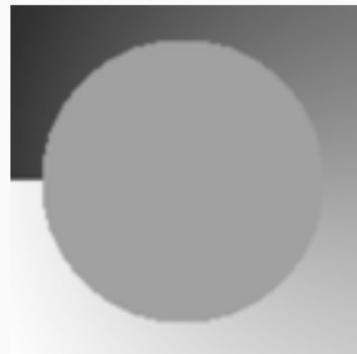
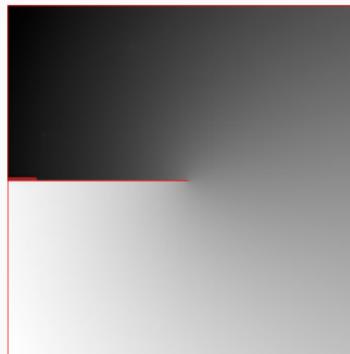


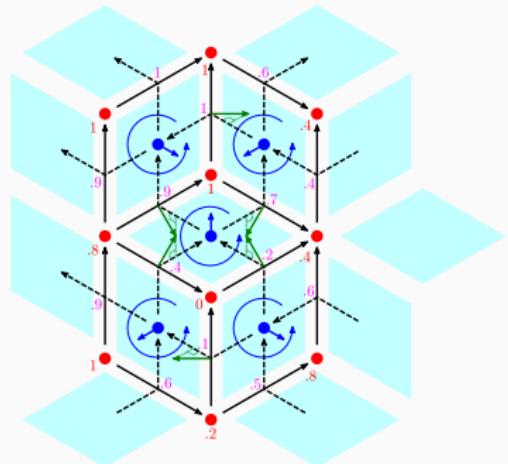
Image inpainting (on classical crack-tip example)

 g mask M  $\text{AT}_\epsilon^{2,0}, \alpha = 1, \lambda = 0.0024$

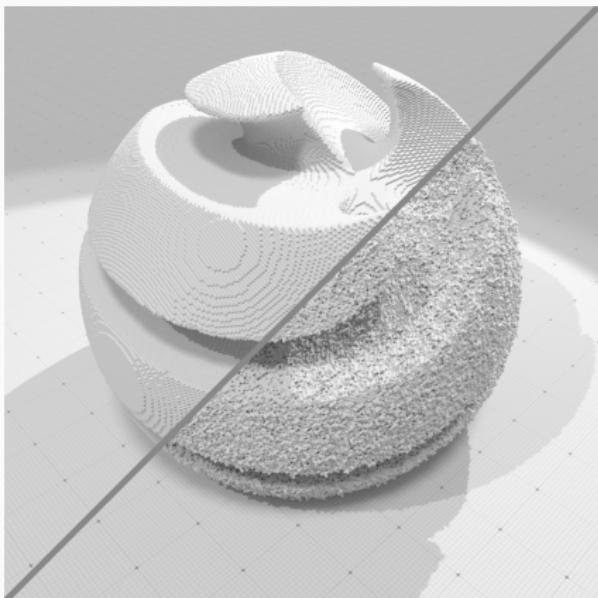
- Decreasing sequence of λ (irreversibility !?)
- same result as [\[Pock, Bishof, Cremers, Pock 2009\]](#), based on MS relaxation of [\[Alberti, Bouchitté, Dal Maso 2003\]](#)
- result independent of initialization as long as first ϵ is big enough (ϵ from 4 to 0.25 here, for image of size 110×110).

Feature delineation on digital surfaces

digital surface = boundary of set of voxels



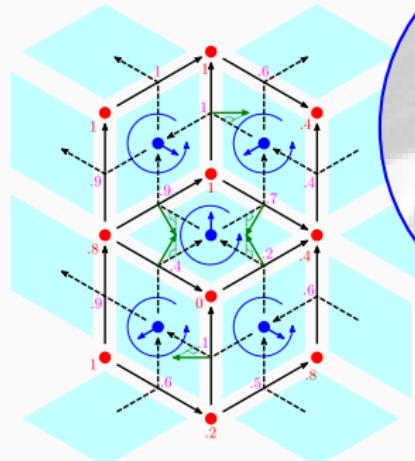
same discrete calculus
same $AT_{\epsilon}^{2,0}$



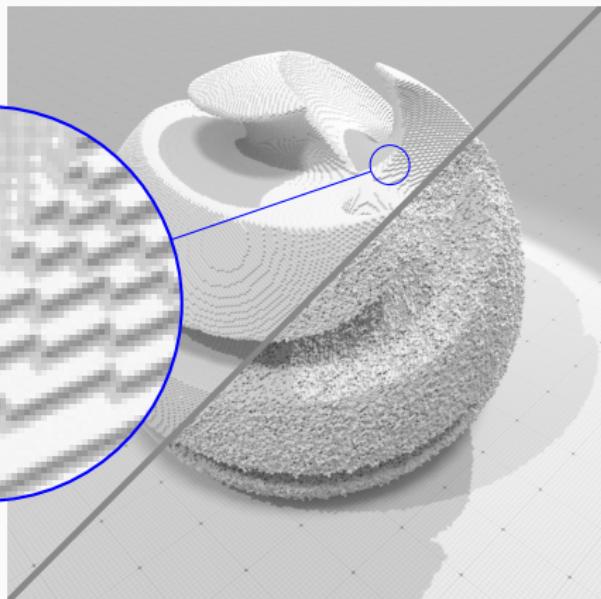
Input: normal vector field g estimated by Integral Invariant digital normal estimator.

Feature delineation on digital surfaces

digital surface = boundary of set of voxels



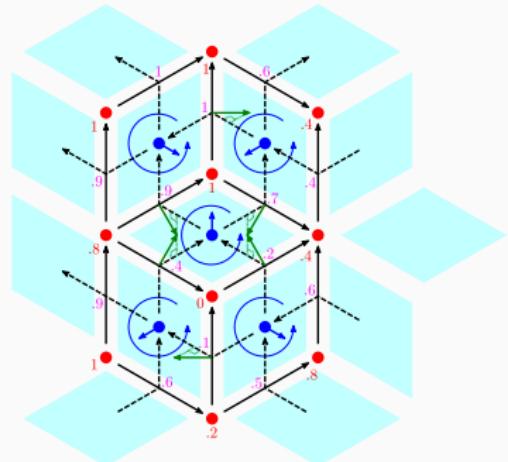
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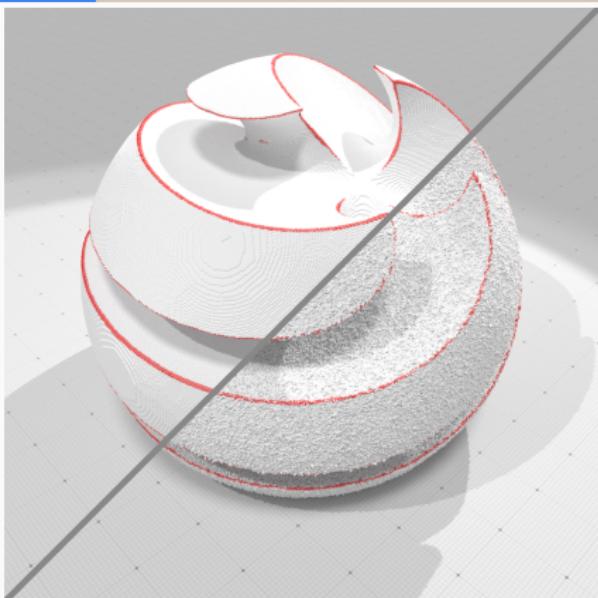
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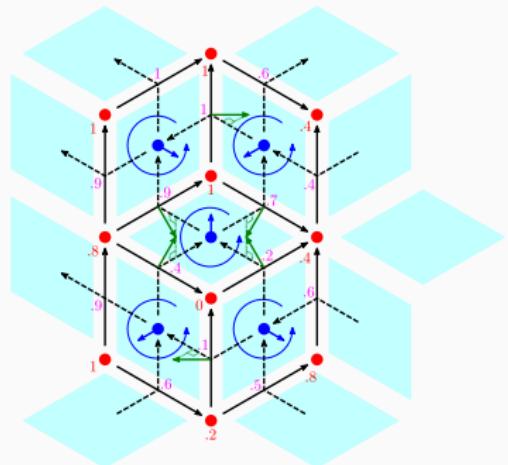


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Output: piecewise smooth normals $(\mathbf{u}_i)_{i=1,2,3}$ and features \mathbf{v}

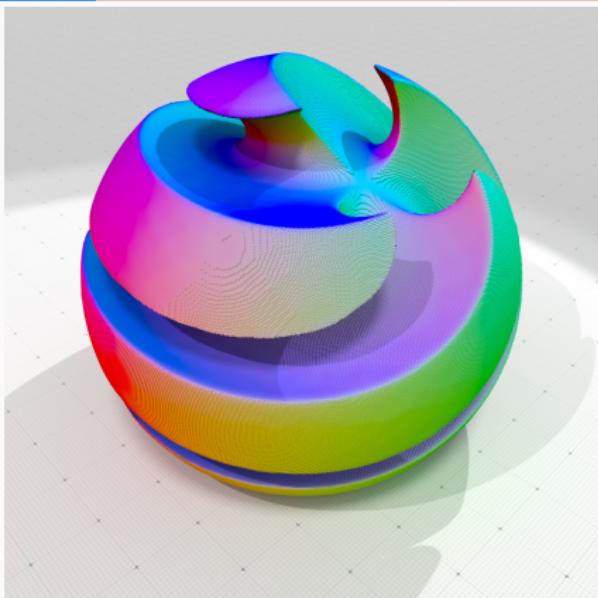
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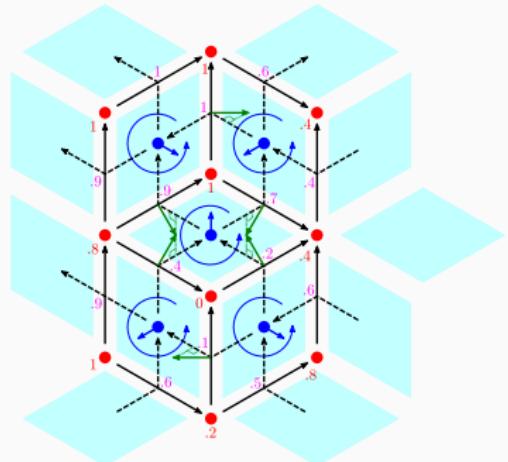


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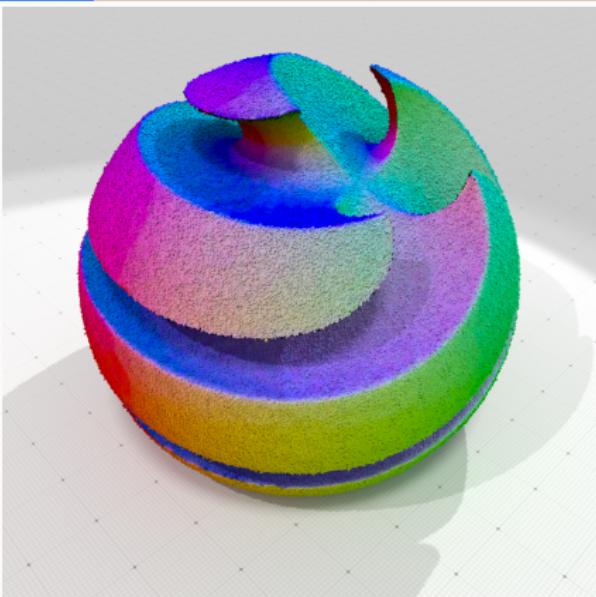
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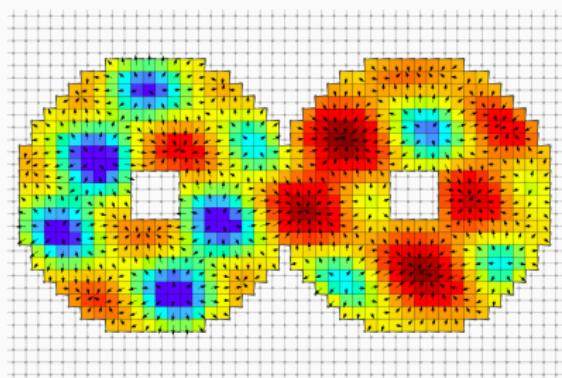
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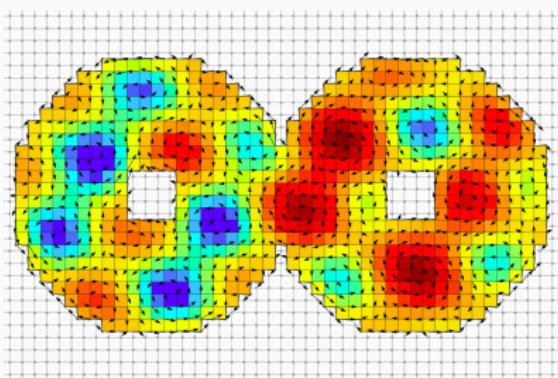
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Discrete Exterior Calculus: conclusion



curl-free $\mathbf{d}_1 \mathbf{v} = 0$



div-free $\delta_1 \mathbf{v} = 0$

- a sound framework for variational modeling / PDE
- well suited to digital domains: images, digital surfaces
- reduces to linear algebra computations
- visit [DEC package](#) on [dgtal.org](#) documentation

3. Reproducible Research

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Overview

- 3.1 (short) Introduction to Reproducible Research.
- 3.2 Rapid overview of the RR platforms.
- 3.3 New ways of publications.

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Reproducible research in sciences:

- *Theoretical scientists share demonstrations;*

$$\begin{aligned}
 \text{CPT}^n &= 2\alpha_1 + C(T\alpha^2) \\
 &= 2\alpha_1 T + 2\alpha_2 T^2 + C(T^2\alpha^3) \\
 &= 2\alpha_1 T + 2\alpha_2 T^2 + 2\alpha_3 T^3 + C(T^3\alpha^4) \dots \text{etc.} \\
 CPO^n &= 2\alpha_1 + 2\alpha_2 + 2\alpha_3 + \dots + 2\alpha_n
 \end{aligned}$$

The recurrence equation shows that we can relate the summation equation to the previous one by adding the first term of the sequence to the summation equation.

$$2\alpha_1 (1 + \alpha^2 + \alpha^3 + \alpha^4 + \dots) = 2\frac{\alpha_1}{1-\alpha}$$

Since we know the converging infinite geometric series states:

$$\sum_{n=0}^{\infty} \alpha^n = \frac{1}{1-\alpha}, |\alpha| < 1$$

This in turn leads us to the closed form formula:

$$\frac{2\alpha_1}{1-\alpha} = 2\alpha_1 \cdot \frac{1}{1-\alpha}$$

Proof by induction: $2\alpha_1 T^n + C(T^n\alpha^{n+1}) = 2\alpha_1 \cdot \frac{1}{1-\alpha}$

Inductive hypothesis: $2\alpha_1 T^k + C(T^k\alpha^{k+1}) = 2\alpha_1 \cdot \frac{1}{1-\alpha}$ $\forall k < n$

Inductive step:

$$\begin{aligned}
 2\alpha_1 T^{k+1} + C(T^{k+1}\alpha^{k+2}) &= 2\alpha_1 T^k \cdot \alpha + C(T^k\alpha^{k+1}) \cdot \alpha \\
 2\alpha_1 T^{k+1} + C(T^{k+1}\alpha^{k+2}) &= 2\alpha_1 \cdot \frac{1}{1-\alpha} \cdot \alpha \\
 2\alpha_1 T^{k+1} + C(T^{k+1}\alpha^{k+2}) &= 2\alpha_1 \cdot \frac{1}{1-\alpha^2} \\
 2\alpha_1 T^{k+1} + C(T^{k+1}\alpha^{k+2}) &= 2\alpha_1 \cdot \frac{1}{1-\alpha} \\
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 \end{aligned}$$

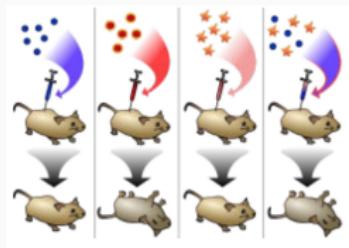
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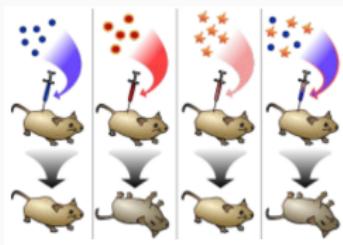
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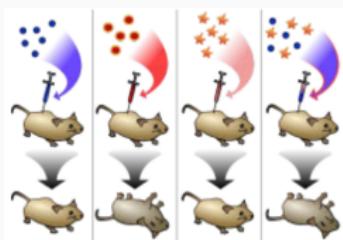
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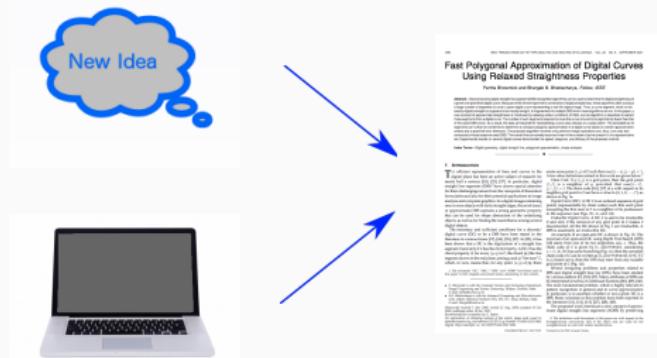
Computer Science:

- Description of methods/algorithms;
- description often limited (constraints on page limits);
- parameters not given or not well described;
- steps of pre/post processing missing.

3.1 (short) Introduction to Reproducible Research (1)

Research in Computer Science:

- 1 New idea;
- 2 demonstration, implementation;
- 3 article publication.



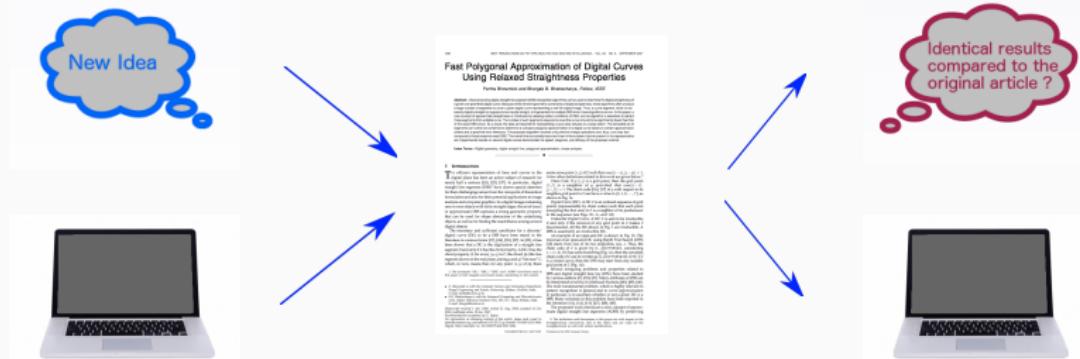
3.1 (short) Introduction to Reproducible Research (1)

Research in Computer Science:

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- 2 demonstration, implementation;
- 3 article publication.

Reusable Research:

- 1 Article which seems interesting;
- 2 re-implement the algorithm;
- 3 result conformity with the original.



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- RR redefines the result of the research. Not just a paper, but also all the procedures needed to obtain the same published results.

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Mention that more than 70% of researchers have already failed to reproduce results from other researchers.

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⇒ more than the half affirm to also fail to reproduce their own results.

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- The descriptions, methodology, source code, and data is available to the scientific community.
- Comparison of methods easier (or even possible!).

Benefit for authors

- possibility of publishing research of high quality.
- increase of the visibility of the publications

3.2 Rapid overview of the RR platforms

- **Galaxy** - <https://galaxyproject.org>
- **IPython** - <https://ipython.org>
- **Jupyter** - <http://jupyter.org>
- **Code Ocean** - <https://codeocean.com>
- Research Compendia - <http://researchcompendia.science>
- RunMyCode - <http://www.runmycode.org>
- **DAE** - <http://dae.cse.lehigh.edu/DAE>
- **IPOL** - <https://www.ipol.im>

3.2 Rapid overview of the RR platforms: Galaxy

Description:

- Platform for **genomic research**.
- It makes available **tools** which can be used by **non-expert** users too.
- Galaxy defines a **workflow** as a **reusable templates** which contains different algorithms applied to the input data.
- In order to achieve **reproducibility** the system stores:
 - the **input dataset**,
 - the **tools** and **algorithms** which were applied to the data along the **chain**,
 - the **parameters**,
 - the **output** result.

<https://galaxyproject.org>

3.2 Rapid overview of the RR platforms: Jupyter

Description:

- Spin-off of IPython in 2014.
- Main goal: separate the Python language used in IPython from all the other functionalities needed to run the notebooks (for example, the notebook format, the web framework, or the message protocols).
- Languages: execution kernels in Jupyter.
- Nowadays it supports more than 40 languages that can be used as kernels.

<http://jupyter.org>

3.2 Rapid overview of the RR platforms: Code Ocean

Description:

- Stated in **2014** as part *Runway Startup Postdoc Program* at the Jacobs Technion Cornell Institute.
- Sponsored by **IEEE**.
- Defined by themselves as a **computational reproducibility platform**.
- **Not a journal** itself. It only runs code, but not publishes articles.
- Assigns a **DOI** to each source code.
- **Several languages** accepted: Python, R, Julia, Matlab, Octave, C++, Fortran, Perl, Java
- They claim *to view and download for everyone for free*. The free plan is **limited** and the other are **paid**.
- **Plans** based on **CPU time** and **storage** usage. For example, the *researcher* plan allows 1h CPU and 5GB of storage per month.
- **No statistics** on usage. **Seems low** by website inspection.

<https://codeocean.com/>

3.2 Rapid overview of the RR platforms: DAE

Description: [Lamiroy & Lopresti 16]

- Platform for Document Analysis and Exploitation.
- Allows to run document analysis algorithms and apply comparisons.

The screenshot shows the homepage of the DAE platform at dae.cse.lehigh.edu. The page has a dark header with the title "Document Analysis and Exploitation". The left sidebar contains sections for "Project Description", "Events and Initiatives", "Analysis Services", "Technical Issues", and "Navigation". The main content area features a "Algorithms" section listing various document processing tools like convert, Stanford-NER, Tesseract, ocrad, NCI-CADD segmentation, MergeImageList, NCI-CADD binarization, DICE, QGar Arc Detection, Kanungo Degradation, and ArcEval, each with its version number. To the right, there's a sidebar with "Recent blog posts" and a "Twitter" feed.

<http://dae.cse.lehigh.edu>

3.2 Rapid overview of the RR platforms: DAE

Description: [Lamiroy & Lopresti 16]

- Platform for Document Analysis and Exploitation.
- Allows to run document analysis algorithms and apply comparisons.
- RR framework for document analysis with image data base.

The screenshot shows the DAE platform interface. At the top, there is a navigation bar with links for User login, Contact us, Copyright Alert, and Job Offerings. A sidebar on the left contains sections for Project Description, Events and Initiatives, Analysis Services, Technical Issues, and Navigation. The main content area features a "Browse Data" section displaying various datasets with thumbnails, titles, ratings, and tags. To the right, there is a sidebar for "Recent blog posts" and a "Twitter" section.

Project Description

- DAE
- Tutorial
- Give Your Opinion

Events and Initiatives

- DAS 2012
- ICDAR 2011 Contest
- DAS 2010

Analysis Services

- Algorithms
- Browse Data
 - About Copyright
- Other Resources

Technical Issues

- Give Your Input

Navigation

- Recent posts

Document Analysis and Exploitation

Browse Data

Browse: New Top Rated Popular Search Names and Tags Filter: All Datasets Root Datasets Page Images

Dataset	Rating	Tags
Lehigh Notebook	★★★★★	0 TAGS: No Tags Yet
UNLV	★★★★★	2 TAGS: No Tags Yet
GREC 2011 Arc Segmentation Contest [Test Images]	★★★★★	0 TAGS: No Tags Yet
GREC 2011 Symbol Recognition Training Set	★★★★★	0 TAGS: No Tags Yet
GREC 2011 Symbol Recognition (OBSOLETE)	★★★★★	0 TAGS: No Tags Yet

Recent blog posts

- Account Requests
- DAE is on Twitter
- Source Code Available
- DAE Public Live
- DAS 2010 Demo Poster

Twitter

3.2 Rapid overview of the RR platforms: IPOL Journal

Description: [Arevalo et al. 16]

- A complete peer-reviewed journal can be considered as a platform.
- Image Processing domain.
- Focused on mathematical rigour. Detailed descriptions.
- Fast to create new demos for editors: automatic system.
- Accepted languages: C/C++, Python, MATLAB, Octave.
- Free to use/submit.
- Next move: machine learning applications. Servers with GPU.

<https://www.ipol.im>

3.3 New Ways of Publications

Recent original journals

- IPOL

<https://www.ipol.im>

- ReScience

<http://rescience.github.io>

- JOSS

<https://joss.theoj.org>

3.3 New Ways of Publications: Image Processing On Line

Origin: <http://www.ipol.im>

- Journal started in October 2009.
- Initiative of Nicolas Limare and Jean-Michel Morel (CMLA).
- First article published in 2010.
- Domain of Image Processing.



3.3 New Ways of Publications: Image Processing On Line

Origin: <http://www.ipol.im>

- Journal started in October 2009.
- Initiative of Nicolas Limare and Jean-Michel Morel (CMLA).
- First article published in 2010.
- Domain of Image Processing.

Motivations

- Reproducible Research.
- New way to publish research results.
- Allows everybody to test the algorithms (with their own images).
- Free online demonstration (user-platform independant) and source code.

3.3 New Ways of Publications: Image Processing On Line

Short overview

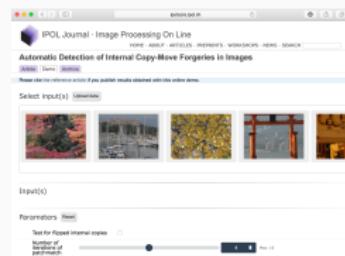
- Journal publishing **algorithm** description, **source code**, online demonstration with experiment archives.



3.3 New Ways of Publications: Image Processing On Line

Short overview

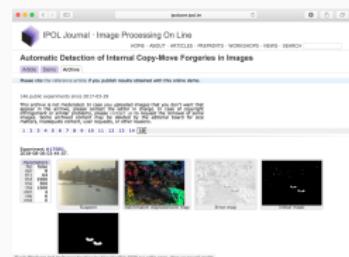
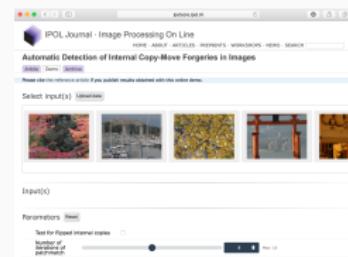
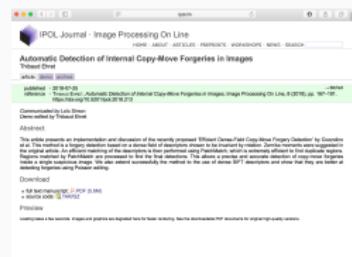
- Journal publishing algorithm description, source code, **online demonstration** with experiment archives.



3.3 New Ways of Publications: Image Processing On Line

Short overview

- Journal publishing algorithm description, source code, online demonstration with **experiment archives**.



3.3 New Ways of Publications: Image Processing On Line

Short overview

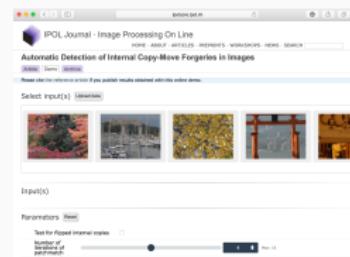
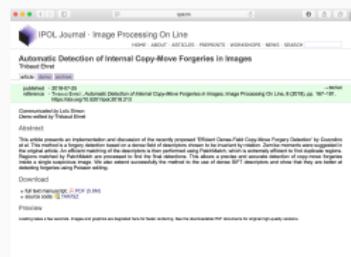
- Journal publishing algorithm description, source code, online demonstration with **experiment archives**.
- The peer-review process includes the article, and source code.



3.3 New Ways of Publications: Image Processing On Line

Short overview

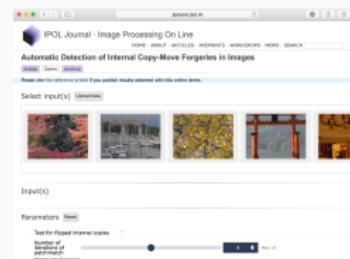
- Journal publishing algorithm description, source code, online demonstration with **experiment archives**.
- The peer-review process includes the article, and source code.
- Open Science journal and Reproducible Research.



3.3 New Ways of Publications: Image Processing On Line

Short overview

- Journal publishing algorithm description, source code, online demonstration with **experiment archives**.
- The peer-review process includes the article, and source code.
- Open Science journal and Reproducible Research.
- Like classic journal: ISSN, DOI, indexed by:
SCOPUS, DBLP, Scirus, Google Scholar, DOAJ, SHERPA/RoMEO, Héloïse, WorldCat, CrossRef, Ulrich, Index Copernicus, PBN, JGate, VisionBib, CVonline, JournalSeek and NewJour.



3.3 New Ways of Publications: Image Processing On Line

Short overview

- Journal publishing algorithm description, source code, online demonstration with **experiment archives**.
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Recent evolution

- New system to automatically create our own online demonstrations (see next session).
- Extended topics to **sound** and **video** processing with **3D** processing.

3.2 ReScience Journal

Philosophy (<http://rescience.github.io>)

- Context of Reproducible research [Buckheit & Donoho 95].
- Explicit replication: propose a new implementation of an existing work.
- Motivated from replication problems in computational science [Hinsen 15], [Topalidou *et al.* 15], [Hinsen 14].



3.2 ReScience Journal

Philosophy (<http://rescience.github.io>)

- Context of Reproducible research [Buckheit & Donoho 95].
- Explicit replication: propose a new implementation of an existing work.
- Motivated from replication problems in computational science [Hinsen 15], [Topalidou *et al.* 15], [Hinsen 14].

Details:

- Origin: first volume in 2015.
- Editorial Board:
 - Editors-in-Chief:
 - Konrad Hinsen (Molecular Biophysics - Python, C, Racket, Clojure).
 - Nicolas P. Rougier (Comp. Neuroscience, Computer Science - Python, C/C++).
 - 11 Associate Editors with roles in: Bioinformatics; Cognitive Modelling; Computational Ecology; Computational Physics; Image processing; Ecology, High-Performance Computing; Physics; Robotics; Signal Processing

3.2 ReScience Journal: short overview

Characteristics

- Same presentation as in a “classic” journal.



3.2 ReScience Journal: short overview

Characteristics

- Same presentation as in a “classic” journal.
- Journal living on *Github*.
- Original submission process through *Pull Request* on *Github*.

The figure consists of four screenshots arranged horizontally. The first three screenshots show the journal's website interface, while the fourth shows a GitHub pull request page.

- Screenshot 1:** The homepage of "The ReScience Journal". It features a header with "The ReScience Journal" and navigation links (ABOUT, READ, PRINT, EDIT, BOARD, PEG). Below the header is a large text block: "Reproducible Science is good. Replicated Science is better." It explains the journal's mission to support reproducibility by publishing code and data alongside research articles. It also mentions the "GitHub pull request submission process".
- Screenshot 2:** A specific article page titled "Current issue". It shows a list of recent publications, such as "Jul 16, 2013: *IPOL* 1(2) (2013) (2013)" and "Jul 16, 2013: *IPOL* 1(1) (2013) (2013)". Each entry includes a thumbnail image, the title, authors, and a "View Article" link.
- Screenshot 3:** An "Overview of the submission process". This page provides detailed instructions for authors, including the role of the editorial board, the review process, and the final steps of publication. It emphasizes the importance of reproducibility and the use of GitHub pull requests.
- Screenshot 4:** A GitHub pull request page for a specific article. The title is "[#6] Spike Timing Dependent Plasticity Finds the Start of Repeating Patterns in Continuous Spike Trains". The pull request was created by "Peter Lethen and Ben F. M. Groen" and is associated with the "IPOL" repository. The page shows the commit history, file changes, and a detailed description of the submission, which includes a screenshot of the journal's interface showing the published article.

3.2 ReScience Journal: short overview

Characteristics

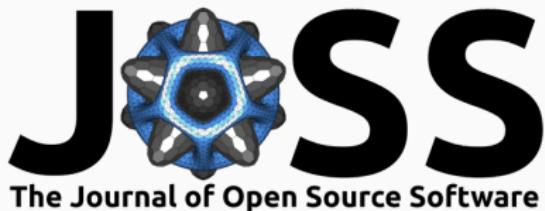
- Same presentation as in a “classic” journal.
 - Journal living on *GitHub*.
 - Original submission process through *Pull Request* on *GitHub*.
 - Peer reviewed journal (**reviews** and **reviewer name** given in the paper).



3.3 JOSS Journal

Journal of Open Source Software (<https://joss.theoj.org>)

- Origin: founded by Arfon M. Smith in May 2016.
- Free and Open Access.
- Peer reviewing.
- Motivated by the fact that [Smith et al. 17]: "*Current publishing and citation do not acknowledge software as a first-class research output*".



3.3 JOSS Journal

Journal of Open Source Software (<https://joss.theoj.org>)

- Origin: founded by Arfon M. Smith in May 2016.
- Free and Open Access.
- Peer reviewing.
- Motivated by the fact that [Smith et al. 17]: "*Current publishing and citation do not acknowledge software as a first-class research output*".

Details

- Design: defined in the current merit system of science.
- Aim: can be considered as a "journal for research software packages".
- Editorial Board:
 - Arfon Smith (@arfon), Editor-in-Chief.
 - 19 Topic Editors: representing: Astronomy; Biodiversity Informatics; Bioinformatics; Computational Science; Data Science; Engineering, Computational Combustion; Computational Social Science; Fluid Dynamics; Energy Engineering; Geophysics; Geoscience; High Perf. Computing; Image; Information Sciences; Machine Learning; Neuroimaging; Nuclear Engineering; Open Science; Psychology; Semantic Web; Social Sciences; Software Deployment; Reproducible Research.

3.3 JOSS Journal: motivations

Motivation of JOSS Editor in chief [Smith et al. 17]:

- Software more and more present in numerous disciplines:
⇒ from a 2014 survey 90% mention to use software and 70% indicates that they were obligatory [Hettrick et al. 14].
- Software leak of scholarly support: no ecosystem of publication, citation, acknowledge.
- JOSS is the contribution to offer modern computational research results.

3.3 JOSS Journal: motivations

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- Software leak of scholarly support: no ecosystem of publication, citation, acknowledge.
- JOSS is the contribution to offer modern computational research results.

As mentioned by Buckheit and Dohono [Buckheit & Donoho 95]:

"An article about computational science in a scientific publication is not the scholarship itself it is merely advertising of the scholarship"

3.3 JOSS Journal: characteristics

Specific form:

- Form: **voluntary short**: short abstract length (author names, list of key references, a link to software repository and a short description of the content)

The screenshot shows a web browser displaying the JOSS (The Journal of Open Source Software) website. The URL in the address bar is `joss.theoj.org`. The page title is "jstor: Import and Analyse Data from Scientific Texts". The main content area displays the article details for this specific paper.

Article details

- View review »
- Download paper »
- Software repository »
- Software archive »

Submitted: 07 August 2018
Accepted: 08 August 2018

Cite as:
Klebel, (2018). jstor: Import and Analyse Data from Scientific Texts . Journal of Open Source Software, 3(28), 883, <https://doi.org/10.21105/joss.00683>

Status badge

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JOSS
The Journal of Open Source Software

jstor: Import and Analyse Data from Scientific Texts

Thomas Klebel
I Department of Sociology, University of Graz

Summary

The interest in text-as-data has seen a sharp increase in the past few years, mostly due to the advent of methods for automated text analysis. At the same time, researchers within the field of econometrics have analysed citations and other aspects of the scholarly literature with great sophistication. The archival content of JSTOR offers a rich and diverse set of primary sources like research articles or book chapters for both approaches. Data-for-Research (DFR) by JSTOR gives all researchers, regardless of whether they have access to the full-text or not, the ability to analyse the archival content. In this special request, full-text metadata about all journal articles and books from JSTOR. The package `jstor` (Klebel, 2018) helps in analysing these datasets by enabling researchers to easily import the metadata to R (R Core Team, 2018), a task, for which no other integrated solution exists to date.

The metadata from DFR can either be analysed on their own or be used in conjunction with n-grams or full-text data. Commonly, metadata from DFR include information on the article's authors, their title, journal, date of publishing, and quite frequently all footnotes and references. This information can be of interest for specific research questions. For the analysis of n-grams or full-texts, the metadata imported with `jstor` allow the researchers to filter articles based on specific journals, the dates of publication, the authors,

3.3 JOSS Journal: characteristics

Specific form:

- Form: **voluntary short**: short abstract length (author names, list of key references, a link to software repository and a short description of the content).
- **Not allowed**: **API** or **novel research** descriptions.

3.3 JOSS Journal: characteristics

Specific form:

- Form: **voluntary short**: short abstract length (author names, list of key references, a link to software repository and a short description of the content).
- **Not allowed**: **API** or **novel research** descriptions.
- Same characteristics than other journals: ISSN, Crossref DOI.
- Code Review: **direct visibility**
⇒ collaboration with classic development tools (based on *GitHub*).

3.3 JOSS Journal: characteristics

Specific form:

- Form: **voluntary short**: short abstract length (author names, list of key references, a link to software repository and a short description of the content).
- **Not allowed**: **API** or **novel research** descriptions.
- Same characteristics than other journals: ISSN, Crossref DOI.
- Code Review: **direct visibility**
⇒ collaboration with classic development tools (based on *Github*).

Content requested:

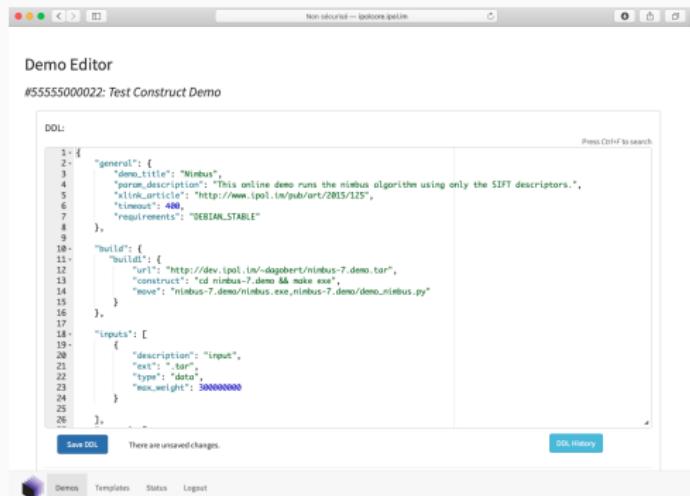
- Software need to be **open source**.
- **Research** application.
- Submitter needs to be **main software contributor**.
- Significant new contribution.
- **Feature-complete** (not partial).

4. Practical Session: Hands on IPOL Demos

4. Practical session: hands on the IPOL Demonstration System

Focus on online demonstration

- Construction of demonstration from your own code.
- New Demo Editor panel:
 - to construct your demonstration without hard coding the demo.



The screenshot shows a web-based application window titled "Demo Editor". The URL in the address bar is "Non secured — ipolone.ipol.eu". The main content area is titled "#55555000022: Test Construct Demo". Below the title, there is a code editor containing a JSON document. The JSON document defines a "general" object with fields like "demo_title" (set to "Nimbus"), "param_description" (describing the SIFT descriptors), "url_ncs" (a URL to a tar archive), "size": 400, and "requirements": "DEBIAN_STABLE". It also contains a "builds" array with one item, which includes a "url" field pointing to a tar archive and a "construct" command to run the demo and make an executable named "nimbus-7-demo.exe". The "inputs" array contains one item, which is a file named "input" with a ".tar" extension, type "data", and a maximum weight of 300000000. At the bottom of the code editor, there are buttons for "Save DOL" and "DOL History". The status bar at the bottom indicates "There are unsaved changes." The navigation bar at the bottom includes links for "Demos", "Templates", "Status", and "Logout".

```
1- {
2-   "general": {
3-     "demo_title": "Nimbus",
4-     "param_description": "This online demo runs the nimbus algorithm using only the SIFT descriptors.",
5-     "url_ncs": "http://www.ipol.im/pub/art/2013/l25",
6-     "size": 400,
7-     "requirements": "DEBIAN_STABLE"
8-   },
9-   "builds": [
10-     {
11-       "url": "http://dev.ipol.im/~dagobert/nimbus-7.demo.tar",
12-       "construct": "cd nimbus-7.demo && make exe",
13-       "move": "nimbus-7.demo/nimbus.exe,nimbus-7.demo/demo_nimbus.py"
14-     }
15-   ],
16-   "inputs": [
17-     {
18-       "description": "input",
19-       "ext": ".tar",
20-       "type": "data",
21-       "max_weight": 300000000
22-     }
23-   ]
24- },
25- .
26- }
```

4. Practical session: hands on the IPOL Demonstration System

Focus on online demonstration

- Construction of demonstration from your own code.
- New Demo Editor panel:
 - to construct your demonstration without hard coding the demo.
- Interpreted in live from the online editor.

The screenshot shows a web-based application window titled "Demo Editor". The URL in the address bar is "Non secured — ipolcore.ipol.in". The main content area displays a JSON configuration file for a demonstration:

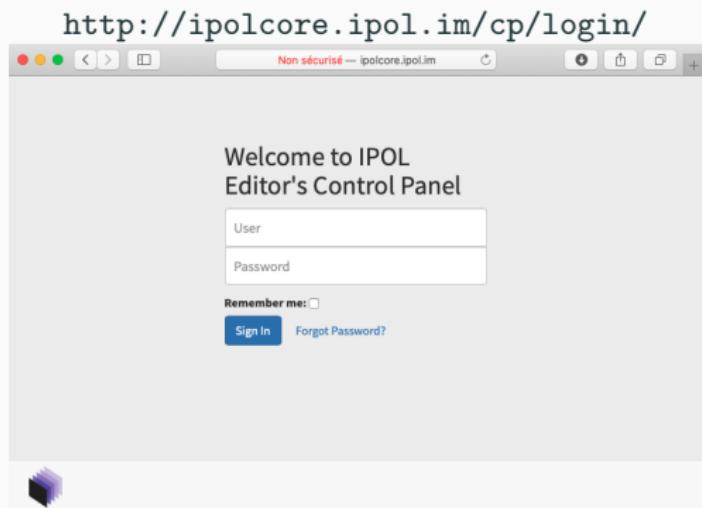
```
DDL:
1- {
2-   "general": {
3-     "demo_title": "Nimbus"
4-   },
5-   "param_description": "This online demo runs the nimbus algorithm using only the SIFT descriptors.",
6-   "link_article": "http://www.ipol.in/pub/art/2015/125",
7-   "timeout": 400,
8-   "requirements": "DEBIAN_STABLE"
9- },
10- "build": {
11-   "build": {
12-     "url": "http://dev.ipol.in/~dogobert/nimbus-7-demo.tar",
13-     "construct": "cd nimbus-7-demo && make exec",
14-     "move": "nimbus-7-demo/nimbus.exe,nimbus-7-demo/demo_nimbus.py"
15-   }
16- },
17- "inputs": [
18-   {
19-     "description": "input",
20-     "ext": ".tar",
21-     "type": "data",
22-     "max_weight": 30000000
23-   }
24- ],
25- }
```

At the bottom of the editor, there are buttons for "Save DDL" and "DBL History". A status message "There are unsaved changes." is displayed. The navigation bar at the bottom includes "Demos", "Templates", "Status", and "Logout".

4. Practical session: hands on the IPOL Demonstration System

What you need to construct your demonstration

1. Request a demo editor account (when submitting a paper to IPOL)
→ use temporary account to experiment the construction.
2. Image based source code archive (to be available online).
3. Typical command line/parameters.



4. Practical session: first step

Step 1: main demo repository construction

1. Login on : <http://ipolcore.ipol.im/cp/login>

(login: acpr2019 password: 222hhh888k)

2. Add a new Demo.

3. Select an number ID and titles using this convention:

DemoID: 555559000XX Title: ACPRMyTestDemoXX

List of Demos

Search

Add a new Demo

My test demo		Date test	Last modification: 28 Oct 2018
My Crash demo		Date workshop	Last modification: 30 Sep 2018
My Crash demo		Date workshop	Last modification: 12 Oct 2018
My Extension of I		Date workshop	Last modification: 04 May 2018

Demosa Templates Status Logout

New Demo data

Demo ID ACPRMyTestDemoXX

Title ACPRMyTestDemoXX

Status Test Demo

Close

List of Demos

My test demo		Date test	Last modification: 28 Oct 2018
My Crash demo		Date workshop	Last modification: 30 Sep 2018
My Crash demo		Date workshop	Last modification: 12 Oct 2018
My Extension of I		Date workshop	Last modification: 04 May 2018

Demosa Templates Status Logout

List of Demos

ACPRMyTestDemoXX

Date test Last modification: 31 Nov 2018

Page 1 of 1

Demosa Templates Status Logout

4. Practical session: second step

Step 2: Edit configuration file

1. Start from the base example available from the tutorial repository:

<https://github.com/kerautret/ACPR19-DGPTutorial> file: [PracticalSession/exDemoDDL.txt](#)



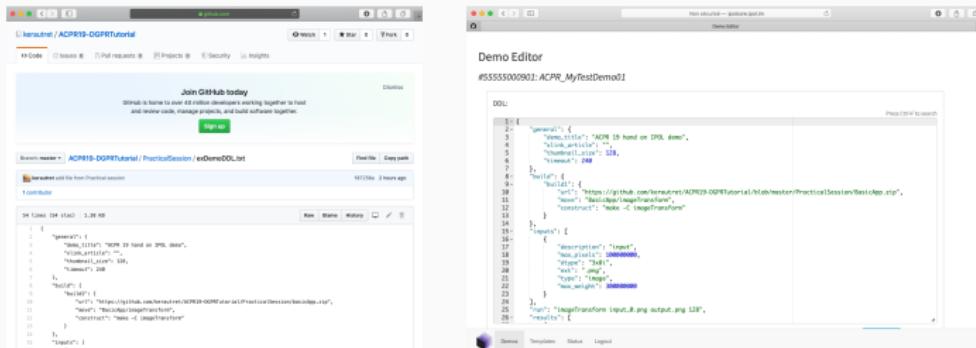
4. Practical session: second step

Step 2: Edit configuration file

1. Start from the base example available from the tutorial repository:

<https://github.com/kerautret/ACPR19-DGPTutorial> file: PracticalSession/exDemoDDL.txt

2. Copy the content in the demo editor panel.



4. Practical session: second step

Step 2: Edit configuration file

- Start from the base example available from the tutorial repository:

<https://github.com/kerautret/ACPR19-DGPRTutorial> file: **PracticalSession/exDemoDDL.txt**

- Copy the content in the demo editor panel.

- Ajust parameters and your source code link: (or this toy example)

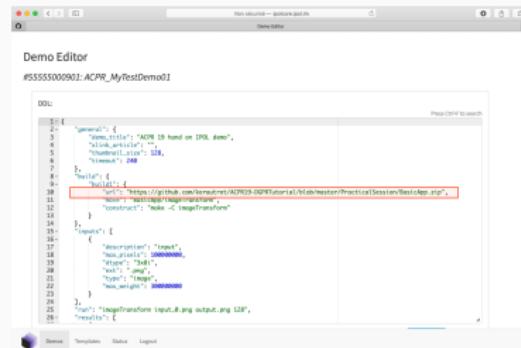
<https://github.com/kerautret/ACPR19-DGPRTutorial> file: **PracticalSession/BasicApp.zip**



```

1  {
2     "general": {
3         "name": "exDemo", // DEMO 19 hand on IPOL demo",
4         "alias": "exDemo", // DEMO 19 hand on IPOL demo",
5         "version": "0.1", // DEMO 19 hand on IPOL demo",
6         "author": "IPOL", // DEMO 19 hand on IPOL demo",
7         "email": "249"
8     },
9     "url": {
10        "base": "https://github.com/kerautret/ACPR19-DGPRTutorial/blob/master/PracticalSession/BasicApp.zip",
11        "script": "https://github.com/kerautret/ACPR19-DGPRTutorial/blob/master/PracticalSession/BasicApp.js"
12    },
13    "inputs": [
14        {
15            "description": "Input 1", // DEMO 19 hand on IPOL demo",
16            "type": "file", // DEMO 19 hand on IPOL demo",
17            "url": "https://github.com/kerautret/ACPR19-DGPRTutorial/blob/master/PracticalSession/BasicApp.js", // DEMO 19 hand on IPOL demo",
18            "name": "BasicAppInput", // DEMO 19 hand on IPOL demo",
19            "constraints": "None", // DEMO 19 hand on IPOL demo",
20            "weight": 1 // DEMO 19 hand on IPOL demo
21        }
22    ],
23    "outputs": []
24 }

```



4. Practical session: last step

Step 3: Select Blobs and start!

1. Need to select the default images to test your demo: use the "Blobs".
2. Customize (or not default blob).

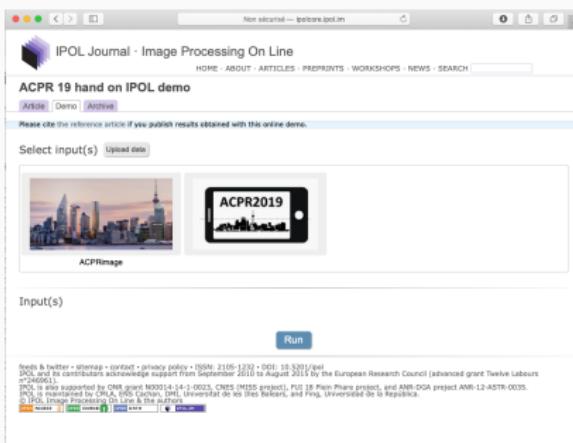


4. Practical session: last step

Step 3: Select Blobs and start!

1. Need to select the default images to test your demo: use the "Blobs".
2. Customize (or not default blob).
3. Check the resulting online demo! (using following url)

<http://ipolcore.ipol.im/demo/clientApp/demo.html?id=555559000XX>



4. Practical session: customize parameters

Exercice

1. Add a new parameter on the demonstration.

→ instead using the default parameter, add a 'params' section in the DDL.
→ use \$ to transmit the parameter.

The screenshot shows a web browser window with the URL [Non sécurisé — ipolcore.ipol.im](http://ipolcore.ipol.im). The page title is "IPOL Journal - Image Processing On Line". The main content area is titled "ACPR 19 hand on IPOL demo". It features two images: "ACPRImage" (a city skyline) and "ACPR2019" (a smartphone displaying a city skyline). Below these images is a "Parameters" section with a "Reset" button. A slider is set to "58" with "Max: 255". At the bottom of the page is a footer with links to "fees & waiver", "atmap", "contact", "privacy policy", "ISSN: 2100-1232 • DOI: 10.5301/ipol", "IPOL and its contributors acknowledge support from September 2010 to August 2015 by the European Research Council (advanced grant Twelve Labours n°246961). IPOL is also supported by ANR grant N0014-14-1-0023, CNES (MISS project), FUI 18 Iren Phare project, and ANR-DGA project ANR-12-ASTR-0035.", "IPOL is maintained by CNRS, EPFL, Inria, DMF, Universitat de les Illes Balears, and Fing, Universidad de la Republica.", "© IPOL 2019. All rights reserved. On the & the IPOL logo", and "IPOL ACCESS", "IPOL DOWNLOAD", "IPOL DATA", and "IPOL API".

4. Practical session: customize parameters

Exercice

1. Add a new parameter on the demonstration.

→ instead using the default parameter, add a 'params' section in the DDL.
→ use \$ to transmit the parameter.

```
22 < "params": [
23 < {
24 <   "id": "parameterID",
25 <   "label": "Label description...",
26 <   "type": "range",
27 <   "values": {
28 <     "default": 50,
29 <     "max": 100,
30 <     "min": 0,
31 <     "step": 1
32 <   }
33 > },
```

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Thank you for your attention!

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