Urban Squares Morphologies, Contributes of a Multidimensional Analysis

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Introduction

The word Square and the Latin – platea – derived terms (piazza, plaza, praça, piaţă) are used to identify a public space of an exceptional character that is morphologically distinct in the urban morphology. The study of urban morphology seeks to understand the spatial structure and character of the city by identifying the patterns of its elements and the process of its development. The characterizing traits of the urban square are diverse and their origin twofold: global properties, referred to its relationships within the whole grid, and local properties, depending on the intrinsic morphologic features of its space; what requires a multi-dimensional and multi-scale approach.

This paper will present a multidimensional analysis of two Italian Tuscan historic squares and two Portuguese historic squares. The squares will be analysed from a simultaneous view of their attributes. Thus, it is proposed, in an ongoing joint research project, to address the limitations of traditional-descriptive urban morphology in dealing with this simultaneity. Developing the relations between formal attributes and intangible spatial properties, their identity and closeness may be disclosed by multivariate statistical analysis and computational techniques.

Research

Urban morphological studies carry out diverse detailed analyses, and classification proposals, of urban environments and elements at various scales and complexity levels. Space Syntax (Hillier and Hanson 1984) approaches public space by focusing on the determination of representations and syntactic quantifiable measures that expose the rules of the social construction and of the perceptive-cognitive apprehension of

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spaces. Campos (1997) studies the relationship between patterns of use and the configuration of the urban network by investigating the penetration of axial lines on the space of a group of urban squares in London, and Campos and Golka (2005) the effect of visual fields through visual graph analysis (VGA, Turner et al. 2001) and isovists (Benedikt 1979). Cutini (2003) studies a number of Tuscan historic squares (piazzas), focusing on the relationship between centrality, configuration and visual measures and tries to extend the typical univariate and bivariate space syntax analysis by creating a new compound VGA index that depicts the hierarchy of convex spaces in settlements.

The methods of urban analysis and classification are usually restricted to 3 or 4 variables, so as to respond to human cognitive, perceptive and visual limitations and, thus, restraining the simultaneous expression of other features that give spaces their individuality. Gil et al. (2012) compile the shortcomings of traditional typomorfological approaches: their time-consuming methods, limiting the amount of morphological examples and dimensions, their relative opacity and subjectivity, their dependence on the analyst's abilities, as well as on geographical and cultural contexts, questioning their reproducibility and generalization. The identified deficiencies can be addressed by the use of new computational and formal architectural methods, entailing algorithmic modelling and design, and exploratory and multivariate statistical analysis.

Moreover, some of the urban square variables are of a configurational and non-discursive nature (Hillier 1996). The combination of several theories and spatial and site analysis methods with data mining allows overcoming this inability through machine learning, creating new bottom-up knowledge from the very structure of the data itself.

Through computational processing of the digital bases of the squares 2D and 3D representations, the collecting of survey and literature information on the sites, and a semi-automatic workflow, we retrieve a heterogeneous set of formal and spatial (metric, geometric and topological-syntactic), environmental and perceptual-cognitive attributes, building an open-ended and scalable database for subsequent multivariate analysis. The identification of correlations and the definition

of a minimum set of attributes capable of characterizing the spaces are central to the investigation.

The present text encompasses five aspects: (i) firming the concepts, criteria and attributes to extract; (ii) survey on theories, methods and spatial analysis tools and shortcomings identification; (iii) adaptation and/or creation of new methods and tools; (iv) creation of databases from CAD and GIS environments; (v) research on multivariate analysis and data visualization techniques.

This study focuses on some original computational tools developed for the extraction of a defined set of formal and spatial attributes of the public open spaces to be analysed (Lopes et al, 2015). They have been exclusively developed in a popular VPI (Rhino/Grasshopper) and include (Figure 1):

1 - Characterization of the urban spaces' boundary roughness through its fractal dimension (Hausdorff dimension). Illustration of an expeditious geometric method of fractal analysis, alternative to box-counting, with the advantages it can be used in three-dimensional shapes and is indifferent to spatial orientation;

2 - Characterization of the public space shape by mapping the connectivity along its border. Quantification of the attributes exposed in Psarra and Grajewski (2001) and Laskari et al (2008);

3 - Determination of the major/minor Euclidean distance (diameters) within the boundaries of a space, convex or not, and sensitive to the existence of "islands", as well as the radii centroid-vertices, and variable radial sampling from a selected point. Determination of attributes related to shape factors.

4 - Construction of rigorous 2D isovists (viewsheds), mapping of isovists fields, and its statistical description. Internal and external isovists to the squares. Illustration of a 2,5D isovist method and the use of components oriented for animation in the production of iterated analysis;

5 - Analysis of the orientation and heights of the buildings surrounding the public space; automatic extraction of these values from the provided conventional 3D CAD models, and inquiry on its variability and entropy;

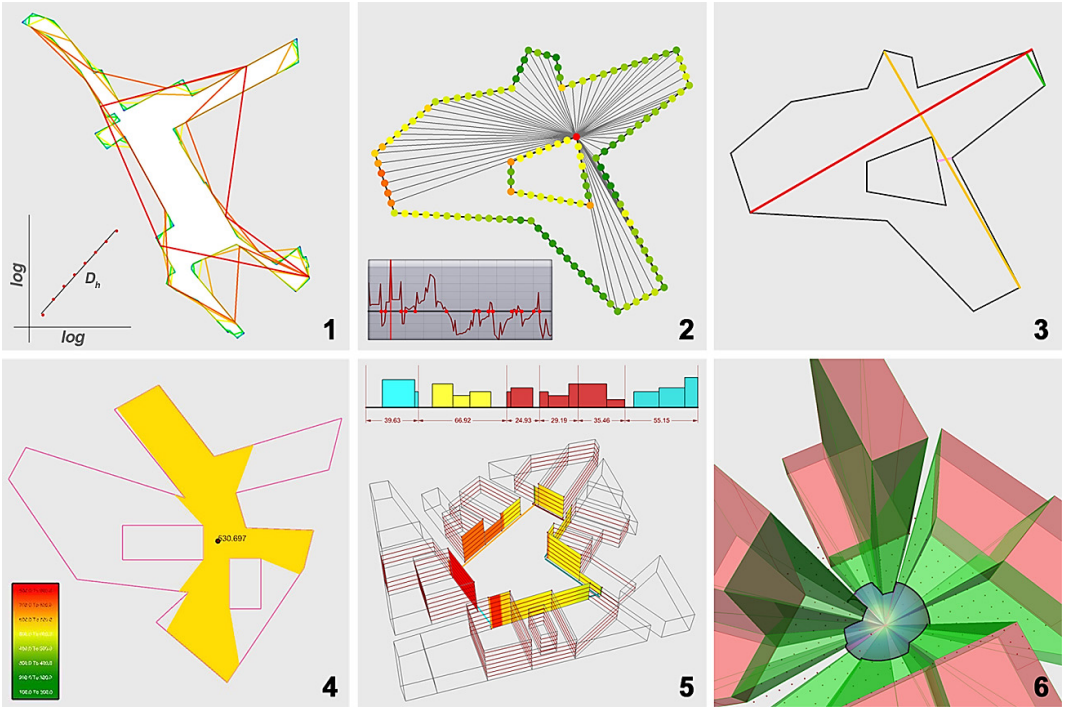

Figure 1: Square Multidimensional analysis. 1. Fractal dimension; 2. Perimeter connectivity; 3. Shape diameters; 4. Parametric isovists; 5. Facades, building heights and solar orientation mapping; 6. Sky view factor.

6 - Determination and mapping of public spaces' sky view factor through a geometric process on a continuous sky dome based on solid 3D isovists; its intersection with solar geometry analysis approximating insolation calculation;

7 - Creation of a data pipeline between these parametric urban models and a database.

Conclusions

The multidimensional analysis of the four historical squares urban elements will enable: (i) to establish a generic method of synchronous analysis and classification of these elements, eventually capable of extending to other kinds of public open spaces and to suggest new lines of research; (ii) to correlate quantitative and qualitative or performance attributes, supporting a stronger evidence-based urban design; and (iii) to comparatively analyse the descriptive-morphotypological and the configurational-structural approaches to urban analysis and design (typo vs population thinking).

References:

Benedikt, ML 1979. 'To take hold of space: isovists and isovist fields', *Environment and Planning B: Planning and Design,* 6(1), pp. 47-65

Campos, MB 1997 'Strategic spaces: patterns of use in public squares of the city of London', *Space Syntax - First International Symposium Proceedings*, London, pp. 26.1-26.11

Campos, AMB and Golka, T 2005 'Public Spaces Revised: of the relationship between Patterns of Stationary Activities and Visual fields', *Proceedings, 5th International Space Syntax Symposium,* Delft

Cutini, V 2003 'Lines and squares: towards a configurational approach to the morphology of open spaces', *4th International Space Syntax Symposium*, London Frankhauser, P 1994, *La Fractalité des structures urbaines,* Anthropos, Paris

Gil, J, Beirão, JN, Montenegro, N and Duarte, JP 2012, 'On the discovery of urban typologies: Data mining the many dimensions of urban form', *Urban Morphology*, 16(1), pp. 27-40

Hillier, B and Hanson, J 1984, *The Social Logic of Space*, Cambridge University Press, Cambridge

Hillier, B 1996. *Space is the machine: a configurational theory of architecture*, Cambridge University Press, Cambridge

Laskari, A., Hanna, S. & Derix, C., 2008. Urban identity through quantifiable spatial attributes. In J.Gero and A.Goel (eds.), *Design Computing and Cognition '08*, pp.615-634.

Lopes, V; Paio, A, Beirão, J N, Pinho, E M & Nunes, L, 2015. Multidimensional Analysis of Public Open Spaces - Urban Morphology, Parametric Modelling and Data Mining, Martens, B, Wurzer, G, Grasl T, Lorenz, WE and Schaffranek, R (eds.), *Real Time - Proceedings of the 33rd eCAADe Conference* - Volume 1, Vienna University of Technology, Vienna, Austria, 16-18 September 2015, pp. 351-360

Psarra, S., Grajewski, T., 2001. Describing shape and shape complexity using local properties. In *Third International Space Syntax Symposium*. Atlanta