Combining Different Methodological Approaches to Analyze the Oporto Metropolitan Area

Ref 088

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Keywords
spatial configuration; methodology; modelling; metropolitan areas; Oporto

Abstract

This paper is part of a wider on-going research project designed to identify and understand the determining factors of the urban change and metabolism of metropolitan areas and city regions. Oporto Metropolitan Area is the case study. Our analysis of this complex urban system combines three different approaches, an accessibility model recently developed at our Research Centre - the Structural Accessibility Layer/SAL, the Space Syntax techniques developed at the Bartlett School of the UCL after Bill Hillier's work, and a morphological approach close to the Conzenian School. The present paper specifically focuses on the interplay between the second and the third approaches. The complementary utilization of these approaches and the results so far obtained in the Oporto case study has been most stimulating. It is our strong believe that, according to each specific urban problem or situation, this utilization shall be considered.

Our research involves the analysis of the past, the present and the likely future urban development of Oporto, considering both its planned and unplanned dimensions. GIS based redrawing of historic cartography, coupled with axial analysis, made possible the rigorous study of the evolution of the urban layout of the city throughout the 19th and the 20th centuries. These techniques enabled the identification and confrontation of, on one hand, the most important morphological periods identified in this time frame and, on the other hand, the particular time periods that have most contributed to the intelligibility of the city, producing the most integrated and connected streets and urban spaces.

Another aspect of our reflection is the importance of the urban plot. While this has been somehow devaluated in Space Syntax theory, one of the key features of the Conzenian approach is the recognition of the threefold division of the townscape into land use, building fabric and town plan, the latter comprising streets, buildings and plots.

The last theme of our reflection is the contribution of the morphological analysis to the formulation of planning proposals and, in particular, to the definition of operational planning areas and to the establishment of specific area-based policies. Within the Conzenian School, this has been approached through the formulation and refinement of concepts such as morphological region, urban tissue, or levels of resolution, and the application of these concepts to a number of urban plans. Oporto municipal plan is a good example of this morphological trend. Space Syntax has also been trying to define the concept of urban area purely in terms of space, and to understand how different urban areas aggregate themselves to form a spatial whole. This has been explored through the analysis of the contextual spatial structure. An open and constructive dialogue between both approaches shall be able to establish a richer concept of planning area, attractive to, and more easily manageable by, planning practitioners.

1. Introduction

The use of different morphological approaches in the analysis and planning of our cities is the main theme of this article. By means of their application to a particular case study, the paper aims at compare two leading approaches in urban morphology, Space Syntax and International Seminar on Urban Form/ISUF. If advantages emerge from the complementary use of these approaches, there will be conditions for the definition of a framework for analysis and prescription in planning including both.

Assuming the predominance of the referred approaches among the different perspectives on the study of urban form, and the fact that Space Syntax is quite familiar to the audience of this conference, the second part of the paper describes the origins, developments and the main characteristics of ISUF. The third section presents the utilization of both approaches in Oporto. It begins with a brief introduction to the second largest city in Portugal and with some considerations on the available cartographic surveys, moving on to the description of morphogenetic and syntactic analysis of a set of fifteen maps produced throughout the last two centuries. The fourth part of the paper presents some reflections on the complementarily utilization of these different approaches.

2. Two different morphological approaches

This second section presents ISUF's approach, highlighting its main theoretical, conceptual and methodological features, distinguishing it from Space Syntax's approach. By designating a ISUF's approach the authors do not intend to erase the differences between all the schools and researchers that have been finding in this group a privileged platform for debate. Nevertheless, we believe that there is a solid shared base, in terms of theory and methods that allows for this designation. Most of the morphological work developed in our research centre, CITTA, is grounded in ISUF's approach.

The International Seminar on Urban Form was established in the beginning of the 1990s. It gathers a curious balance in terms of schools and traditions. On the one hand, there has been an increasing presence of researchers from new countries in its annual conferences, and of scientific papers on national morphological traditions in its journal, 'Urban Morphology'. On the other hand, there is a clear predominance of its seminal traditions, the British historical-geographical school grounded on the work of Conzen, and being mainly developed by the Urban Morphology Research Group/UMRG, and the Italian school of urban morphology and building typology founded by Muratori, and being mainly developed by the Centro Internationale per lo Studio dei Processi Urbani e Territoriali/CISPUT. For additional information on the former see Larkham (2006) and Whitehand (2001, 2007) and on the latter see Cataldi (2003) and Cataldi et al (2002).

A major theoretical aspect of this approach is Conzen (1960)'s division of the townscape in three main parts, the town plan, the building fabric, and the land use and building utilization. He defines town plan as the topographical arrangement of an urban built-up area in all its man-made features. The town plan contains three distinct complexes of plan elements: streets, and their arrangement in a street system; plots, and their aggregation in street-blocks; and the block-plans of buildings.

Another important theoretical issue, mainly explored by Conzen, is the conceptualization of historical development. One of these concepts is the morphological region, defined by Conzen (1960), as an area of homogenous urban form in terms of plan type, building type and land use, becoming distinguishable from the surrounding areas. Kropf (1993) links this concept of morphological region with the idea of urban tissue, developed by the Italian school, and proposes the concept of levels of resolution. According to the latter, the physical form of a city can be divided in a number of levels, each forming the basis for analysis to prescription. These levels can range from the whole municipal territory to the different parts of a building.

Another key concept proposed by the German *émigré* geographer is the fringe belt, corresponding to a zone originating from the temporary stationary fringe of a town and composed of a characteristic mixture of land-use units initially seeking peripheral location. When residential urban growth restarts, this area becomes surrounded, but assumes a number of characteristics that are different from the involving urban tissues.

A third fundamental concept is the morphological period, corresponding to the influence exerted by a time period on the urban forms of a particular territory. This idea can be linked to the concept of typological process, developed by the Italian school, in which new building types are viewed as products of a process of learning from the adaptations of previous building types (Whitehand, 2001).

Conzen (1960) conceptualizes the burgage cycle as the progressive filling-in with buildings of the backland of burgages terminating in the clearing of buildings and a period of urban fallow prior to the initiation of a redevelopment cycle. Finally, Conzen defines the morphological frame as the set of urban form preexistences that stand for and that condition, at least in an initial stage, the process of urban development.

Some fundamental methods have been proposed throughout the years within this approach, namely: morphogenetic method, aiming at reconstructing the historical development of the physical configuration of urban areas, using different sources of information; town plan analysis, focusing on the arrangement of streets, plots and buildings; cartographic redrawing, involving the redrawing of maps from different historical periods and with different levels of rigour in order to produce an unified set of representations (this will be expanded in the next section); and, metrological analysis, corresponding to the detailed measurement of plot sizes.

3. Oporto case study

The next section presents the application of both approaches, Space Syntax's and ISUF's, in the analysis of the evolution of Oporto urban form during the last two centuries. Oporto is the centre of its metropolitan area and the most important city in the North of Portugal, taking advantage of a unique location facing the sea and the Douro River. The city recorded its maximum population at the beginning of the 1980s. This number had fallen to 221.000 in 2007 mainly due to the relocation of population within its metropolitan area (1.6 million inhabitants), particularly to the surrounding cities of Maia and Gaia. Part of the city, corresponding to the medieval borough located inside the 14th century Romanesque wall was classified as a UNESCO World Heritage Site in 1996. Currently, Oporto comprises the largest Portuguese university and the most visited museum of modern art in the country. Oporto has a good road network, a modern airport and a dynamic seaport.

Oporto town plans	
1813	*Planta Redonda* - George Balck
1824	*Plano da Cidade do Porto* - José Francisco de Paiva
1833	*Oporto* - W. B. Clarke
1839	*Planta Topográfica da C. do Porto* - Joaquim da Costa Lima
1865	*Planta da Cidade do Porto* - Frederico Perry Vidal
1892	*Planta Topográfica da C. do Porto* – Telles Ferreira
1903	*Planta da Cidade do Porto* - STCMP
1932	*Planta Topográfica da Cidade do Porto* - STCMP
1937	*Planta Topográfica da Cidade do Porto* - STCMP
1948	*Carta Militar de Portugal* - IGE
1960	*Planta Topográfica da Cidade do Porto* - STCMP
1978	*Levantamento Aerofotogramétrico* - DGPU
1992	*Cartografia Digital* - STCMP
1997	*Carta Militar de Portugal* - IGE
2005	*Planta da Situação Existente* - STCMP

Table 1
Oporto town plans: 1813-2005

The definition of the last two centuries as the timeframe for this study was due to the availability of cartographic material and to the low rates of urban growth prior to 1800s. The first known representation of the city of Oporto is the Planta Redonda from George Balck, made in 1813. Table 1 shows all the cartographic surveys available for Oporto. This table reveals that the preparation of the town plans is not evenly distributed over time. Long time periods appear between the maps of 1865 and 1892, and between the maps of 1903 and 1932. Another limitation of this research was, in the maps of the beginning of the nineteenth century, the lack of information on the peripheral parts of the municipal territory. For this reason these areas are not represented in the maps between 1813 and 1865. The lack of information on the urban plot in some of the original cartography made it impossible to include it in our analysis.

3.1. Morphogenetic analysis

The morphogenetic analysis of Oporto was already described in three previously published papers. Oliveira and Pinho (2006) identified and characterized the different periods of urban development in Oporto. Oliveira and Pinho (2008) critically reviewed the most influential planning policies in the city since the second half of the nineteenth century. Finally, Pinho and Oliveira (2009) evaluated the use of cartographic redrawing, in the analysis of a particular city during a long period of time. Accordingly, the next paragraphs provide only a synthesis of the procedures and the main results of this analysis. The work in our GIS Laboratory started with the preparation of an updated and rigorous computer-made representation of Oporto. After some initial work that included the erasing of all unnecessary layers of information, the most recent map of our set was ready to generate all the previous maps, by successive subtractions of all physical elements that were not built in the time period between two consecutive maps. Each re-drawn map was the framework for redrawing the previous. In this process, it was necessary to introduce a set of detailed adjustments for a precise overlapping of each pair of maps. Making all the successive representations strictly compatible, we were able to construct a model, permanently updatable and open to different kinds of analysis. The analysis of the fifteen maps of Oporto suggested the existence of three morphological periods over the last two centuries: a monarchic period (1813-1865), a late-monarchic and dictatorial period (1892-1960), and a democratic period (1978-2005). The analysis also made evident the importance of some singular axis in the evolution of Oporto urban layout: Rua do Almada, supporting the initial stages of urban expansion outside the medieval walls; Avenida da Boavista and Rua da Constituição, guiding the Northern and Western urban expansions in the second morphological period; and the Avenida Marechal Gomes da Costa and Avenida Antunes Guimarães, structuring the western part of the city in a complementary way to Avenida da Boavista, throughout the second half of the second morphological period. Finally, this analysis has demonstrated that the dominant urban forms in Oporto are much more influenced by the relationships between the private initiative and the development control mechanisms in the short term, than by long term design proposals included in local planning documents. Within eight municipal plans, the only exception to this situation seems to be the Plano Regulador do Porto prepared in the beginning of the 1950s.

3.2. Axial analysis

A number of studies on the evolution of a city throughout a long period of time can be found in Space Syntax literature. Perdikogianni (2002) compares the evolution of spatial and functional patterns of two Cretan 'organic' cities – Heraklion and Chania – since the seventeenth century (1666-1990), demonstrating how the morphology of their grids was determinant for the development of two different historical cores. Dai (2004) analyses the evolution of the Chinese city of Suzhou throughout the last seven centuries (1229-2004), investigating the relationships between the changing functional pattern and its spatial structure in the urban transformation process. Gemil (2007) analyses the sequential development and the consequent urban patterns of Bucharest since 1852. Azimzadeh (2008) analyses the different periods of urban development of the Swedish city of Gothenburg between 1644 and 2004, focusing on the urban layers resulting of planned developments.

Our analysis, carried out with Depthmap software, focuses on the axial map of Oporto throughout its historical process of development. The analysis comprises global (radius n) and local (radius 3) integration, connectivity, global and local intelligibility, and synergy. Global integration measures the relative depth of each axial line to all other lines of the system. Local integration measures the accessibility up to three steps away. Connectivity measures the degree of intersection or one step possibilities of each axial line. Global intelligibility, expresses the degree of linear correlation between connectivity and global integration, and is defined as the degree to which what we can see and experience from the spaces that make up (or are connected in) the system and what we cannot see - the integration of each space into the system as a whole. Local intelligibility is calculated by the degree of linear correlation between connectivity and local integration. Synergy, expresses the degree of linear correlation between local and global integration, and somehow intends to reduce the influence of the system size. Figure 1 shows the evolution of the urban layout of Oporto from the historical town of 1813 until 2005. All the fifteen axial maps have similar scale in order to be comparable. Table 2 provides a synthesis of the metric and axial parameters of this historical process.

Map	Number of Lines	Line Lenght	Global Integratio n	Local Integratio n	Connecti-vity	Global Intelligibi-lity	Local Intelligibi-lity	Synergy
1813	477	154,356	0,867	1,703	3,790	0,195	0,705	0,456
1824	486	155,378	0,875	1,710	3,814	0,209	0,710	0,466
1833	491	155,896	0,886	1,712	3,825	0,216	0,708	0,478
1839	503	164,521	0,917	1,737	3,869	0,253	0,691	0,539
1865	542	165,241	0,898	1,730	3,875	0,249	0,689	0,520
1892	2248	179,608	0,555	1,562	3,382	0,095	0,628	0,300
1903	2286	182,204	0,585	1,593	3,441	0,109	0,588	0,352
1932	2379	186,849	0,630	1,642	3,542	0,122	0,571	0,392
1937	2494	185,060	0,639	1,657	3,572	0,106	0,565	0,360
1948	2645	183,068	0,636	1,673	3,602	0,092	0,567	0,323
1960	2978	177,974	0,652	1,699	3,632	0,086	0,551	0,308
1978	3505	172,424	0,702	1,704	3,597	0,076	0,529	0,310
1992	3728	171,642	0,715	1,720	3,610	0,073	0,511	0,317
1997	4065	169,539	0,713	1,712	3,577	0,071	0,512	0,302
2005	4287	168,983	0,744	1,725	3,599	0,076	0,510	0,322

Table 2
Oporto metric and axial parameters: 1813-2005

Oporto axial system of 1813 is constituted by 477 lines with an average length of 155m. It presents an average global integration of 0,867. The main integrator of the system is Calçada dos Clérigos / Rua de Santo António (1,391), an East-West axe that separates two different types of urban tissues of the city, the 'historical areas' in the South, and the 'areas of continuous building frontages and largely replete plots' in the North (for a characterization of these tissues see Oliveira, 2006). Calçada dos Clérigos (see Figure 2 for the street location) is linked to five lines presenting the other highest values for integration – longer lines in the North (1267m and 767m), and shorter lines in the South. Within the interstices of a main structure of quasi-radial lines, red and orange, are found green and blue lines. The analysis of integration radius 3 shows that some of these green areas, particularly in the West, and in the South along the Douro River, have as a local focus, yellow lines. The average connectivity of the system is 3,790 and the most connected line is Rua do Almada (13), an emblematic street of a successful planning intervention carried out in the second half of the eighteenth century. The local structure of the 1813 Oporto system, described by the synergy, has a value of 0,456 that is a reasonable correlation. Regarding intelligibility, the system holds two different performances: it has a value of 0,195 for global intelligibility, implying an unintelligible system, and a value of 0,705 for local intelligibility, implying an intelligible system at the local scale.

The four maps comprised between 1813 and 1865 do not appear to have significant changes. Nevertheless, and mainly due to different territories considered in the period between 1813 and 1865 (the central area of the city), and between 1892 and 2005 (the whole city), the highest values for the syntactic measures under analysis are comprised in this period. The 1824 map holds the highest value for local intelligibility. The 1839 plan presents the highest values for global integration (even so, a very poor correlation), local integration, global intelligibility, and synergy. The 1865 map holds the highest value for connectivity.

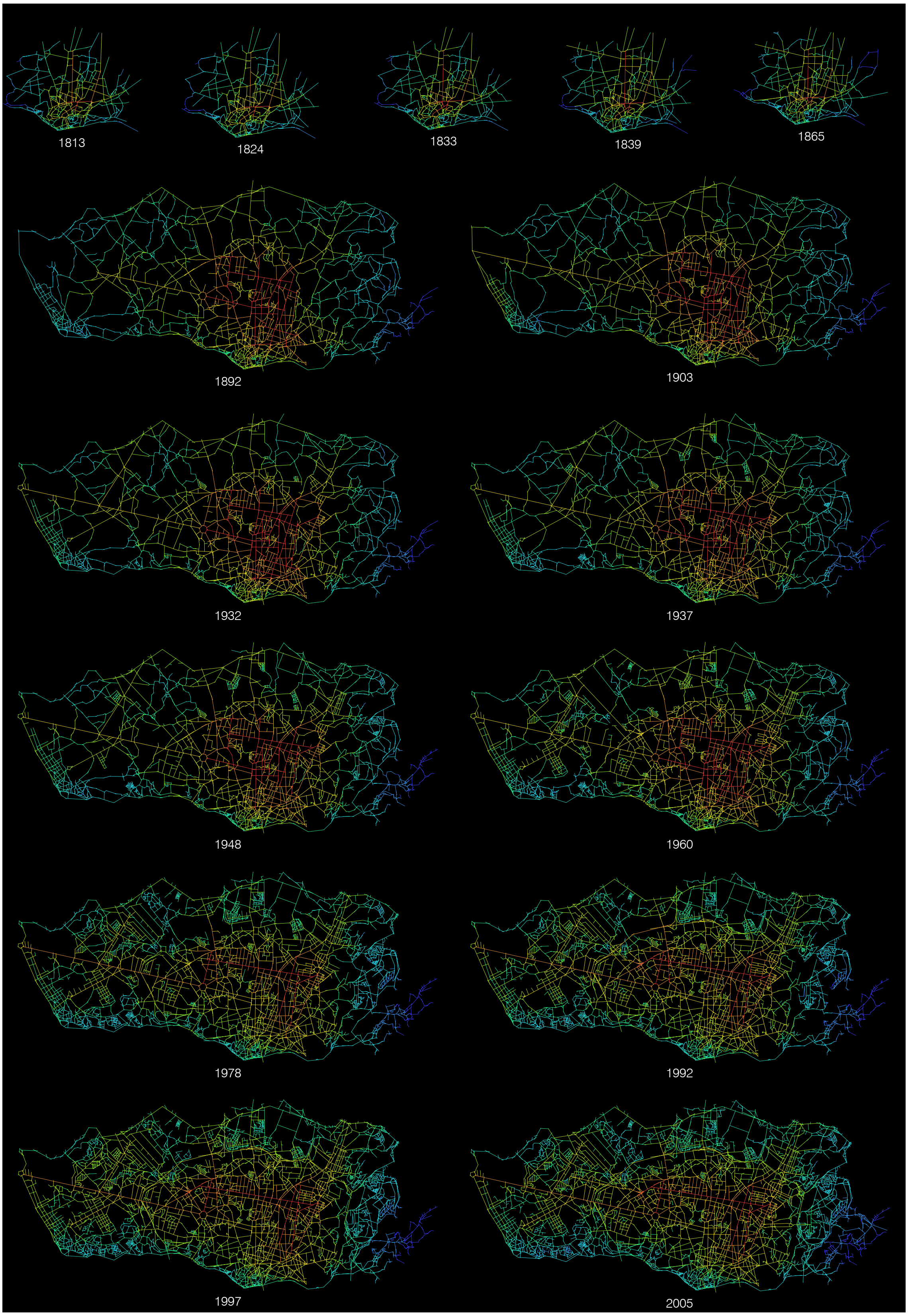

Figure 1

Oporto axial maps (global integration): 1813-2005

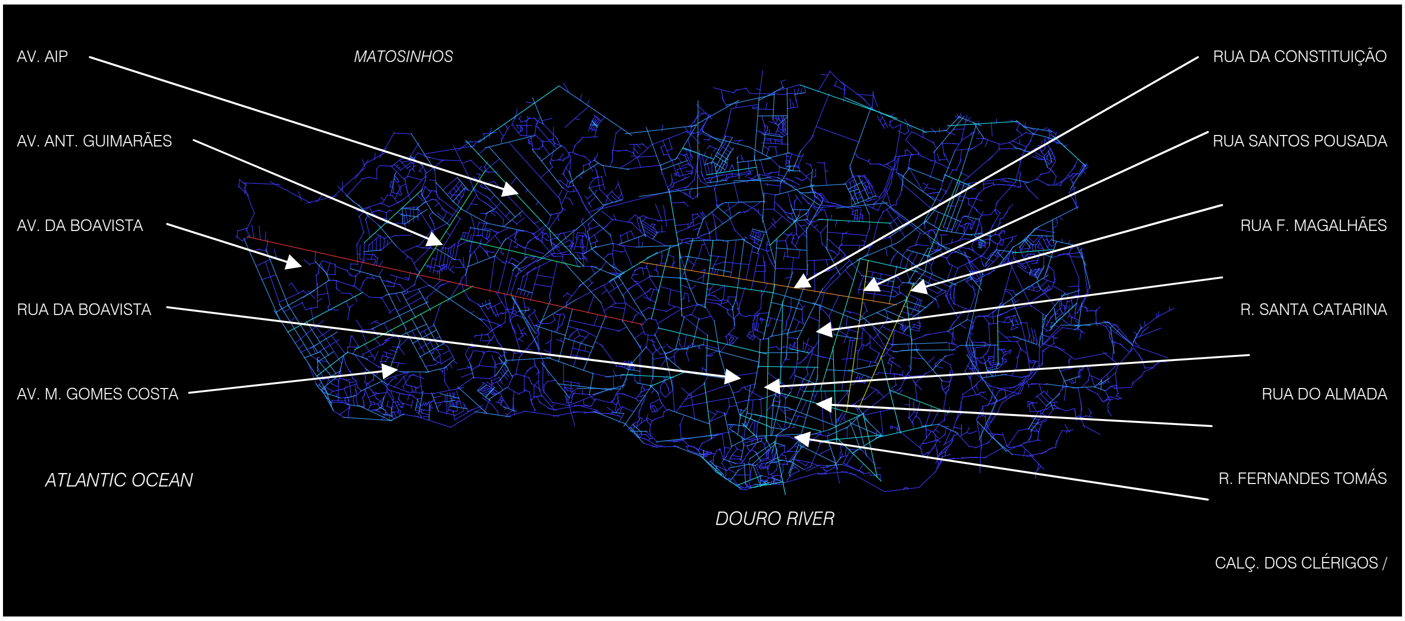

Figure 2
2005 Oporto axial map (connectivity) with the streets names of Oporto referred to in the text

Our historical review of the evolution of the urban structure of Oporto focuses on the 1892 map which was, as referred to before, the first map to represent the whole municipal territory. The process of urban expansion – as well as the integration core – seems to be oriented to the West and to the North. While the number of, and the length of axial lines has increased (particularly the former) all the other syntactic measures under analysis have decreased. Decreases in global integration (from 0,898 to 0,555) and intelligibility (from 0,249 to 0,085) are particularly significant. Rua da Constituição at North of the historical kernel is the main integrator of the system (0,878). The Eastern area of Campanhã emerges as the most segregated part of the city including the deepest lines of the system with integration below 0,3. Av. da Boavista, the longest axe of the system, located at Northwest of the integration core, has the highest local integration (3,455). Far from the city centre and facing the Atlantic Ocean, Foz emerges as a blue area in terms of global integration, but as a yellow (the main lines) area in terms of local integration. Av. da Boavista is the most connected line of the system (22), a situation that will remain until the end of the period under analysis.

The 1903 map holds increases in the first level measures – global and local integration, and connectivity. Within the second level measures only local intelligibility has decreased. The integration core remains almost the same and Rua da Constitução remains as the main global integrator (0,919). In the turning to the twentieth century Av. da Boavista was extended until the seafront and its connectivity increased from 22 to 30. Its local integration has also increased from 3,455 to 3,785. The local integration of the system will be always increasing from 1903 until 2005.

The two axial maps from the 1930s are very similar. The main exception seems to be the construction, in the five years period comprised between these maps, of a number of social housing neighborhoods (including detached and semi-detached houses) in the peripheral parishes of the city, and the extension of some important streets. The 1932 and 1937 maps hold, as the former did, increases in the first level measures. The integration core has a slight extension into the Northeast. Its overall form starts changing, taking advantage of: i) the extension and subsequent connection of two key streets, Constituição and Santos Pousada, and ii) the extension of Avenida Fernão de Magalhães and its subsequent connection with another new axe, Av. dos Combatentes, which was also linked with the gateway road to the town of Guimarães. The main global integrator in 1932 is Rua Santa Catarina, a North-South axe linking the central area of the city with Constituição in the North. In 1937 the main global integrator is once again, and it will remain until 2005, Rua da Constituição. While global and local intelligibility are lower in 1937, synergy is higher in the end of the 1930s. From 1932 onwards the average length of axial lines will decrease from 186,8m (the maximum for the period under analysis) to 168,9m.

While connectivity and local integration increases in the 1948 system (reinforcing the tendency of the four former maps) global integration decreases. As for the second level measures, global intelligibility and synergy are lower in 1948, while local intelligibility is higher.

The 1960 map presents different courses for the first level and second level measures: the former increased (connectivity and local integration increased for the fifth time consecutive), and the latter decreased. In the twelve years that separate this map from the former, the Western part of the city has become more structured. Foz and the areas around the two avenues constructed in the beginning of the century are more closely linked. Local integration values of Av. Antunes Guimarães increased from 3,076 to 3,384, and of Av. Marechal Gomes da Costa increased from 3,056 to 3,397. Still in this part of the city, the end of the construction of Av. AIP enabled the linkage between Oporto, and particularly the Boavista area, and the seaport and the airport, in the municipality of Matosinhos.

The 1978 system holds the highest increase in the number of axial lines. This is mainly due to the conclusion, in 1966, of the largest social housing programme in Oporto involving the construction of sixteen neighborhoods (with more than 6000 dwellings) in expansion areas. Also, the area of Boavista goes under significant changes due to the construction of the third bridge over the Douro and of the first phase of the internal ring road. While the local and global integration of the system increase, connectivity decreases. From 1978 onwards Rua da Constituição (instead of Av. da Boavista) will present the highest values for local integration. As so, it has the highest global (above 1,193) and local (above 4,117) integration.

The two axial maps from the 1990s are quite similar. The main differences appear to be the conclusion of the Eastern part of the internal ring road, and the emergence of some short streets supporting the construction of new housing developments both of public and private promotion. While all first level measures increased between 1978 and 1992, only local integration followed this course in the period between 1992 and 1997.

Oporto axial map of 2005 is constituted by 4287 axial lines (14,7% below the average European city – see Hillier, 2002). It has always been increasing since 1813, when the axial map was composed by 477 lines. The evolution of the average length of an axial line throughout the period under analysis can be divided in two different parts, an increase from 154,3 in 1813 to 186,8 in 1932, and a subsequent decrease until 168,9m in 2005. Global integration in the 2005 map is 0,744 (18,9% below the average European city). It has suffered several variations throughout the period under analysis, the most expressive in 1892 when it decreased from 0,898 to 0,555, due to the consideration, for the first time, of the whole municipal territory. Connectivity in the 2005 map is 3,599 (21,9% below the average European city). As in the case of global integration, connectivity suffered several variations between 1813 and 2005, although with a more reduced expression than the former. Local integration in the 2005 map is 1,725 (23,5% below the average European city). The evolution of local integration has fewer variations than the former measures – increasing from 1,703 in 1813 to 1,737 in 1839, decreasing until 1,562 in 1892, and increasing until 1,725 in the end of the period. All the second level measures suffered several fluctuations throughout the period under analysis and the 2005 Oporto system presents very poor correlation between global integration and connectivity (0,076), poor correlation between global and local integration (0,322), and reasonable correlation between local integration and connectivity (0,510). Finally, it should be mentioned that for all these measures Oporto is closer to UK rather than to European cities.

3.3. Comparing the use of Space Syntax's and ISUF's approaches in Oporto case study

The results from the application of space syntax methods in the analysis of Oporto have, on the one hand, reinforced the main conclusions of our previous study under ISUF framework, and on the other hand, made evident some aspects that have not emerged in the morphogenetic analysis.

One key issue in our previous analysis was the definition of three morphological periods comprised between 1813 and 2005. Tables 3 and 4 make evident the link between morphological periods and integration measures. The maps included in the first morphological period have a global integration comprised between 0,8 and 1,0, and a local integration comprised between 1,70 and 1,75. The maps included in the second morphological period hold a global integration comprised between 0,5 and 0,7, and a local integration comprised between 1,55 and 1,70. Finally, the maps included in the third morphological period have a global integration comprised between 0,7 and 0,8, and a local integration comprised between 1,70 and 1,75. Despite some similarities between the definition of the morphological periods and the values for connectivity, it was not possible to establish such a direct link as in the case of integration.

Global Integration	Maps	Morphological Periods
0,5-0,6	1892, 1903	2nd Morphological Period
0,6-0,7	1932, 1937, 1948, 1960	
0,7-0,8	1978, 1992, 1997, 2005	3rd Morphological Period
0,8-0,9	1813, 1824, 1833, 1865	1st Morphological Period
0,9-1,0	1839	

Table 3
Global integration and morphological periods

Local Integration	Maps	Morphological Periods
1,55-1,60	1892, 1903	2nd Morphological Period
1,60-1,65	1932	
1,65-1,70	1937, 1948, 1960	
1,70-1,75	1813, 1824, 1833, 1839, 1865	1st Morphological Period
	1978, 1992, 1997, 2005	3rd Morphological Period

Table 4
Local integration and morphological periods

These interesting results motivated the application of a different configurational technique, the Angular Segment Analysis/ASA, to Oporto case study. According to its main proponents, the fundamental advantages of angular analysis over axial analysis are as follows: it provides a more refined output data in relation to the integration value in a single line, thus allowing the visualization of different mean depth values for the same axis (Medeiros and Holanda, 2007); it can minimize the effects of cartographic differences between representations, such as axial lines and road-centre lines (Tuner, 2007); and it reflects a cognitive model of how route choice decisions can be made (Conroy Dalton, 2003; Turner, 2007). The segment map, generated from the axial map, consists of the disposition of lines between each node of an urban grid. The analysis comprises segment length, mean depth, and choice/betweenness, using metric radius at different scales, micro, meso and macro. Mean depth is calculated by taking the average length of all angular shortest paths. Choice/betweenness is calculated by generating shortest paths between all segments within the system – the journey with the lowest angular cost for each possible origin and destination pair of segments. Finally, we have followed Turner (2004) conclusions using a tulip analysis at 1024 bins instead of a standard angular analysis.

Table 5 provides a synthesis of the evolution of these measures throughout the period under analysis. Our definition of three morphological periods has a stronger link with the values for choice and for segment length than for mean depth. In relation to choice, the link is reinforced with the definition of metric radius at micro scale – see Table 6. The maps of the first period have choice (radius at 400m) values comprised between 0,060 and 0,065, of the second period between 0,070 and 0,090, and of the third period between 0,065 and 0,070. In relation to the segment length, a key indicator of the urban block size, the links are as follows: the maps of the first period have segment values comprised between 45 and 50m, of the second period between 55 and 65, and of the third period between 50 and 55.

Map	Number segment	Segment Length	T1024 Choice/Betweenness (length-weighted)					T1024 Mean Depth				
			R400m	R800m	R2000m	R5000m	R10000	R400m	R800m	R2000m	R5000m	R10000
1813	1410	46,73	0,061	0,031	0,017	0,019	0,019	2,21	3,18	4,34	4,50	4,50
1824	1451	46,55	0,060	0,031	0,017	0,018	0,018	2,25	3,21	4,35	4,48	4,48
1833	1472	46,43	0,060	0,031	0,016	0,018	0,018	2,25	3,19	4,32	4,47	4,47
1839	1531	48,46	0,061	0,030	0,015	0,017	0,017	2,23	3,14	4,24	4,41	4,41
1865	1646	48,71	0,062	0,031	0,015	0,016	0,016	2,19	3,12	4,24	4,46	4,46
1892	5805	62,00	0,086	0,047	0,021	0,010	0,009	1,93	2,79	4,25	6,45	7,66
1903	6029	61,70	0,085	0,047	0,020	0,010	0,009	1,92	2,78	4,21	6,41	7,52
1932	6504	61,25	0,082	0,045	0,019	0,009	0,008	1,92	2,73	4,13	6,13	7,26
1937	6900	60,02	0,080	0,044	0,018	0,008	0,008	1,93	2,75	4,16	6,17	7,31
1948	7398	58,77	0,078	0,042	0,017	0,008	0,007	1,95	2,78	4,25	6,35	7,52
1960	8555	55,78	0,072	0,040	0,016	0,008	0,007	2,00	2,87	4,36	6,37	7,66
1978	10005	54,33	0,069	0,036	0,014	0,007	0,006	2,09	2,98	4,51	6,51	7,70
1992	10708	53,71	0,067	0,035	0,014	0,006	0,006	2,10	2,98	4,50	6,47	7,58
1997	11590	53,37	0,066	0,034	0,013	0,006	0,005	2,13	3,04	4,56	6,47	7,58
2005	12337	52,67	0,065	0,032	0,012	0,006	0,005	2,15	3,07	4,61	6,39	7,49

Table 5
Oporto metric and angular parameters: 1813-2005

Choice/Betweenness	Maps	Morphological Periods
0,060-0,065	1813, 1824, 1833, 1839, 1865	1st Morphological Period
0,065-0,070	1978, 1992, 1997, 2005	3rd Morphological Period
0,070-0,075	1960	2nd Morphological Period
0,075-0,080	1937, 1948	
0,080-0,085	1903, 1932	
0,085-0,090	1892	

Table 6
Choice/Betweenness and morphological periods

Map	Number of lines	Line length (Maximum)	Integration (Maximum)	Connectivity (Maximum)	Control (Maximum)	Local Integration (Maximum)
1813	477	1267,080 ALM	1,391 CLE	13 ALM	3,418 ALM	2,957 ALM
1824	486	1267,080 ALM	1,402 CLE	13 ALM	3,418 ALM	2,954 ALM
1833	491	1267,080 ALM	1,410 CLE	13 ALM	3,368 ALM	2,963 ALM
1839	503	1369,070 BOA	1,471 CLE	13 ALM	3,287 FER	3,011 ALM
1865	542	1369,070 BOA	1,455 CLE	13 ALM+FER	3,621 FER	3,006 ALM
1892	2248	2830,930 aBOA	0,878 CON	22 aBOA	6,750 aBOA	3,455 aBOA
1903	2286	5021,930 aBOA	0,919 CON	30 aBOA	9,333 aBOA	3,785 aBOA
1932	2379	4961,380 aBOA	0,979 SAN	32 aBOA	11,060 aBOA	3,861 aBOA
1937	2494	4961,380 aBOA	1,018 CON	32 aBOA	10,893 aBOA	3,839 aBOA
1948	2645	4961,380 aBOA	1,018 CON	32 aBOA	10,824 aBOA	3,846 aBOA
1960	2978	4961,380 aBOA	1,033 CON	37 aBOA	13,779 aBOA	3,924 aBOA
1978	3505	4961,380 aBOA	1,194 CON	39 aBOA	13,834 aBOA	4,117 CON
1992	3728	4961,380 aBOA	1,210 CON	44 aBOA	16,163 aBOA	4,208 CON
1997	4065	4961,380 aBOA	1,193 CON	45 aBOA	16,780 aBOA	4,227 CON
2005	4287	4961,380 aBOA	1,259 CON	46 aBOA	16,847 aBOA	4,221 CON

Table 7
Oporto fundamental axes: 1813-2005

Another important feature of our previous study was the identification of the most important axes for the overall structure of the city. As we can see in Table 7 (including an additional axial measure of first level, control) syntactic analysis reinforced the importance of: Rua do Almada (the longest axial line between 1813 and 1833; the line with the highest connectivity between 1813 and 1865, the highest control between 1813 and 1833, and the highest local integration between 1813 and 1865); Rua da Boavista (the longest line in 1839 and 1865) and Av. da Boavista (the longest line between 1892 and 2005; the line with the highest connectivity and control between 1892 and 2005, and with the highest local integration between 1892 and 1960); and Rua da Constituição (the line with the highest global integration in 1892, 1903 and between 1937 and 2005, and with the highest local integration between 1978 and 2005). Besides these streets and avenue, axial analysis have also highlighted the importance of other axes that have been somehow devaluated in our previous analysis, Calçada dos Clérigos/Rua de Santo António, Rua de Santa Catarina, and Rua Fernandes Tomás.

4. Discussion

Space Syntax and ISUF propose different morphological approaches. These approaches are hardly used in a complementary way in the study of particular urban forms and cities. However, the channel of communication between them has been open. Leading proponents of both approaches have been participating in the conferences, or publishing in the journal of the 'other' approach – see for example Hillier and Hanson (1998), Marcus (2006), and Whitehand (2007). In addition, a number of papers has been sustaining a complementary utilization (Hanson and Zako, 2007; Larkham, 2006; Marcus, 2007).

Based on the state-of-the-art and on our case study, we suggest a number of issues for a common morphological agenda. The recognition of the tripartite division of the townscape into land use, building fabric and town plan, the latter comprising streets, plots and buildings, is one of the key features of the ISUF approach. ISUF theoretical development rests on this assumption that is gaining more importance over the years. We believe that Space Syntax theoretical framework should embrace a similar valuation of the urban plot. This is not a novel idea, being already explored by authors such as Marcus (2006, 2007). This author proposes an analytical theory on urban form that highlights the importance of three fundamental themes, accessibility (analyzed within space syntax), density (dominant in geographic analysis of urban space) and diversity. The importance of the urban plot in this theory is reflected on its correlation with diversity indices, such as the presence of different age groups or the co-existence of different types of businesses. A specific software, place syntax, has been designed to support this research.

We also suggest linkages between some concepts around the definition of planning areas. Within ISUF, this issue has been approached through the formulation, refinement and application of the concepts of morphological region, urban tissue, and levels of resolution, referred to in section 2. Space Syntax has also been trying to define urban area in terms of space purely, and to understand how different urban areas aggregate to form a spatial whole (Hillier et al, 2007, Yang and Hillier, 2007). Based on the duality between locally metric (highlighting the importance of urban block analysis) and globally topo-geometric measures, a partitioning of the background network of urban space was proposed. By applying metric universal distance measures at different metric radii, a network of semi-discrete patches was identified, suggesting a natural spatial area-isation of the city at all scales. We believe that both approaches will benefit from an open and constructive dialogue. This should be able to establish a richer concept of planning area, attractive to, and easily manageable by, planning practitioners.

Using Oporto as a laboratory we showed that the analysis of the evolution of a particular territory throughout a long period of time can benefit from information provided by both approaches. In particular, we made evident, for this case study, a link between the definition of morphological periods and: i) axial measures (global integration and local integration), ii) angular measures (choice/betweenness); and iii) metric measures (line length and segment length). This should be further explored in other case studies. If this link proves to be consistent, it will give ISUF approach an additional tool for the conceptualization of historical development, and Space Syntax an additional perspective on the evolution of cities.

5. Conclusions and further research

This paper was written by two researchers in planning and urban morphology (mainly inspired by ISUF's approach). Our first goal was the exploration of a complementary utilization of Space Syntax's and ISUF's approaches on the study of a particular territory. Advantages from these complementarities were found in the Oporto case study. Particularly stimulating was the identification of a link between morphological period and integration, both global and local. Further research should focus on our second goal, the use of both approaches in a framework for analysis and prescription in planning

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