SPACE SYNTAX ANALYSIS OF FOSHAN STREET NETWORK TRANSFORMATION IN SUPPORT HISTORIC AREA REDEVELOPMENT

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ABSTRACT: This study investigates the evolution process of a traditional organic town becoming a modern grid city. It takes a case study of Foshan, a city in the south China in the Pearl River Delta. Space syntax approaches have been adopted to visualize the dynamic socio-spatial relations during the modernization process. The significant differences between traditional and modern spatial structure have been presented in this paper, which are helpful to explore the conservation challenges and redevelopment opportunities.
KEYWORDS: Chinese historical town, street network, transformation, space syntax, conservation and redevelopment

1 INTRODUCTION

During the rapid modernization process in China, the old cities have witnessed a different kind of urban development pattern which could be categorized as mega-scale, short-period, and mass produced. In recent decades, this development approach has raised serious concerns about the preservation of historic communities, old buildings, urban context, as well as cultural identities. Although a great deal of efforts has been made by both city managers and researchers, many uncertainties still surround conservation theories and methodologies. Particularly they lack systematic and quantitative approaches to investigate the relations between historic areas and the changing urban context and support the delimitation of conservation boundaries[1].

Firstly, conventional studies and practices that mainly focus on the specific historic sites, are very questionable in terms of the interrelations between old and new urban areas. In the field of conservation and urban design, it could be found that most of studies are focusing on the richness and complex of the creation of ‘places’ in traditional Chinese cities[2,3]. Many scholars of historic geographical field who devoted their works to explain the development of the whole townscapes[4,5]. But little analytic endeavor links individual places and the whole city, to understand how the physical and functional cities of the past gave rise to those ‘places’. The part-whole problem is actually very difficult to answer, like Hillier B.[6] said that it is almost impossible to make a clear morphological distinction between one part and another. But through computing the topological relations among the network, *space syntax* is such a kind of technologies, to some extent, providing a quantitative method to interpret the relations between the place and the surroundings; the small space and the entire city[6,7,8].

Secondly, Chinese cities had experienced a series of tremendous transformations with western influences and technologies during the last century. However, most of previous conservation studies focus on either the ancient “golden time” or the current status, rather than on the critical modernization process. Before the first Opium War of 1839-42, the urban development of Chinese cities was a relatively close hierarchy system[1]. Then western colonialists and Chinese intellectuals who studied western sciences have started to introduce modern planning schemes and construction technologies to old Chinese cities. After the

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1 Most of capital cities followed the ideological pattern described in *Kaogongji* (the Artificer’s Record), with several remarkable features: ‘grid pattern’, ‘north-south oriented’, ‘symmetric layout emphasizing an axis and centre’, and ‘multi-enclosed city-wall’. But most secondary cities and small towns, in the opposite side mainly formed their urban spaces based on the local geographical benefits and constraints, presenting the disordered and stretched characters.

Communist Party took power of China in 1949, the cities have been dramatically reformed by applying socialist development ideology and planning principles. In the later part of the century, with the initiation of ‘open door’ policies in 1978, China has witnessed a super rapid urbanization process[9]. Therefore, the current Chinese historical cities are presenting a very dynamic and complicate system, not only for traditional images, but also for superimpositions of different periods. It is necessary to investigate in detail of the urban form evolution happened during the continuous modernization period.

Thirdly, it is noticed that researches have concentrated on the large, ancient Chinese cities, such as Beijing, Xi’an, Nanjing, Suzhou, and Guangzhou. Less attention has been given to small- and medium-sized cities, which are the majority of Chinese urban settlements[10]. Those small towns might not have great palaces or be important in the political history; but they have formed fascinating vernacular settlements and local cultures. The study method should also be very different from the conventional preservation practices which focus on the restoration of historical buildings or sites. More attention might be paid to the whole image of historical environment and the development needs of the entire town. Like recent exercises of historical water towns in south Yangtze river, Lu Z. [11] and Duan J. [12] both emphasized on the street and landscape conservation to keep the traditional spatial organization. However, being lack of the scientific and quantitative means, the historic areas might not be preserved with appropriate urban environment. For example, the redevelopment strategies will attract too many people and the old facilities and narrow streets will be overloaded; a new town center development will accelerate the decline of the historic blocks; etc.

Figure 1 Position map of Foshan city

Therefore, this study is to investigate the evolution process of a traditional organic town come into a modern grid street network by a case study of Foshan, a city in the south China in the Pearl River Delta (Fig. 1). It origins from fifteen villages; gradually consolidated into a famous trading town during Ming and Qing Dynasty. But politically Foshan was a *xiang*, a low-level administrative unit in imperial China. Thus, unlike the capital cities with ideological grids, the spatial structure of Foshan was more organic and naturally determined by geographical conditions[13]. However, like other cities in Pearl River Delta Region, Foshan has experienced the dramatic economical growths and urban extensions since the Reform and Open-door policy in 1978, as shown in Fig. 2. Especially entering the 21st century, the city is not only spreading, but also combining with neighboring towns and villages (Fig. 2). The modern roads have formed a new grid system and intervened into the historical areas. Therefore, it is necessary to investigate in detail of what are differences between traditional and modern network; which is current spatial position of the historic core; when those interventions get into the historical areas and how they affect the surrounding heritage sites?

The objectives of this study are to

1. Identify the historical phenomena of Foshan street network transformation during the modernization period (1920s – 2000s)
2. Formulate quantitative analyses by space syntax to assess the spatial relationships between Foshan historical areas and the developing urban context.
3. Interpret transformation pattern of spatial-functional distributions of historic areas, to support conservation or redevelopment decisions.

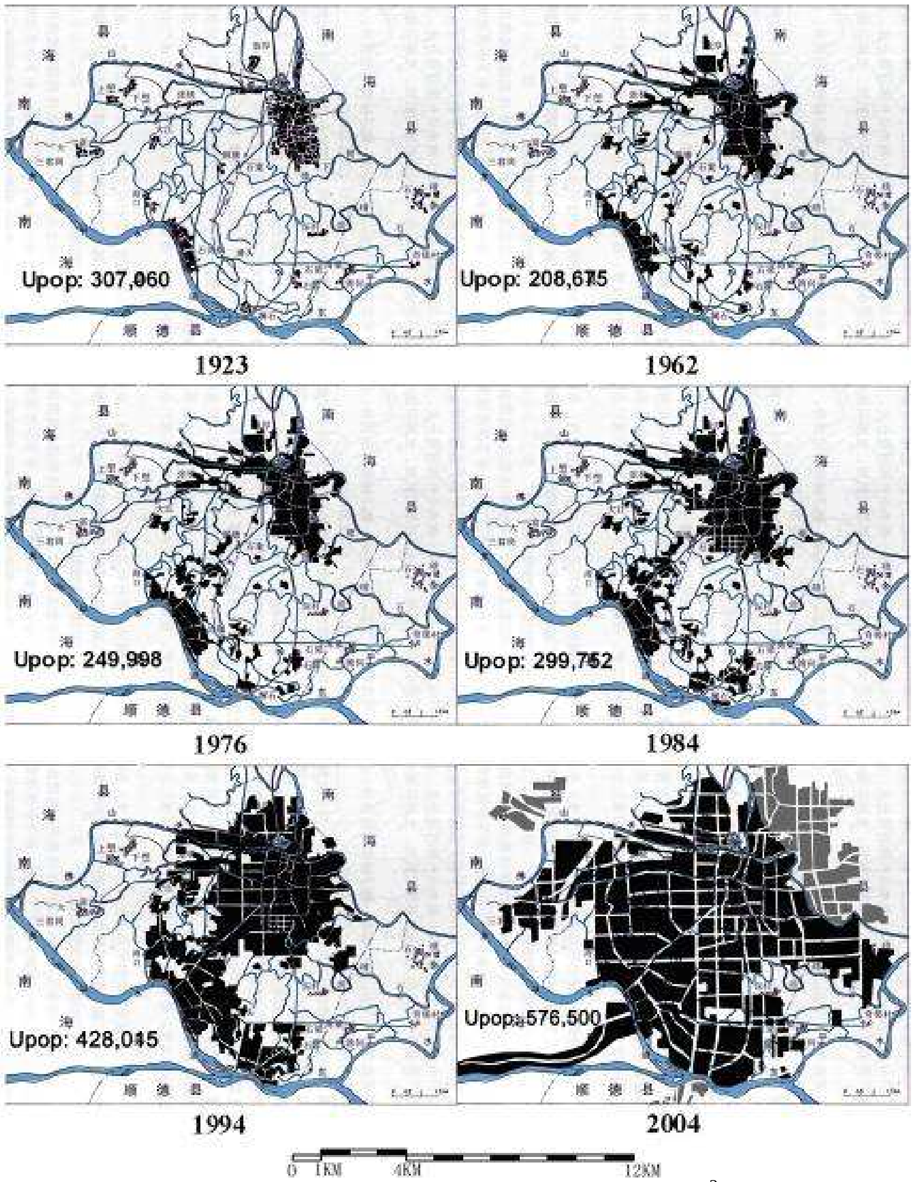

Figure 2 The spatial growth of Foshan (1923-2004)[2]

Note: 1. grey parts of 2004 map are built-up area of Nanhai district (Nanhai county before 2002)

2. Upop: Urban population, but not included the immigrant population[3].

2 SPACE SYNTAX METHODS

Before asking the question 'how the traditional organic town comes into a modern grid-like city' or 'what is the transformation pattern of Foshan's spatial structure', there is a fundamental problem to be solved, that is how we represent the 'spatial structure'? Hillier and Hanson coined space syntax in their book, *The Social Logic of Space*[7], as a new method to abstract the free spaces and discuss the relationships between physical urban form and human activities. It follows the traditions of graph theory (or topology), which divides the space system into units and then calculates their inter-relationships[14,15]. The description of how buildings and urban spaces are configured, specifically, articulated into discrete and interconnected pieces, is proposed to explain a variety of characteristics of the environmental psychology of places. To some extent,

[2] redrew historic maps from Foshan Archives Bureau, Foshan Planning Bureau, Foshan Bureau of Land and Resources, and Foshanshi chengshi jianshezhi, (History of Foshan Urban and Rural Construction), 1990

[3] There are 466,000 immigrants according to the Yearbook 2004.

the syntactical results simulate how people will experience the place, where they will likely move within the place, and what they will notice and remember[16].

It is notable that there are three basic activities human beings performed in the spaces: moving through space, interacting with other people in space, or even just seeing ambient space from a point in it. Considering their natural geometries, the small-scale space could be represented as following three kinds of basic spaces: (1) *axial space* is composed of straight lines accommodating movement, (2) *convex space* where any two points in this space are mutual visible, (3) *isovist space* is a space constructed by the range with respect to viewsheds.

Since the free spaces in cities are most linear, such as roads, avenues, streets, alleys, etc., this study would mainly apply axial models and related parameters. Meantime, it is the most relevant model regarding movement patterns, which would be further discussed in the followings.

2.1 Axial model

According to the definitions in *The Social Logic of Space*[7], axial lines are used to represent directions of unblocked movement and visibility. The axial model is consisted of ‘the least set of longest straight lines to cover the whole space’, Fig. 3 (a,b) as an example.

Using each circle as an axial line and each linking line as an intersection, we could identify the spatial interrelations between root axial line and others (Fig. 3 (c,d)). *Depth* is an important parameter to represent the topological interrelations, which means the minimum distances (or steps) between two nodes. For instance, in Fig. 3, the depth between space 1 and space 7 is three.

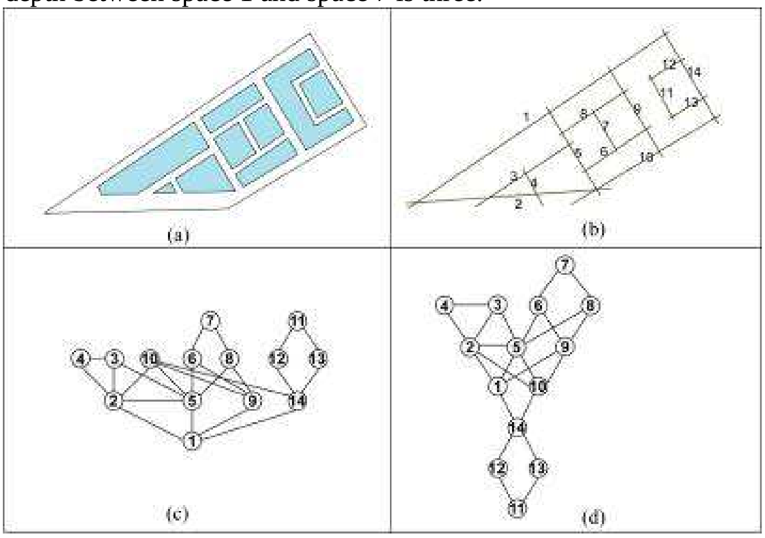

Figure 3 Axial model and justified graphs
(a) a portion of urban street map; (b) axial model;
(c) justified graph from space 1; (d) justified graph from space 11;

Based on the measurement of cluster effects, the depth concept could be further represented by *Integration value*. The node with high integration value means that it is easier to be accessed from others because it locates at shallow level of whole graph. On the contrary, the node with small integration value represents the segregation trend since it is hard to be reached[4]. A series of investigations showing the high correlations between integration pattern movement distribution[19], as well as functional places (i.e. retail shops) [20].

2.2 Global and local configuration

As mentioned before, free space could be divided into a number of small-scale subspaces; which would be represented as nodes in justified graphs. Thus, the space system is literally read – and readable – with a different topological *radius*. In space syntax analysis, integration values at varying radii reflect different

[4] In order to better counter the effect of size of the system, now space syntax community use following formulae standardized by Kruger M.J.T.[18].

scales of urban system. If counting all nodes in the system, we could get *global integration* values, presenting the correlation between one node with all the others. But if only counting the nodes within a search radius *k*, we could *local integration* values characterizing the relationships between that node and the neighboring nodes within the search radius. Therefore, it will turn out that the key to understand parts and whole is to understand the similarities and differences between global and local integrations.

But how to define the search radius *k* for local parameters has not been clearly defined. Hillier (1996:161) argues that pedestrian densities could be best predicted by calculating the lines up to two lines away from each line (*radius-3 integration*). However, few papers discuss how exactly big the 'radius-3' local scale is, or what kind of neighborhood units it represents. By contrast, Eisenberg B. (2005) found that radius-7 is actually more fit with sub-centers in the city of Hamburg; since radius-3 grids containing much fewer axial lines than the real local cores.

In recent years, space syntax researchers have started to develop techniques to distinguish sub-areas in the complex urban context. Their approaches mainly based on the statistical analysis of basic parameters like depths, node amounts, integration values[21,22,23]. This study adopted Yang's method[22] to identify the spatial discontinuities by calculating the change rate of node count with increasing radius from each line. Then we could find one or several big jumps between the consecutive ranges, implying kind of 'boundary' of an area. To some extent, the embeddedness (*Emd*) value calculated from the Eq. (1), helps to light on the radius of spatial differentiation. Where *k* denotes the search radius, N_k represents the number of nodes that keep k steps from the root node.

$$Emd(k) = \frac{\ln(N_k \div N_{k-1})}{\ln(k \div (k-1))} \qquad (1)$$

3 STUDY FRAMEWORK

As mentioned above, this study would investigate the dynamic spatial relationships between old and new urban fabric in Foshan by the tool of space syntax. Then it would involve the changes in two dimensions. One is the spatial scales would be investigated from the entire city to small regions. The other is the time scale that would cover the modernization period from 1920s to 2000s. The proposed study framework has been illustrated in Fig. 4.

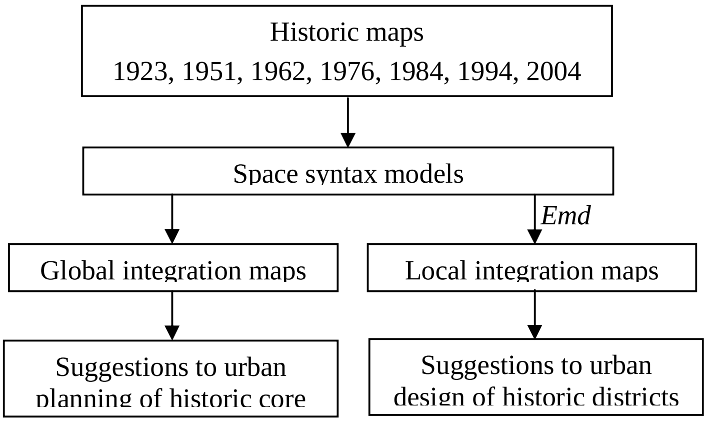

Figure 4 Diagram of study framework

4 ANALYSIS AND RESULTS

To visualize the transformation process of street network in Foshan, a series of historical maps had been employed from multiple sources[5]. The axial model analyses had been made by the software of Depthmap 4, which is one of the most popular platforms to perform space syntax calculations[24].

[5] Map sources: 1923 map from Foshan planning exhibition hall; 1951, 1962, 1976 map from Foshan Archives Bureau; 1984 map from "History of Foshan Urban and Rural Construction, 1990", pp.20; 1994 map from "Local History of Foshan Municipality, 1994", plate1; 2004 map from website of Foshan Bureau of Land and Resources: http://www.fsgt.gov.cn/zxbd/szdt/ opened in Sep, 2009

4.1 Transformation of global integration distributions

With urban development in the last century, the mean global integration degrees have been significantly increased, reflecting the general improvements of accessibility and configurability of Foshan urban spaces (Table 1). But for different periods, the integration distributions have various characteristics (Fig. 5), as well as the related movement and land use patterns.

Table 1 Transformation of global integration values in Foshan

Period	Year	Axial size	M. Con.	M. Rn
1	1923	2421	2.719	0.415
	1951	2589	2.722	0.565
	1962	1366	2.835	0.669
2	1976	347	2.847	0.699
	1984	373	2.997	0.813
	1994	355	3.110	0.896
3	2004	5061	3.387	1.076

Table 2 Global integration values of other cities around the world[7]

Region	Number of cities	M. Axial size	M. Con.	M. Rn
USA	12	5420	5.835	1.610
European	15	5030	4.609	0.918
UK	13	4440	3.713	0.720
Arab	18	840	2.975	0.650

Note: Axial size: the amount of axial lines
M. Con: mean connectivity
M. Rn: mean global integration value (radius n)

According to the urban growth speed, I categorized the seven time slots into 3 periods to better compare the evolution of spatial structures. The first period includes 1923, 1951 and 1962, when the transformations mainly happened inside the old townscope. The second period covers the early urban development stage of 1976, 1984 and 1994. The last period presents for the rapid urban growth in Foshan since 2000s.

Similar to the most of old cities in the world, old Foshan town have 'organic' characteristics, which was constituted by many short lines and irregular grids as shown in Fig. 5 (1923). Meantime, according to the reference Table 2, the average global integration values of early years were closer to the Arab cities, which have similar organic forms. During the first period, the urban size of Foshan has not changed much, but the street density decreased significantly during the socialist development in 1950s. The degree of global integration had been greatly increased by constructing new roads and destructing small lanes. Like Fig.5 shown, the old mass-like integration core had been gradually changed to a few newly-built lines. Another trend could be read from the analytical maps is that the condense integration core has been spread around in a big area, even reaching the edge of the city. Some big working and living spaces had been distributed to the urban edge; more movements had been concentrated into the central roads.

When urban area gradually extended during the second period, the integration core has been moved towards the west and south. Within the old areas, the long main roads were still integrated; while most of the short lines segregating and being lower than the average global integration degrees. Besides, road density in the new development area is much lower than old centre city. For the new long integration lines in map of 1984 and 1994, only few small lanes connect to them (Fig. 5). Potentially those long integrated lines will attract movements and businesses to intensify the local grids. On the other hand, the modern urban grid is apparently larger than the traditional grid, which is also found in other cases[25].

During the last period, the global integration values of Foshan are just a bit lower than cities in USA, with similar rectangle grid networks. According to the rapid developing trend, it could be foreseen to catch up with US cities in the coming future. The integration core had grown larger and larger, moving out from the historic areas, shown in Fig. 5. Most of axial lines inside the historic core are low of integration value, losing the advantages of spatial aggregation. Particularlly the northern part of the old city, which used to be the busiest commercial area, is segregating from the new centre. In addition, several long lines dominate the integration core, which is very different from traditional spatial organization logic. If deleting the longest 8 lines, the mean global integration value suddenly drops from 1.076 to 0.607. Consequently, those central roads would be built wider and wider in order to satisfy the large amount of traffic, reducing the walk-ability and causing another kind of spatial segregation.

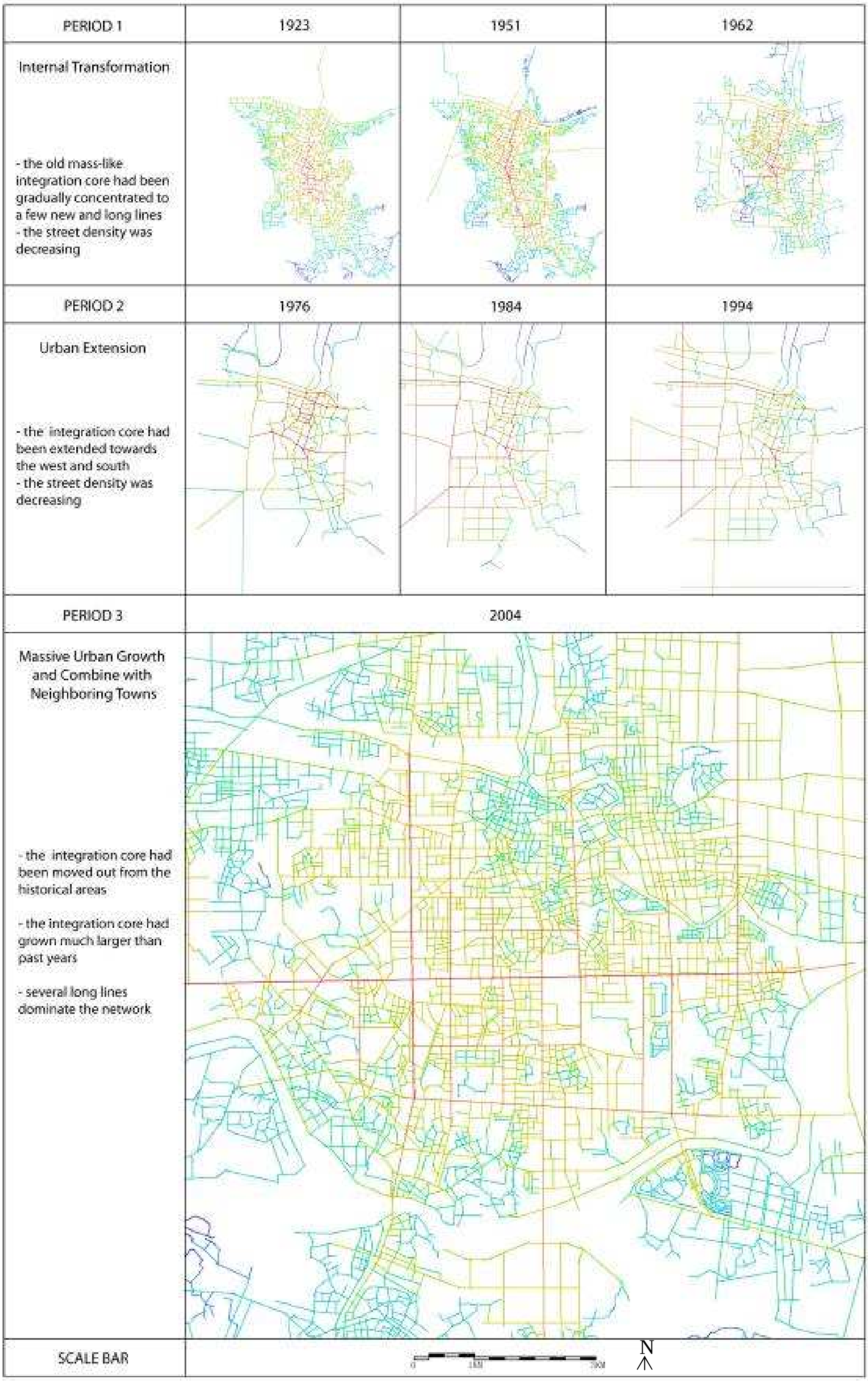

Figure 5 Global integration maps (radius n) of different years
Note: equally classified the global integration values for 10 levels, red for highest, blue for lowest.

4.2 Transformation of local integration distributions

Like Hillier suggested that the global integration analyses reflect the generic properties of city growth, while the local integration maps seem to give a more detailed picture of the movement structure[5]. Meanwhile, the differences between local and global integration maps might suggest the social or spatial variables that dominate in some places.

As mentioned before, the search radius *k* for local calculations should be defined first. The following Fig. 6 of mean embeddedness curve shows that the axial lines reach the maximum speed to embed into the extensive contexts at the similar radii for those years. The inflexion point – radius 6 lights on the differentiation of area structure, which might imply kind of 'boundary' of a local area in Foshan city.

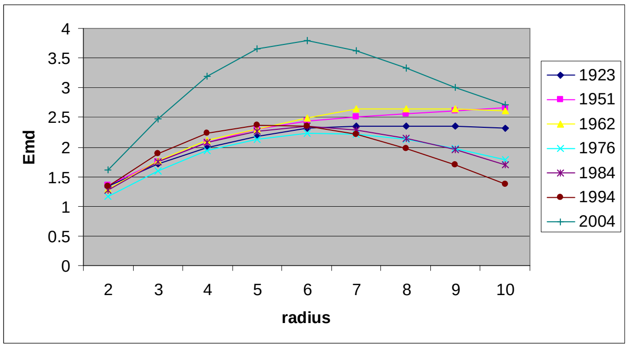

Figure 6 Mean embeddedness in continuous radii of different years

If comparing the global and local (radius 6) integration map, there are significant differences for 1923 axial models (Fig. 5&7). It is notable that the northern parts have relatively higher local integration degrees than the rest areas in 1923 map. Because the commerical activities along the norther river had attracted a lot of visitors and businessmen. But at that time, this kind of movements did not spread to the whole city, perhaps due to the complicated street network separating the strangers and native residents.

However, the variances have become fewer and fewer in the following years like Fig. 7 shown. One of the biggest changes is that the northern zone of historic town was no more local or global integration centre. Most of traditional commercial places there had being declined or abandoned. Meantime, the rise of integration degrees in middle region leads to a big challenge that how to maintain the historical meanings of ancestral halls and settlements among the rich-movement region.

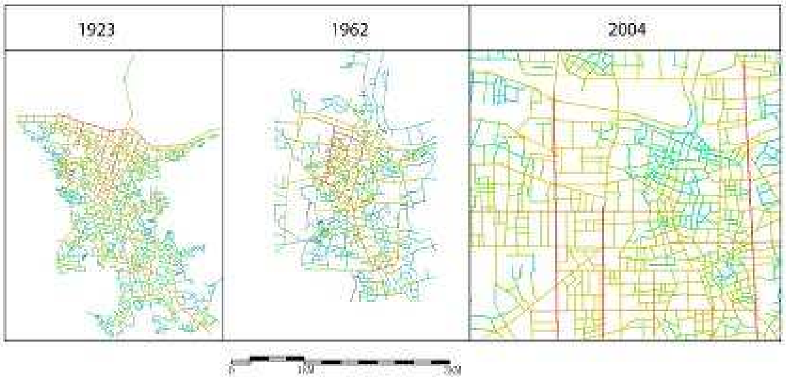

Figure 7 Local integration maps (radius 6) of different years

Note: equally classified the local integration values for 10 levels, red for highest, blue for lowest.

5 DISCUSSIONS

Based on the above syntactical results, it is obvious that the old core had lost its central position among the city in the last decade. When the global integration core changes from a condensed line-mass to several long roads, movement would be attracted in a very different pattern (Fig.8). The former bounded ring roads had become the integration centre; while the old core inside is losing its spatial benefits and attractiveness.

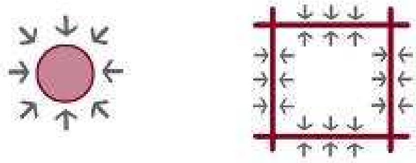

Figure 8 Diagram of different integration cores and their attracting directions

It is a difficult task to renovate historical small-scale fabrics among current big grids without intervening new roads. Therefore, the possibilities of reforming social functions in the old core might be suggested. For instances, the northern commercial centre could be gradually transformed to leisure and tourist areas with local small businesses. Although there are few historical buildings remained in this zone, it is still an opportunity to keep the old trading identity by encouraging small local shops, exhibitions, art workshops, restaurants, etc. Meanwhile, the intensified grids would help to form local integration cores giving benefits to the community economy. However, we should avoid the waterside high-rise real estate development, which is actually happening in the city. One of the reasons is that the big-scale buildings would destroy the traditional spatial structure of the entire old core. And besides that they would seriously block the water landscapes from other residents, as well as their comforts of inner low-rise buildings.

Besides, modern transportation alternatives, such as subway system, make it is possible to re-attract movements in old areas, but not building cut-off roads. And the selection of stations should be carefully designed with respects to historical contexts. However, the subways constructing in Foshan now will not pass through the traditional commercial zone. The only station in the old town will be located in the historical residential areas. It could be foreseen the further segregation of northern region and bigger challenges of conservation practices in middle residential settlements.

6 SUMMARY

With investigating the evolution process of a traditional organic town coming into a modern grid street network, space syntax approaches are used to illustrate spatial phenomena and create knowledge-based historical interpretations of old areas in Foshan city. The comparisons of global and local syntactical results help to gain an insight of the spatial relations among the changing urban contexts. The traditional spatial organization pattern is greatly different from the current structure in Foshan city. And the differences between global and local integration maps have become fewer and fewer. Those challenges have contributed to make the historical commercial areas decline in recent decades. Meantime, the increase of integration degrees in middle settlements leads to a big challenge for conserving historical ancestral halls and dwellings among the rich-movement region.

However, the interpretation of space syntax results has several limitations. First, this study faces difficulties to interpret spatial characteristics for individual places. Because the space syntax results mainly show the inter-relations and statistical performance of nodes. But in terms of particular places, the absolute syntactical value from axial model might be insufficient to explain the socio-spatial variables. Meanwhile, that the available data of 1:5,000 or 1:15,000 maps are limited to explain the details of small scales. Second, space syntax calculations only concern the network interconnectivities, but special topographical conditions and social functions cannot be reinforced in the model. For instance, the influences of water transport are difficult to be weighted appropriately in 1923 map. Although axial lines could be conducted to cover the river spaces, how to quantize the relations between water transport routes and normal lines is still an open question. Third, the embeddedness method applied in this study still has some uncertainties. Unlike the relations between movement and network configuration, it has difficulties to quantitatively compare the fuzzy embedding boundary with a related social function. Nevertheless, the spatial differentiations of an area are hot topics in the field of urban form studies. More studies shall be conducted to figure out how different cities make places through the interaction between area and its context. Fourthly, the space syntax approaches mainly have been applied in the closed models, which are limited to seek predictions. Other graph-based technologies like cellular automaton, which see the same problem from the bottom-up generation angle, could be introduced to re-interpret the spatial evolution process.

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