The Fuzzy Boundary: The Spatial Definition of Urban Areas

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Abstract: Cities seem to have some kind of area structure, usually distinguished in terms of land use types, socio-economic variables, physical appearance or historical and cultural characteristics. Is there any possibility that urban areas could in general be differentiated from the spatial perspective? What is the nature of boundaries between areas in terms of space? These questions could be approached by the analysis of internal or contextual spatial structure, or the relation between the two. Most studies on area structure however had focused in the main on the internal area with a secondary role for the context. Is there any way in which we could give more explicit attention to the context, following the clue that had come out of the earlier studies? This paper is to try to develop spatial techniques for identifying area boundaries, and looking at their performance in both the traditional areas, such as the Central London and the Inner City of Beijing, and the new development of the London Docklands. It focuses on explicitly exploring the properties of contextual structure in the formation of area boundaries rather than simply the properties of internal structure. After much experimentation, a new technique was arrived at for exploring properties of the context. Each axial line or segment in the whole map is taken as the root of a graph, and the numbers of axial lines, or segments, found with increasing radius from the root is calculated, and expressed as a rate of change. This rate of change value is then assigned to the original axial line and expressed through bands of colour. The results show strong areal effects, in that groups of neighbouring lines tend to have similar colouring, and in many cases these suggest natural areas. Through the case studies, this paper suggests that historic areas typically have what we will call fuzzy boundaries. Fuzzy boundaries arise from the way space is structured internally and how this relates to the external structure of space. Such boundaries can be effective in supporting functional differentiation of areas or the growth of areal identities and characters, but do not depend on the area being either spatially self contained or geometrically differentiated, or having clear spatial limits. It is the relation of urban areas and their further surroundings that determine fuzzy boundaries of these urban areas.

Keywords: Space Syntax, Urban Areas, Fuzzy Boundary

Introduction

Morphologically speaking, cities are very large aggregates of buildings linked by the continuous space of the street network. The part-whole problem is that in spite of the fact that most cities have some kind of named area structure, and this often seems important to the perceived character and functioning of the city, it is often very hard to detect this area structure in the *spatial* form of the city. This has historically posed two fundamental questions for the theory and practice of urban spatial planning and design. What, in terms of space, is an urban area? And how do the areas aggregate to form a spatial whole? These questions have been extensively discussed in the theoretical and professional literatures in the twentieth century. Most of this work has focused on functional and socio-economic aspects and has tended to distinguish urban parts in terms of land use types, socio-economic variables, physical appearance or historical and cultural characteristics. Is there any possibility that urban boundaries between areas might in general be best identified in terms of some relation between internal and external spatial structure, with the external perhaps not less important than the internal? Is there a general spatial mechanism that can be found in the formation of part-whole structure?

In contrast to many literatures, writers such as Lynch and Rossi suggested a less determinate and perhaps more original notion of urban areas. Lynch (1961) argued that urban area, termed as district in his book, need not to be a unified pattern with a solid boundary. “District may join to district, by juxtaposition, intervisibility, relation to a line, or by some link such as a mediating node, path or small district…Such links heighten the character of each district, and bring together great urban areas” (Lynch, 1960: 104-105). Rossi (1984:63) also argued that urban areas, identified as the study areas in his book, “can be defined or described by comparison to other larger elements of the overall urban area, for example, the street system.” At the same time, he suggested that the formation of urban areas could be identified through their location in the city, their imprint on the ground, and their topographic limits as well as their physical appearances which he saw as representing a consistent mode of living, involving a whole historic process of urban growth and differentiation.

Although the ideas of Lynch and Rossi are very suggestive of a more complex definition of the urban area, neither really looks at the spatial dimension with any precision or clarity. It was left to the space syntax movement to begin to open up this question. It was Hillier's establishment of a theory of space as configuration, and a series of related methodologies, called space syntax, (Hillier & Hanson, 1984; Hillier, 1996) that cast a new light on the spatial formation of area structure. Hillier (1987, 1989) first suggested that optimizing correlations between spatial configuration measured by integration and movement rates might provide a good method for picking out sub-areas within a larger urban areas. Such kind of sub-areas within urban districts was thought of as "natural areas" whose structure could predict movement rates. Peponis (1989) took this another step by suggesting, in a study of towns in Greece, that the variable of choice could be used to mark out boundaries of sub-areas, in the expectation that the boundaries of sub-areas should have more through-movements measured by choice.

In a later paper, Hillier (1996a, and 1996b) proposed that the part-whole structure of city was shaped by the local and global spatial configurations, correlated with local and global scales of movement. Urban structure as spatial configuration shapes urban movement, and this then impacted on patterns of land use and building densities, feeding back movement and its relation to urban structure, and creating multiplier effects and created differently scale centres of the kind normally found in well-functioning cities. Against this background, Hillier (1996b) proposed that the correlation between global integration and local integration, could be see as creating synergy between local and global movement, and used to identify urban parts: the steeper slope of the regression line of sub-area across the regression line for a whole city could imply this distinctive sub-area.

Read (1999, 2003, 2005) studied the Dutch cities and asserted that those cities usually comprise both global supergrid and local grids, self-similar but operating at different scales, and further argued that the vertical jumping between supergrid and local streets which he called 'vertical ecology', according to the differentiated movement speed and the space-time experiences, casts the light on the understanding the contemporary urban form. He proposed two techniques to explain this biplex urban structure. One was the integration gradient map, picking out streets with high integration values relative to other streets proximate to them and then tracing streets of high integration gradient based on integration R3 or Rn through the urban grid, as a way to highlight the supergrid. The other was the area integration map, indicating the concentrations of high integration at the radius 3 through giving a line the average of local integration values of all the lines within a topological distance of two or three (or within a certain metric distance) from this line, as a way to highlight areas.

In her doctoral thesis, Kasemsook (2003) then explored the relationship between area spatial structure and the dominant land use type in Bangkok, concluding that areas with different spatial configurations could indeed be associated with different functions. Later, Raford (2004), with Hillier, further developed the technique of the ‘correlation contour’ map, meaning the definition of areas through the optimisation of the correlation between local integration and movement, and in this way distinguished sub-areas in the fragmented urban context, of downtown Boston. Dalton (2006) spatially differentiated urban places by a method called point intelligibility mapping that is that a fixed subsystem connected to a root line is first defined, and then intelligibility or synergy of this subsystem is assigned to the root. Park (2007) also gave the suggestion that urban patchworks can be highlighted by three kinds of distribution of node count of axial lines. Hillier (2007) further showed that area structure of a city could be identified by calculating metric mean depth from segments within a metric radius.

These studies suggest that three spatial factors could be involved in defining urban areas: internal structure, contextual structure, and the relation between the two. The syntactic studies on area structure however had focused in the main on the internal area with a secondary role for the context. Is there any way in which we could give more explicit attention to the context? The aim of this paper is to try to develop spatial techniques for identifying area structure, and looking at their performance over a range of areas types from historical central areas through the range of recent typologies.

Multi Power Law Relation between node count and radius

Which syntactic variable could be used to indicate the process of embeddedness of urban space into its external structure? A draft idea is first proposed. Each axial line/segment is taken as the root of a graph, and the numbers of axial lines found k depth (or metric distance of k) away from the root is calculated, and then denoted as node count Rk of an axial line/segment. It approximately measures the degree to which an axial/segment is embedded into its surroundings at the radius k. For example, if randomly selecting a line in the axial map of London, and then computing its point depth at the radii of from 4 to 7 that picks out all other lines 4, 5, 6, or 7 depth away from that selected axial line respectively, we can approximately get node count at the radius of 4, 5, 6, or 7 that demonstrates how large area this line respectively covers within the topological distance of 4, 5, 6, or 7 (Fig. 1). The change rate of node count from R4 through R5 and R6 to R7 could illustrate how fast this line is embedded into its surroundings from radius 4 to 7 step by step. Then, does node count have any mathematical relation to radius? If so, might this rigidly explain the embeddeness of urban space?

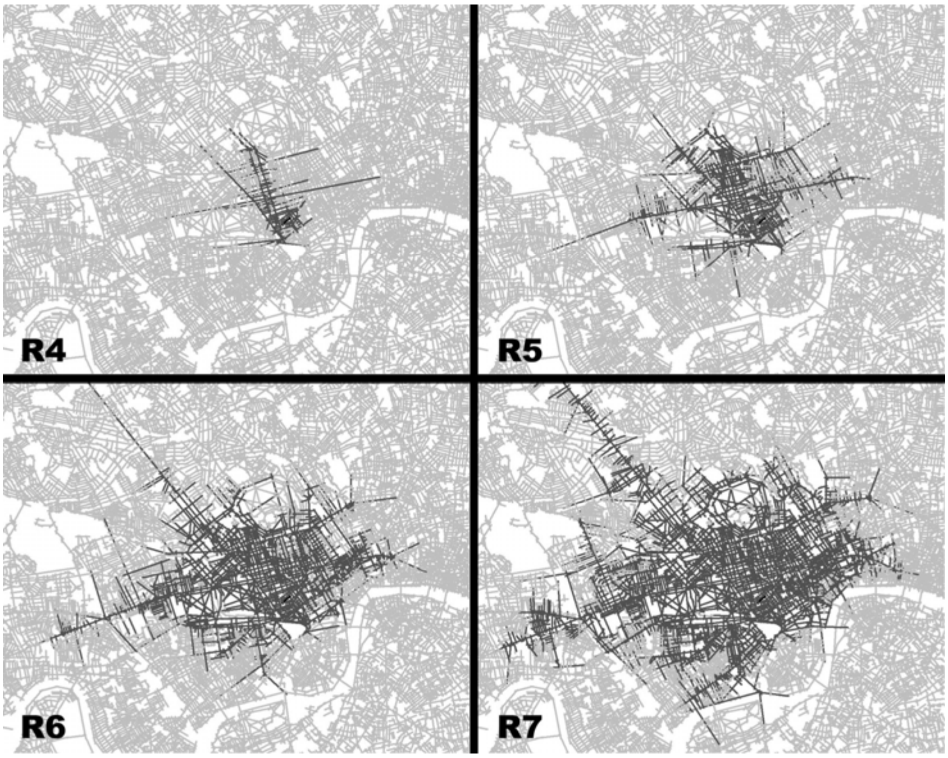

Fig. 1 Topological point depth from a selected axial line

This question is approached by the case studies of Central London, London Docklands and Inner City of Beijing. First, all of them with their context are so large systems that variety of sample areas could be selected from them without the edge effect that node count value of the line near the edge of an axial map could be biased by the edge of this map. The axial map of the Central London has 17,320 lines and its radius-radius, that is the radius at which the most integrated line approximately reaches at least one line at the edge of the system, is 10; the map of the London Docklands having 28,225 lines and its radius-radius being19; and the map of the Inner City of Beijing having 20,511 lines and its radius-radius being 10. Second, the geometric features of these regions are very different in the sense that the Central London is an organic and irregular structure; most parts of the London Docklands are new large scale developments, also with irregular grids, since the 1980s; but the Inner City of Beijing is more like a traditional orthogonal structure. This could set the analyses in more complex contexts and might get more general results.

Fig.2 The study areas of Central London, London Docklands and Inner City of Beijing

The study starts by exploring the relation between mean node counts of the whole axial map, average node counts of all lines in the map, and radius, in the cases of the Central London, the London Docklands and the Inner City of Beijing (Fig. 2), which could proximately show how an axial line in average is embedded into the surroundings.

When the natural logarithms of both mean node count and radius are plotted, called radius plot, the linear regression line seems to appear within the certain radius ranges with adjusted R-square over 0.99. In the case of Central London, for instance, there is a linear regression line within the range from radius 2 to radius 14. It is the same in the case of the Inner City of Beijing where a linear regression line comes out within the range from 2 to 12. It is a bit different in the case of the London Docklands where the linear regression line could be found in the ranges of 1 to 11 and 11 to 40 (Fig.3;Table 1). All these linear regression lines mostly lie within the range below the radius-radius so that these correlations had not been greatly impacted by the edge effects. Thus, it could be formulated as the following:

$$\ln(NC) = \alpha \times \ln(R) + \beta \qquad R \in [a,b] \qquad (1)$$

NC denotes mean node count of a map and R denotes radius.
Then, it can be transformed as:

$$NC = K \times R^{\alpha} \qquad R \in [a,b] \qquad (2)$$

The exponent of 'α ' can measure a rate of change of mean node count of a region as radius increasing, and the constant K relates to the mean connection of this map.

	Axial		Metric	
	Radius Range	α	Radius Range	α
London Map	(1,2)	2.117	(400,11000)	1.861
	(2,14)	3.039		
Docklands Map	(1,11)	2.788	(400,8000)	1.82
	(12,40)	1.552		
Beijing Map	(1,2)	2.028	(400,2000)	1.678
	(2,12)	3.166	(2100,9900)	1.877

Table1: change rate of mean node count of the maps and their radius ranges

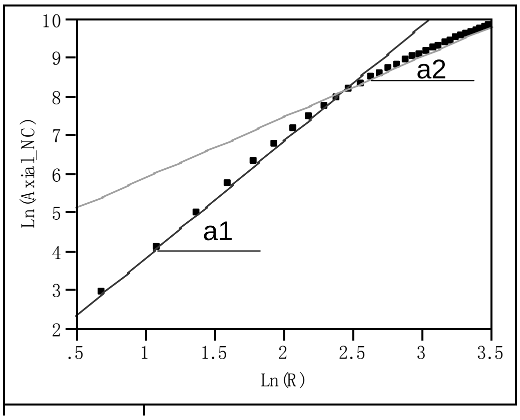

Fig. 3 The relation between node count and radius in the log-log radius plot

It might be suggested that mean node count of a map, such as the Central London, could have an approximate power law relation with topological radius within the certain radius range, in which the parameter of a could indicate the average speed of all lines of a region topologically reaching surrounding lines as radius rising up.

If using metric radius rather than topological radius, can we find the similar relation between mean node count and radius in these cases? In a segment map generated by the DepthMap, node count of a segment at the metric radius k can be defined as the number of all segments k meters (Manhattan distance) away from this segment. As for the above three cases, the mean node counts against the metric radii from 400m to 11,000m, is produced in the log-log radius plot respectively, and then a linear regression line appears within the certain radius ranges, under the condition of adjusted R-square over 0.999 (Table 1). It means that mean node counts of these three maps could have a proximate power law relation with metric radius within certain radius range.

Then, we focus on the study areas that are the Central London, the London Docklands and the Inner City of Beijing (Fig. 2). Table 2 shows that the mean node count of these study areas also has the power law relation with the radius, whether topological or metric, within the certain radius ranges. Furthermore, the radius ranges and the corresponding exponents could tell the differences between three cases. Measured by the topological radius, the Central London and the Inner City of Beijing are different from the London Docklands in the sense that the first two areas have similar exponents in the corresponding radius ranges and their exponents in the second range, that is the main range, are larger than the exponent of the London Docklands in its first range, that is also the main range. It demonstrates that the Central London could have more similar topological structure with the Inner City of Beijing although both have more differences in the geometric character, compared with the London Docklands. On the other hand, measured by the metric radius, the Central London and the Inner City of Beijing have larger exponents than the London Docklands at the lower radius, which could suggest that the first two have higher density on segments.

	Axial		Metric	
	Radius Range	α	Radius Range	α
Central London	(1,2)	2.48	(400,3600)	1.828
	(2,10)	3.353	(3700,11000)	1.495
London Docklands	(1,25)	2.631	(400,3000)	1.746
			(3100,8000)	2.16
Inner City	(1,2)	2.278	(400,9900)	1.836
	(2,10)	3.579		

Table 2: change rate of mean node count of the study areas and their radius ranges

Is there the similar kind of relation between mean node count of an area extracted from these three study areas and radius? Several named areas or estates, whose boundaries have been described in the website of Wikipedian, travel books or other planning documents, are selected in the centre of these study areas to serve as the samples. Since the Central London and the Inner City of Beijing are the historic districts with many well-defined named areas coined by the collective over hundred years, the samples are selected in terms of those names. For example, nine samples in the Central London are Soho, Covent Garden, Mayfair, St. Jame's, Bloomsbury, Holborn, Marylebone, the City and Westminister, whilst, the other nine samples in the Inner City of Beijing are Shi Chahai, Fengsheng, White Pagoda, Xin Taicang, Wang Fujing, Nan Luogu, Dongsi, Zhong Gulou and Dongdan. However, as the London Docklands is a new development district, the samples are chosen according to the planning documents by the London Docklands Development Cooperation (LDDC). There are two kinds of the samples. The first samples are larger development areas in the brochure of LDDC, namely Wapping, Limehouse, Isle of Dogs, Royal Docks, Beckton, Bermondsey and Surry Docks, and the second are the smaller projects and estates whose have the similar number of the axial lines to that of the samples in the Central London and the Inner City of Beijing. These smaller samples include a luxury estate and a social housing in Surry Dock, a luxury estate in Wapping, two estates in Beckton, the old estate in Poplar, a social housing estate in Limehouse, two social housing estates in the Isle of Dog and the regeneration flagship of Canary Wharf.

The log-log radius plot is respectively produced for each named area or estate in these three cases, and then the linear regression line is generated respectively within any possible radius ranges with the adjusted R-square over 0.99. It seems that the logarithm of mean node counts of each area had the linear correlation with the logarithm of topological/metric radius, and this indicates that there is a proximate power law relation between mean node count of an area and radius within the certain radius ranges. Table 3 and 4 show the radius ranges in which the linear regression line can appear in the log-log radius plot for each area, as well as the slopes of the regression lines that could demonstrate average speed of the lines in an area topologically reaching the surrounding lines in the given radius ranges.

In general, it demonstrates that mean node count of a named area or an estate has a power law relation with topological or metric radius within the certain radius range, which can be verified in the log-log radius plot. As to any an area, the exponents between the consecutive ranges change much, which could indicate the fact that there exist one or several big jumps in the average speed of the lines/segments of this area reaching its surrounding spaces across radii, whether topological or metric. For example, the slope of regression line of Canary Wharf in the London Docklands case changes from 2.247 to 3.055, 2.417 and 3.963, corresponding to the consecutive radius ranges of 1 to 6, 6 to 10, 10 to 17, and 17 to 25.In other word, the graph of the plot-plot radius plot of Canary Wharf had three points of inflexion that are 6, 10, 17, in which the tangent line of the graph suddenly changes much. Such inflexion points might imply kind of ‘boundary’ of an area where the degree of this area being embedded into its surroundings could fluctuate much. This cases light on the differentiation of area structure in terms of the change of radius.

Then, it raises a question: do axial lines or segments within an urban area have same or similar exponent within the certain radius ranges? If so, could the exponent at the certain radius be served to distinguish the area structure?

Fuzzy Boundaries of Spatial Patchwork

Does node count of a line or a segment have a power law relation with radius? In general, Park (2007) discovered that 62% of the axial lines of London, forming a well-organised street network, have power law relation with the radius under the radius-radius. For segment map, we also find out that 74% of the segments in the London map, 68% in the Beijing, 63% in the London Docklands, have power law relation with radius from 100 meters to 8000 meters.

Since the exponent of ‘α’ is exactly equal to the slope of regression line in the log-log radius plot, it can measure the rate of change of node count of an axial line or a segment, that is the extent to which this line or segment is embedded into its surroundings, at a radius. Then, a change rate of node count of an axial line at the radius of k is equal to the exponent of ‘α’ at the radius of k, denoted by embeddedness Rk:

$$Emd(k) = \alpha(k) = \frac{\ln NC_k - \ln NC_{k-1}}{\ln k - \ln(k-1)} \qquad (3)$$

Emd(k) denotes embeddedness of an axial line at the radius k, to measure the extent to which this axial line is embedded into urban grid at the scale of radius k. Variable of $\alpha(k)$ denotes the exponent ‘α’ at the radius k, and NC_k denotes the node count of an axial line at the radius k.

If the values of change rate of node count are only compared between all lines at the certain radius of k, the value of ln(k/(k-1)) becomes the constant for each line because k is the same for every lines. Thus, the formula could be transformed into the following:

$$Emd(k) = \alpha(k) \sim \ln\left(\frac{NC_k}{NC_{k-1}}\right) \sim \frac{NC_k}{NC_{k-1}} \qquad (4)$$

This transformation indicates that the change rate of node count of an axial line can be measured by the node count at the radius k divided by that at the radius of k-1, with no change of the rank order of embeddedness Rk.

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As to a segment model, the similar formula is developed to measure the extent to which a segment is embedded into urban grid at the certain metric radius.

$$Emd(k,m) \sim \ln\left(\frac{NC_k}{NC_m}\right) \sim \frac{NC_k}{NC_m}\ (k > m) \qquad (5)$$

Emd(k,m) denotes a change rate of node count of a segment from radius k to radius m, namely embeddedness Rk, and NC_k denotes node count of a segment at the radius k.

Do the neighbouring lines or segments tend to have similar embeddedness as a way to generate the distinguishable areas? In the case of the Central London, for instance, Emd (k) of each axial line, that is the slope of a regression line in the log-log radius plot, is expressed by angular degree of the slope.

$$Emd(k) \sim \arctan(\alpha(k)) = \arctan\left(\frac{\ln NC_k - \ln NC_{k-1}}{\ln k - \ln(k-1)}\right) \qquad (6)$$

The slopes of 99.5% lines vary from 82.5° to 35.4° at the radius of 3, those varying from 84.7° to 51.1° at the radius of 4, and all slopes varying from 84.3° to 50.9° at the radius of 7, and till all varying from 83.3° to 52.2° at the radius of 10, the radius-radius. If these ranges are separated into 16 bands, each band can be about 2°. The lines within such band could be considered to have similar embeddedness. Are these lines neighbours?

First, Emd(k) or Emd(k,m) is assigned to each axial line or segment in the DepthMap, and then the whole axial map or segment map is exported out and then is imported into Mapinfo. Second, each axial line or segment is coloured from red to dark blue according to its value of Emd(k) or Emd(k_m) crossing radii, with 16 bands, the red indicating higher change rate of node count and the blue indicating lower one. Finally, the results show strong areal effects, in that groups of neighbouring lines tend to have similar colouring that also means they have similar embeddedness. In the three cases these suggest natural areas. However the areas defined vary with the rate of change at different radii, with larger areas being identified by large radii (Fig.4,5).

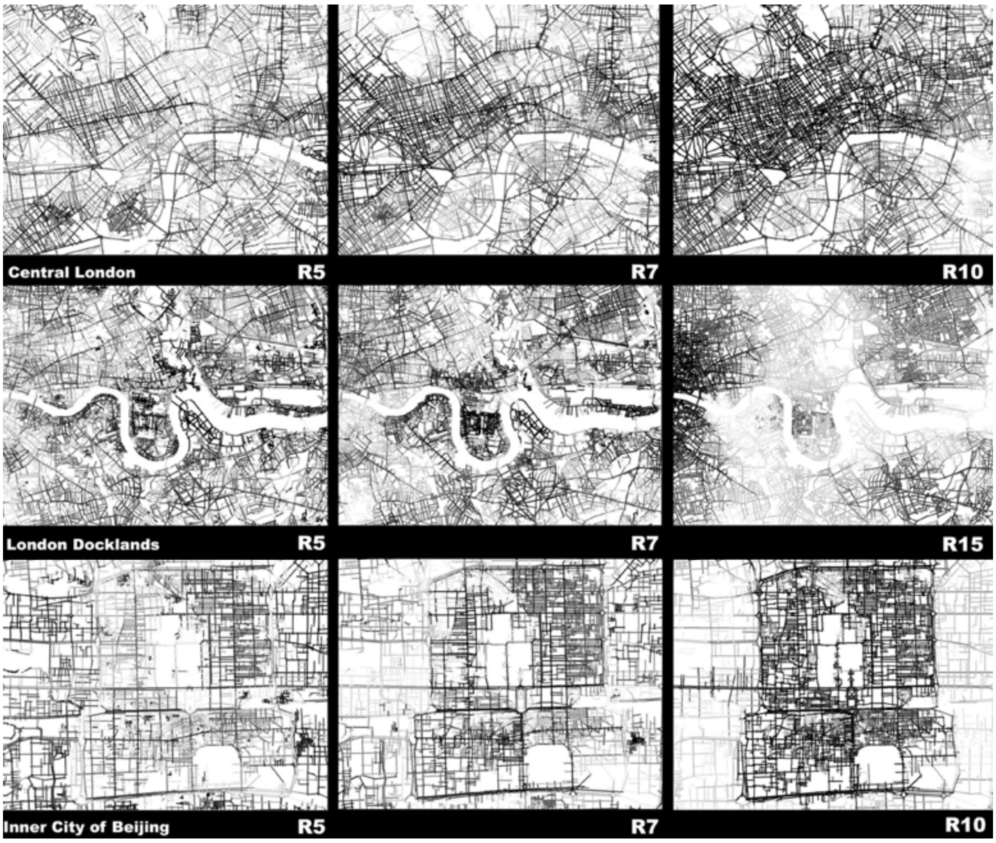

Fig.4: Emd(k) of the Central London, the London Docklands and the Inner City of Beijing

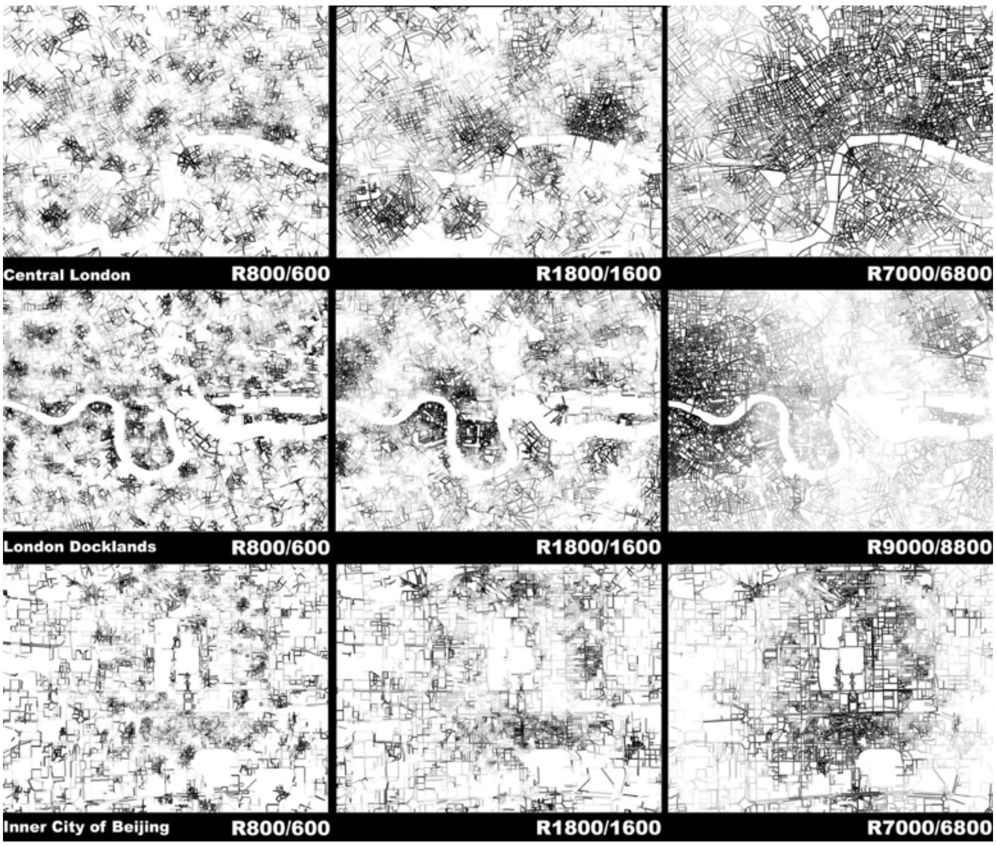

Fig.5: Emd(k,m) of the Central London, the London Docklands and the Inner City of Beijing

On reflection, the radius of the patchwork identified by embeddedness Rk seems to be smaller than the radius of k. In other words, a rate of change of node count of an axial line or a segment at the larger radius could generate a patchwork with the smaller radius. In the topological case, if any a line is selected from the patchwork by embeddedness Rk as a root, the neighbouring lines found k depth away from this root could constitute the patchwork larger than the first one. For instance, an area is generated by the embeddedeness at the radius of 6. Emd (6) is more affected by the new lines added from the radius 6 to 5, showed by the black lines in the right of the Fig.6, but the lines 5 depth away from the least integrated line of the area is outside the boundary of the area (Fig.6). This is the same in the metric case. The patchwork generated by the embeddedness at the metric radius of k could be smaller than the patchwork constituted by the segments that metric distance of k away from any a segment within the original one. This implies the remote effect that the definition of urban patchwork could be more influenced by the external structure of the area. It could suggest that the spatial context of an area act as a reference to outline the area.

Fig. 6 An area is distinguished by Emd (6) and is more affected by its external black lines showed at the right.

Moreover, Since the lines/segments both inside and outside the boundaries of the patchworks are involved in the calculation of Emd(k) or Emd (k, m), the definition of the boundaries seems to be fuzzy in the sense that the boundaries depend not only on how a space is configured with other spaces within these patchworks, but also on how it is embedded into the extensive contexts of these areas. As the context of an area is altered, such as the change of topological or metric radius, the boundary of the area could be redefined. Thus, the patchworks identified by embeddedness Rk have no clear boundaries in the normal sense, but have fuzzy boundaries according to the definition of their external structures.

Primary Functional Implication

Do these area structures of cities defined by embeddedness at different radii have any correspondence to the areal patterns in regard to other factors, such as socio-economical variables or culture characters? The known place names are used as a first but imprecise step towards understanding and representing spatial aspects of area structure in the cases of the Central London and the Inner City of Beijing. Then, the index of socio-economic classes in the Census 2000 is adopted to produce the area structure in the case of the London Docklands. All these area structure are visually compared with those pattern generated by spatial configuration. However, the limitation of this kind of comparison is obvious because it is arbitrary and inaccurate.

Place names had been coined by our ancestors as descriptions of urban areas in terms of their situation, use, appearance, topography, ownership or other association, and most of them could make the sense for the local residents and even tourists although their definition of an area might always be ambiguous and vary to everyone (Mills, 2001). As the Central London and the Inner City of Beijing have evolved over centuries, the definition of the named areas remains more consistent across different agencies, which can be verified in the website of Wikipedia and Wikitravel, as well as the other books for tourists. The different named areas in these two cases usually reflect different urban places with specific characteristics.

In the cases of the Central London and the Inner City of Beijing, the axial maps coloured in terms of the value of embeddedness at the topological radius of 5, less than radius-radius of 9, seem to visually correspond to the named areas to some extent, respectively (Fig.7). As for the segment model, both the Central London coloured by Emd(1000, 800) and the Inner City of Beijing coloured by Emd (1500, 1300) seem to visually correspond to the named areas to some degree, respectively. (Fig.7). It might hint that the change rate of node count at the certain scale could more or less play a role in the formation of the area identified by place names.

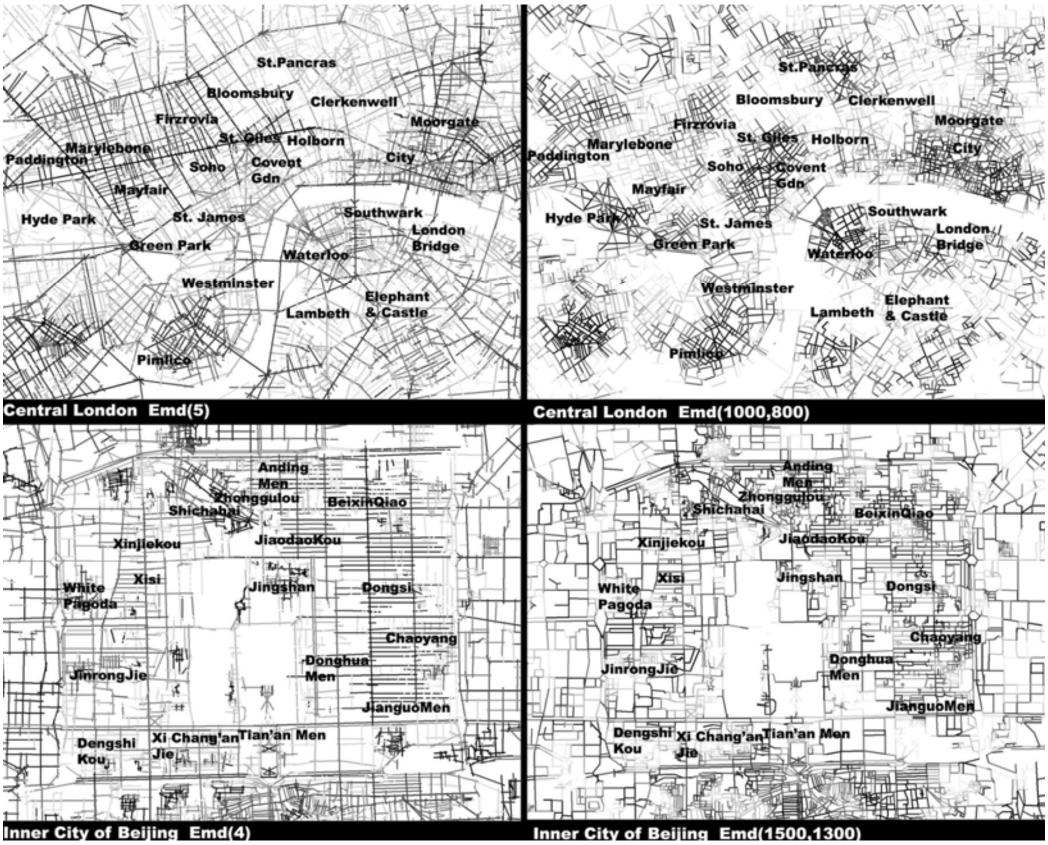

Fig.7 The named areas in Central London and Inner City of Beijing and areas by Embeddedness

Then, the place names in the London Docklands maybe not represent spatial structure correctly because most of its areas have been regenerated rapidly, including various estates, in the last two decades. The recent demographic data could be a suitable option to demonstrate its spatial aspects. This study adopted the variable of households of tenure in 2001 that was mainly classified into six ranks from Owns Outright to Housing Association till Private Letting. In order to capture the general picture, it combines the ranks of Council and Housing Association together to represent the households in social housing. Then, it generates the thematic map of the proportion of the households of the social housing in Output Area to show the character of the estates in the London Docklands.

Fig. 8, the demographic map, shows that the development area of Bermondsey generally has three components with different proportion of the households of the social housing that are the area between London Bridge and Tower Bridge, the Butlers Wharf area and mainly residential area to the east of St. Saviours Dock.

This pattern seems to correspond to the patchwork differentiated by the embeddedness at the topological radius 8. Fig. 8 also demonstrates a poor area along the Wapping Lane in Wapping, namely an old council housing area, also corresponding to the patchworks by the embeddedness at the topological radius 12. Fig. 8 exhibits three poor council house areas and the regeneration flagship of Canary Wharf. These areas are also differentiated in the segment map by the embeddedness from the metric radius of 1000 meters to 800 meters

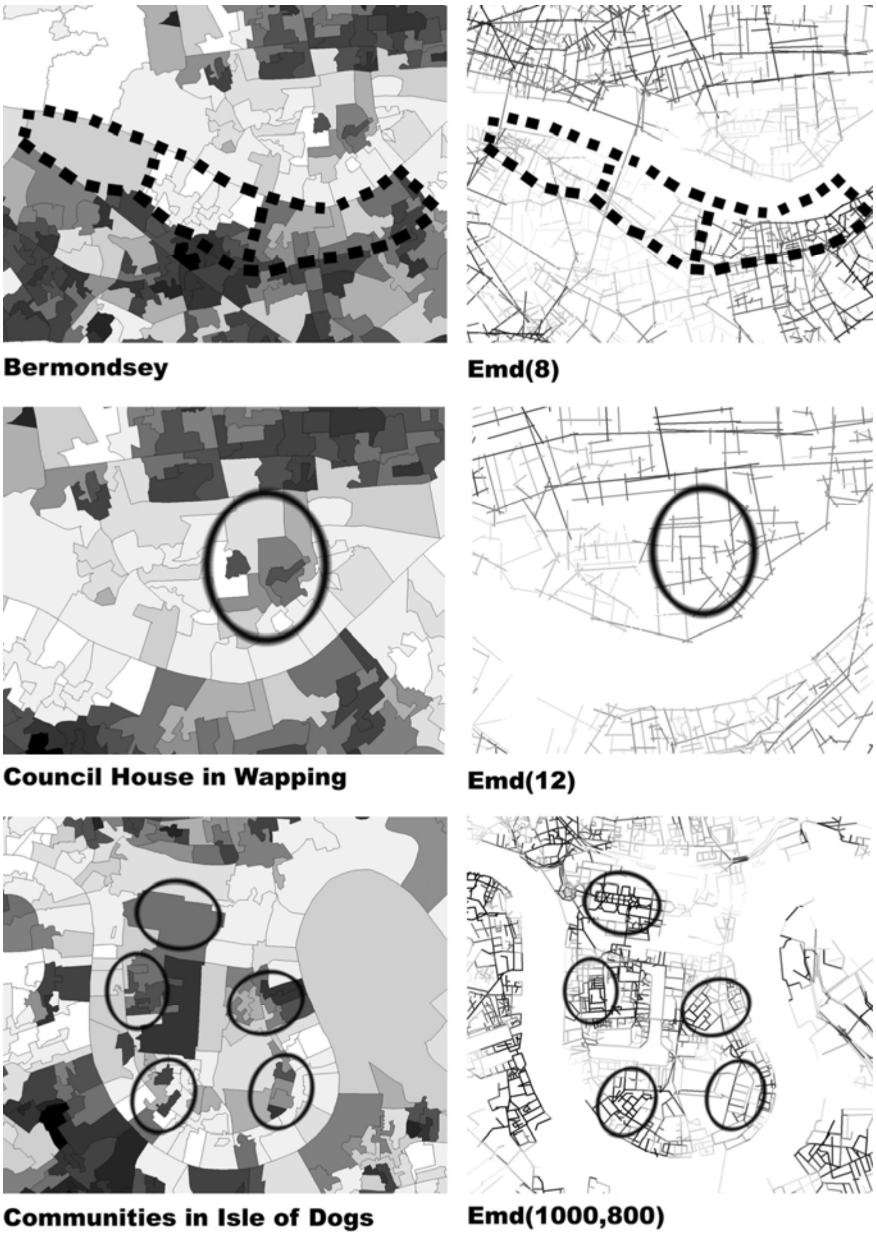

Fig.8 Sub-areas in terms of socio-economic variables and patchworks in terms of space

These primary findings suggest that urban parts defined by spatial configuration could reflect the reality of urban structure in the sense that they could support urban functioning and social activity to some extent. The patchworks picked out by different radii might relate to the urban patchworks functioning at different scales. However, the more considerable research should be carried out further.

Conclusion

Through these studies, this paper suggests that urban areas, whether in historic cities or in new development districts, typically have what we will call fuzzy boundaries. Fuzzy boundaries arise from the way space is structured internally and how this relates to the external structure of space. Fuzzy boundaries can be effective in supporting functional differentiation of areas or the growth of areal identities and characters, but do not depend on the area being either spatially self contained or geometrically differentiated, or having clear spatial limits. It is the relation of urban parts and their further surroundings that determine fuzzy boundaries of these urban parts.

However, just as Hillier (1996:151) argues that "it is cities that make places", these studies also suggest that fuzzy boundaries of urban areas are at least as much more influenced by contextual structure as by the internal structure itself. It demonstrates kind of 'remote effect' through which the spatial structuring in the larger – even much larger- context interacts with the local spatial properties of an area, and creates the fuzzy boundary effect which become a main factor in the definition of the area represented at the local level. In addition, urban areas defined by fuzzy boundaries vary at different scales, larger areas being identified by larger scales at which broader contextual area has been taken into account. But the point is that remote effect shows how cities make places through the interaction between area and its context.

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Area	Radius Range 1	α 1	Radius Range 2	α 2	Radius Range 3	α 3
Marylebone	1,2	2.867	2,8	3.173	8,15	1.643
Mayfair	1,2	2.740	2,8	3.308	8,15	1.696
Soho	1,2	2.612	2,9	3.150	9,14	1.723
Covent Garden	1,2	2.663	2,8	3.216	8,14	1.746

Bloomsbury	1,2	2.581	2,8	3.347	8,14	1.703
Holborn	1,2	2.547	2,10	3.365	10,15	1.480
St.James's	1,2	2.434	2,10	3.153	10,16	1.635
City	1,2	2.480	2,10	3.292	10,16	1.602
Westminster	1,2	2.109	2,12	3.278	12,17	1.746

Table3_a: ‘a’ of the sub-areas of London and their topological radius ranges

Area	Radius Range 1	α 1	Radius Range 2	α 2	Radius Range 3	α 3
Wangfujing	1,2	2.842	2,8	3.210	8,15	1.508
Dongdan	1,2	2.746	2,9	3.298	9,16	1.391
Dongsi	1,2	2.662	2,10	3.150	10,18	1.350
Nanluogu	1,2	2.661	2,10	3.171	10,17	1.335
Xintaicang	1,2	2.425	2,10	3.202	10,17	1.401
Zhonggulou	1,2	2.351	2,10	3.328	10,17	1.339
Fengsheng	1,2	2.228	2,9	3.545	9,16	1.588
Shichahai	1,2	2.122	2,9	3.559	9,17	1.632
White Pagoda	1,2	1.984	2,10	3.563	10,17	1.580

Table3_b: ‘a’ of the sub-areas of Beijing and their topological radius ranges

Area	Radius Range 1	α 1	Radius Range 2	α 2	Radius Range 3	α 3	Radius Range 4	α 4
Bermondsey	(1,3)	2.17	(3,15)	3.19	(15,40)	1.06		
Wapping	(1,4)	2.16	(4,16)	3.37	(17,40)	0.93		
Limehouse	(1,3)	2.08	(3,21)	2.96	(21,38)	0.95		
Poplar	(1,3)	2.23	(3,19)	2.79	(19,35)	1.06		
Surry Dock	(1,14)	2.45	(14,24)	3.68	(25,29)	1.37	(30,40)	0.67
Isle of Dogs	(1,11)	2.36	(12,26)	3.34	(26,40)	1.18		
Beckton	(1,3)	1.92	(3,37)	2.60				
Royal Docks	(1,5)	1.85	(5,40)	2.96				

Table3_c: ‘a’ of the development areas of London Docklands and their topological radius ranges

Area	Radius Range 1	α 1	Radius Range 2	α 2	Radius Range 3	α a3	Radius Range 4	α 4
Surry Dock (LuxuryH)	1,2	1.663	2,12	2.869	13,24	3.943		

Surry Dock (SocialH)	1,3	1.578	3,8	2.995	9,13	2.034	12,25	4.194
Beckton N	1,2	1.585	3,30	2.544				
Beckton W	1,2	1.700	3,30	2.657				
Beckton E	1,2	1.700	3,30	2.657				
Limehouse (SocialH)	1,2	1.585	2,21	3.032				
Poplar	1,2	1.700	2,22	2.909				
Canary Wharf	1,6	2.247	6,10	3.055	10,17	2.417	17,25	3.963
NE_Isledog (SocialH)	1,2	1.807	2,7	2.832	7,14	1.777	15,27	3.799
NW_Isledog (SocialH)	1,6	2.803	6,15	1.527	15,27	4.007		

Table3_d: ‘a’ of the estates and centres of London Docklands and their topological radius ranges

Area	Radius Range 1	α 1	Radius Range 2	α 2	Radius Range 3	α 3
Covent Garden	400-4100	1.727	4200-11000	1.44		
Holborn	400-2800	2.032	2900-11000	1.436		
Marylebone	400-6500	1.955	6600-11000	1.45		
Mayfair	400-2500	1.965	2600-11000	1.721		
City	400-1800	1.686	1900-11000	1.452		
St.James	400-4800	1.769	4900-11000	1.485		
Bloomsbury	400-1400	1.936	1500-4100	2.132	4200-11000	1.436
Soho	400-2100	1.755	2100-4200	1.908	4300-11000	1.48
Westminister	400-1800	1.904	1900-3100	2.263	3200-11000	1.734

Table4_a: ‘a’ of the sub-areas of London and their metric radius ranges

Area	Radius Range 1	α 1	Radius Range 2	α 2	Radius Range 3	α 3
Dashila	400-2500	1.84	2600-8100	1.387		
Dongdan	400-4700	2.209	4800-9900	1.769		
Nanluogu	400-2000	2.015	2100-7400	1.616		
Shichahai	400-2400	1.774	2500-7300	1.563		

Xintaicang	400-9900	1.751				
Dongsi	400-1400	1.8	1500-2600	2.045	2700-9900	1.799
Fengsheng	400-1000	1.677	1100-9900	1.999		
Wangfujing	400-1000	1.841	1100-4400	2.44	4500-9900	1.579
WhitePagoda	400-1600	1.499	1700-9900	1.99		

Table4_b: ‘a’ of the sub-areas of Beijing and their metric radius ranges

Area	Radius Range 1	α 1	Radius Range 2	α 2	Radius Range 3	α 3
Bemondsey	400-1500	1.754	1600-3400	2.159	3500-8000	1.558
Wapping	400-1500	1.793	1600-4700	2.508	4800-8000	1.664
Limehouse	400-3300	1.601	3400-8000	2.134		
Surry Dock	400-3300	1.641	3400-8000	2.653		
Royal Dock	400-1500	1.624	1600-8000	2.423		
Beckton	400-2400	1.826	2400-8000	2.161		
Poplar	400-5000	1.707	5100-8000	2.249		
Isle of Dogs	400-1800	1.763	1800-4300	1.496	4400-8000	2.496

Table4_c: ‘a’ of the development areas of Beijing and their metric radius ranges

Area	Radius Range 1	α 1	Radius Range 2	α 2	Radius Range 3	α 3
Canary Wharf	400-2600	1.578	2700-3700	1.237	3800-8000	2.438
Beckton_E	400-5300	1.881	5400-8000	2.758		
Beckton_N	400-2300	1.704	2400-8000	2.14		
IsleofDogs_NE	400-5500	1.58	5600-8000	2.8		
IsleofDogs_NW	400-1900	1.573	2000-3700	1.082	3800-8000	2.507
Limehouse_SH	400-3500	1.53	3600-8000	2.115		
SurryDock_LH	400-3800	1.683	3900-8000	2.712		
SurryDock_SH	400-2800	1.317	2900-8000	2.738		
Wapping_LH	400-1600	1.44	1700-4500	2.283	4600-8000	1.722

Table4_d: ‘a’ of the estates and centres of Beijing and their metric radius ranges