Fusions of Ground Truths and of Hierarchies of Segmentations*

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Journee ISS
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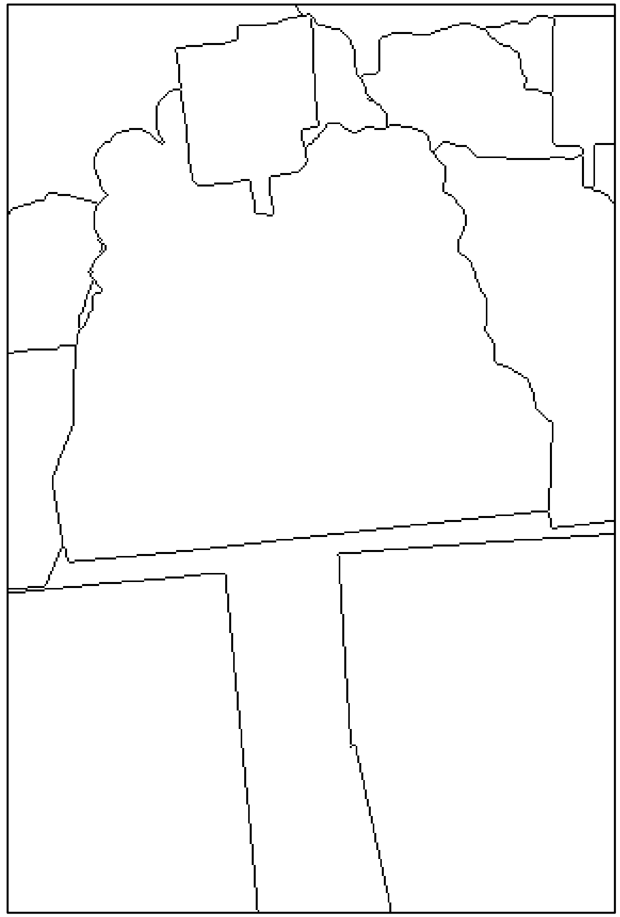
Problem context

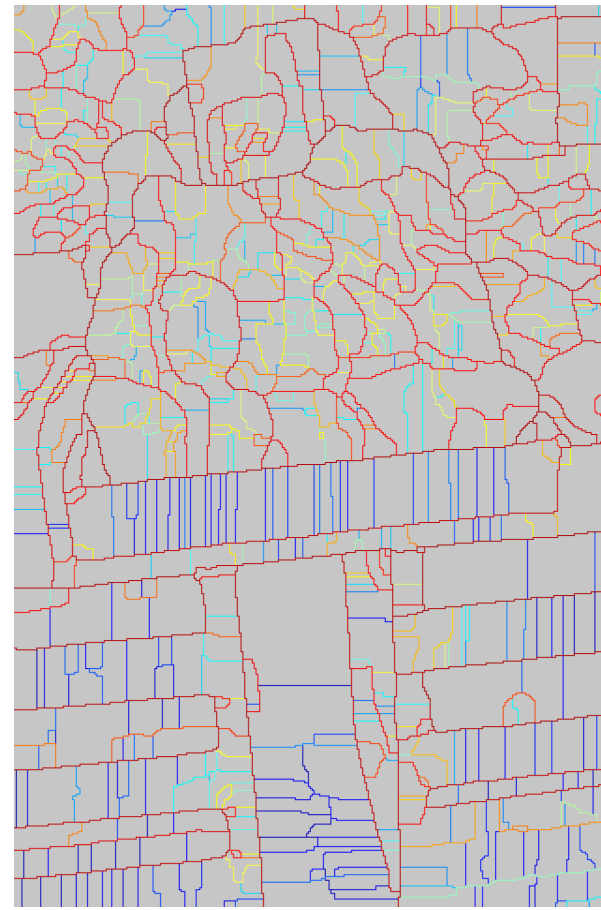
Theory of Optimal Cuts (PR 2013)	Energy minimization on hierarchies of partitions
Ground truth energies (ISMM 2013)	Extracting closest cut in hierarchy to ground truth set.
Saliency transforms (SSVM 2013)	Using distance function of ground truth to **reorder saliency values**
Current Work (Submitted to PRL 2014)	Lattice of Jordan Curves

Ground truth Evaluation of Hierarchies
The Saliency function

Input Image



Ground truth Set



Saliency Function

[Najman Schmidt 1995]
[Arbelaez UCM 2011]

Transforming Saliency functions

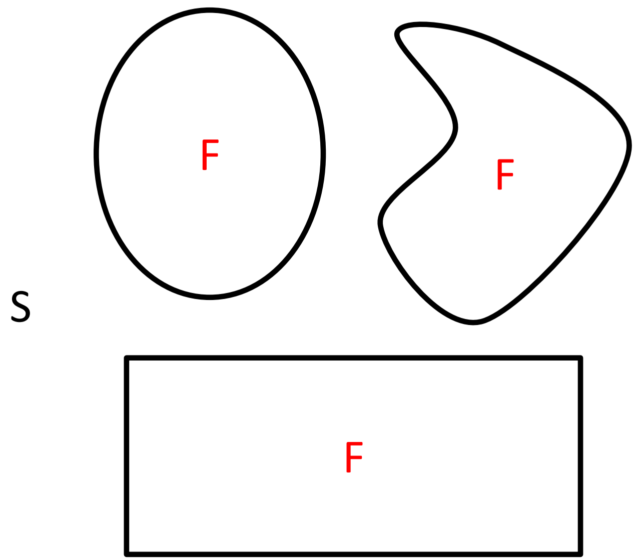
- What do we need to describe a partition of the space?
- Introduces external information on hierarchy of partitions.
- Transforming hierarchy of partitions by proximity to ground truth set.
- Transforming the hierarchies using intrinsic features of the partition.
- Where is the lattice in these problems ?

Assumptions

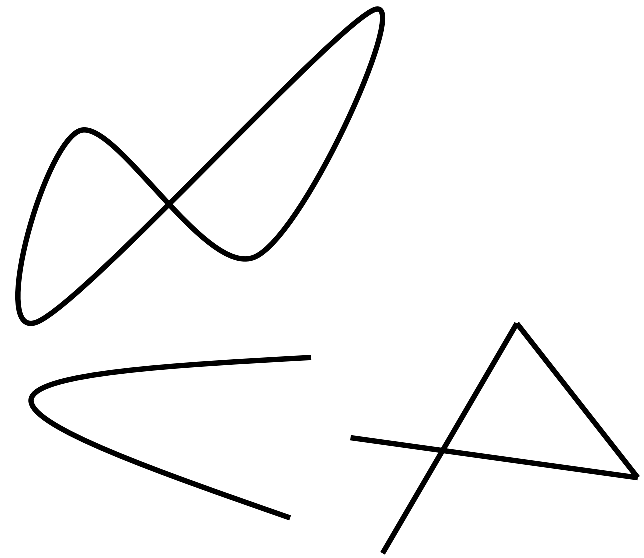
1. The working space is Euclidean plane $\mathbb{R}^2$,
2. $\mathbb{R}^2$ is partitioned into faces and contours by Jordan curves,
3. There exists a finest partition with a **finite** number of faces, called leaves.

This last axiom permits to construct a lattice structure and hierarchies.

Jordan Curves



Jordan Curves



Not Jordan Curves

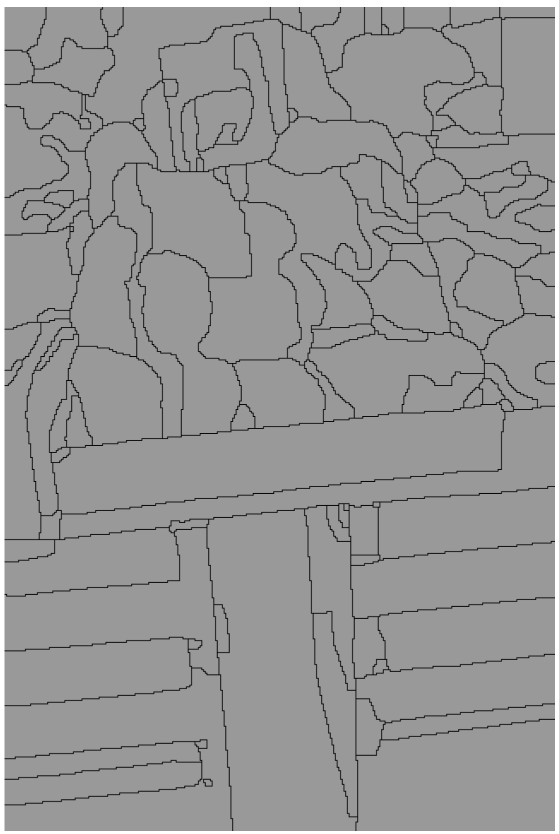
Jordan Curves can be fractal, but they still split $\mathbb{R}^2$.

[Morel Solimni 1995]
[Monasse Guichard 1998]

We do not measure lengths here.

Jordan Net: Ordering Jordan Curves

Jordan Net N_0, is set of Jordan curves C_i that delineate a finite numbered open faces F_i



N_0

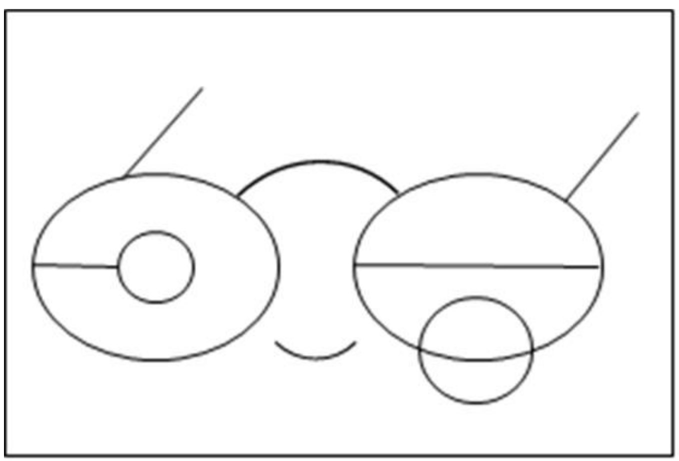
Two Lattices:
$\mathcal{P}(N_0)$- sets whose points in N_0
$\mathcal{N}(N_0)$ of all J-nets included in N_0

Jordan Net Opening

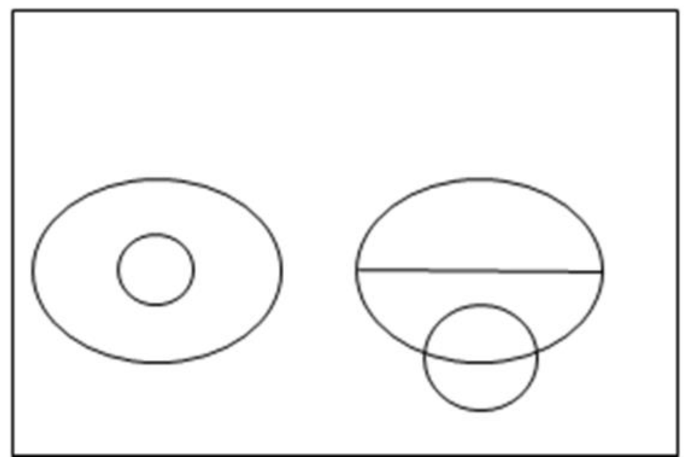
Given $X \in \mathcal{P}(N_0)$ the union $\gamma(X)$ of Jordan curves C contained in X

$$\gamma(X) = \cup\{C \subseteq X, C \in \mathcal{N}(N_0)\}$$

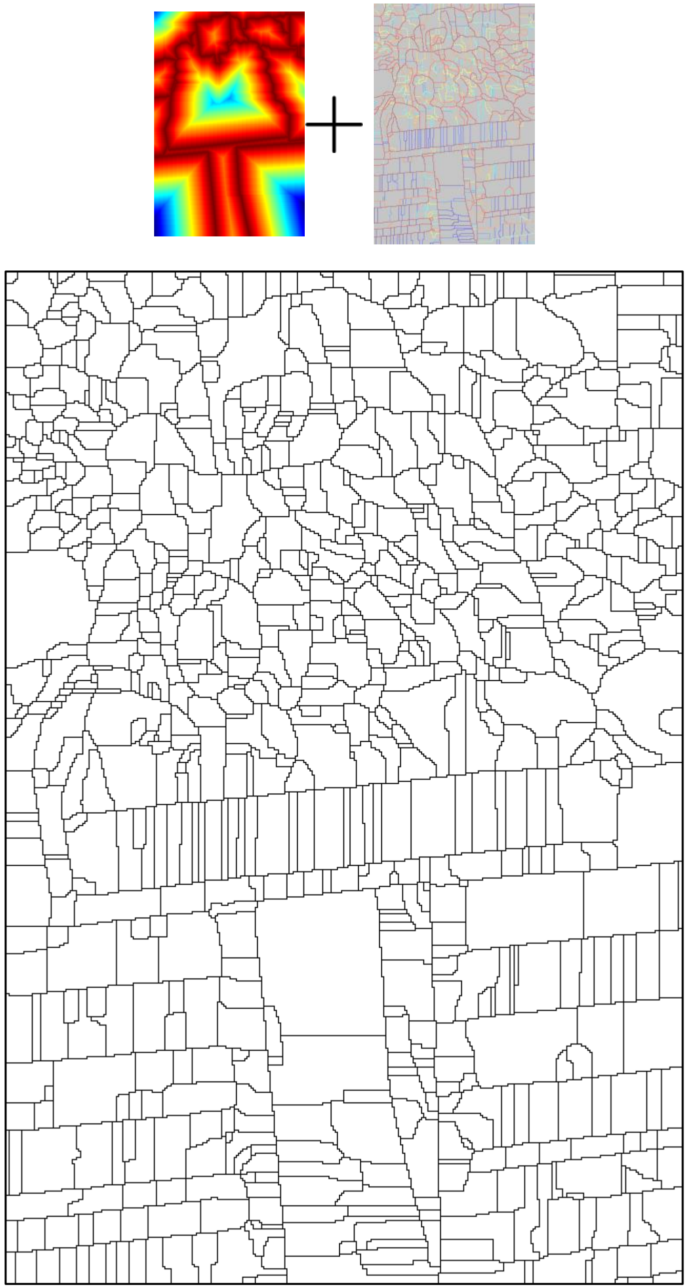
X



$\gamma(X)$

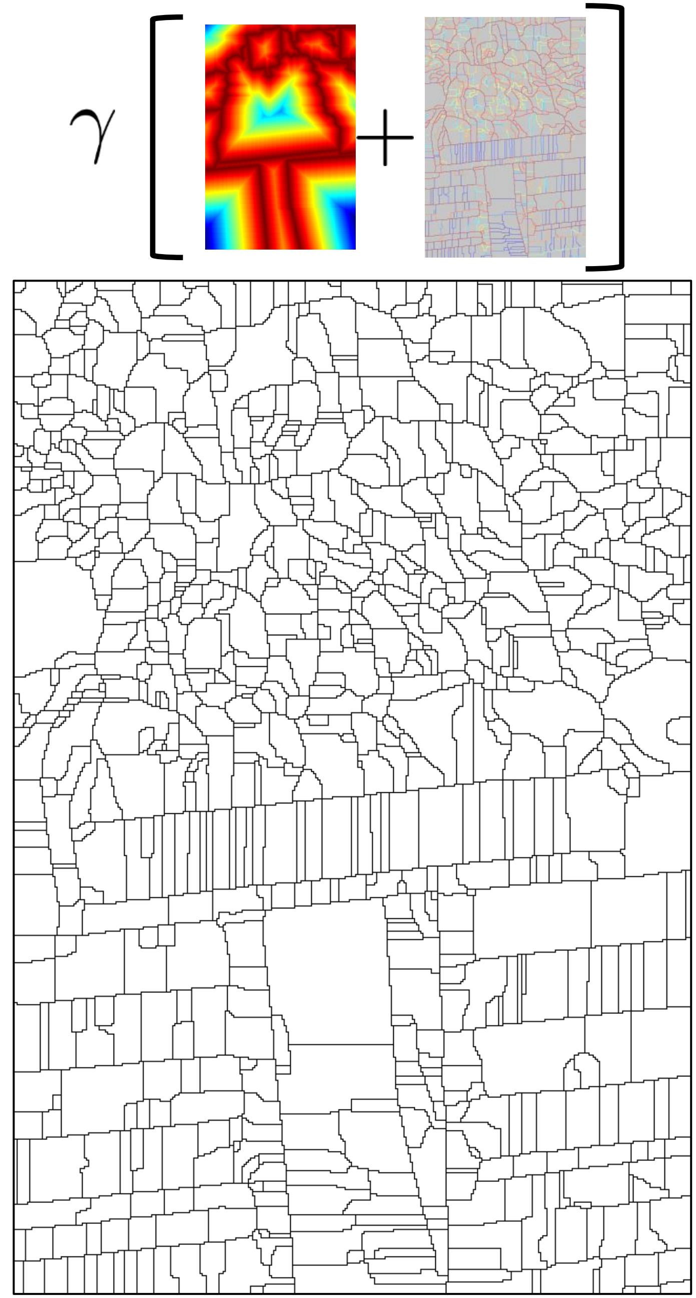


$X_t[\gamma(\varphi)] = \gamma[X_t(\varphi)], \quad t > 0$. Numerical Version by stacking.



Thresholded similarity function

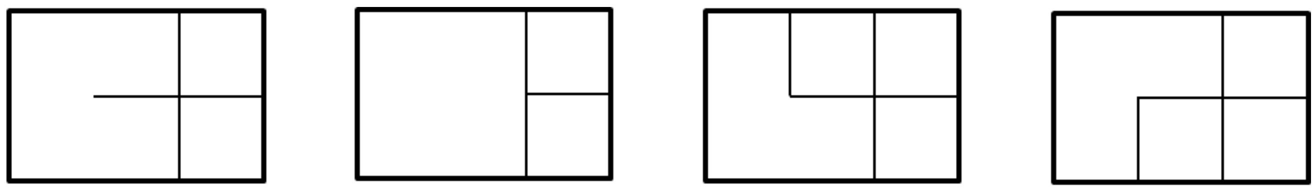
φ_t



Net opening

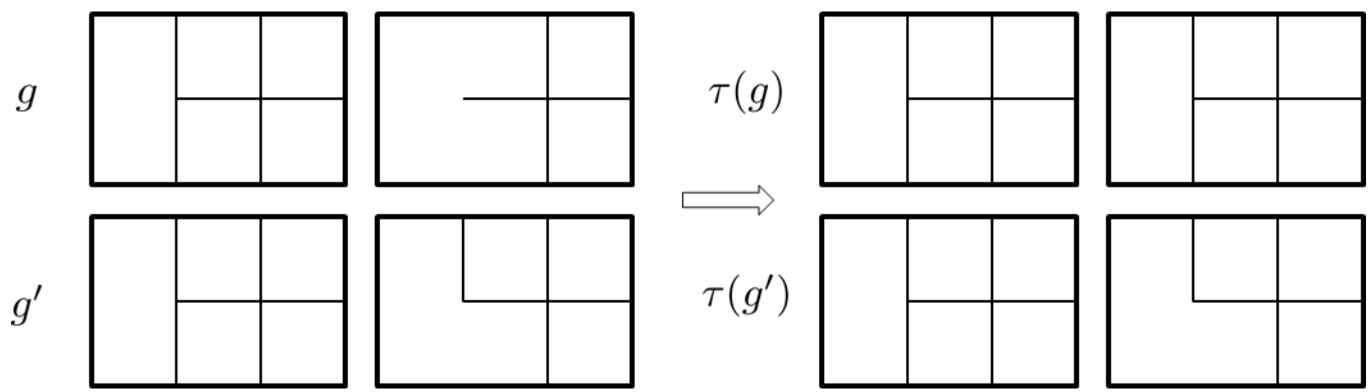
$\gamma(\varphi_t)$

Lack of upper bounds



Level set $X_t = g \geq t$ Net opening $\gamma(X_t)$ Two possible pseudo-closing solutions

No unique closing possible.



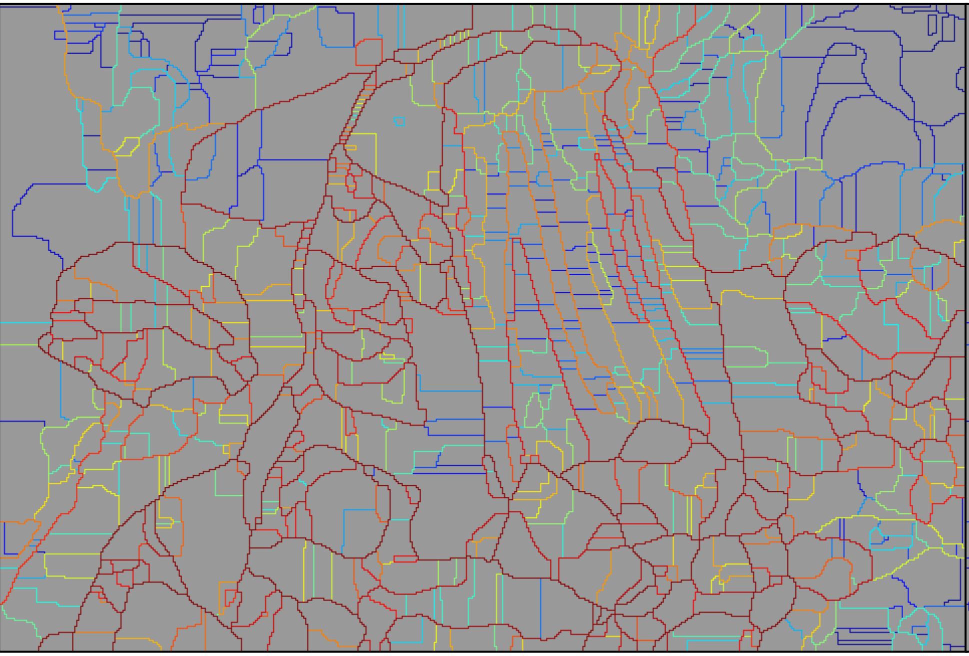
$g < g'$ $\tau(g) > \tau(g')$

The dual closing is not increasing.

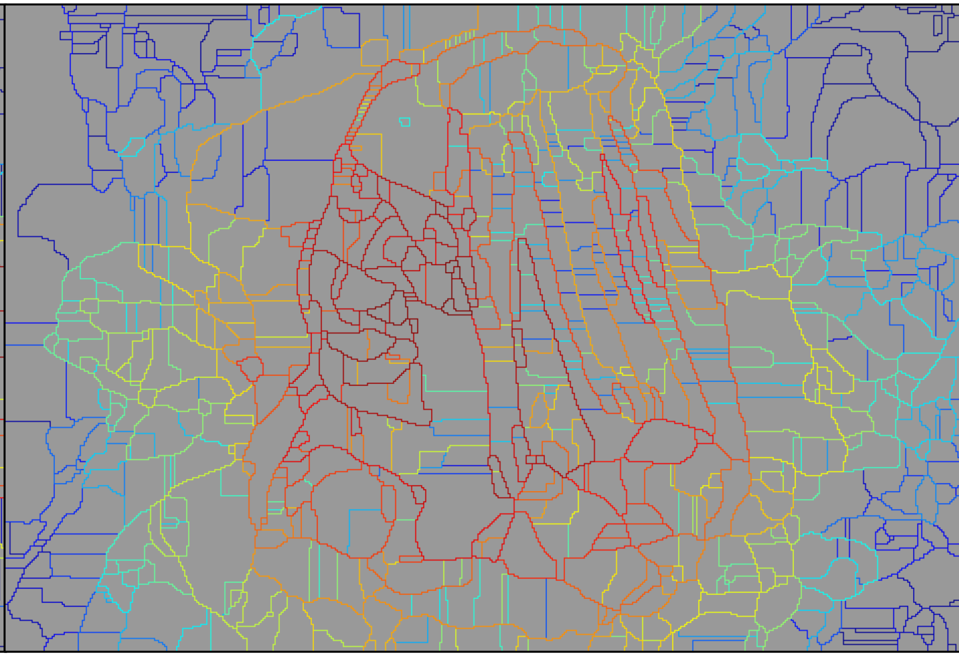
Applications

1. Introducing proximity to GT
2. Measure for structural changes
3. Transforming quadtrees to K-d Trees
4. Using intrinsic properties: Curvature
5. Application to GIS data:
   Transforming commune contours

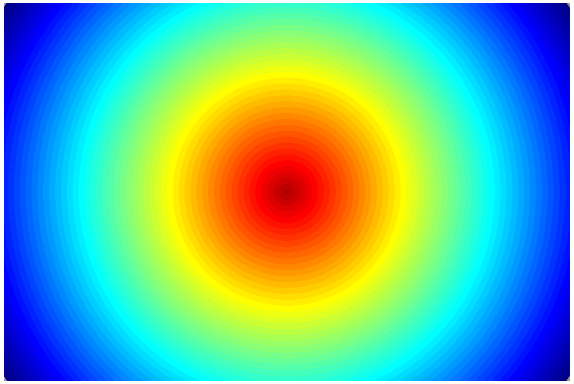
Introducing External functions



Input Saliency s

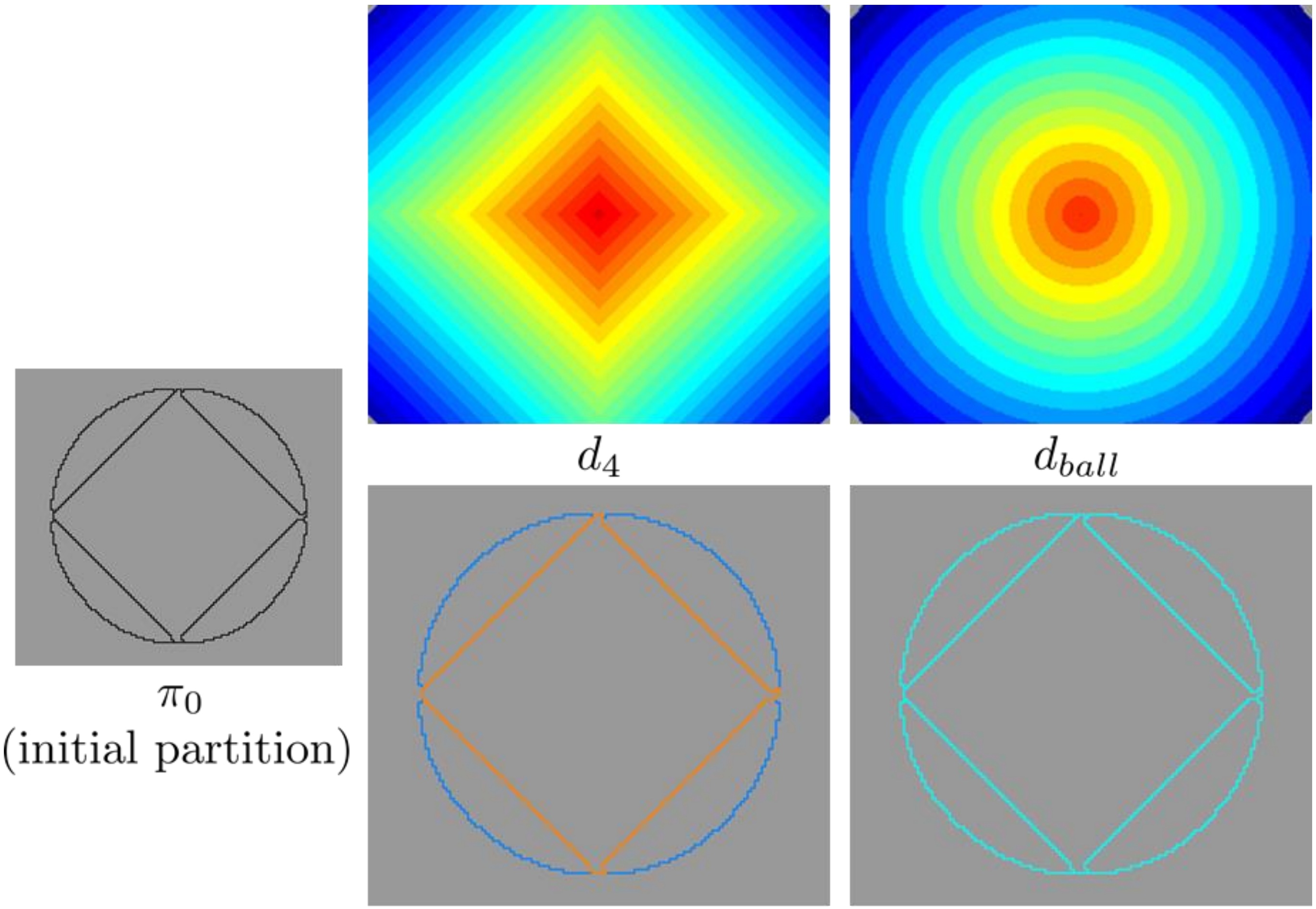


Transformed Saliency $\gamma(s + d_{pt})$



Point Distance function d_{pt}

Distance function scale space



π_0
(initial partition)

d_4

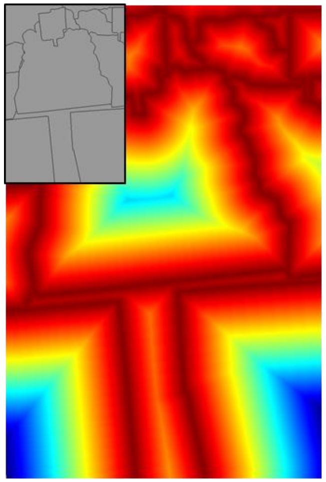
d_{ball}

$\gamma(d_4 + \pi_0)$

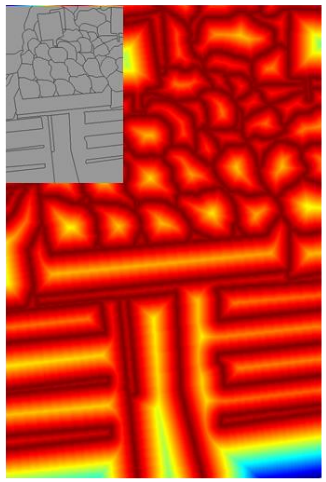
$\gamma(d_{ball} + \pi_0)$

Measuring Structural Changes

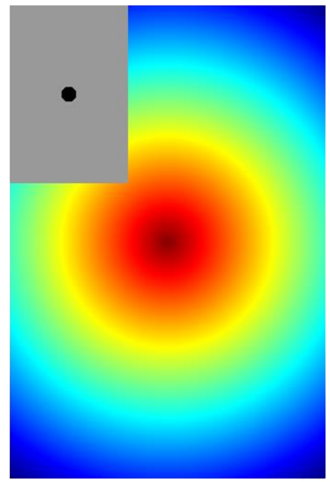
$$M = \frac{\|\pi_i\|_L}{\|\pi_{i+1}\|_L} = \frac{\#labels \quad in \quad childLevel}{\#labels \quad in \quad parentLevel}$$



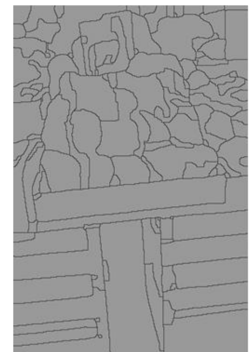
d_{GT2}



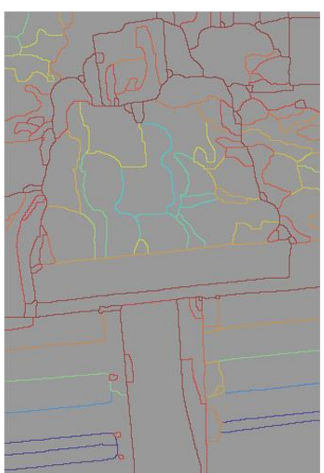
d_{GT4}



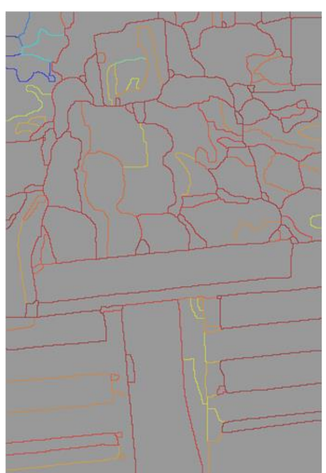
d_{pt}



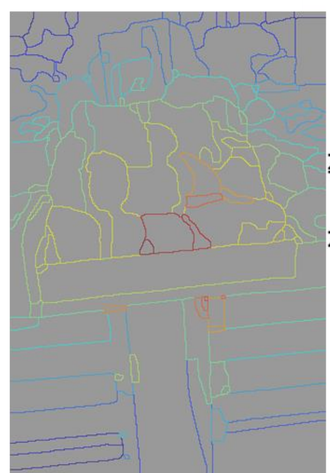
π_0 (leaves partition)



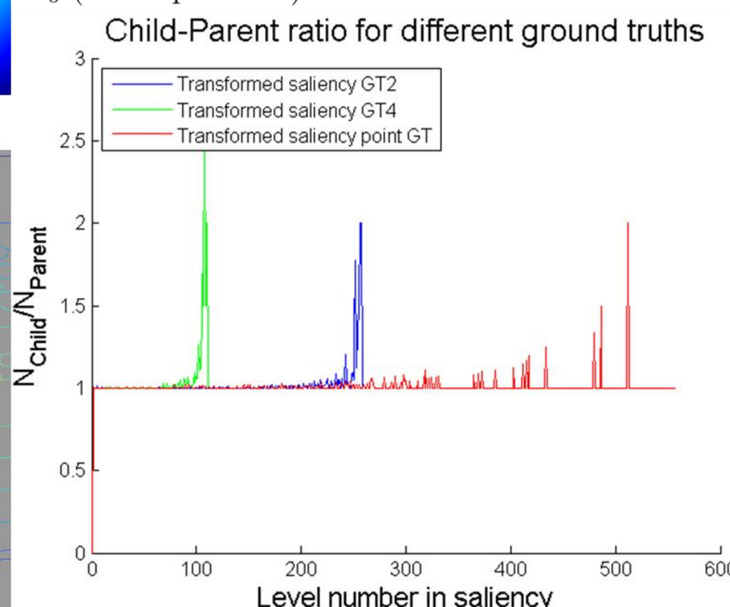
$\gamma(\pi_0 + d_{GT2})$



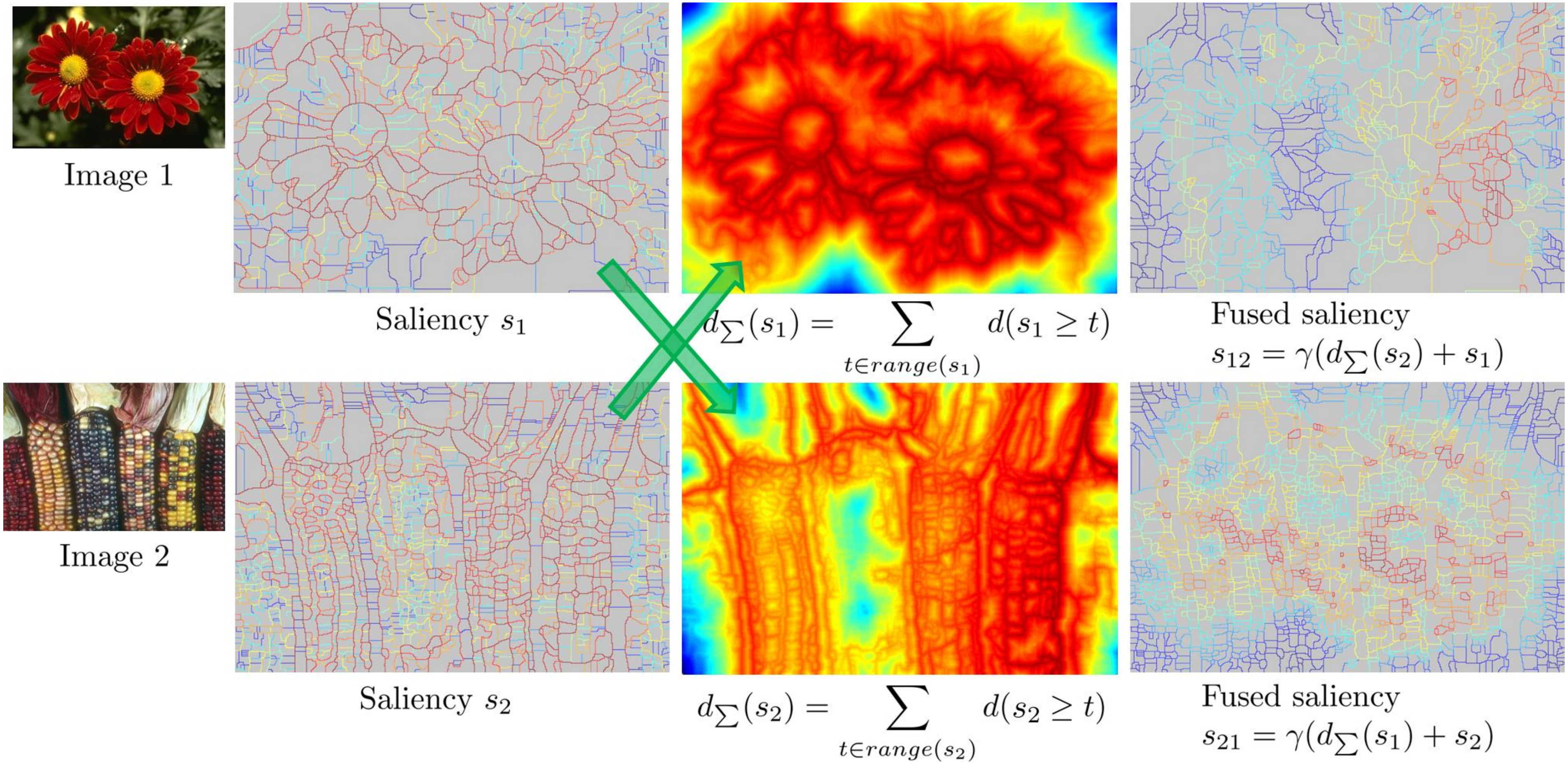
$\gamma(\pi_0 + d_{GT4})$



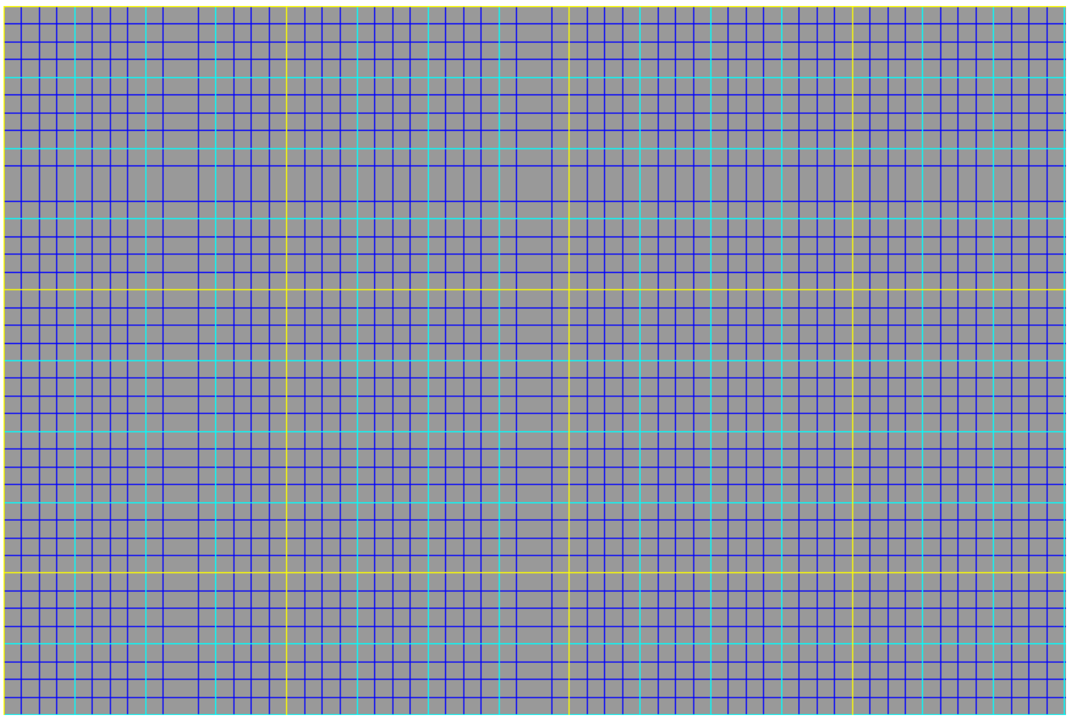
$\gamma(\pi_0 + d_{pt})$



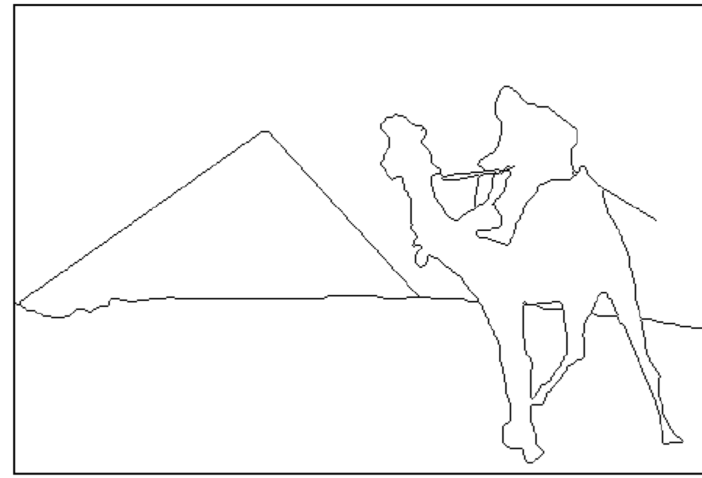
Fusion of Hierarchies



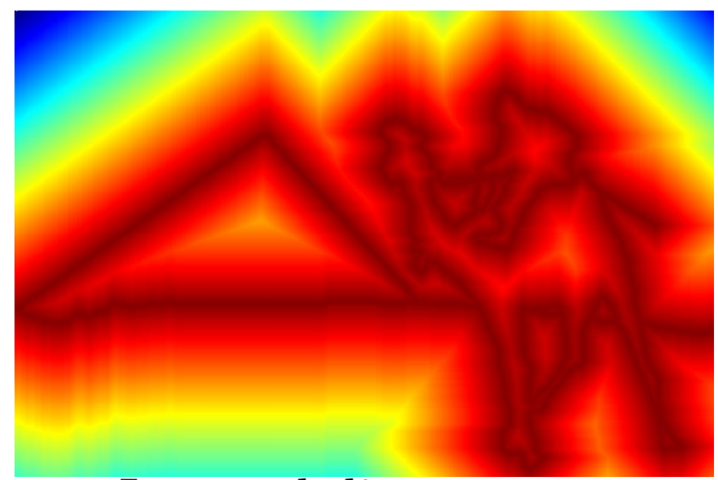
QuadTree to K-D Tree



Initial quadTree saliency s^4

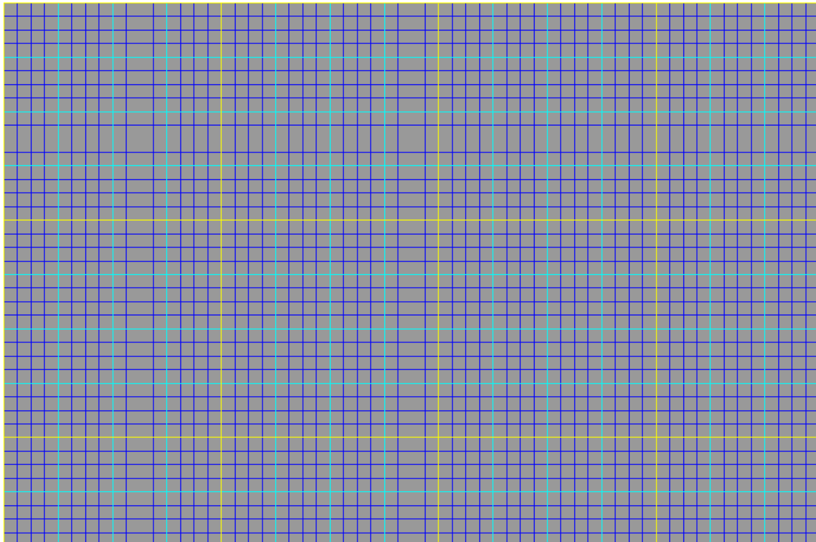


Ground truth G

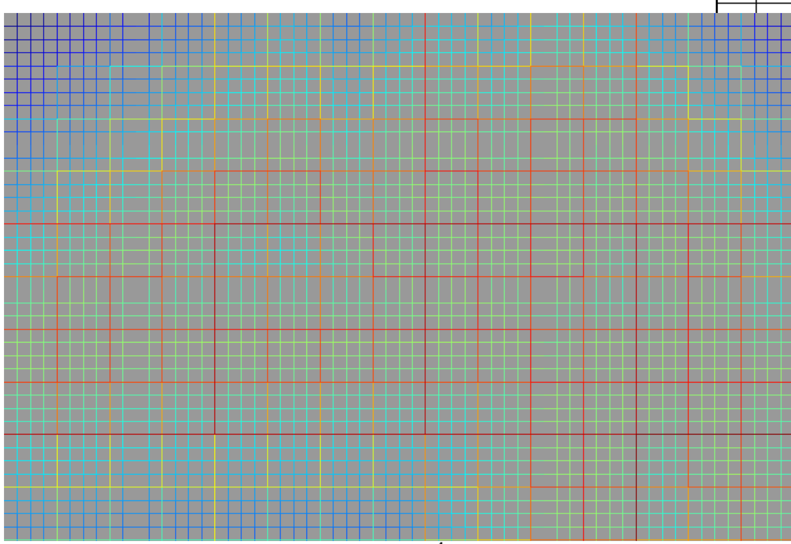


Inverted distance function $g = 1 - d_4(G)$

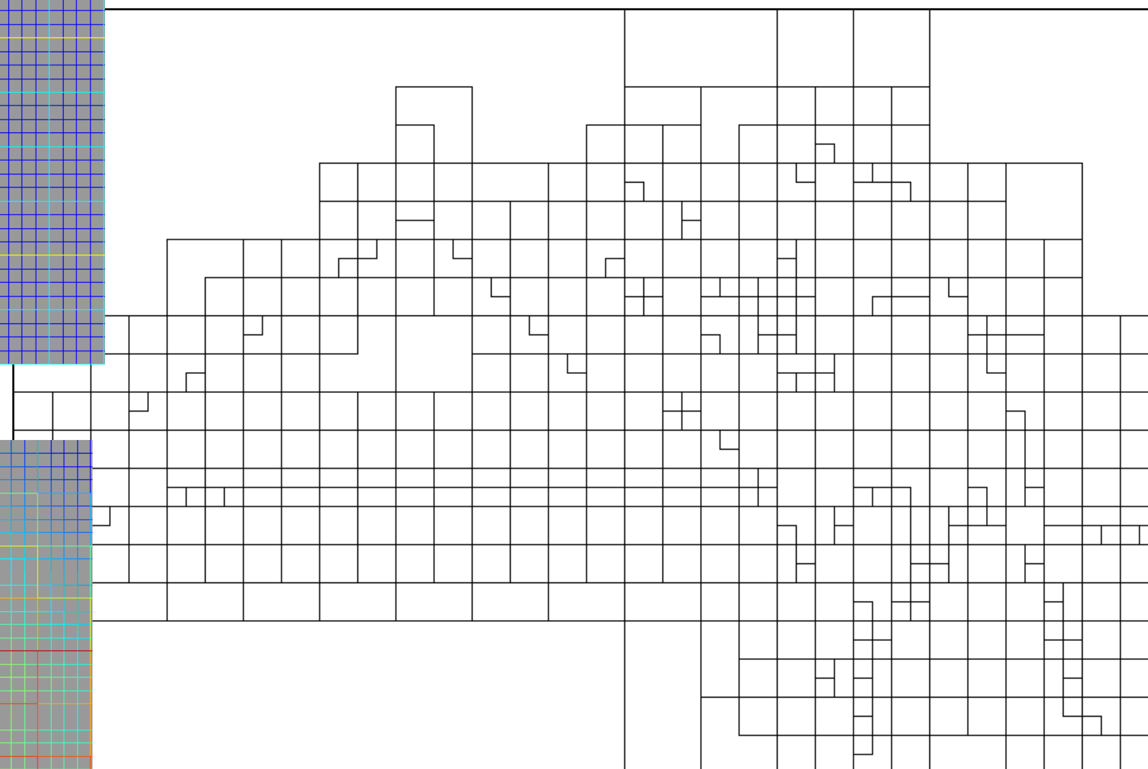
Transformed saliency



Initial Quadtree saliency s^4

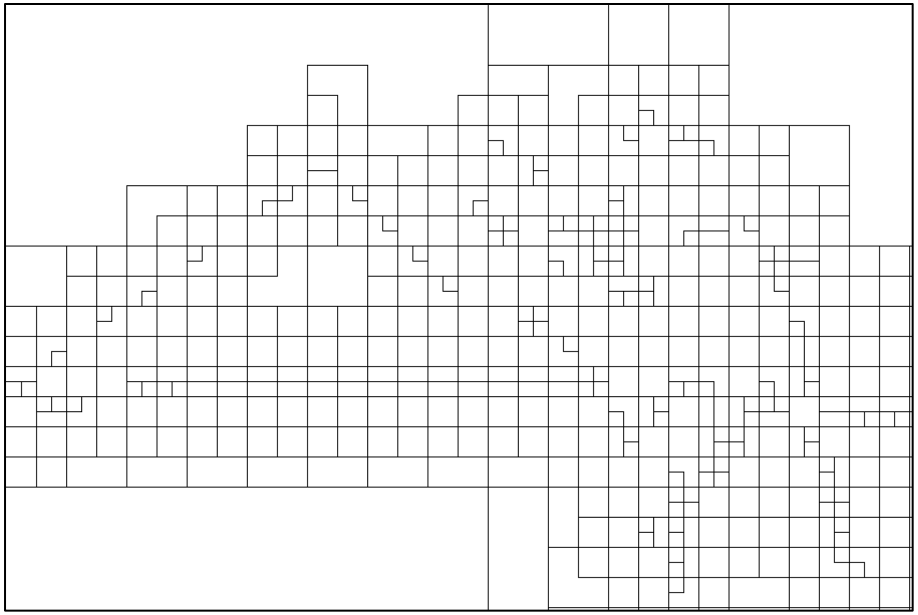


$s\prime = \gamma(s^4 + g)$

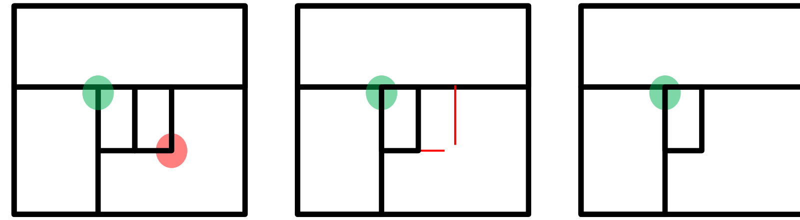


Partition $\pi_t = s' \geq t$

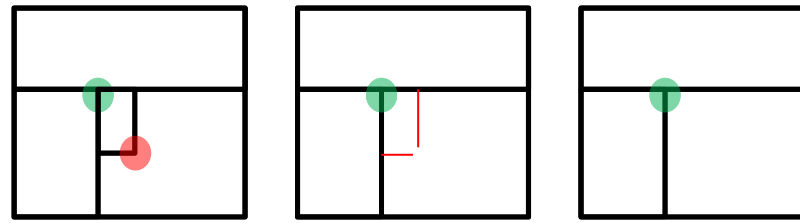
L-openings



Input Partition π

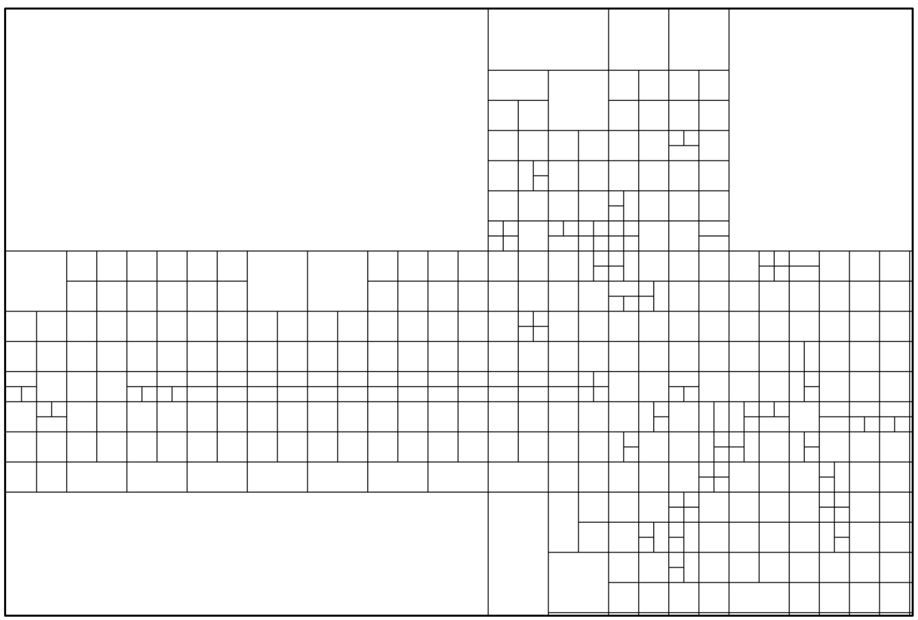


Iteration #1

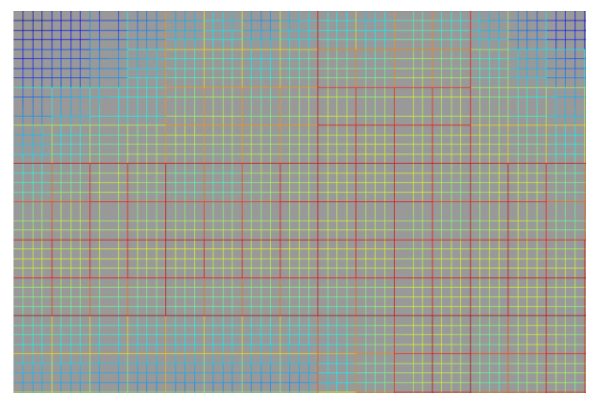


Iteration #2

$$\gamma_L = \cap_n [\gamma \circ \varepsilon_L]^{(n)}, \varepsilon_L = \varepsilon_h(g) \vee \varepsilon_v(g)$$

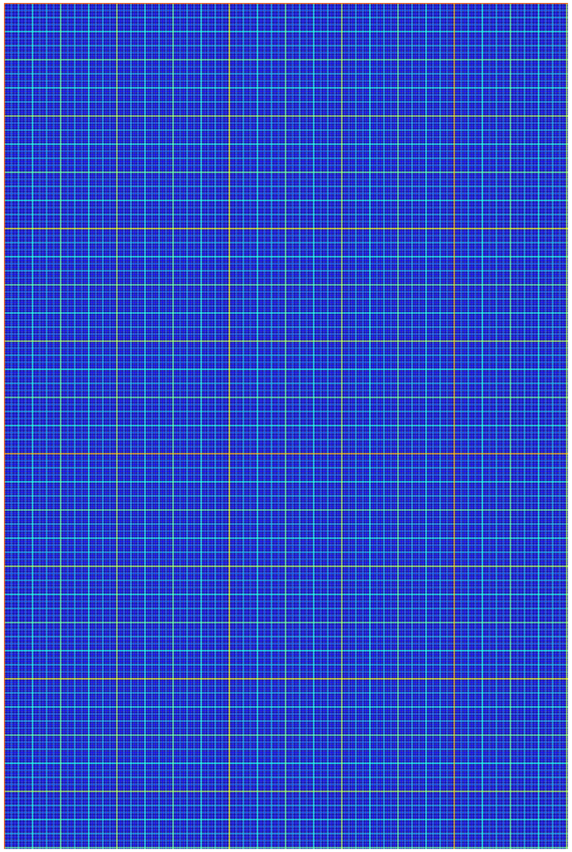
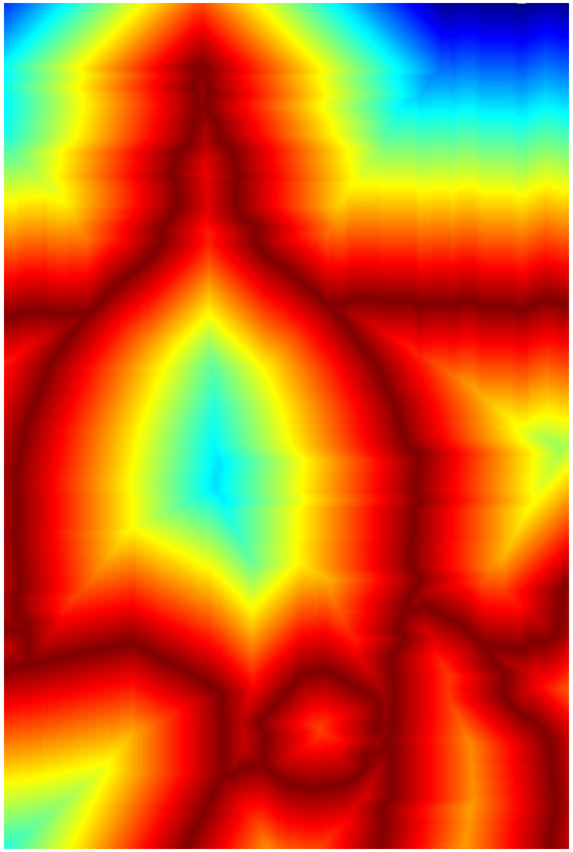
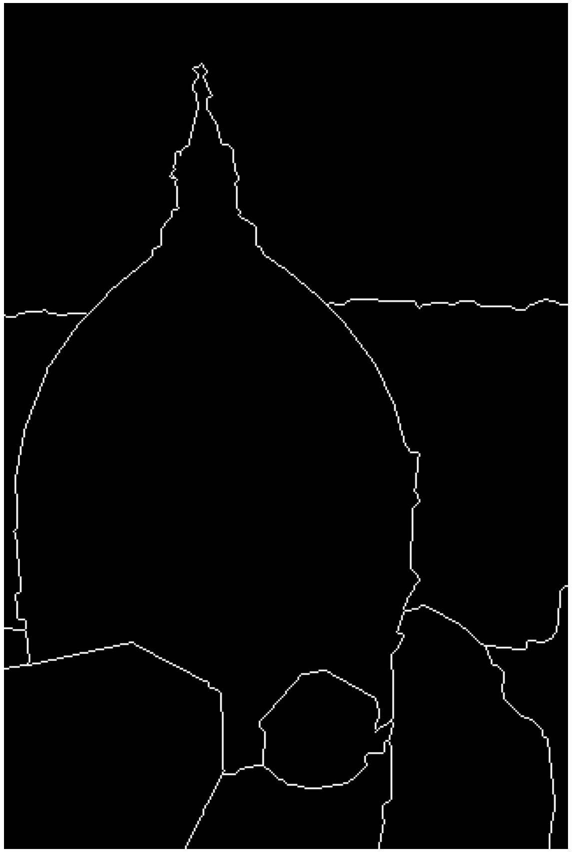


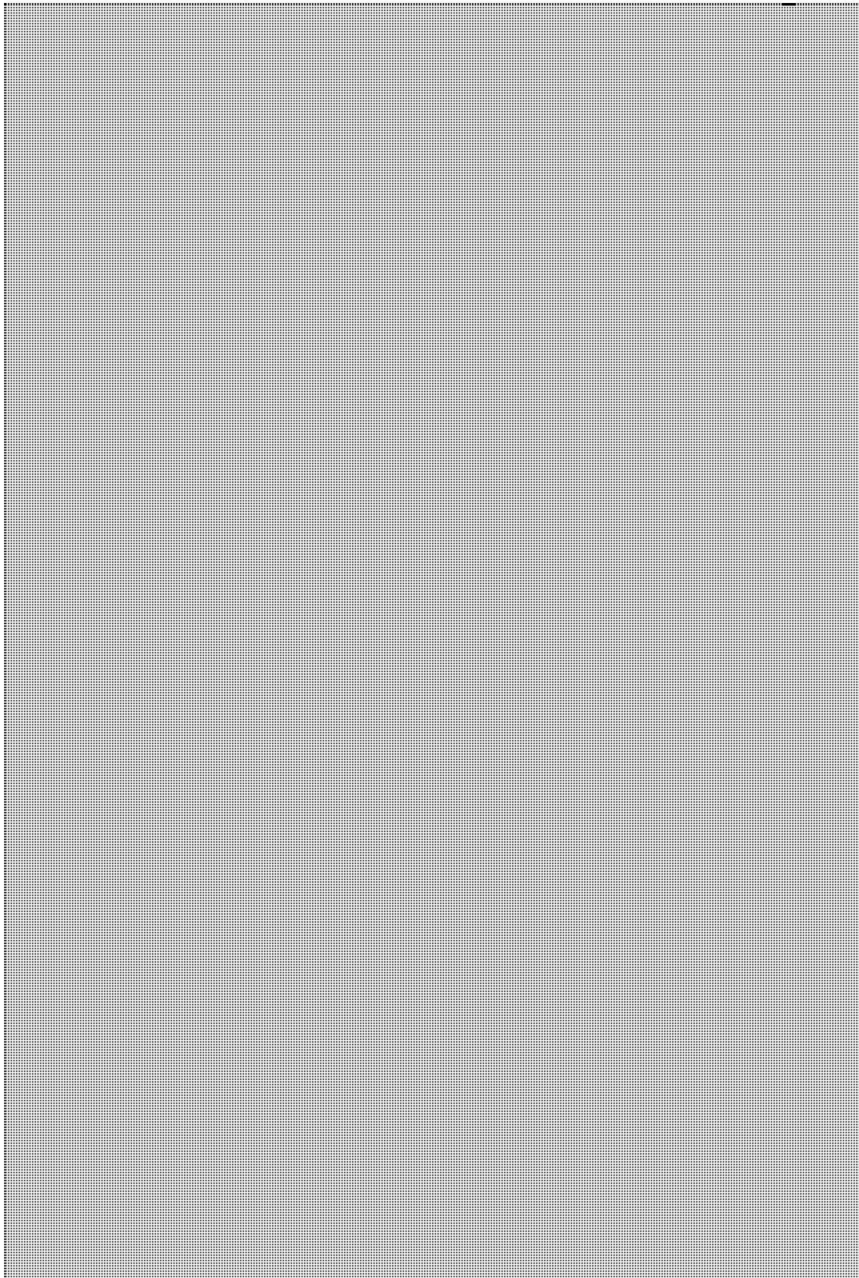
Binary L-opening $\gamma_L(\pi)$



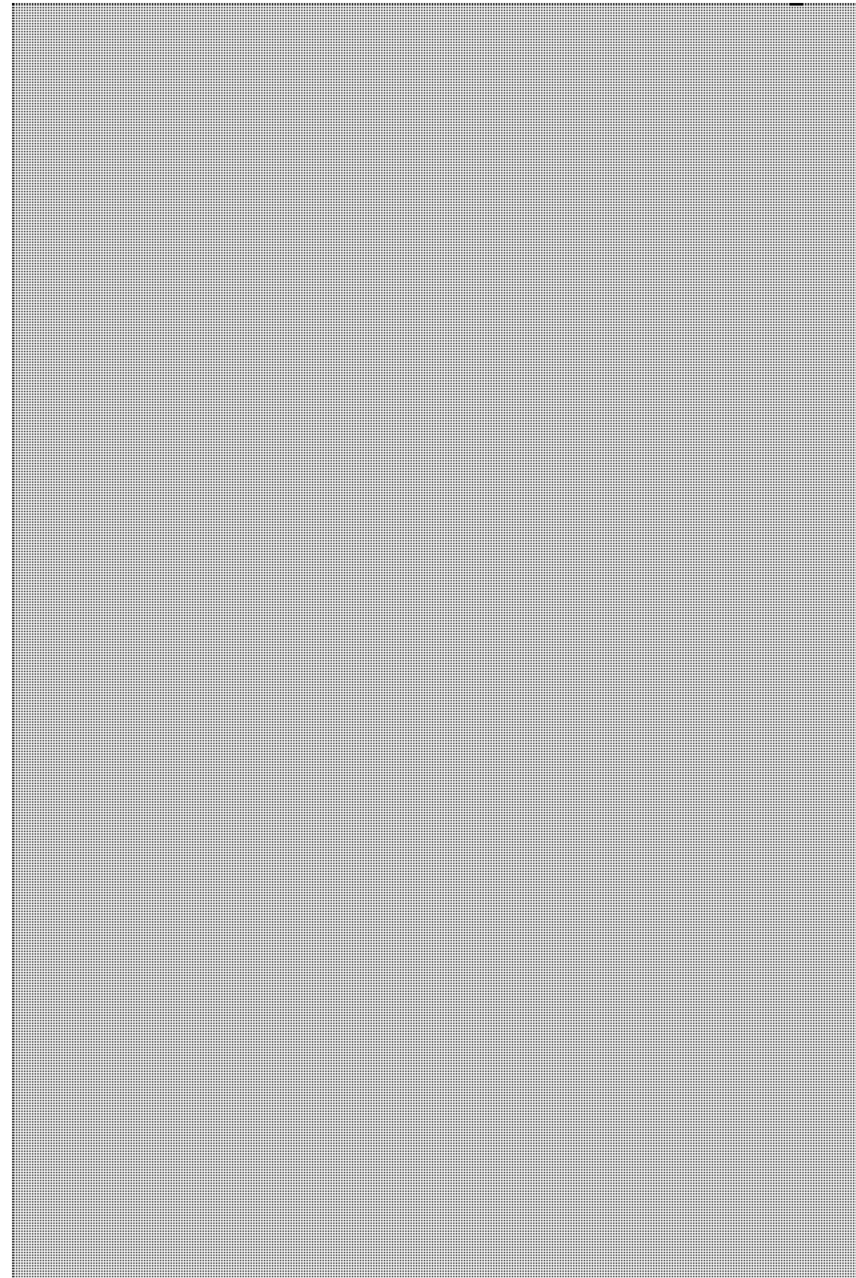
$\perp$-saliency $s_\perp = \gamma_L(s')$

Example



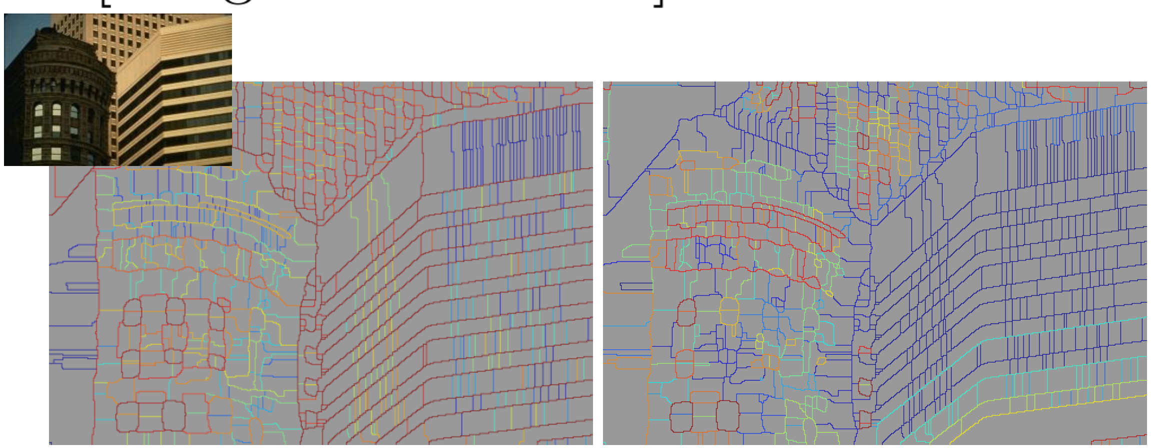
Net opening



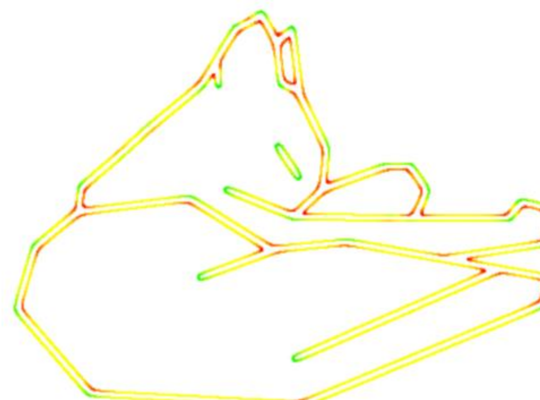
L opening

Intrinsic properties of J-nets

- Local radius of curvature of level lines [Morel, Cigoma, Monasse 2010]
- Mean Curvature Watersheds [Romstad B & Etzelmuller B 2012]
- Perimeter and surfacial properties [YongChao Xu 2013]



(a). Attneave's cat



(b). Curvature map.

GIS applications

Accessiblity between communes in PACA region:

1. Principle Autoroutes

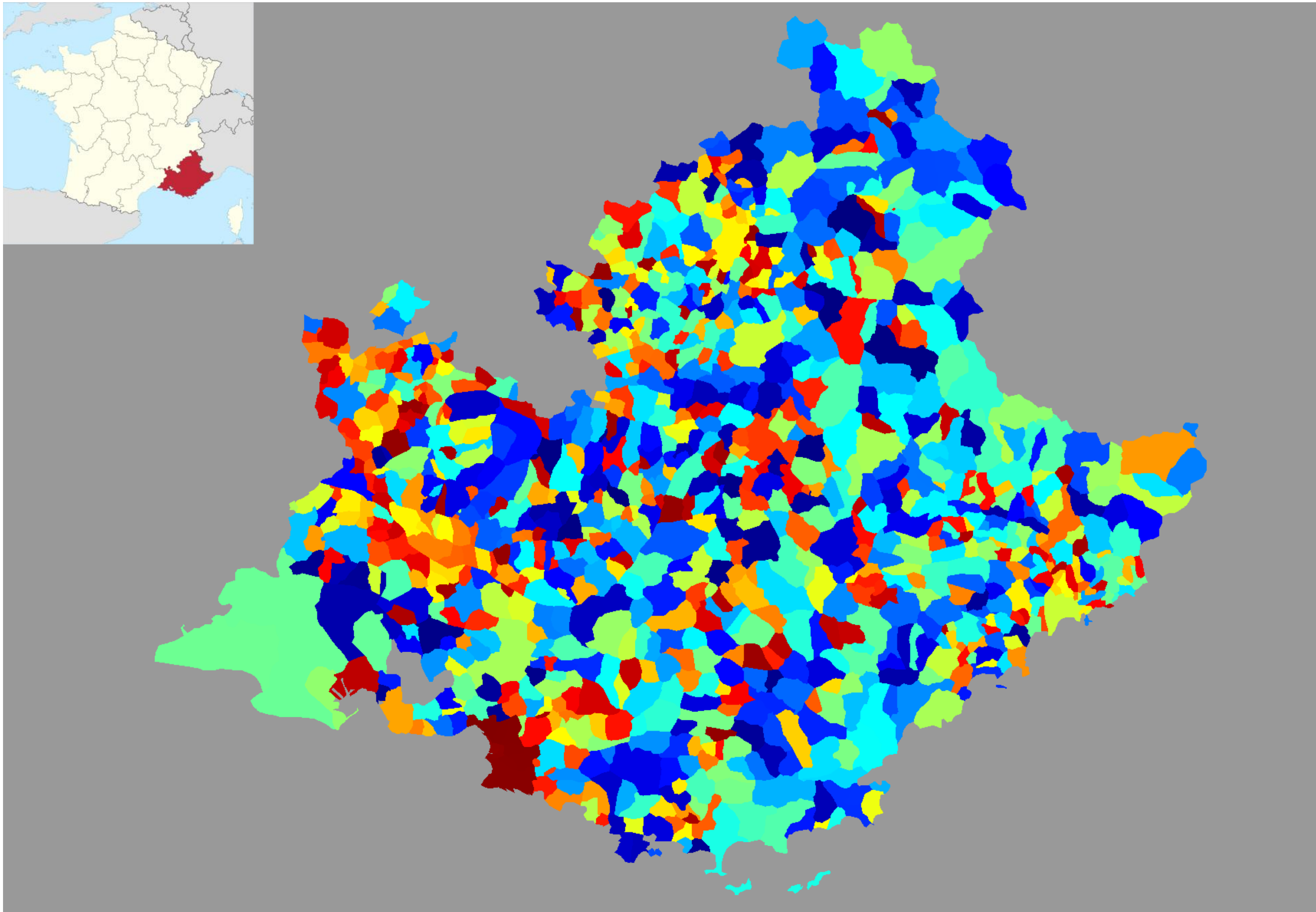
2. Internal connectivity of communes

3. Topography (mountains, lakes)

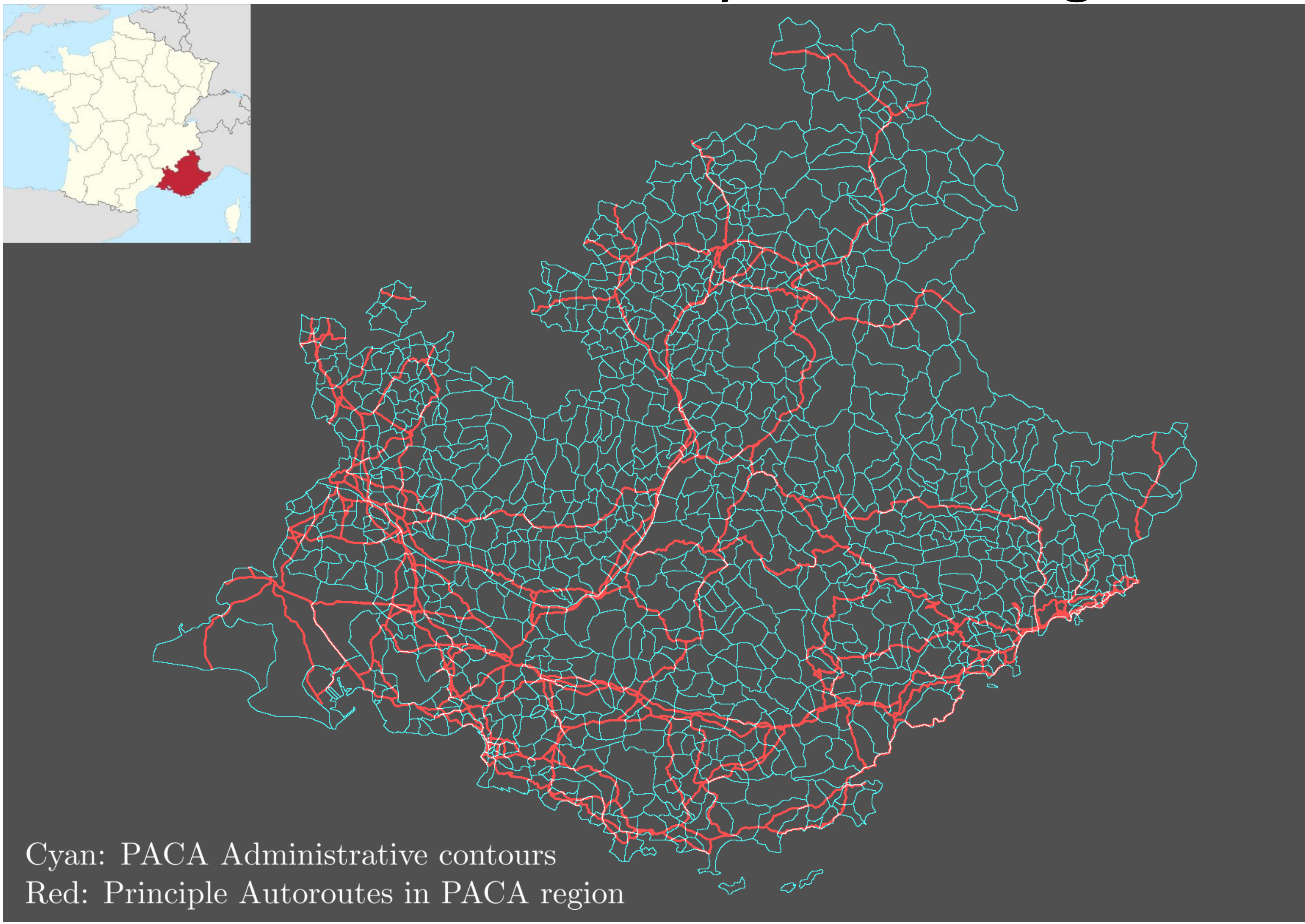
4. Sea Coast connectivity

Joint work, University Of Nice:
UMR ESPACE, Department of Geography
Christine Voiron, Pierre Alain Mannoni

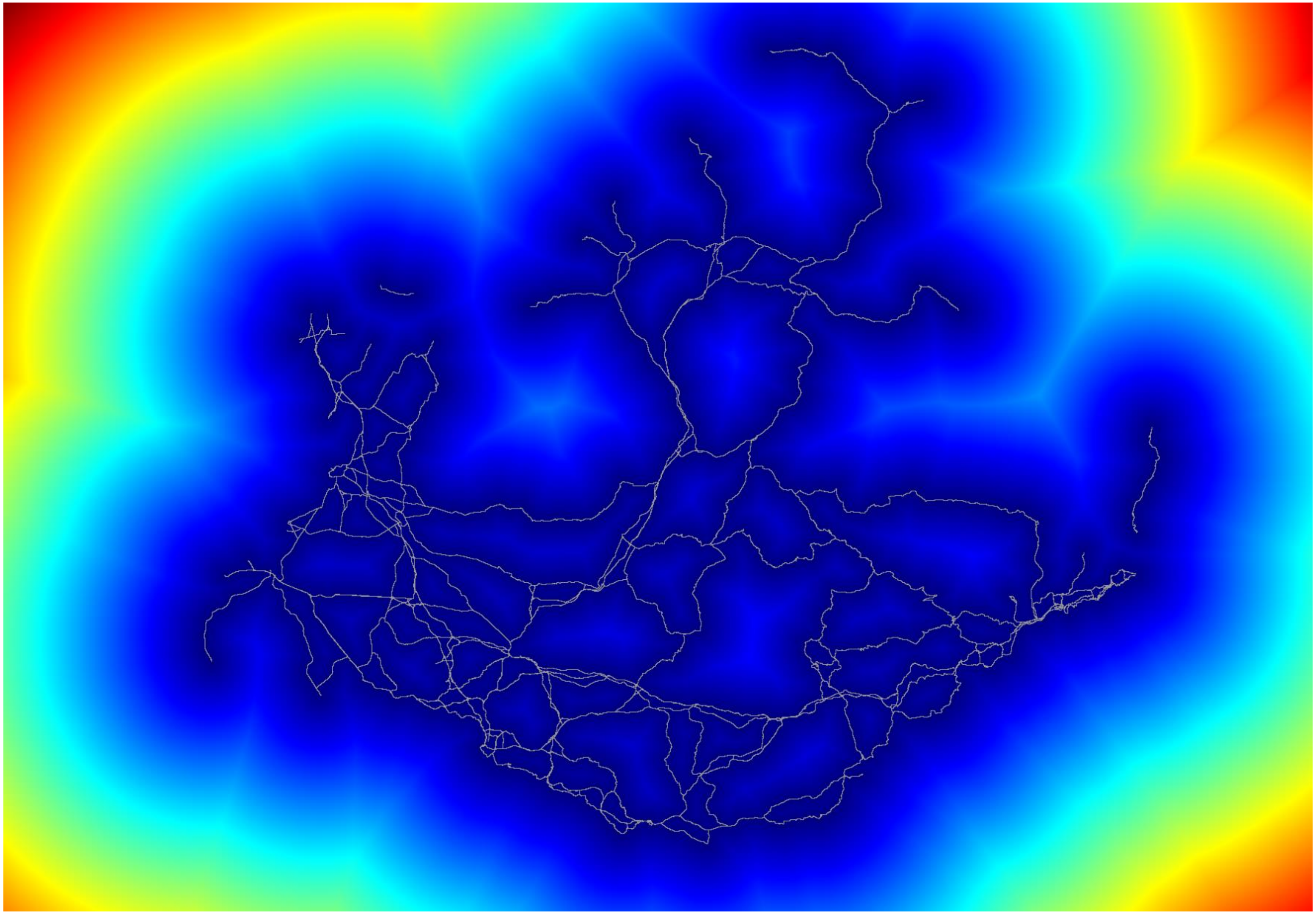
Commune PACA



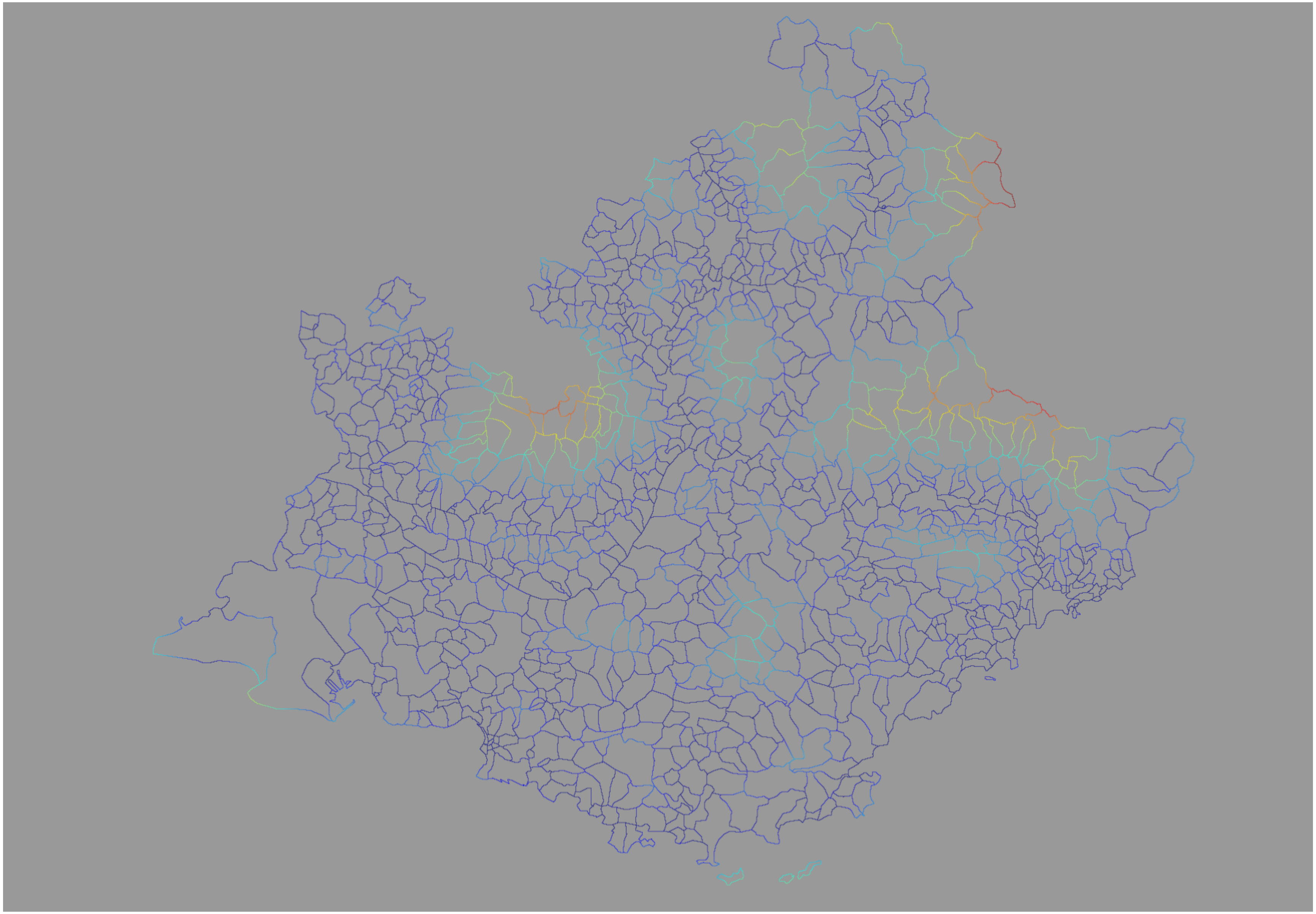
Proximity based regrouping of to determine commune accessibility in PACA region



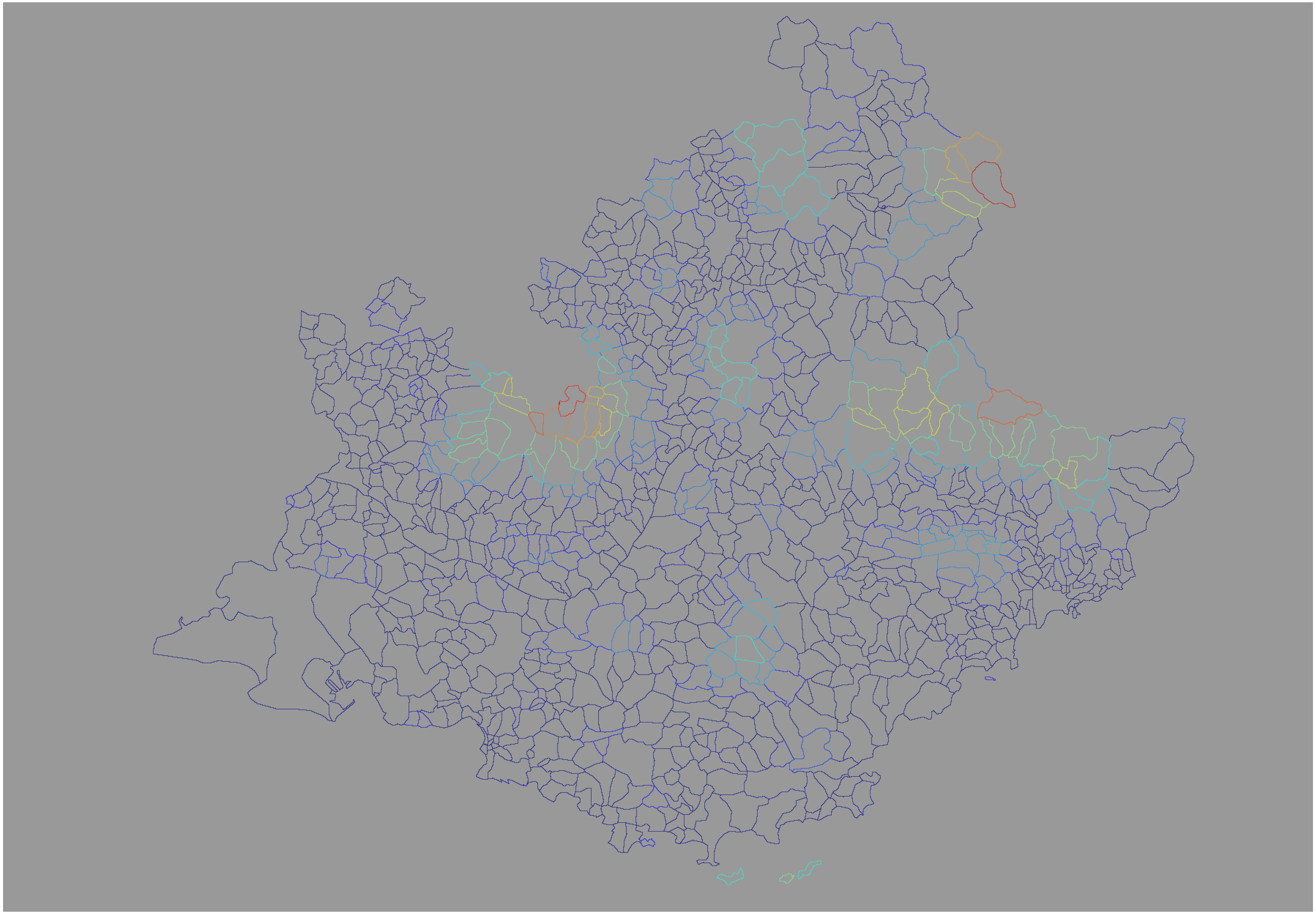
Proximity by distance function



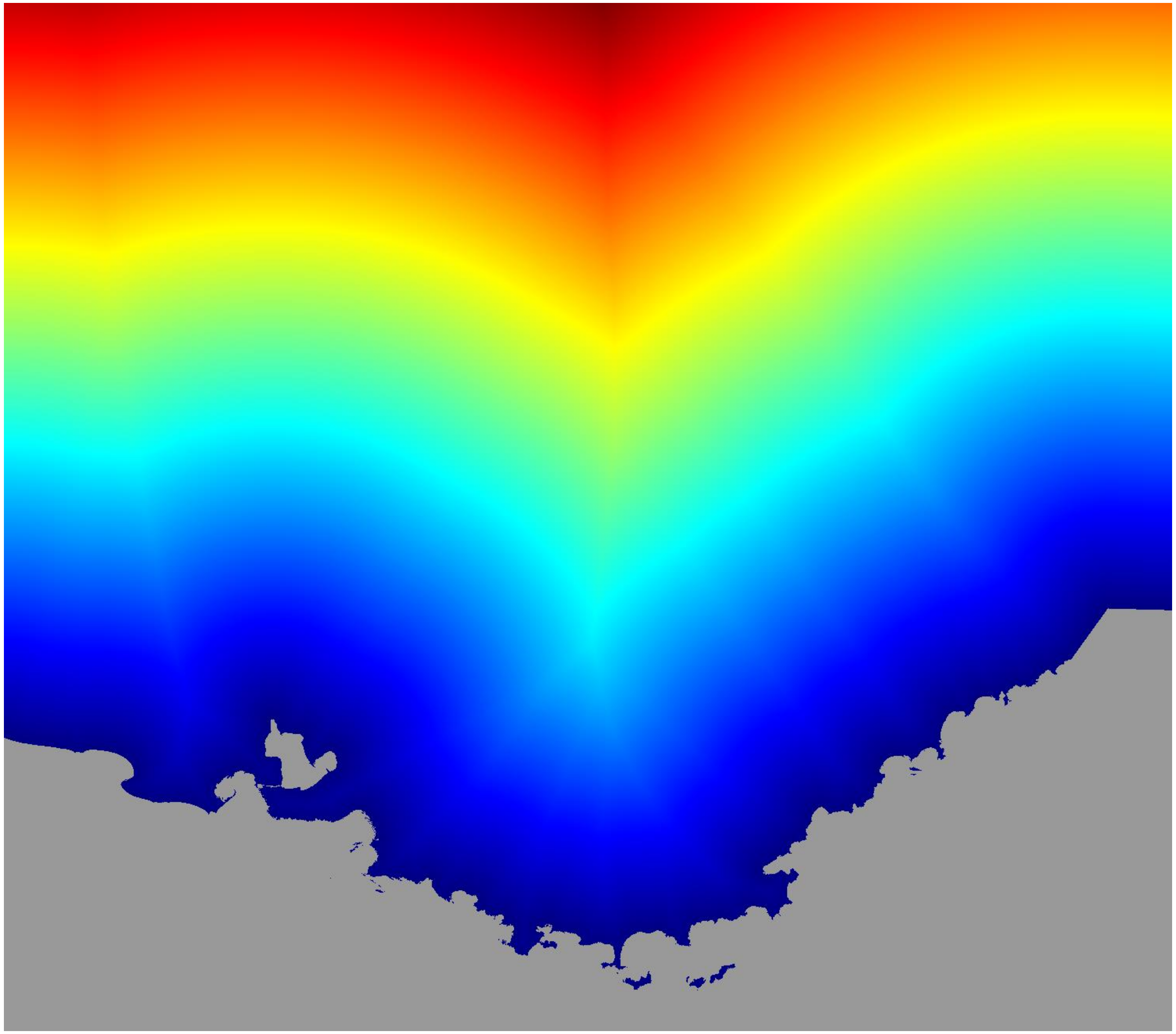
Proximity Function on Commune Contours



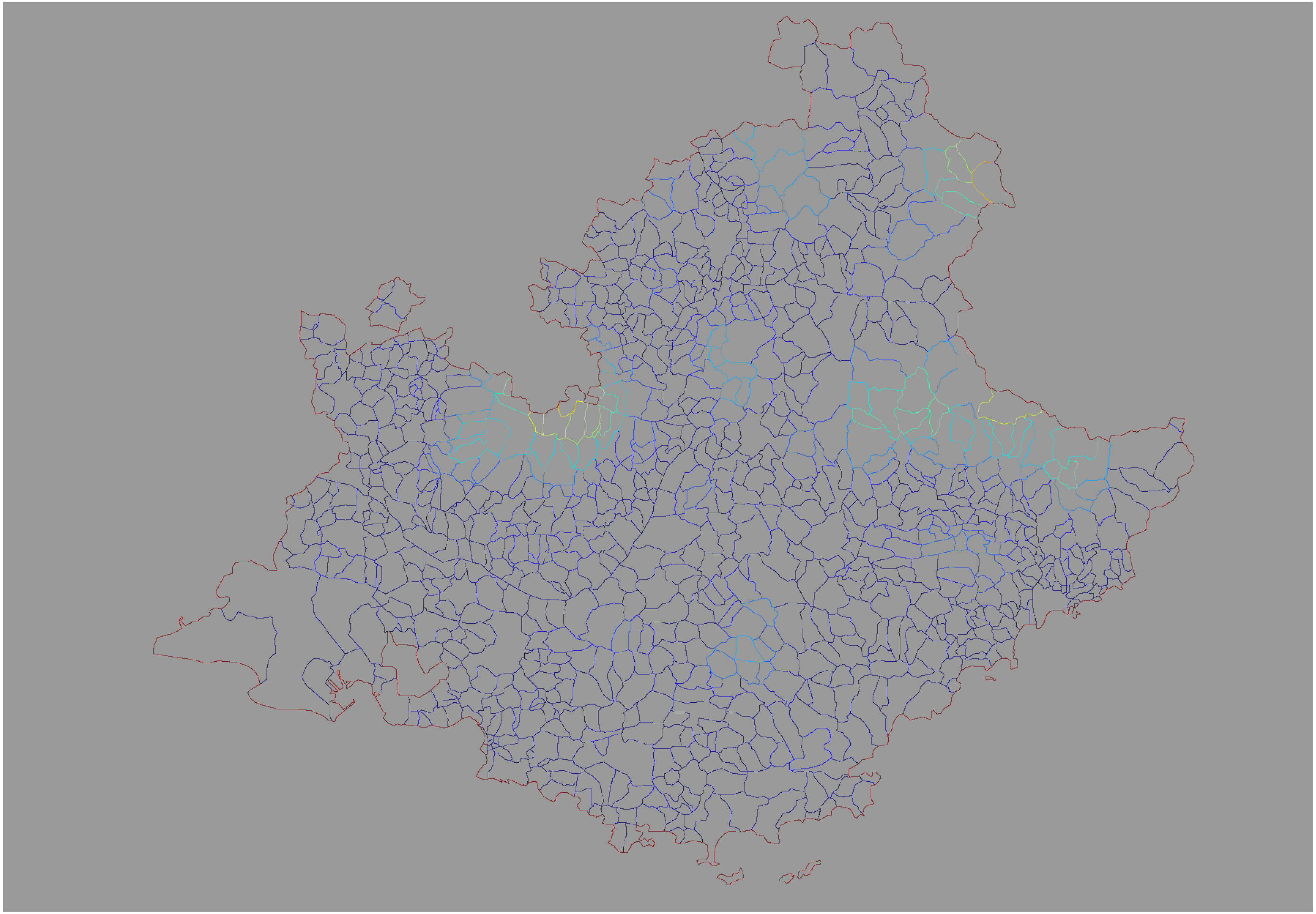
Saliency of Commune Contours using Net opening



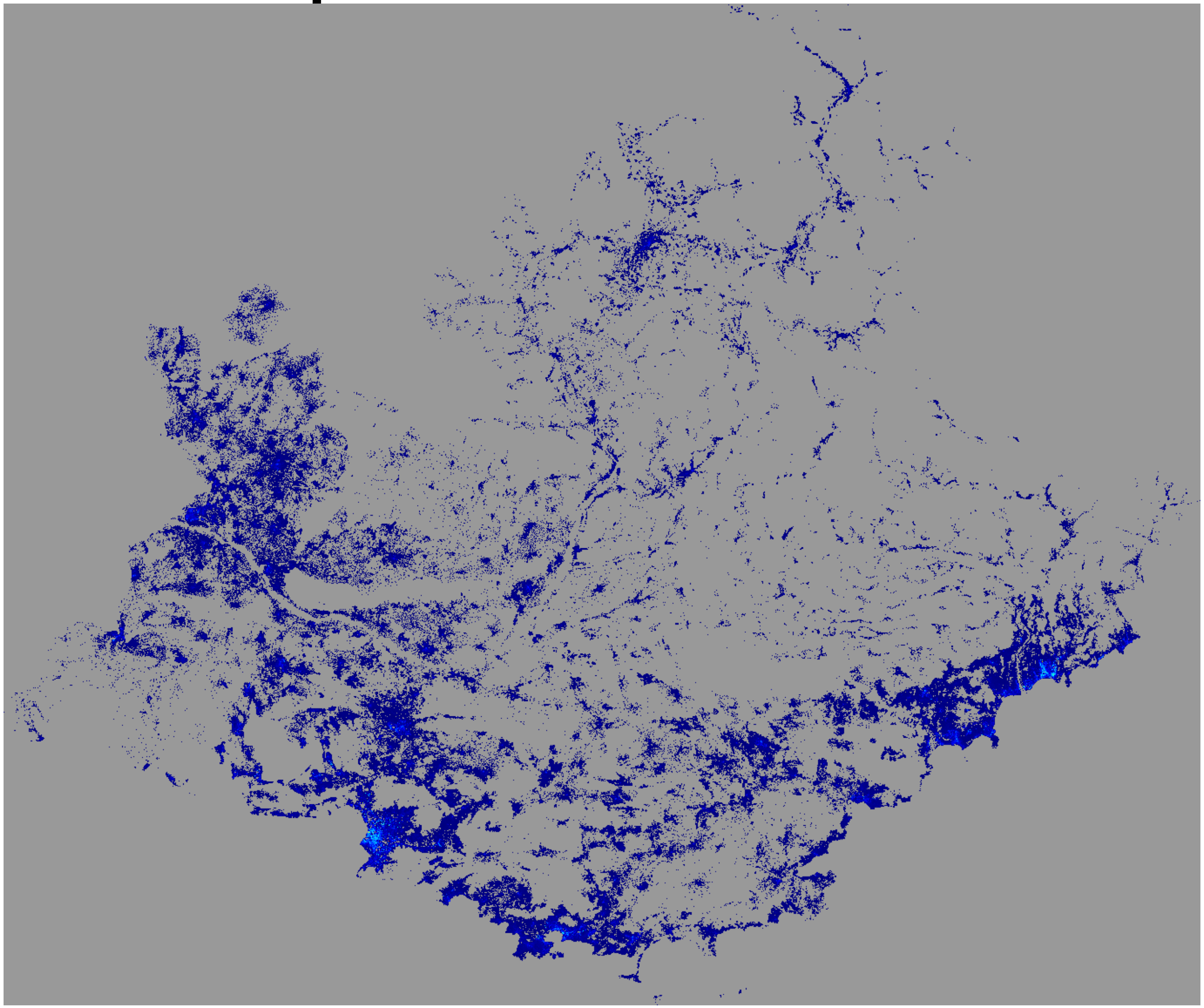
SeaCost



Saliency with Geographic & Department Contours

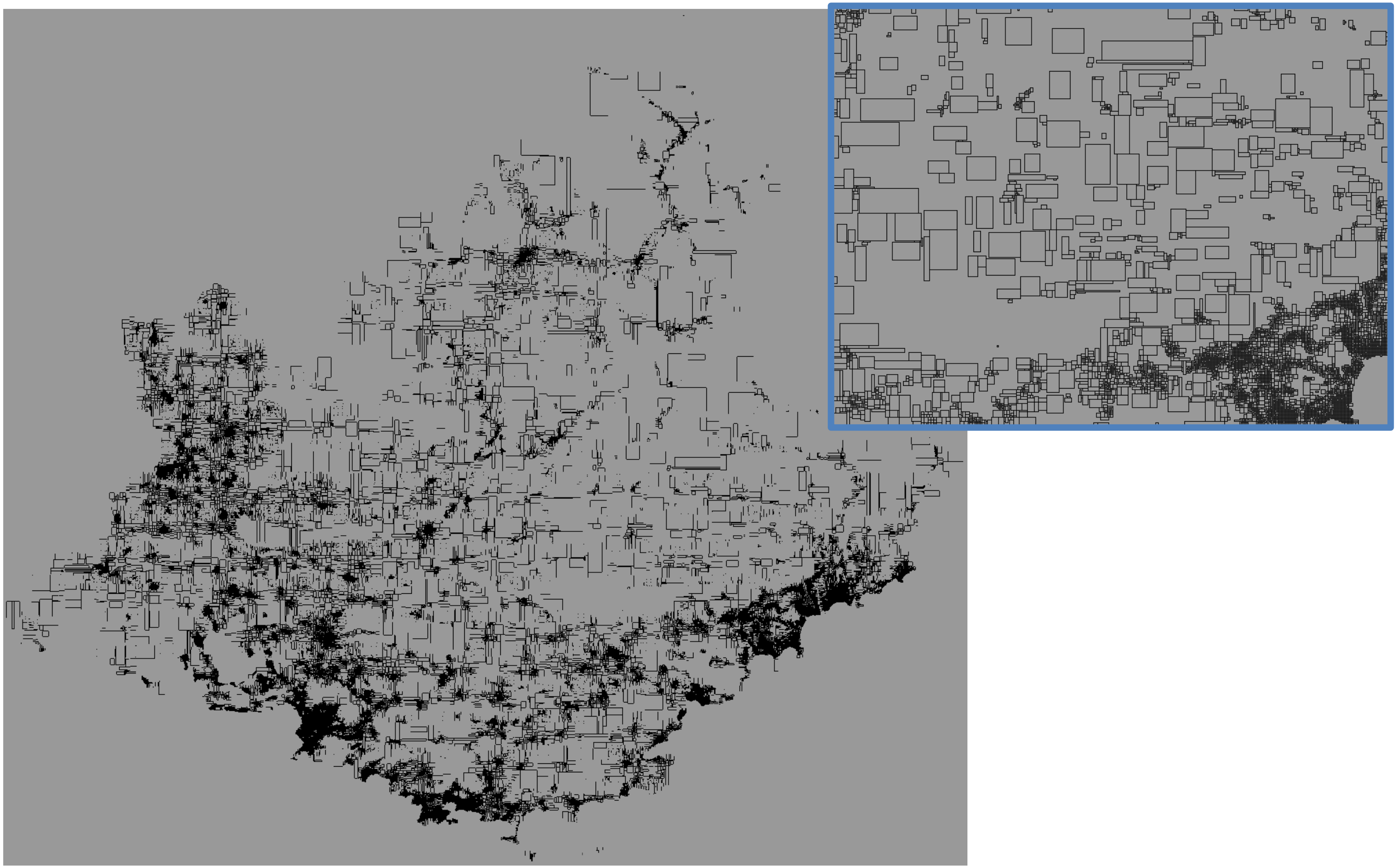


Population Datasets

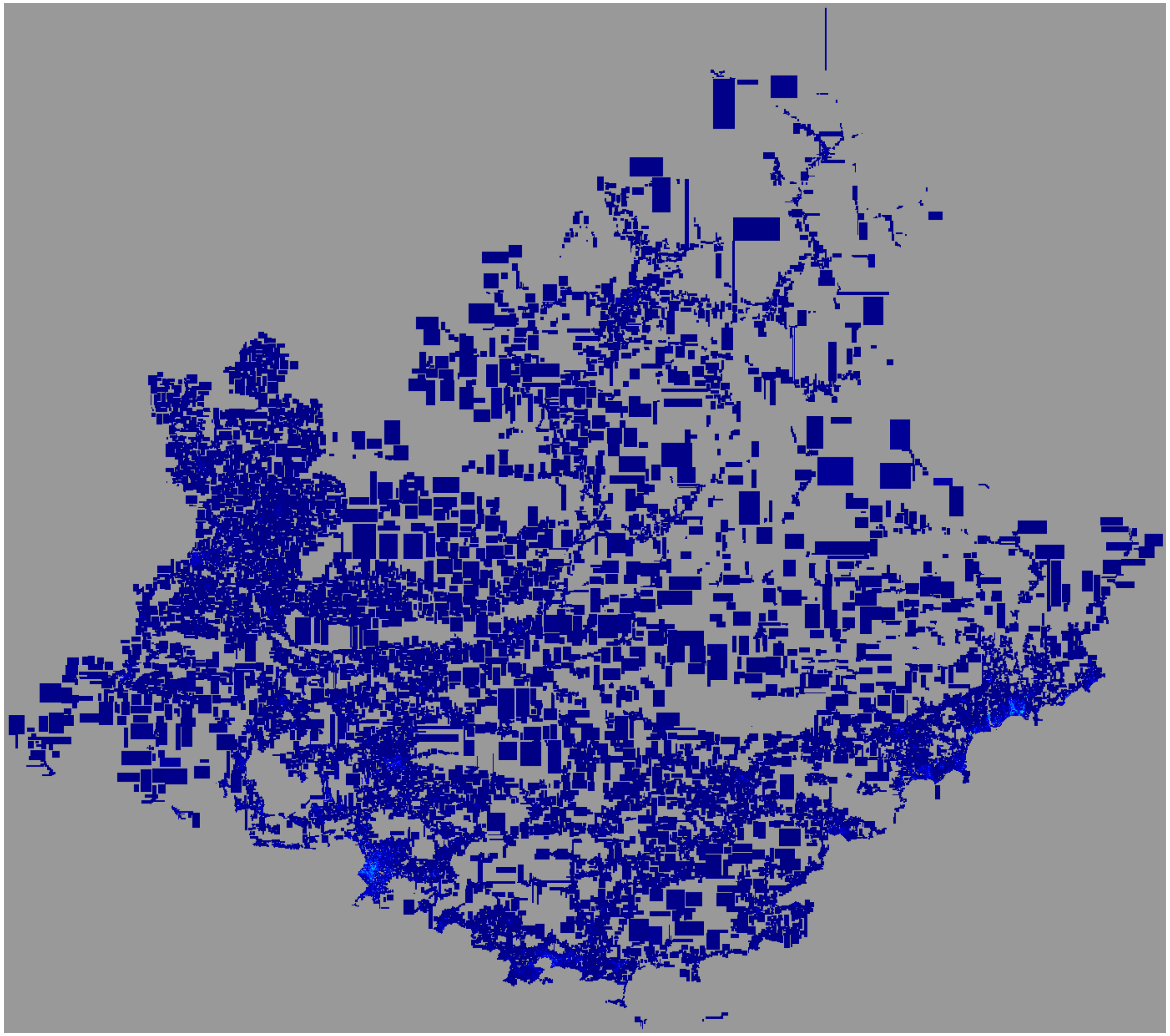


200mx200m

Revenue Rectangles



Revenue Values on Rectangles



Future work

- Vectorial image net opening for polylines
- Introduce spatio-temporal problems: Optical flow estimation in fixed grids
- Multidimensional(hyperspectral) hierarchy transformations and optimization
- Wavelet scaling function localization.

Net opening in literature

1. Pruning branches (thinnings) in digital skeletons.
   [Serra 1982]

2. Discrete classifications by ultrametric.
   [Leclerc 1981]

3. Similar line of thoughts for Topological Watersheds.
   [Bertrand 2005]

4. Saliency contours from watershed of edge weighted graphs.
   [Cousty & Najman 2011]

Related Work

1. Hierarchical skeletonization based on an external function while preserving topology. [Couprie. M 2013]

2. Mean Curvature Watersheds [Romstad B & Etzelmuller B 2012]

3. Hierarchical Segmentation by Edge contraction. [Haxhimusa & Kropatsch 2004]

4. Edge and vertex labeling for Multi-cut problems. [Kappes et al. 2011]

5. Globally optimal closed-surface segmentation for connectomics. [Andres et al. 2012]

Optimal Cuts Progression

- Lagrangian optimization on hierarchies, of partitions (ICIP 2014 Special Session), Jean Serra, B Ravi Kiran
- Optimizations on Hierarchies of Partitions, Workshop accepted at ICIP 2014, B. Ravi Kiran, Jean Serra, Jean Cousty, and Hughes Talbot

Merci beaucoup pour

- Votre patience
- Et votre attention

Avez vous des questions ?

Subsampling Algorithm