

**First European Asymmetry Symposium
Nice, March 16th 2018**

UNIVERSITÉ
CÔTE D'AZUR



Complex Systems Academy of Excellence

Asymmetry along the way. Applications and conceptualizations for the morphology of urban fabrics.

Giovanni FUSCO¹, Alessandro ARALDI¹, Stefano BORGO², Rossella STUFANO³

¹Université Côte d'Azur, CNRS, ESPACE, France

²Laboratory for Applied Ontology, ISTC CNR, Trento, Italy

³Politecnico di Bari, Bari, Italy



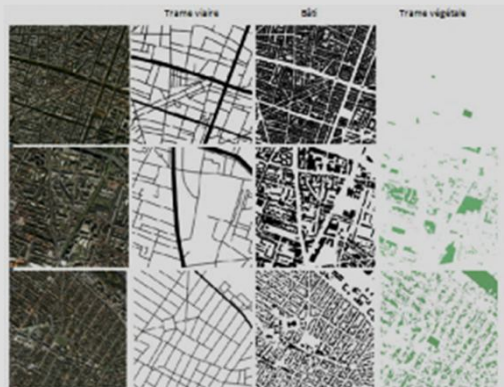
Urban Form – Urban Fabric

Urban form: Spatial organization of physical elements of the city.

The expression of an urban society (socioeconomic organization, culture).

Urban fabric: the **finest scale of analysis of urban form** (city block, urban fragment).

Classical schools of urban morphology (Italy, France, UK): **typical relations between streets, buildings, plots and site** (topography).



Emphasis on urban form analyzed on plan.

Little attention to questions of symmetry/asymmetry (plot layout, overall city layout).



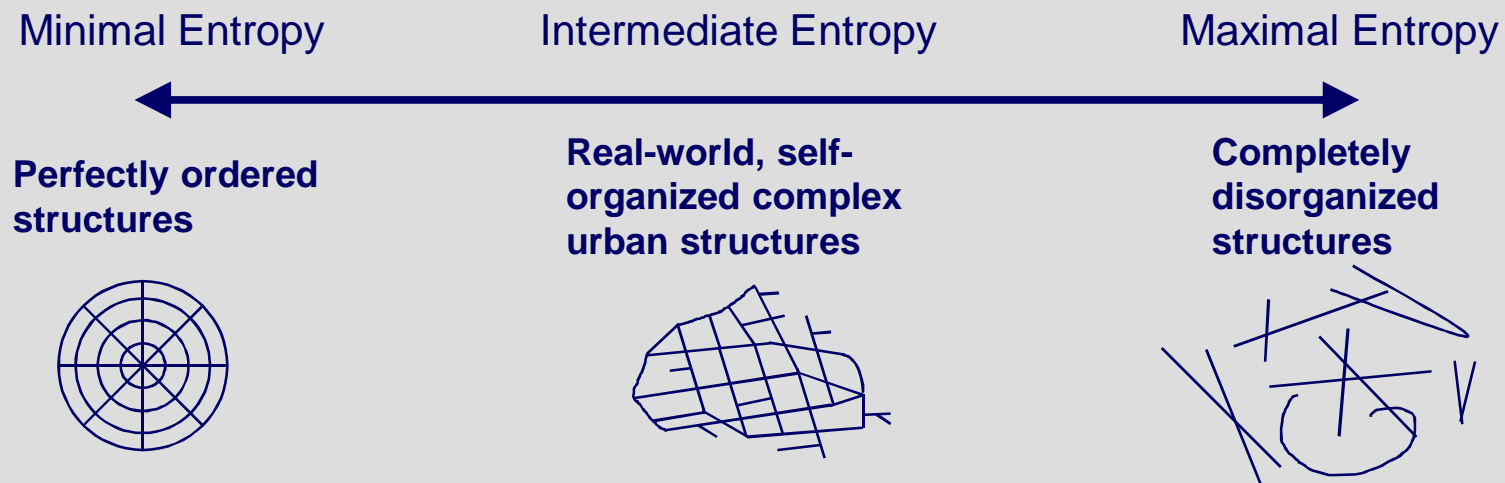
A different strain of research: urban form **observed from pedestrians.**

Questions of geometrical symmetry/asymmetry gain importance.

Research Stance

- **Empirical research on real cities**, big cities and their complexity, not on ideal cities, ideal communities, Kibbutz projects ...
- Goal: **identify open questions** by highlighting aspects of asymmetry in urban form.

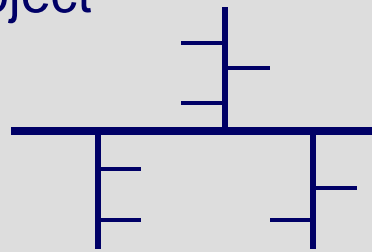
The Complexity Approach (*Wolfram 1984, Wuenche 1999, Morin 2005*):



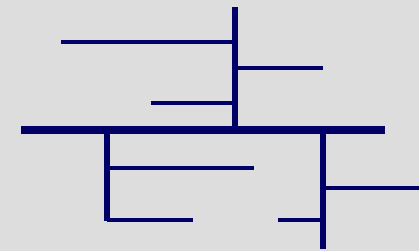
Asymmetry = degree of departure from too ordered structures

Dimensional Asymmetry in Urban Form

- Before the Renaissance : Symmetry = Proportionality, existence of stable dimensional ratios among the parts of an object

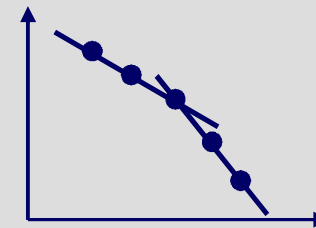
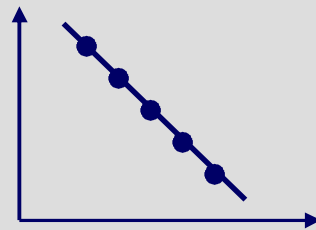


Symmetry



Asymmetry

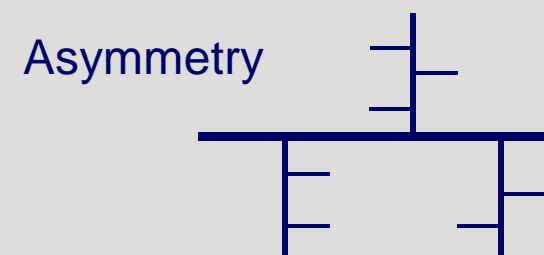
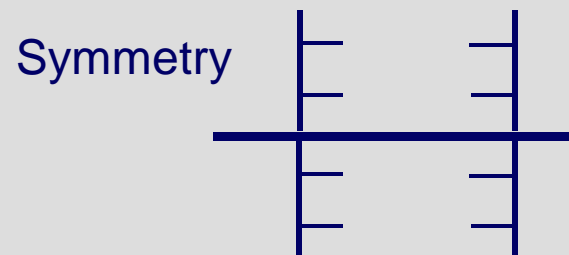
Scale invariance of proportions = unique fractal dimension of the form



Dimensional asymmetry = departure from a unique fractal dimension
Interest of the question: dimensional ratios are local rules, revealing logics of self-organization

Geometric Asymmetry in Urban Form

- Classical Form Symmetry (Renaissance, Baroque) : possibility to obtain the total form from rotation / flipping / translation of a part



Patterns of urban fragments, expansion projects, small-scale settlements...

Geometric Asymmetry = departure of global urban form from simple rotation/flipping of constituent parts

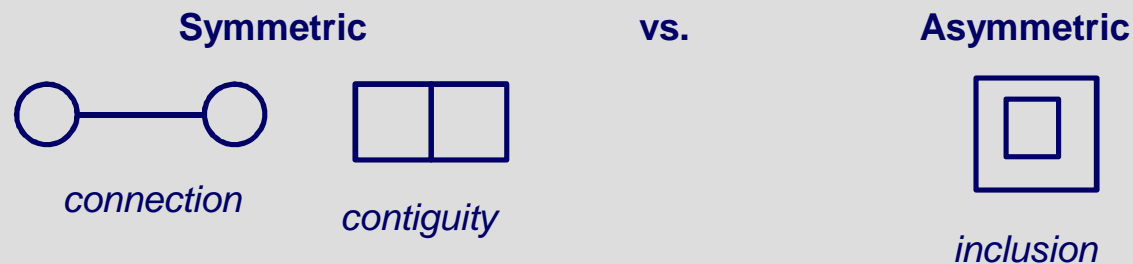
Interesting in presence of an attempt to impose a global pattern (Barcelona, Brasilia, ...)

Heuristic interest: relation between spontaneous growth and attempts of control

Topological Asymmetry in Urban Form

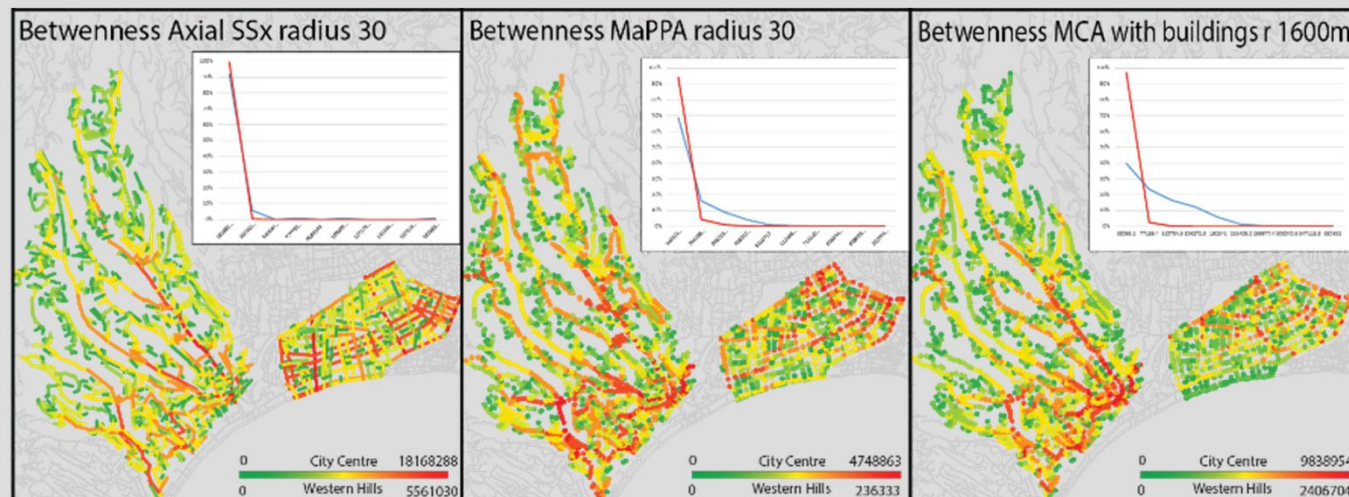
Focus on topological relations within elements of urban form

A founding opposition in topological relations among elements of urban form (*Hillier & Hanson 1984*):



Centrality = an asymmetric relation

Asymmetry : the very existence of central elements and the kind of spatial organization induced by their presence.



Our Focus

(A)symmetry

Dimensional
/ Transcalar

Geometric

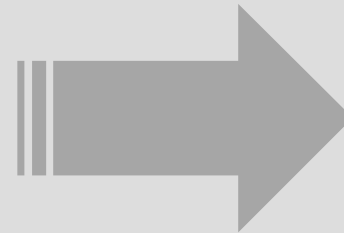
Topological

Urban
Form

City
Layout

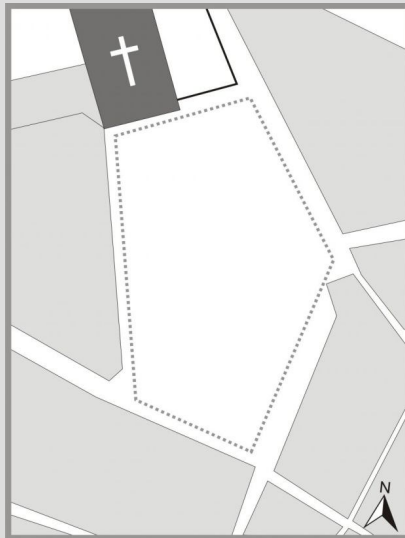
Urban
Fabric

Building/Plot
Layout

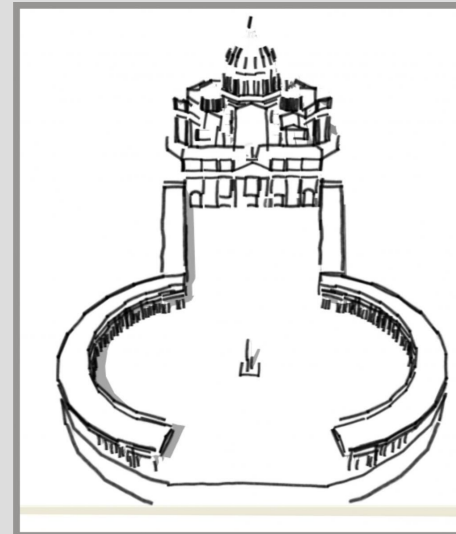


A forerunner: Camillo Sitte

The Art of Building Cities (1889): qualitative analysis of layout of urban squares & their perceivable form



Asymmetries and the irregular layouts of squares in medieval European cities



Control of forms through symmetries in Baroque and neoclassical layouts

As a reaction to modernist urban design, post-war authors rediscovered Sitte's work and recognized asymmetry as an essential component in urban design.

Asymmetry in perceived urban form: Kevin Lynch

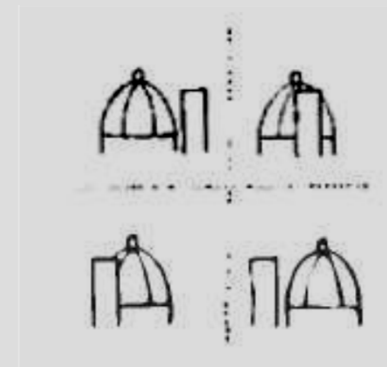
The Image of the City (1960): asymmetric designs foster imageability of townscapes around paths

Directional Differentiation along the street: asymmetries, gradients, and radial references which differentiate one end from another (as on a path going uphill, away from the sea, and toward the center); or one side from another (as with buildings fronting a park)



Asymmetric compositions of landmarks.

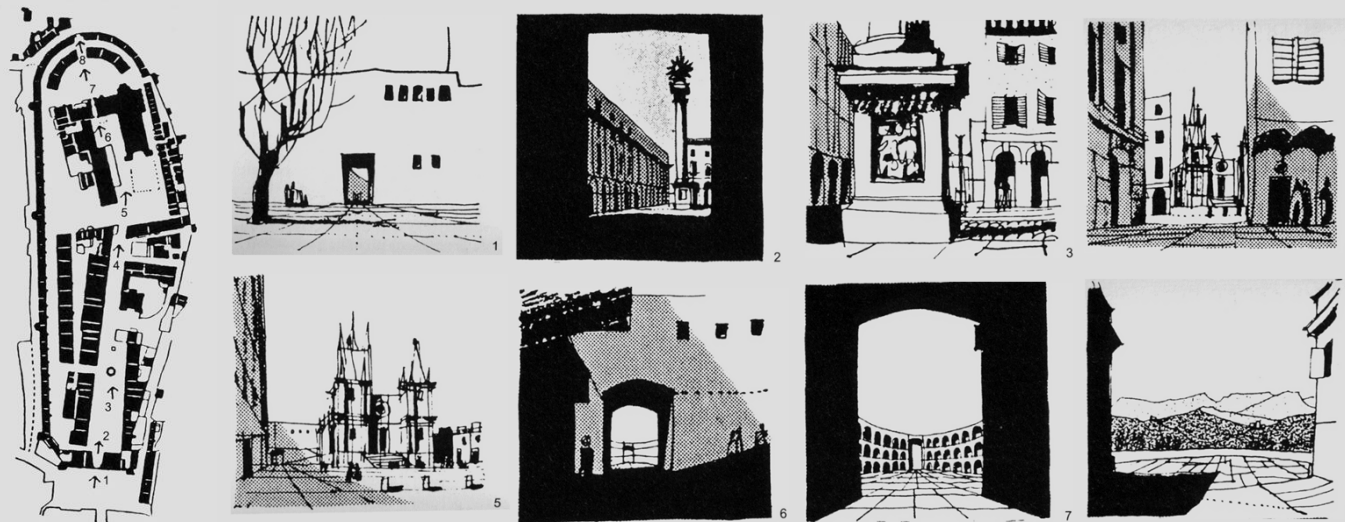
The asymmetric coupling of Duomo and campanile in Florence, allows pedestrians to better situate themselves within the urban space.



Asymmetry in Picturesque Compositions

Cullen (1959), Pinon (1991), Greenberg (1995): asymmetric designs contribute to the “picturesque” effect of townscapes. They are associated to effects of surprise and, more in general, to perceived variability of urban forms along the street.

Symmetric compositions, typical of the Baroque culture, contribute to a more monumental register, showing the capacity of the political power to give a desired shape to the urban form.

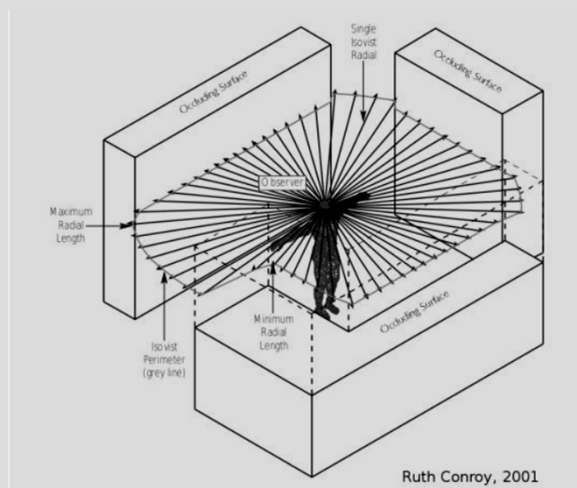
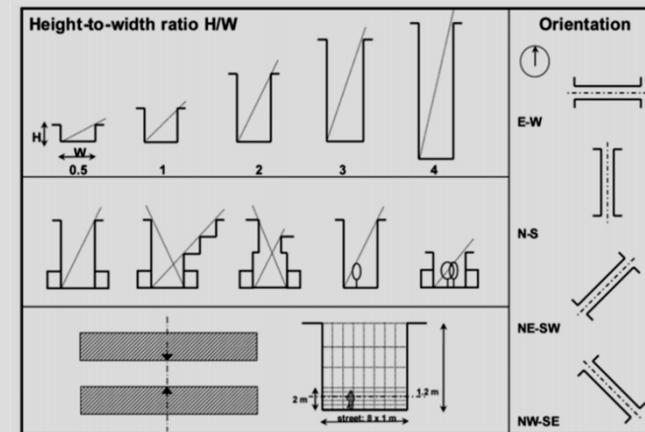


Salingaros (2003) asymmetry, the natural outcome of self-organizing processes. Self-aware human interventions introduce elements of symmetry as a way of imposing a visual control on spontaneous forms.

Asymmetry, a Methodological Issue

So far, only qualitative evaluation of symmetry/asymmetry in urban form.

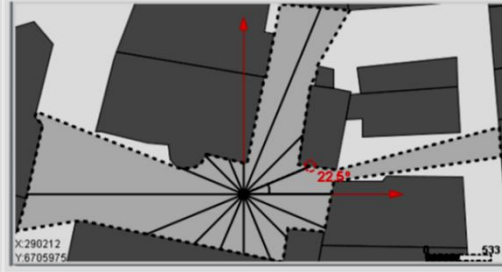
Need of quantitative analysis for urban bioclimatic phenomena (Todhunter 1990, Ali-Toudert and Mayer 2006).



The Isovist analysis in the perception of urban form (Benedikt 1979).

The human as a 360° scanning sensor.

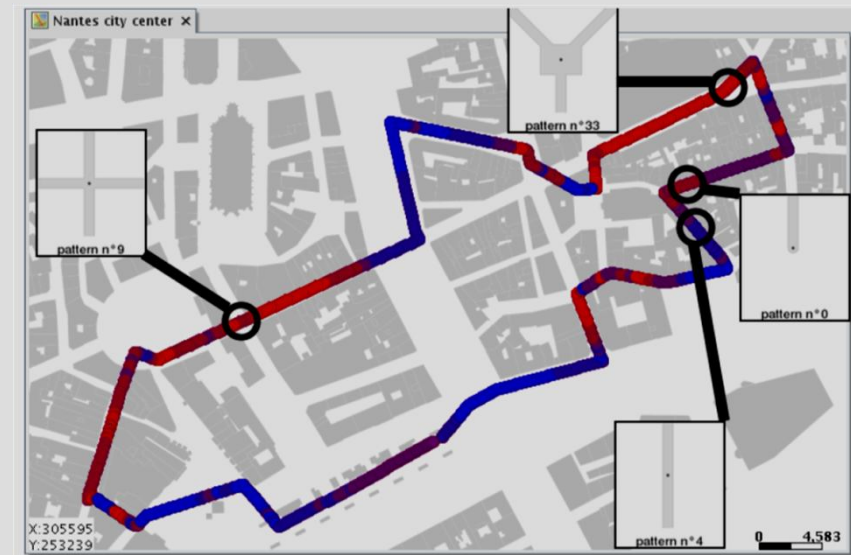
Asymmetry through Isovists



Leduc et al. (2011): symmetrical and asymmetrical long-range peaks within the isovist of a pedestrian walking in the city can be used to detect street junctions within an urban path.

A computationally intensive analysis.

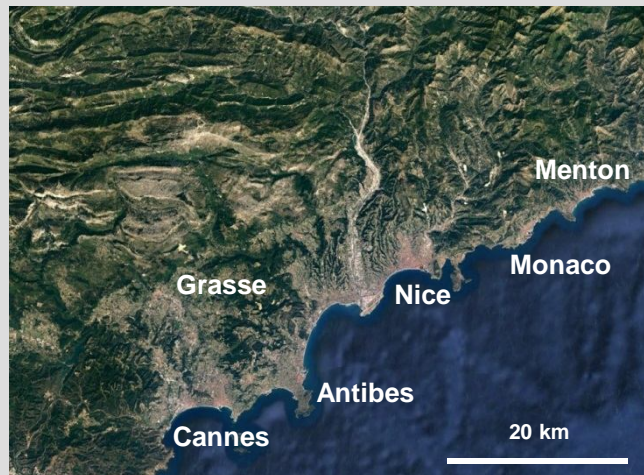
Main goal: not to detect morphological asymmetries in urban form, but to use isovists asymmetry and peakedness to identify patterns of street junctions.



Multiple Fabric Assessment

A new geoprocessing method for the identification of the form of urban fabrics through geoprocessing of morphological indicators in proximity bands around street segments (Araldi and Fusco 2017, Fusco and Araldi 2017)

- From manual calculations → to a computational geoprocessing
- From expert-based detection → to a bottom-up procedure
- From planner's point of view → to pedestrian point of view
- From Small scale → to a Large scale



First application :
Coastal conurbation of the
French Riviera (1510 km²)

MFA Methodology

Spatial Unit Definition



Computation of Morphological Indicators



Identification of Spatial Patterns
Through Local Indicators of Spatial Association



Bayesian Clustering of Combinations of Spatial Patterns



Identification of Families of Urban Fabrics



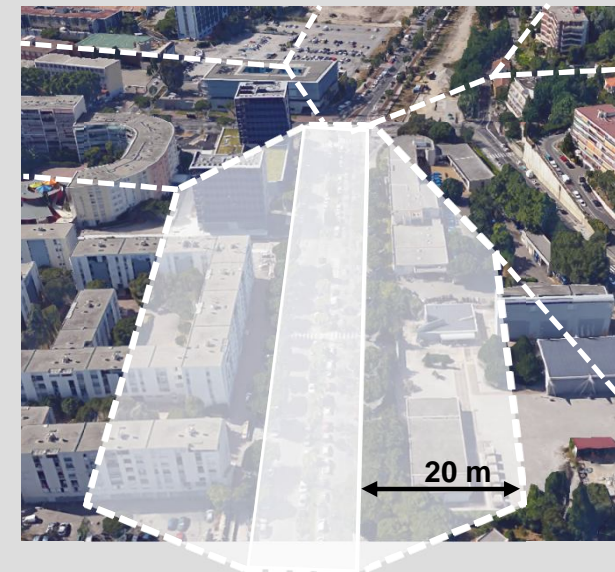
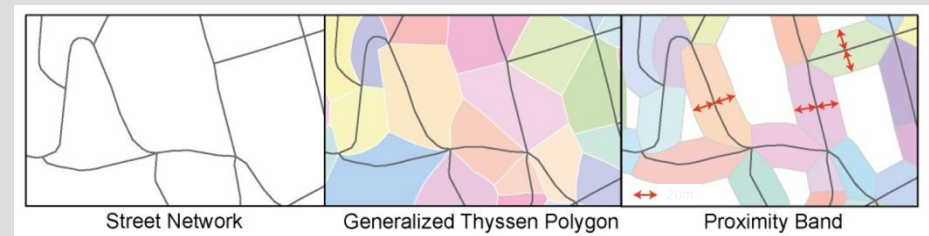
Spatial Organization of the Urban Landscape



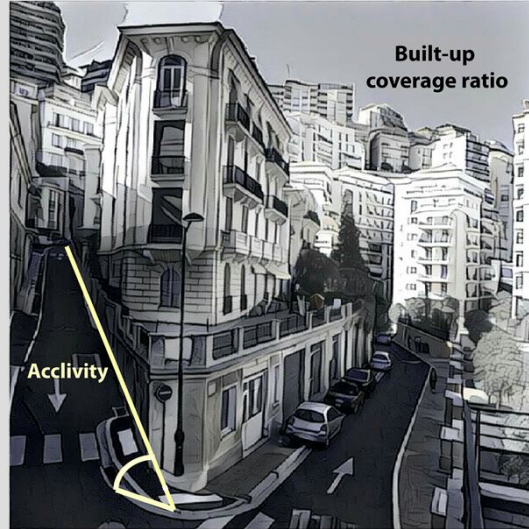
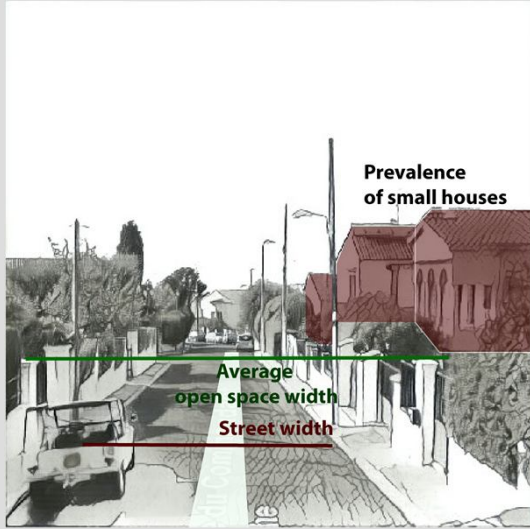
Spatial Unit Definition

Street proximity bands: the pedestrian point of view of urban fabric.

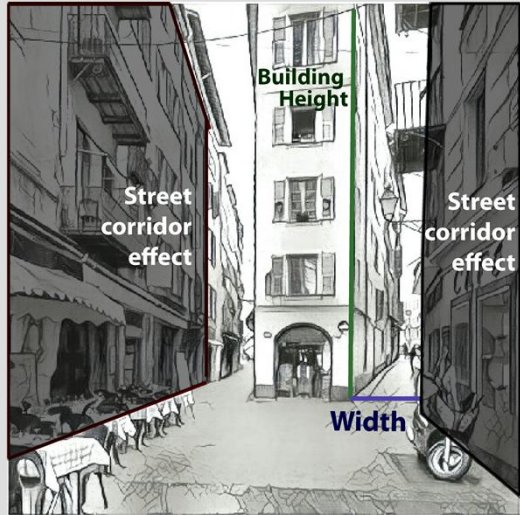
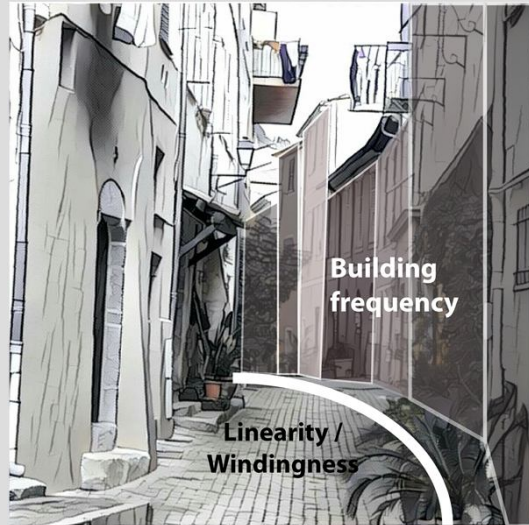
Partition of the planar urban space into regions based on closeness to each network segment within a certain distance from the segment (10 m, 20 m, 50 m)



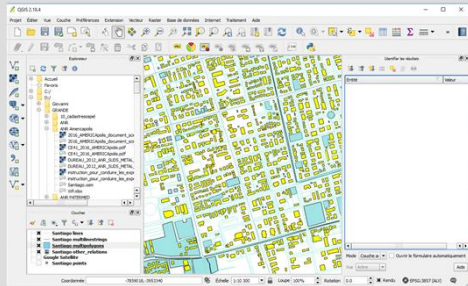
100 000 street segments



Morphological indicators for pedestrians



Geographical Information System (GIS)



Computation of morphological indicators through automated geo-processing

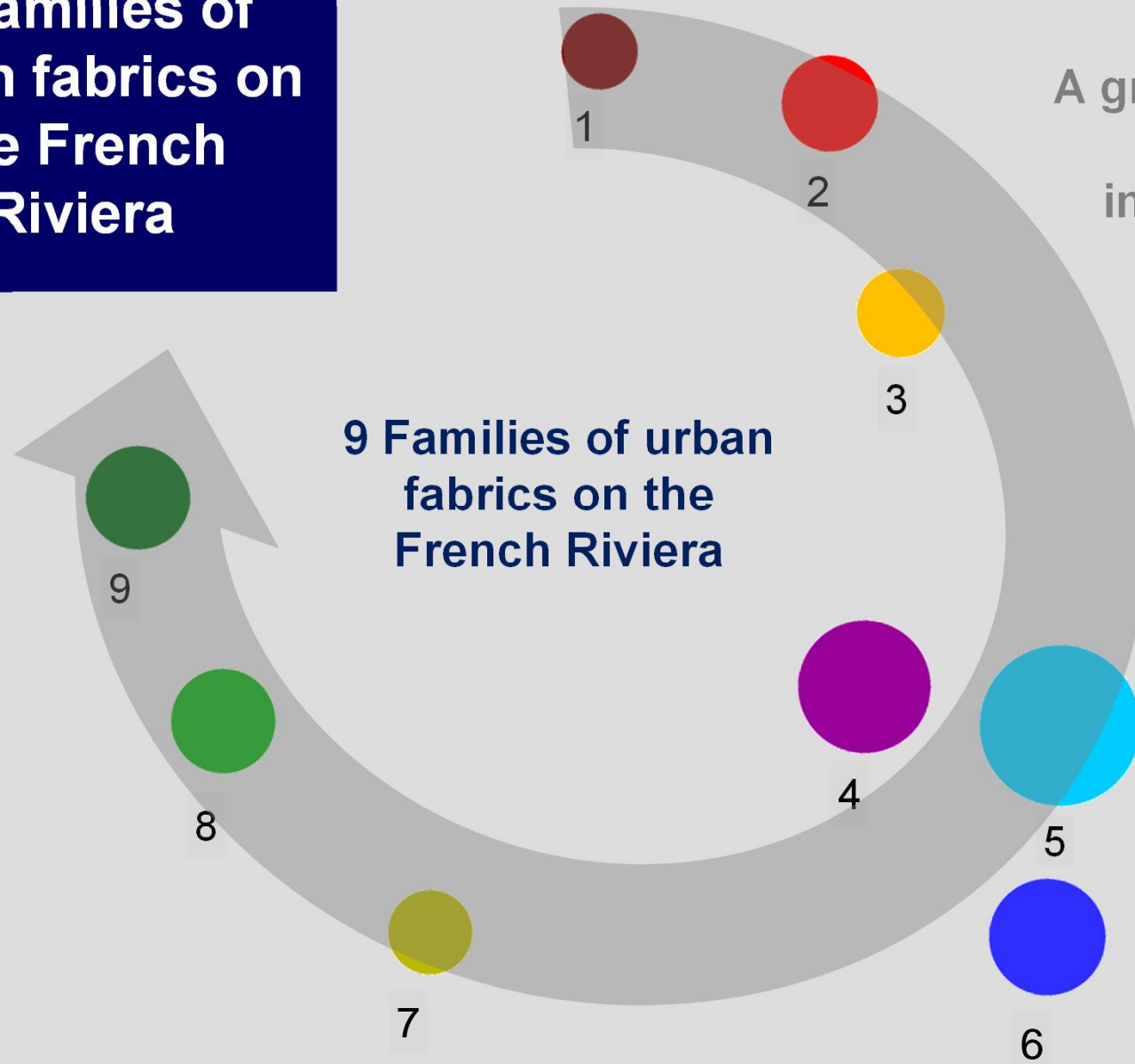


Urban Fabric Component	Indicator	Definition
Network Morphology	Street Length	Network length of the street segments between two intersections [m]
	Linearity/ Windingness	Ratio between Euclidean distance and segment length
	Local connectivity	Average presence nodes of degree 1
Average presence nodes of degree 4		
Average presence nodes of degree 3, 5 or more		
Built-up Morphology	Prevalence of Building type	Ratio between 0-125 m ² building surf. and total built-up surf. in 50 m PB
		Ratio betw. 125-250 m ² building surf. and total built-up surf. in 50 m PB
		Ratio betw. 250-1000 m ² building surf. and total built-up surf. in 50 m PB
		Ratio betw. 1000-4000 m ² building surf. and total built-up surf. in 50 m PB
		Ratio between >4000 m ² building surf. and total built-up surf. in 50 m PB
	Proximity band coverage ratio	Building coverage ratio on the 50 m proximity band
	Building Contiguity	Weighted average of buildings frequency on built-up units
Specialization of Building Types	Ratio between specialized building footprint and 50m PB surf.	
Network-Building Relationship	Street corridor effect	Ratio between parallel façades and street length in 10 m PB
	Proximity band building height	Ratio between building vol. and surf. inside 20 m proximity band
	Open Space Width	Ratio between open space within 20m PB and street length
	Height/Width Ratio	Ration between average building height and average open space width within the 20m PB
	Building frequency along street network	Ratio between number of buildings in 20m PB and street length
Network-Parcels Relationship	Plot fragmentation along street network	Ratio between number of parcels in 20m PB and street length
Site Morphology	Surface slope	Ratio between high sloped ($S > 30^\circ$) and total space-unit in 50m PB
Network-Site Relationship	Street acclivity	Computed as segment average of $\arctan(\text{slope})$

9 Families of urban fabrics on the French Riviera

A gradient of urban intensity

9 Families of urban fabrics on the French Riviera



Old constrained urban fabrics of town-houses



1



2

Traditional urban fabrics of the plain with adjoining buildings

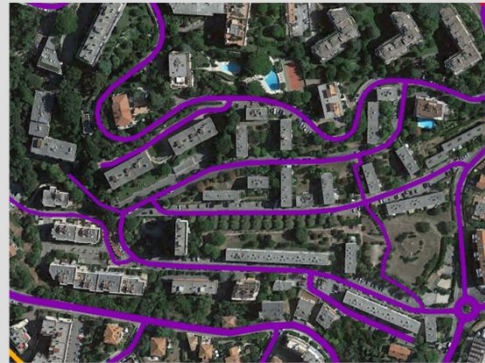
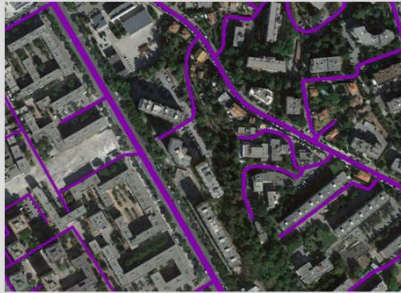


3



Discontinuous and irregular urban fabrics with houses and buildings

Modern discontinuous urban fabrics with big and medium-sized buildings



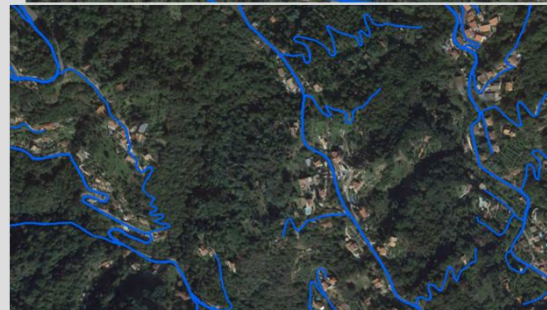
4



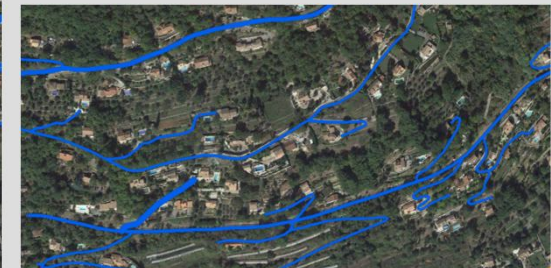
5



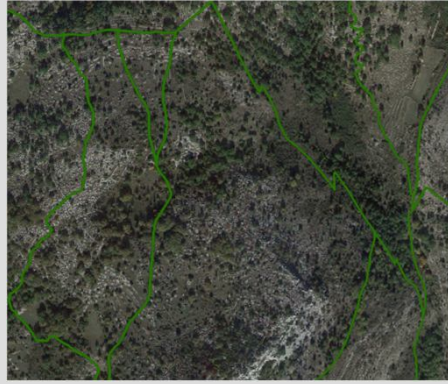
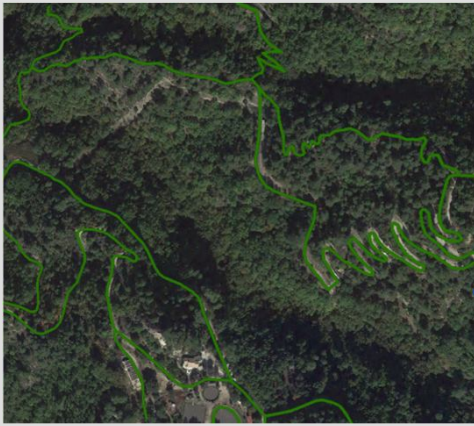
6



Suburban residential fabrics in hills or plain



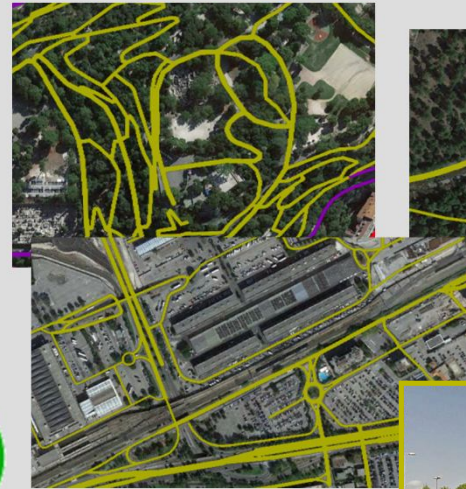
Small house constrained suburban fabrics



Mountain natural space with sparse houses



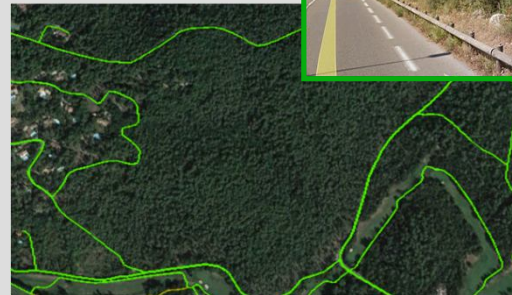
9



Non urbanized space in hills or plain with sparse homes and buildings



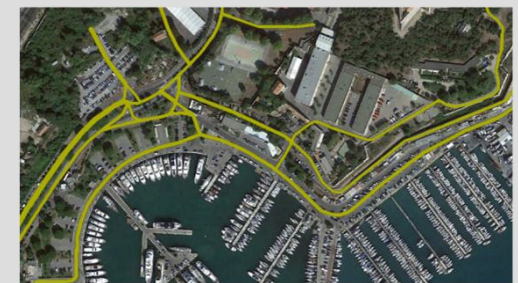
8



7



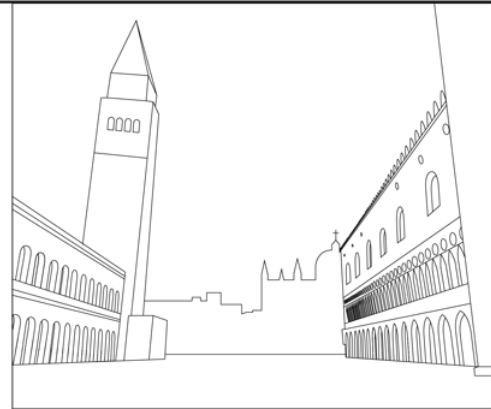
Connective artificial fabrics with sparse specialized big buildings





Urban Fabric Component	Indicator	Definition
Network Morphology	Street Length	Network length of the street segments between two intersections [m]
	Linearity/ Windingness	Ratio between Euclidean distance and segment length
	Local connectivity	Average presence nodes of degree 1 Average presence nodes of degree 4 Average presence nodes of degree 3, 5 or more
Built-up Morphology	Prevalence of Building type	Ratio between 0-125 m ² building surf. and total built-up surf. in 50 m PB
		Ratio betw. 125-250 m ² building surf. and total built-up surf. in 50 m PB
		Ratio betw. 250-1000 m ² building surf. and total built-up surf. in 50 m PB
		Ratio betw. 1000-4000 m ² building surf. and total built-up surf. in 50 m PB
	Proximity band coverage ratio	Ratio between >4000 m ² building surf. and total built-up surf. in 50 m PB
	Building Contiguity	Building coverage ratio
	Specialization of Building Types	Weighted average of building types
Network-Building Relationship	Street corridor effect	Ratio between specialized buildings and total built-up surf. in 50 m PB
	Proximity band building height	Ratio between parallel buildings and total built-up surf. in 50 m PB
	Open Space Width	Ratio between building volume and total built-up surf. in 50 m PB
	Height/Width Ratio	Ratio between open space and total built-up surf. in 50 m PB
	Building frequency along street network	Ration between average building volume and total built-up surf. in 50 m PB
Network-Parcels Relationship	Plot fragmentation along street network	Ratio between number of parcels in 20m PB and street length
Site Morphology	Surface slope	Ratio between high sloped ($S > 30^\circ$) and total space-unit in 50m PB
Network-Site Relationship	Street acclivity	Computed as segment average of $\arctan(\text{slope})$

Possible Geometrical Asymmetries



Geometrical Asymmetries: a Conceptualisation

Borgo and Masolo (2009): 3 kinds of symmetry/asymmetry relations which arise from ontological distinctions:

(R) Region-based (a)symmetry applied to a system viewed as a combination of regions.

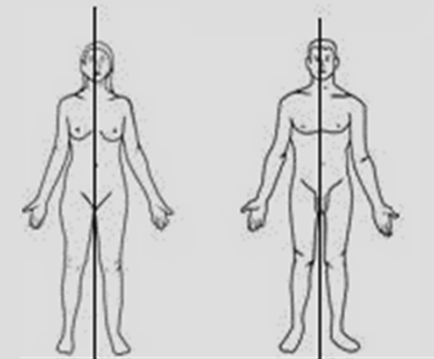
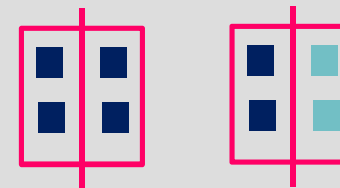
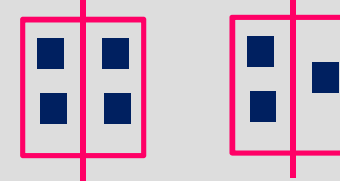
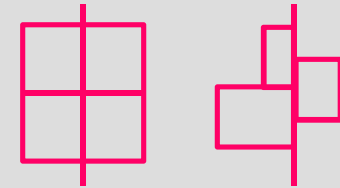
(O) Object-based (a)symmetry applied to the spatial distribution of specific objects in the regions.

(Q) Quality-based (a)symmetry applied to either region's or object's attributes.

Choice of axis / plan / point to assess (a)symmetry.

MFA assumption: the right/left distinction is a human-centered projection of our body and vision system, characterized by an axial symmetry.

MFA focused on the pedestrian moving along the street more than with the 360° "visual sensor" (Isovist).

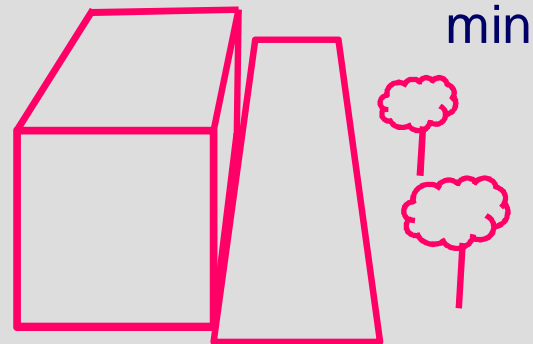


Geometrical Asymmetries of Urban Form

MFA: O & Q (a)symmetries of buildings and their relation to streets within proximity bands.

For each Morphological Indicator :

Max



$$\text{Asymmetry} = \begin{cases} \text{Max} - \text{min} \\ \text{Max} / \text{min} \end{cases}$$



Conceptualizing Perceived Asymmetries of Urban Form

How to normalize asymmetries to obtain an asymmetry score over the 15 morphological indicators?

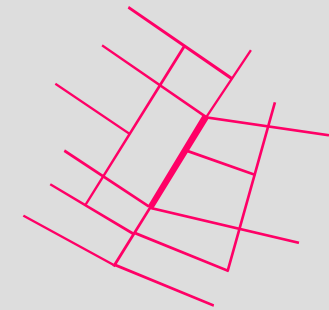
Hyperlocal normalization

$$A_i = \frac{Max_i - min_i}{Max_i}$$

Max / *min*

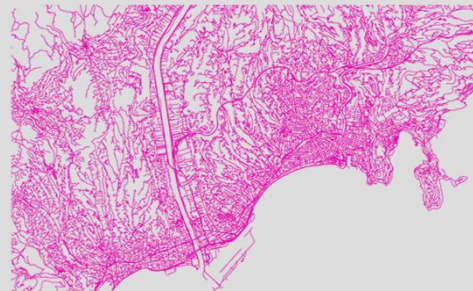
Local normalization

$$A_i = \frac{Max_i - min_i}{Avg Loc_i}$$



Global normalization

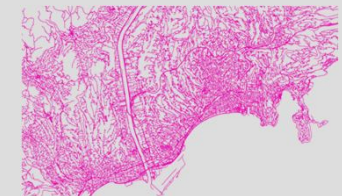
$$A_i = \frac{Max_i - min_i}{Avg Glob_i}$$



Global / Hyperlocal normalization

$$A_i = \frac{Max_i - min_i}{\sqrt{Avg Glob_i * Max_i}}$$

Max / *min*

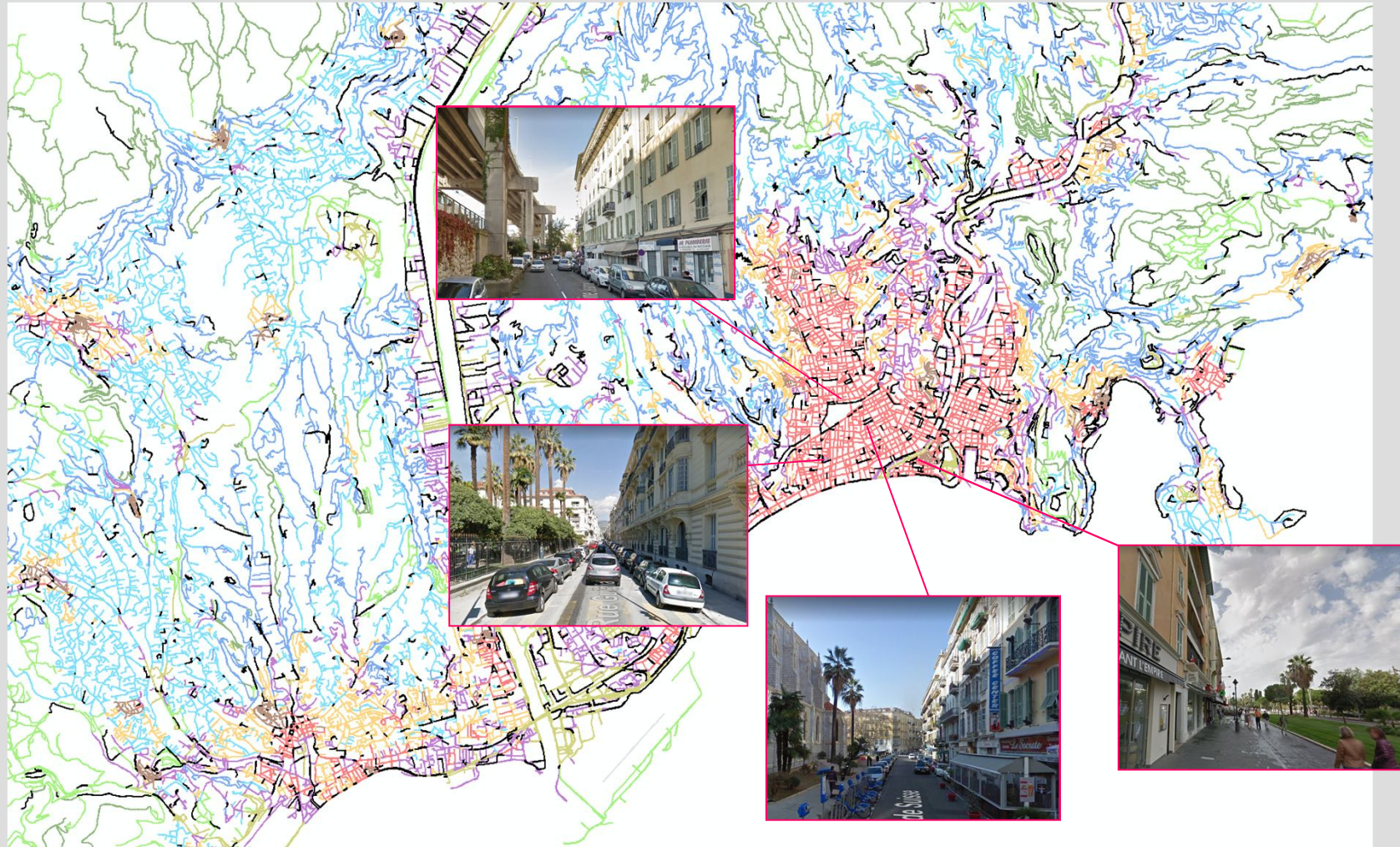


Asymmetry Score

$$A = \sum A_i$$



Hyperlocal Asymmetry Score



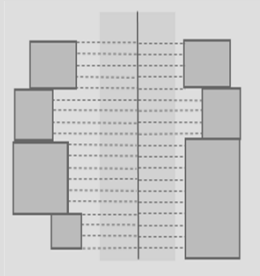
Discontinuities in the urban morphological landscape: railways, gardens, large specialized buildings, dividing lines between different urban fabrics

Global Asymmetry Score



Ability of traditional urban fabrics to produce asymmetric visual compositions → composite asymmetry, picturesque

Simplifying Isovist within MFA



Visual rays perpendicular to street segments.

Point-wise calculus of selected MFA indicators (open space width, W/H ratio, etc.)



From punctual values

...

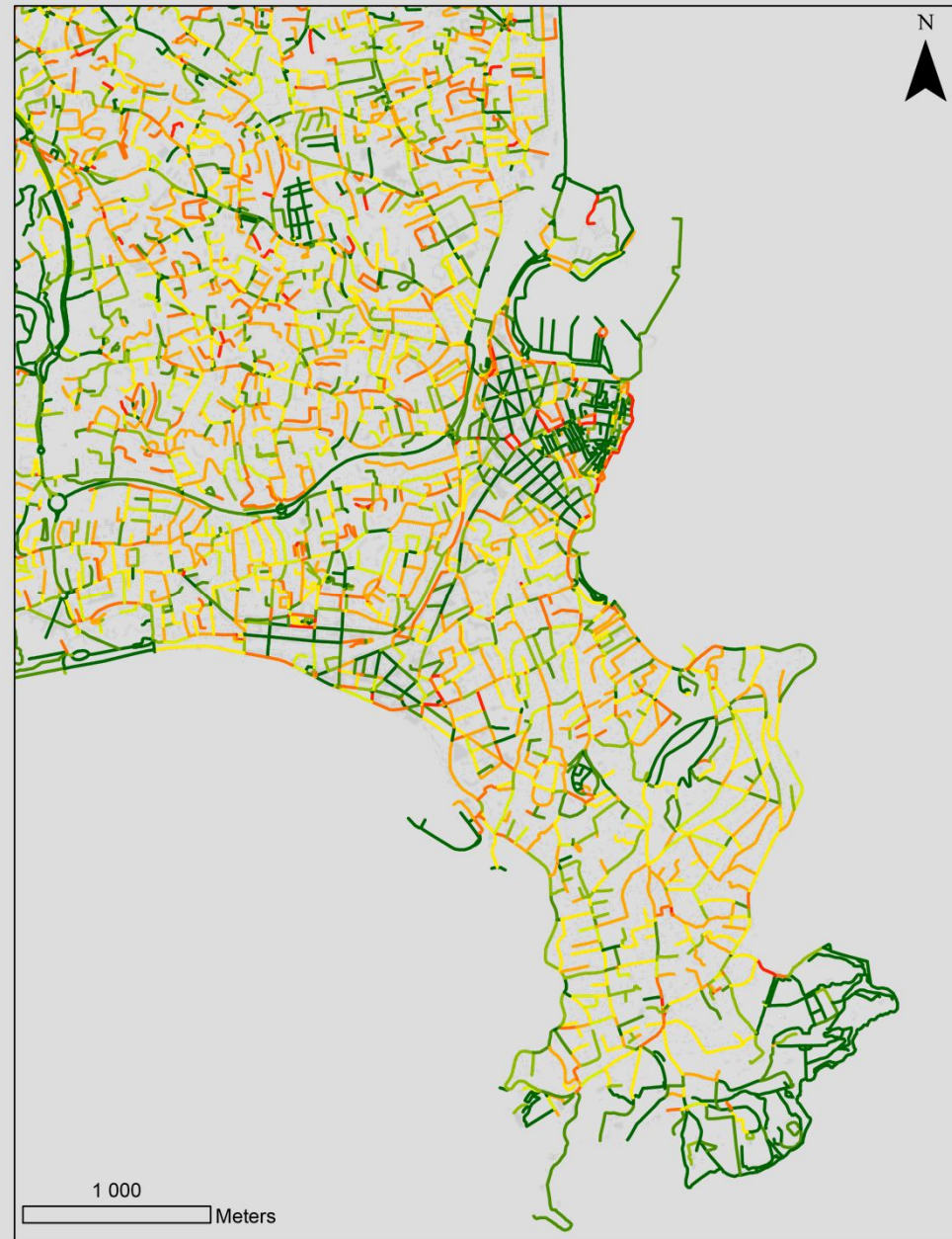


to a statistic summary

Different spatial logics within the urban space

Traditional urban fabrics (families 1-2): highly asymmetric exceptions (squares, boardwalks) within symmetrically built-up streets... topological and geometrical asymmetries meet.

Modern and suburban fabrics (families 4-6): more heterogeneous patterns





Asymmetries Along the Way - Conclusions

- **MFA:** possibility to detect families of urban fabrics through automated spatial analysis of a metropolitan area
- Analysis of urban fabrics poses the **question of geometric asymmetries** → **gain of knowledge on the spatial logics of urban fabrics.**
- Interest of the **pedestrian point of view** differentiating the two opposite sides of street segments
- Different ways of measuring asymmetries for pedestrians:
 - **Hyperlocal Asymmetry Score:** asymmetries resulting from discontinuities between and within urban fabrics
 - **Global Asymmetry Score:** Different urban fabrics are more or less apt to produce composite geometric asymmetries
 - **Point-wise calculus for selected indicators:** additional knowledge on urban fabrics

Future Developments

- **Extension to region-based asymmetry:** surface and shape of proximity bands, with qualities that are now referred to regions (concavity/convexity of proximity bands introducing asymmetry in the visual field)



- Geometrical and topological asymmetries: what changes?
- The **role of asymmetries:** study the **relation between form asymmetries and urban functioning / human behaviors** (linked to perception of urban form like retail activity, neighborhood satisfaction, aesthetic appreciation of urban landscape, etc.)

First European Asymmetry Symposium
Nice, March 16th 2018

UNIVERSITÉ
CÔTE D'AZUR



Complex Systems Academy of Excellence

Thanks for your attention

