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EVALUATING WAY-FINDING ABILITY WITHIN URBAN ENVIRONMENT

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THEME: Spatial Cognition

Abstract

This paper discusses attempts to understand how we find our way through the real world, depending on both of spatial configuration and visual form of the city. It presents two different theories: First, the concept of legibility, coined by Kevin Lynch (1960), which states that wayfinding is related to the process of forming mental maps of our environmental surroundings based on sensation and memory. Second, the concept of intelligibility— coined by Bill Hillier, the father of Space Syntax theory— which holds that an urban environment can be better understood through its spatial configuration. The paper explores the relationship between the two concepts in a serious attempt to bridge the gap between them. Heliopolis, Maadi, and Cairo CBD were investigated in detail. The reason for the selection of the case studies is that they have a relative similarity in their morphological structure. Moreover, each case has distinct individual characteristics and rich historical and cultural background. Methodological procedures consisted of interviews, questionnaires, sketch maps, and researcher's site observation of physical environment; and spatial configuration analyses measuring global and local integration values using UCL Depthmap software. Analyzing the case studies according space syntax technique helped in growing the body of data on them, and gave a numerical interpretation for such cases. The results showed that spatial configuration of an environment and spatial cognition are closely related, and that there is a juxtaposition between legibility and intelligibility. In other words, space syntax technique is a good predictor of wayfinding ability. But in a special case like Maadi where longer and shorter axial lines have the same width, the results of spatial configuration analysis won't be accurate and therefore space syntax methodology won't be appropriate for analyzing this kind of axial maps. The findings also demonstrated that spatial configuration and visual form are closely linked. As such, cities should be visually and structurally legible for better wayfinding abilities.

1. INTRODUCTION

Wayfinding is a vital and intuitive process within which the observer can perceive and organize his environment. Tolman (1948) used the term cognitive map to study the behavior of rats in a maze. After that, many studies on the nature of cognitive representations have been carried out. Two publications were really influential in paying attention to cognitive mapping studies, the first is *the image* by Boulding in 1958, and the second is *The Image of the City* by Kevin Lynch in 1960. Boulding emphasized that understanding what people do requires understanding what they know, and that understanding the image in people's minds is essential in understanding human behavior. Gyorgy Kepes (1944) urged that we create symbols and images to understand environmental surroundings, individually in our personal images and socially in images we share with others. Lynch tried to explore the relation between an observer and his environment and how the image is built up. He aimed to investigate people's feelings and knowledge about their environment. According to him, finding one's way depending on environmental knowledge requires, first, to know what internally represented about his environment. Sketch maps and interviews can give us what's coded in people's minds about their environment. The degree of completeness of sketch maps and the way people use in describing a way for strangers can predict the degree of urban legibility; and outline the actual reasons behind wayfinding problems. Lynch (1960) defined legibility of a city as "the ease with which its parts can be recognized and organized into a coherent pattern" (Lynch, 1960:2). This definition states that the degree of legibility depends upon the formation of cognitive maps within wayfarers' minds (Arthur & Passini, 1992). Lynch identified five elements (Paths, Edges, Nodes, Districts and Landmarks) people tend to pick up from the environment to build their images. He urged that these elements are the design criteria for a highly legible and imageable environment. Lynch's work is still used widely, it is the classic reference in cognitive mapping. In it, Lynch constructed a methodology for studying cognitive maps depending on questionnaire and field reconnaissance analysis (Bell et al., 2005).

Space syntax, originated and developed in the 1970s at the Bartlett Unit for Architectural studies, University College, London (Hillier et al., 1983; Hillier & Hanson 1984), is a robust technique that can be used to describe and analyze patterns of architectural space both at the building and urban level. It attempts to explain human behaviors and social activities from a spatial configuration point of view (Hillier, 1996). The relationship between any two spaces taking into account their relationship to at least a third space, and at most all other spaces in a system was termed as spatial configuration (Hillier, 1996; Edwards, 2006). Space syntax measures the distance between spaces topologically, representing the space that can be accessible to all other spaces with the fewest number of changes in direction as the most integrated. In other words, integration means counting how deep or shallow each line in is from all lines up to n steps away. The type of integration varies according to radius-n. That is, if n includes all levels then the integration obtained is called global integration; if n is up to three steps then the integration obtained is radius-3 integration etc. Connectivity is integration when n equals one. Wayfinding ability, according to space syntax, can be measured respecting to what Hillier called intelligibility. Intelligibility, a key property of the spatial structure, is defined as "the degree to which what can be seen and experienced locally in the system allows the large–scale system to be learnt without conscious efforts" (Hillier, 1996: 171). It is the relationship between connectivity and global integration (Hillier et al, 1983). There is a different kind of intelligibility called synergy, the relation between local integration (R3) and global integration (Rn).

Many studies examined the juxtaposition between legibility and intelligibility, and confirmed the strong relation between the two approaches. Dalton and Bafna (2003) studied the relationship between the concepts of intelligibility and imageability. They tried to redefine the Lynchian elements from a syntactic

perspective, using spatial descriptors like axial line and isovist[1]. They found a relationship between the two approaches, asserting the existence of an underlying cognitive basis to space syntax. Kim and Penn (2004) found that "the spatial syntax of configuration in real environments and spatial syntax of cognitive maps in spatial cognition are closely related". Long and Baran (2006) conducted a two staged research study in Changsha, China, to explore the relationship between spatial configuration and sketch maps. In other words, they attempted to find if intelligible an environment results in a legible one. In addition, they tried to explore the effects of spatial configuration on urban legibility. They used space syntax technique to measure syntactic properties of neighborhoods and sketch maps, cognitive mapping and interviews to measure legibility of the environment. They found that there is a positive relation between legibility and intelligibility. Turner (2007) tried to explore the relation between the perception and intelligibility of a spatial configuration. He found a strong relation between the intelligibility of spatial configuration and spatial cognition. That is, the routes with high integration values are the most perceivable and legible ones. On the other hand, Omer and Jiang (2008) used a multi-perspective approach, combining the graph theory and Q-analysis, to study the effects of topological quantities of urban street network on the image of the city at both local and global levels. They demonstrated the relevance of the multi-perspective approach for understanding the correlation between configurational qualities of the street network and the image of the city. Nevertheless, they assured that the contribution of this approach to networks and cities different in character, size and topology should be evaluated in further study. Similar to previous studies, this paper tries to explore the relation between legibility and intelligibility. But, it adopts a clear simulation for both of Lynch's and Hillier's mapping methods. In other words, this paper examines the correlation from a different point of view. It, also, examines the effect of the absence of road hierarchy on intelligibility results when both longest and shortest axial lines have the same width. The main premise of this research is: "wayfinding is closely linked with the interaction between both sides: spatial configuration and cognitive map elements". To our knowledge, to date, only two studies have explored the relationship between legibility and intelligibility. In addition, this is the first study that addresses the correlation between legibility and in intelligibility in an Egyptian urban context.

2. HISTORIC CONTEXT OF THE CASE STUDY AREAS

For the purpose of applying Kevin Lynch's mapping method, three Egyptian areas were selected: Heliopolis, Maadi, and Cairo CBD. The areas selected are unique in their characters among Cairo districts, and vivid and similar in form. Here is a brief historic context of each area ordered according to the date of their establishment from the oldest to the latest.

[1] Isovist is defined as "the set of all points visible from a given vantage point in space and with respect to an environment"(Benedikt, 1979: 47).

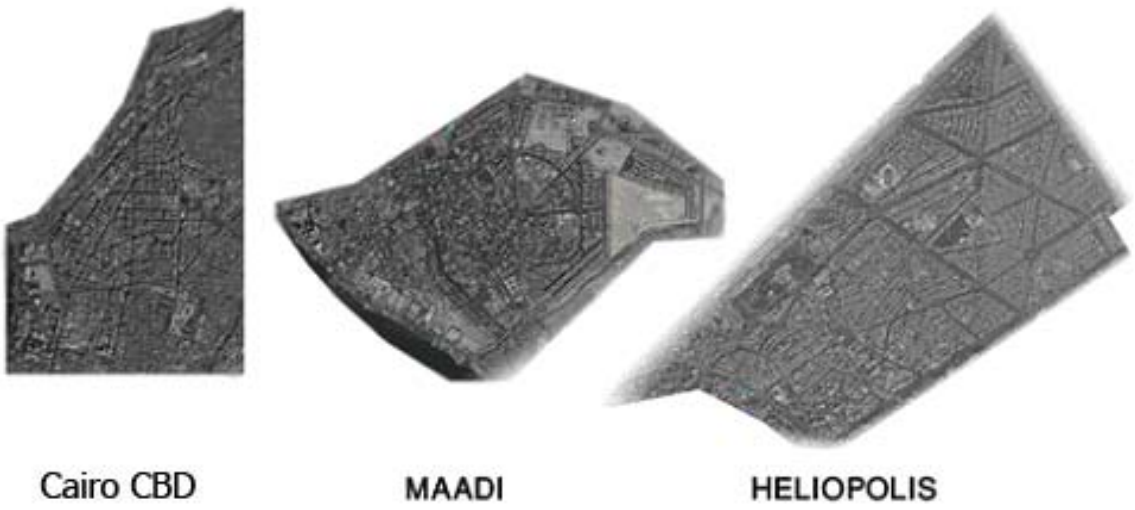

Figure1. Map of Case studies (source: google earth).

Cairo CBD (1860s): Cairo CBD stands for the area sandwiched between the old Fatimid Cairo and the river Nile to the west. It forms a triangle, its three furthest points situated at Al-Tahrir Square, Ramsis and Abdin (Elshahed, 2007). The real drive to modernize Egypt was made by Mohamed Ali Pasha (1805-1848) who established the history of modern Egypt. Khedive Ismail (1863-1879), Mohamed Ali's ancestor, wanted to Europeanize Cairo and make it Paris of the region. Grand Beck, a French planner and a student of Haussmann, was commissioned by Khedive Ismail to prepare a new planning scheme for Cairo CBD. The vision was to make Cairo CBD as an open air museum; wide and clean streets with areas for pedestrian only and spacious gathering points for cultural discussions. The area has a French touch in its layout like Haussmann planning of Paris. It has a radical axes with secondary lines linking them. Moreover, it contains a high artistic ornamentation of frontages like that established in Paris, one can observe the distinctive French touches in balconies: iron work, ornate cantilevers, marbles steps and entrances (Myntti, 1999). Of course, over the decades much beauty has been tampered by both the hands of time and the absence of good maintenance[2].

Maadi (1905s): Maadi, Cairo's greenest suburb, lies on the river Nile about 12 km upstream from Cairo CBD, on the east bank. The suburb tracks its modern history to 1904 when the railway between Cairo and Helwan was built. The whole area was laid out in the nineteenth century. It was planned in 1905 by a retired Canadian officer Captain Alexander J. Adams. There were very strict rules associated with residential development in Maadi with regards to the size of houses, how much of the property could be occupied by the house and how much had to be left for the garden, and the size of the sidewalks (Raafat, 1994). "Even window shutters had prescribed colors (red or green)"[3]. Maadi is the least densely populated neighborhood in Greater Cairo. It is a green paradise built in English countryside cottage style. Its streets are laid out in a mostly grid pattern; nevertheless, there are several wide boulevards running at angles across the grid. Maadi's smart, low-rise apartments, and wide Villas line streets bristling with shady palms and sweetly-scented trees (Beattie, 2005). Maadi's greenery and quiet streets are distinguished by the kind of flowers planted in them. For instance, some streets had roses while others had Jasmine. In fact, the

[2] http://weekly.ahram.org.eg/2009/930/feature.htm.

[3] http://en.wikipedia.org/wiki/Maadi; http://weekly.ahram.org.eg/2007/830/fe1.htm.

landscape features of the suburb form its distinct character. Many of the houses have yards filled with flowers and even garden vegetables. Currently, there is a series of ugly and high buildings along the Corniche by the river, as well as in the newer, eastern part of Maadi, known as Degla[4]. Maadi has geographical boundaries make it semi-isolated. The suburb ends at the flash flood line -Magra Al-Seil located under Tura bridge- where a man-made duct separates it from Torah to the south[5]. "The Autostrade and Wadi Degla Protectorate mark Maadi's eastern border and to the west is the River Nile"[6].

Heliopolis (1910s): The earliest records of Heliopolis date back to the first decade of 20th century when Baron Edward Empain, the Belgain banker and business tycoon, bustled to Cairo in anticipation of the economic boom (Elsheshtawy,2004). In 1905, Empain established the Cairo electric railway and Heliopolis oasis company. Boughos Nubar, son of the country's first prime minister, assisted Baron Empain in purchasing the 5,952 feddans (1 feddan = 4,200 square meters) of empty desert from the colonial government at one pound each on which he built Heliopolis(Dobrowolska & Dobrowolski, 2006). Baron efforts culminated in 1907 with the building of the new town of Heliopolis, in the desert ten kilometers from the center of Cairo, situated between the airport and the city center. Heliopolis, the current seat of power, was designed as a paradise or "city of luxury and leisure". One can feel the influence of Haussmann's Paris in the plan of Heliopolis, as it was designed to have a garden type city: its master plan contained public gardens, parks and playgrounds; restrict building rules were set (no more than half of the private lots could be built up), and buildings heights were also set. In other words, the suburb's original design is represented in grand avenues, spacious city squares linked by wide streets or arching boulevards; and a range of landmark buildings carefully placed to impose grand views on the cityscape (Dobrowolska & Dobrowolski, 2006). There was an attempt to give Heliopolis buildings an Islamic look, despite the fact that the suburb has a Western urban layout. The suburb is no longer small and luxurious, as it has expanded to take in part of the growth of the metropolis[7]. Moreover, Heliopolis company allowed land owners to build all the entire spaces of the lands as a result of the rise in land prices[8]. Consequently, many shops encroached on greenery. Modern Heliopolis has always been the glamorous residence for cosmopolitans and native aristocratic Egyptians. "After the 1952 military coup d'état led by Nasser, it became home to much of Cairo's educated middle class"[9].

3. METHOD

3.1. Sites Selection

Analyses were made of Maadi, Heliopolis, and Cairo CBD. Maadi is unique in its character, urban fabric, green areas along its streets, and its upper-class housing. Nevertheless, it has many problems in orientation, and is full of locational difficulties; Heliopolis, likewise, was selected for its unique character, landmarks, and squares. Moreover, the informal talks with the interviewees showed that Heliopolis is easily to navigate. As for Cairo CBD, it shows another example of a suburb with several high-density residential districts, ranging from slum to upper-class housing, and distinct European-style, specifically French.

[4] http://www.absoluteastronomy.com/topics/Maadi.

[5] http://weekly.ahram.org.eg/2009/932/sc3.htm.

[6] Ibid.

[7] http://weekly.ahram.org.eg/2005/741/feature.htm.

[8] http://weekly.ahram.org.eg/2005/742/fe1.htm.

[9] http://www.search.com/reference/Heliopolis_(Cairo_Suburb).

Heliopolis area is about 7.2 km²; Maadi is about 5km²; and Cairo CBD is approximately 2.75km².[10] The outer suburbs of Maadi, Cairo CBD, and Heliopolis formed their far-flung colonies. Both of Maadi and Heliopolis were constructed in colonial epochs as imitations of garden suburbs. "Maadi and Heliopolis are home to wealthy Egyptians and to large expatriate communities, and are among the most western-looking parts of Cairo" (Beattie, 2005: 183).

Area	Counts	%
Heliopolis	21	30
Maadi	57	81
Cairo CBD	34	48

Table 1. Results of a questionnaire distributed amongst 70 subjects. They were asked at what areas they had most difficulties in wayfinding.

3.2. Kevin Lynch's Mapping Method

In this part we make a clear simulation of Lynchian thoughts. City elements of each case study were defined and integrated into two kinds of maps:

A- The Physical Form Maps: They were produced from a systematic field reconnaissance of every area. This started by finding out the existing potential by the site and its surroundings. Field reconnaissance was made on foot by the researcher who mapped the three areas and explored the visibility of them— defining their elements, recording any existing activities and forms that could be used to make the place more legible, and dividing their elements into major and minor categories according to significance and strong visibility. The maps resulted from this analysis are abstractions of true physical maps, since the mapping process itself is subjective and done independently from the interview analysis. Automobile survey can also predict the probable composite image, as some minor elements could be neglected in foot survey.

Lynch's checklists of elements are helpful here for stimulating the analysis:

- **Paths:** Recording routes that adjoin or cross the area, and classifying them according to their significance in the area.

- **Edges:** Recording any strong linear barriers and any distinct limits to areas with different patterns of use or visual character.

- **Landmarks:** Recording any distinct elements wither in shape, meaning or location.

- **Nodes:** Recording focal points like squares, intersections, and plazas; recording buildings that attract people and create movement like cinemas and shopping malls.

- **Districts:** Recording areas that differ from each other in character and use, and specifying the factors that outline these differences, for example material and form.

[10] Lynch had taken in his case studies an area of approximately 2.5 by 1.5 miles (mile=1.6093 km). Meanwhile, the influence of strong edges that define the outline of each case study, and the pattern of urban fabric were taken into account. Fortunately, the areas of the three case-studies are also comparable in syntactic size (number of axial lines in axial map).

B- Mental Maps

Sample Selection

Three groups of people were interviewed: (1) Those who vitally depend on the studied spaces (live or work there); (2) Those who are not necessary in daily interaction with studied spaces but use them frequently for different reasons; (3) Occasional visitors (tourists and alike) to uncover which are the most important elements of the case study. Meanwhile, most of the interviewees work or reside in the case study areas to reduce the bias of familiarity. In addition, they were between 20-40 years old, since in this age range people's ability to draw maps reaches its optimum level (Shokouhi, 2003). Thirty persons were interviewed in Heliopolis[11], and twenty each in Maadi and Cairo CBD. They were selected equally between males and females because of gender differences in cognitive mapping abilities (Kitchin, Freundschuh, 2000)[12]. The selected sample was more nearly random in residence, work place and class distributions. In other words, the participants were well balanced as to age, sex, class, residence and work place[13].

Sketch Mapping and Analysis

Mental maps were elicited from the sketch maps that were drawn by volunteers who were asked to draw a map of Heliopolis, Maadi, and Cairo CBD with characteristical elements of the three case studies. Drawing maps was not limited by a specific period of time. Each sketch map took 15-20 minutes on average to be drawn. After gathering the data, maps were evaluated to specify which area would score the highest degree of legibility. The maps were evaluated according to their completeness and accuracy. Completeness was measured by the amount of information and details represented in the sketch maps (between 0-100%); the number of identifiable elements included in them; and the completeness of the general structure, the general organization of the sketch maps. Values of general structure were evaluated from one, for sequential maps, to five, for complete patterns, i.e., the simplest form of the map has value of one, then through two (for scattered maps), three (mosaic and linked), four (pattern incomplete) and five for the completed pattern[14]. The accuracy of the sketch maps was measured by comparing the attributes of objects, size, and position on sketch maps with their real-world counterparts. Maps with few elements, little information, and wrong positions were classified as poor maps. Likewise, maps with large number of identifiable elements, and positions closed to the real world locations were classified as rich maps. Eventually, the frequency of mention of elements in sketch maps was posted to produce the mental map.

- The difference between the physical form map and the mental map indicated the gap between actual visual form and the form in people's mind.

[11] The size of samples is similar to Lynch's sample sizes of 30 interviewees in Boston, 15 in Jersey and 15 in Los Angeles. The sample size in this paper is limited by time and resources, increasing the number of data collection sites may generate more accurate results.

[12] Males have been found to draw complete, extensive, and accurate cognitive maps. Women seem to focus on landmarks and districts, whereas men are more likely to emphasis path directions and distance estimates. Women may know more information about a district than they include on their sketch maps.

[13] For more details of residency and demography of participants refer to Mohamed A. unpublished M.Sc. Thesis, Ain Shams University, 2010.

[14] In completeness the Shokouhi's study (2000) in evaluating maps was considered.

3.3. Space Syntax's Mapping Method:

The procedures have concluded these steps:

a) Drawing The Axial Maps

The axial map of an area consists of the fewest and longest sets of lines till all entire spaces are covered. The axial maps of the case studies were drawn by AutoCAD program and exported as dxf. Cad files to UCL Depthmap software[15]. The axial maps of Heliopolis, Maadi, and Cairo CBD are composed of 501, 443, and 523 lines respectively.

b) Processing The Axial Maps

Processing the axial maps is to run UCL Depthmap on them in order to get values of integration (with different radii), connectivity, control, mean depth, and intelligibility[16]. The greater the radius, the more global the extent of the measure (Kim & Penn, 2004). The axial lines are represented from red to blue— red means the highest value of the parameter while blue means the lowest. For instance, for the integration value, the red lines means the most integrated (i.e., the fewest changes of direction from others on average); the blue ones mean the most segregated (i.e., the least integrated).

c) Predicting Intelligibility: Checking the correlations between local and global integration to predict intelligibility.

Comparing the results of Lynch's and Hillier's methods has indicated the relation between visual image and spatial structure of the city.

4. FINDINGS

4.1. Mapping Case Studies According to Kevin Lynch's Method

The first step of analysis was to get the physical form map produced from the field reconnaissance analysis. The second step was to get that mental maps created from the results of interviews. The difference between the map derived from field reconnaissance and that derived from interviews indicated the degree of legibility, and outlined the visual problems of every area. Figures (2-7) below show the legibility and problems of the three urban areas.

[15] Depthmap, created by Alasdair Turner at University College London, is an application used in visibility analysis of architectural and urban systems.

[16] The integration analysis should be made within much larger system than the real study area to minimize the 'edge effect'. The edge effect states that the results of axial maps analysis are influenced by the extent of the urban system that is being considered (Ratti, 2004). In other words, integration values for the lines on the edge of the axial maps will be incorrect, as they will appear not connected onwards. The other way to minimize edge effect is to use local measures that consider limited number of steps in a graph analysis, such as the connectivity of a line (Desyllas& Duxbury, 2001).

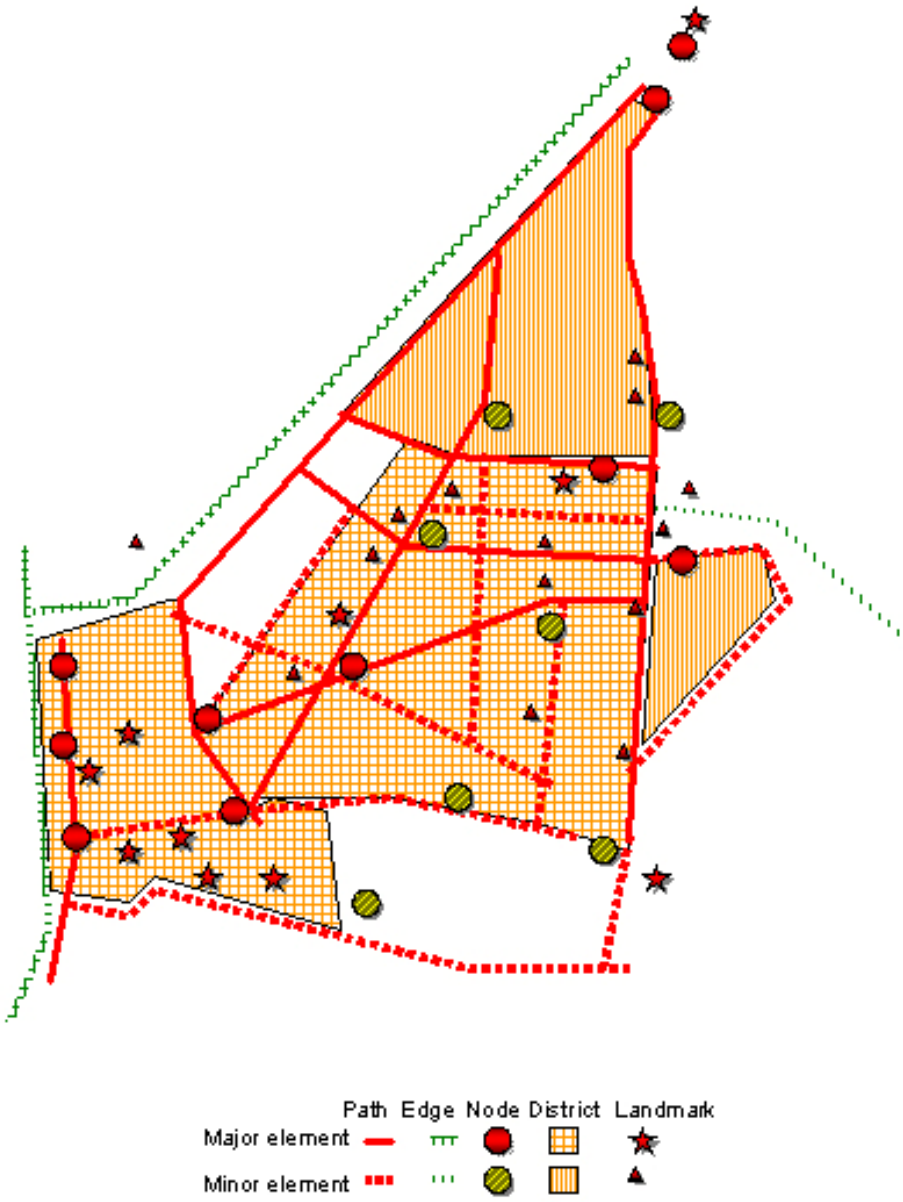

Figure 2. Cairo CBD image as seen in the field (Source: MSc thesis by the author).

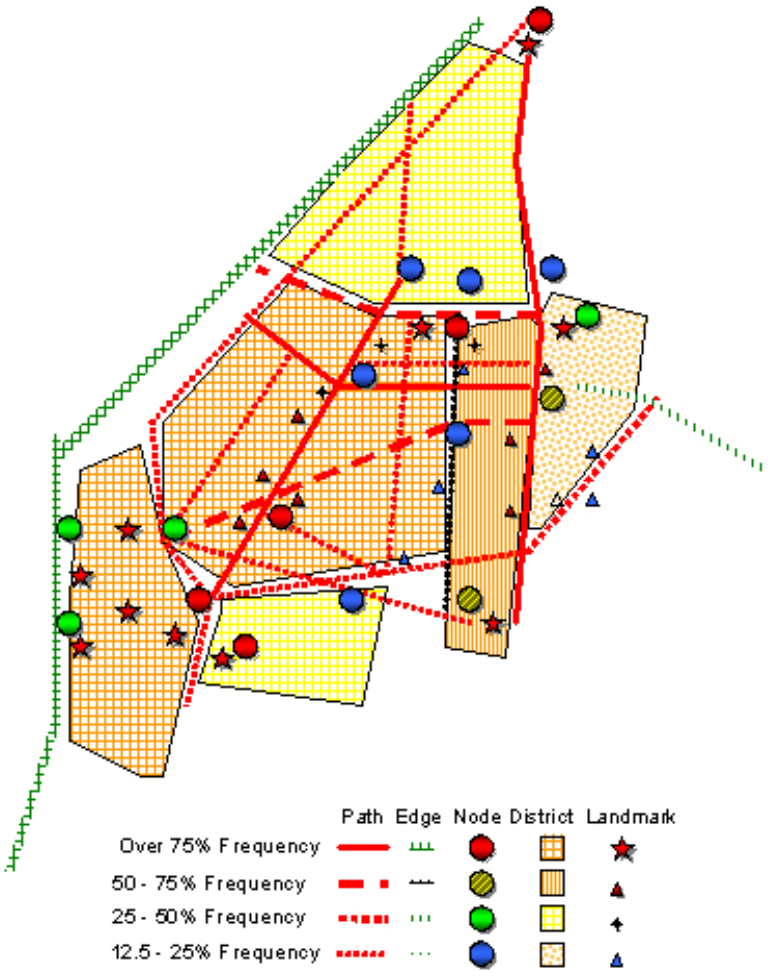

Figure 3. Cairo CBD image as derived from sketch maps(Source: MSc thesis by the author).

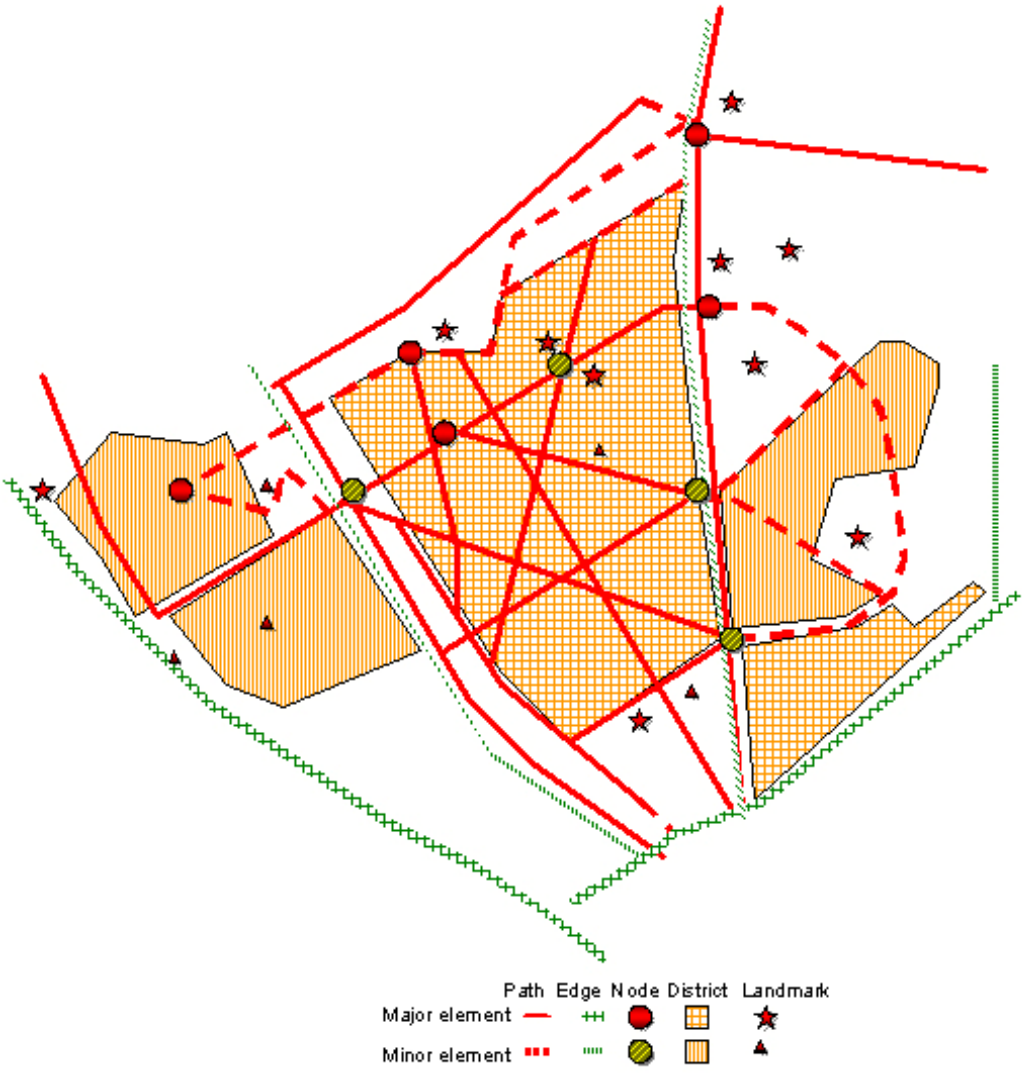

Figure 4. Maadi image as seen in the field(Source: MSc thesis by the author).

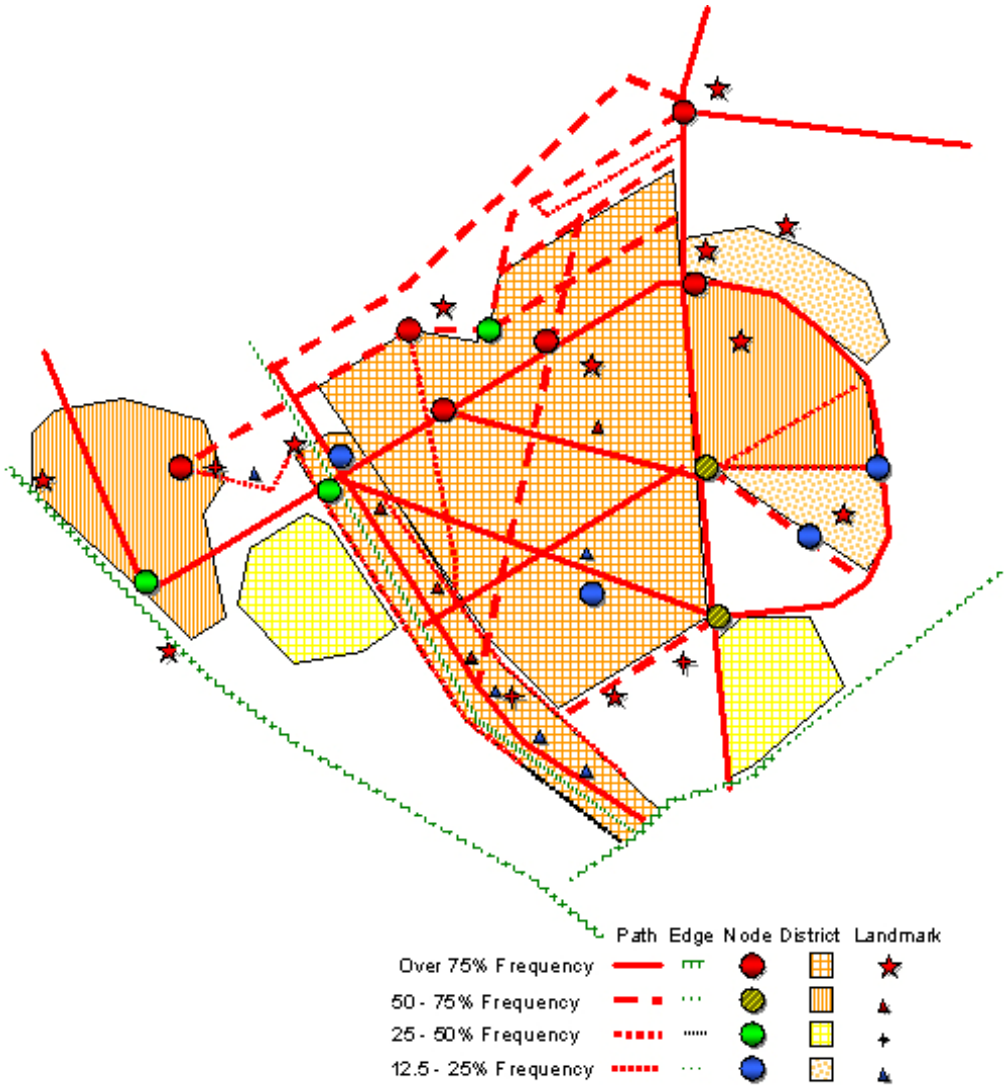

Figure 5. Maadi image as derived from sketch maps(Source: MSc thesis by the author).

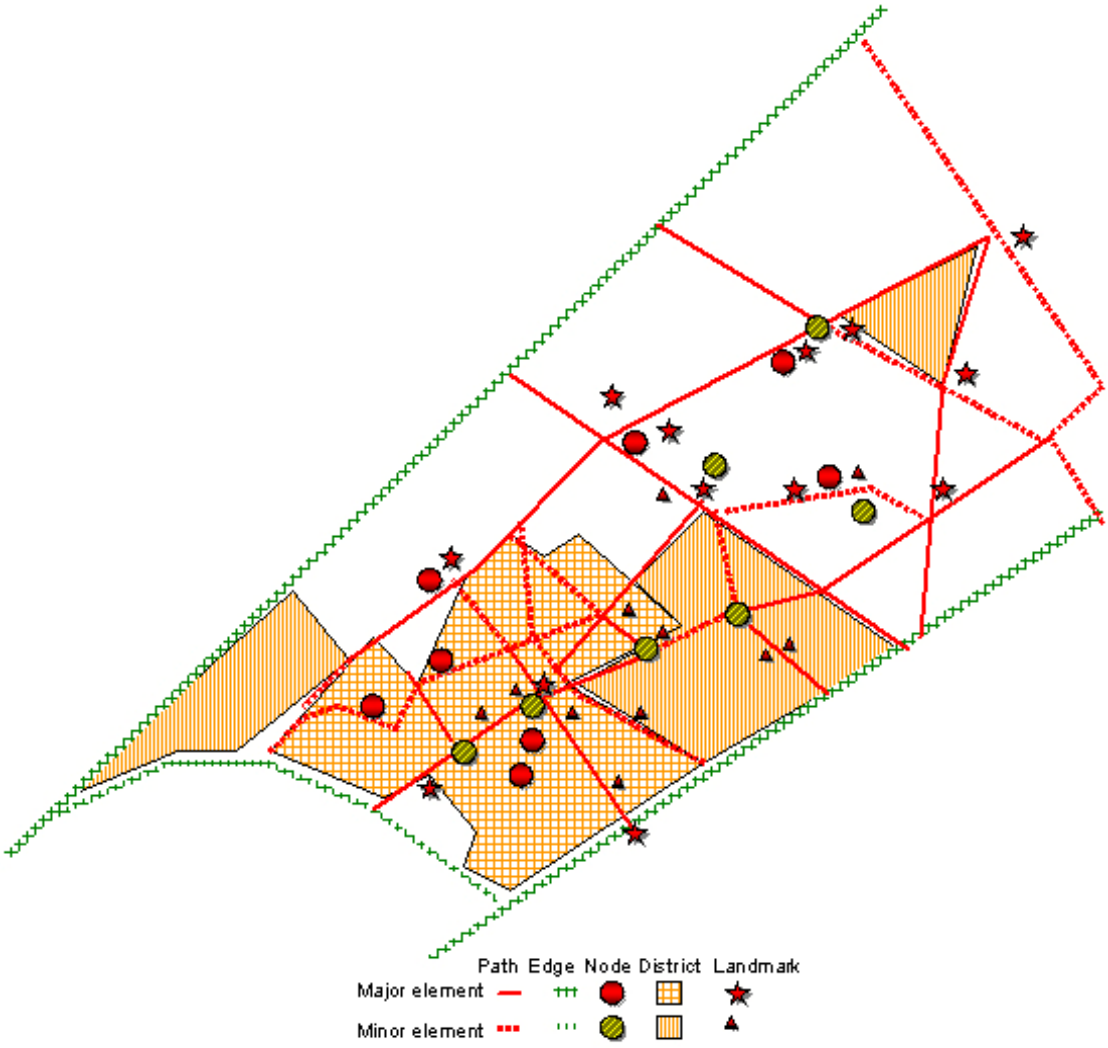

Figure 6. Heliopolis image as seen in the field(Source: MSc thesis by the author).

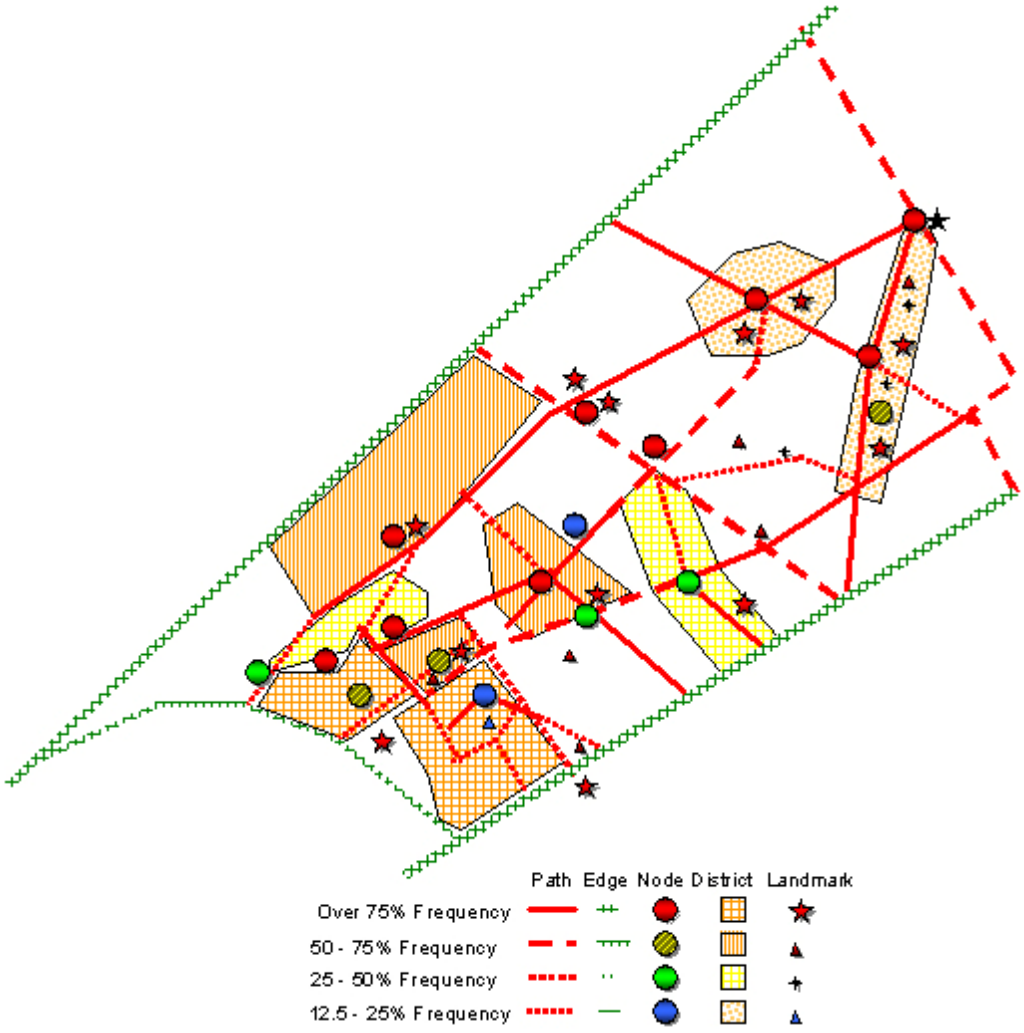

Figure 7. Heliopolis image as derived from sketch maps (Source: MSc thesis by the author).

Design element	Cairo CBD	Maadi	Heliopolis
Path	Moderate	Low	Low
Edge	Low	High	Moderate
Landmark	High	Low	Moderate
Node	High	Moderate	Moderate
District	Low	Low	Low

Table 2. Overall Legibility Score for the case study areas.
Legibility of the five elements for each area is derived form mental maps and interview responses using the following:

High:	50or more respondents thought the element had high legibility.
Moderate:	50or more respondents thought the element had moderate legibility.
Low:	50or more respondents thought the element had low legibility.

Comparing the three areas showed that Heliopolis is the most legible. After it, come Cairo CBD and Maadi respectively. This is due to the strong interrelation, coherence, between the Lynchian elements in Heliopolis compared with Cairo CBD and Maadi. In Heliopolis, the districts are joined with paths, and paths are connected with nodal points distinguished by landmarks. In contrast, Cairo CBD is rich of the Lynchian elements, but the correlation between them is less strong than their counterparts in Heliopolis. It worth mentioning that Cairo CBD's too many landmarks undermined their helpfulness. Furthermore, many of Cairo CBD nodal points are underutilized[17]. Nevertheless, the familiarity with the area increased by reasons of work and variety of uses that activate the area and, thus, expand the people's knowledge. Pathetically, the beautiful suburb Maadi has a very low degree of legibility[18]— because of paucity of recognized landmarks, underutilization of nodal points as a result of restrict security, absence of road hierarchy, and ambiguity of path system[19]. We suspected that there may also be a problem of understanding global orientation, as the various angles at which the main grid and the diagonals run seem not to be related to very much in the wider world. We tested this by asking people on the street whether they are local and know the area well or they are just visitors; then, to point in the direction of some global landmarks that cannot be seen directly but are well known and quite explicit, we asked people to suggest which road they would take to get there from where they are. We noted the actual directions people point for these on the real map (but we didn't show them this). We did this with a number of people in each area and have got a good idea of how disoriented people are and how much they are influenced by the orientation of the street grid they happen to be standing in.

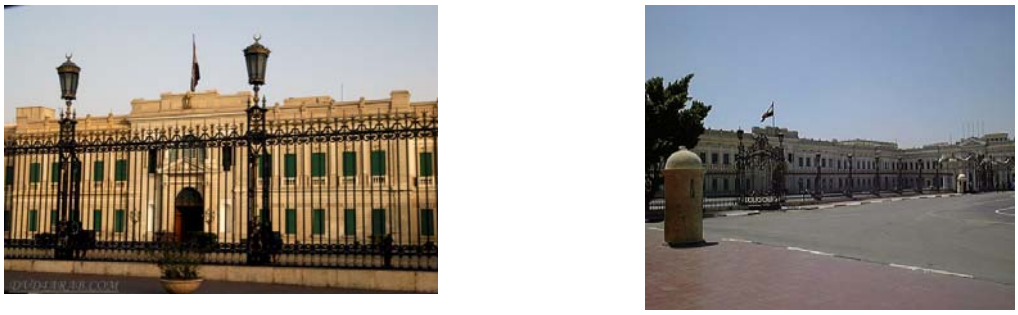

Figure 8. Abdeen palace, Cairo CBD: the palace has been fenced with a visually permeable fence which allows for visual connection but blocks physical access.

[17] This underutilization is due to the unfriendly nature of the buildings around some nodes like Tahrir square, and the existence of strict security around important buildings like Abdeen palace. Moreover, there is a complete lack of trees and hard landscape except very few nodes like Tahrir square.

[18] The maps drawn by subjects were often fragmented, with large blank areas, concentrating most often on clear edges and few unmistakable landmarks. Most interviewees found it difficult to draw or image the suburb as a whole, and most obtained information was verbal more than sketched.

[19] Most of Maadi's roads have the same characters like tracks in a maze. Furthermore, branching of paths with confusing directions is a frequent feature in the suburb. Consequently, Maadi never gives a clear message for either pedestrians or drivers.

Figure9. Midan Victoria, Maadi: The plaza has been fenced with a visually permeable fence which allows for visual connection but blocks physical access.

Figure 10. An off limit street in Maadi because of strict security. (source: http://www.oldroads.org/pastblogs/archive_ 2006_august.htm).

4. 2. Mapping Case Studies According to Space Syntax Technique

4.2.1. Integration Values

The integration maps of the three areas are shown in figures (8-22) below. The integration values were calculated with much larger systems than the real study areas to overcome the 'edge effect'. The most integrated lines have red color (the fewest changes of direction from others on average), then through orange, yellow, green, to deep blue for the most segregated (the least integrated).

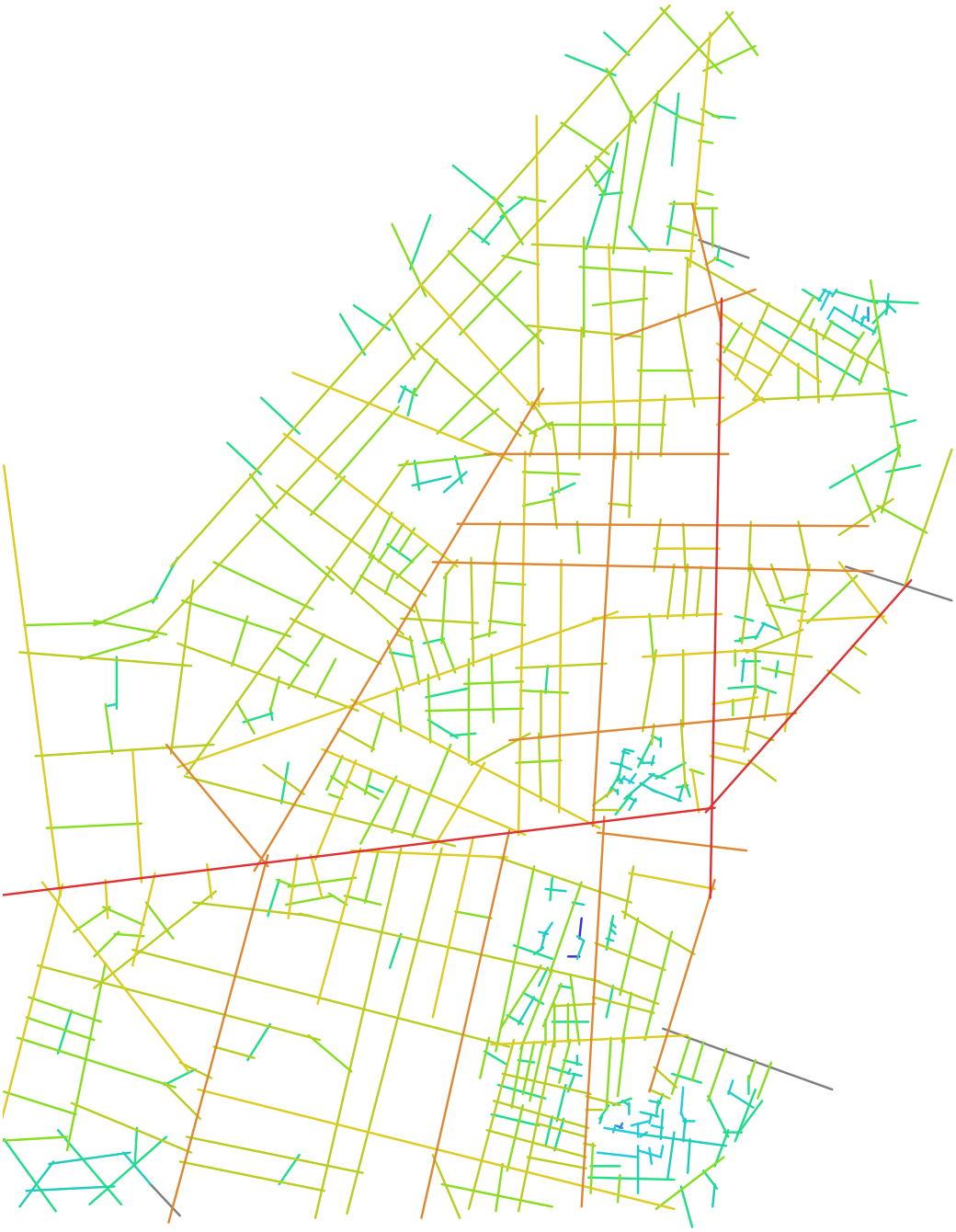

Figure 11. Cairo CBD Global integration.

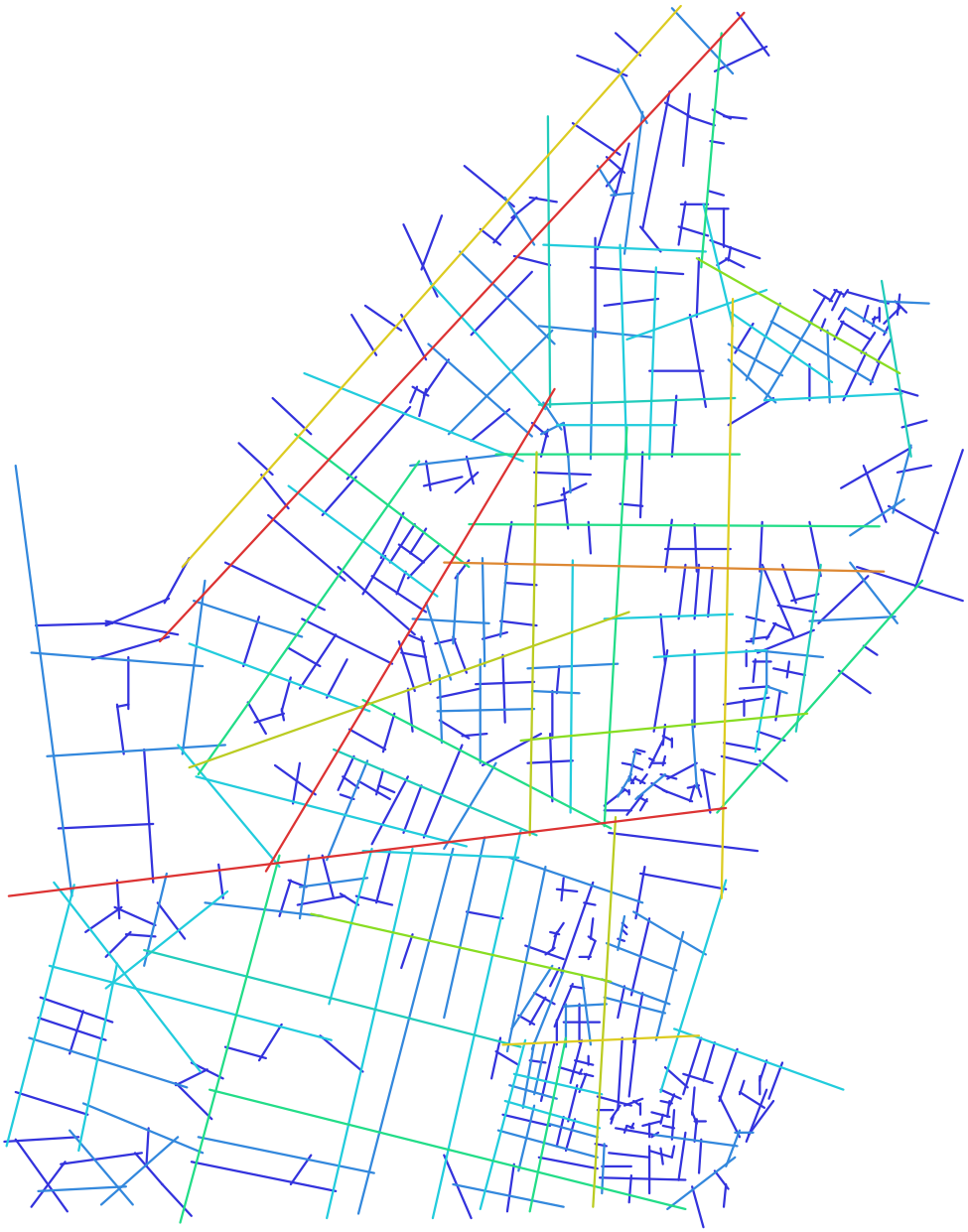

Figure 12. Cairo CBD Connectivity.

Figure 13. Cairo CBD Local integration R3.

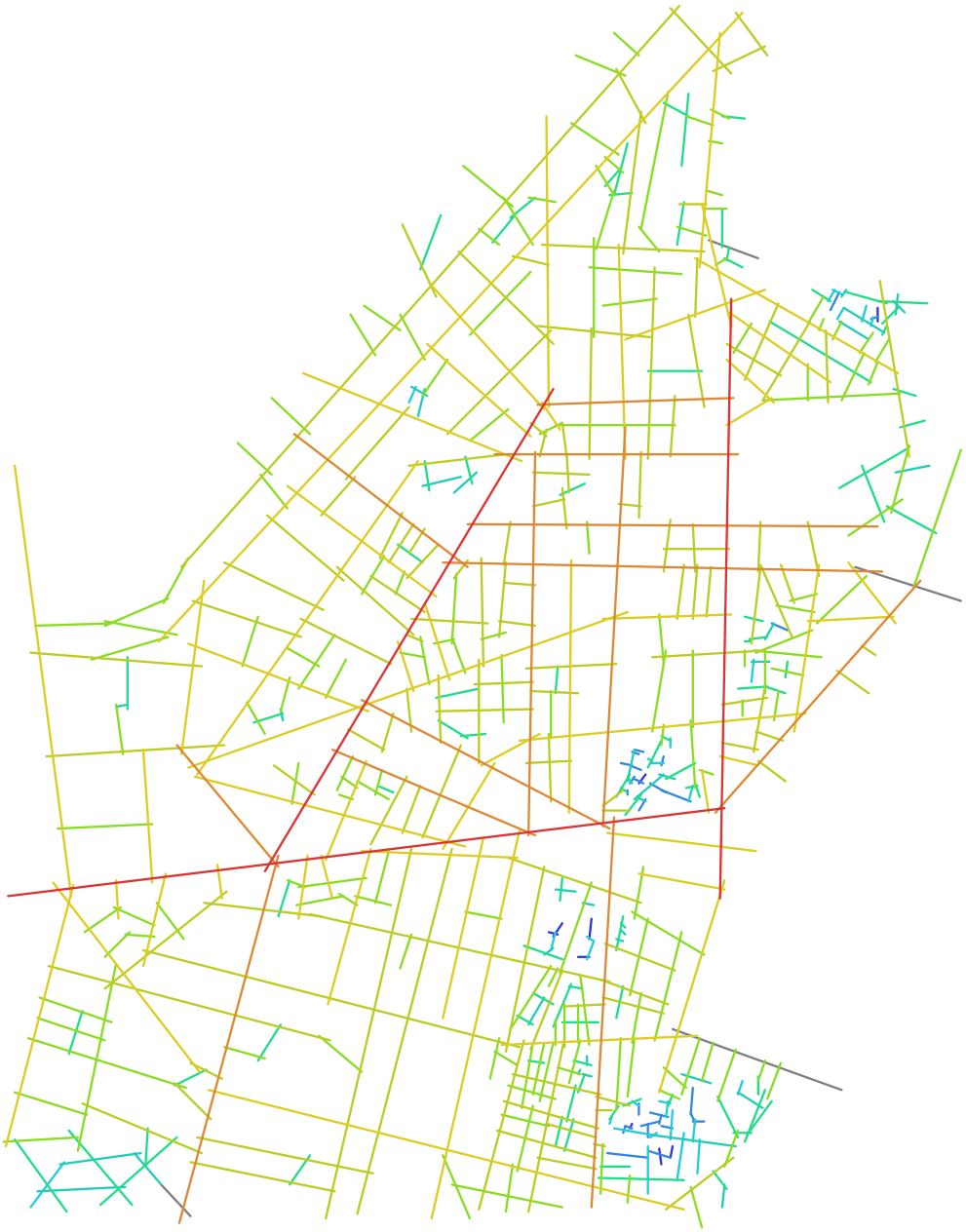

Figure 14. Cairo CBD Local integration R5.

Figure 15. Cairo CBD Local integration R7.

Figure 16. Maadi Global integration

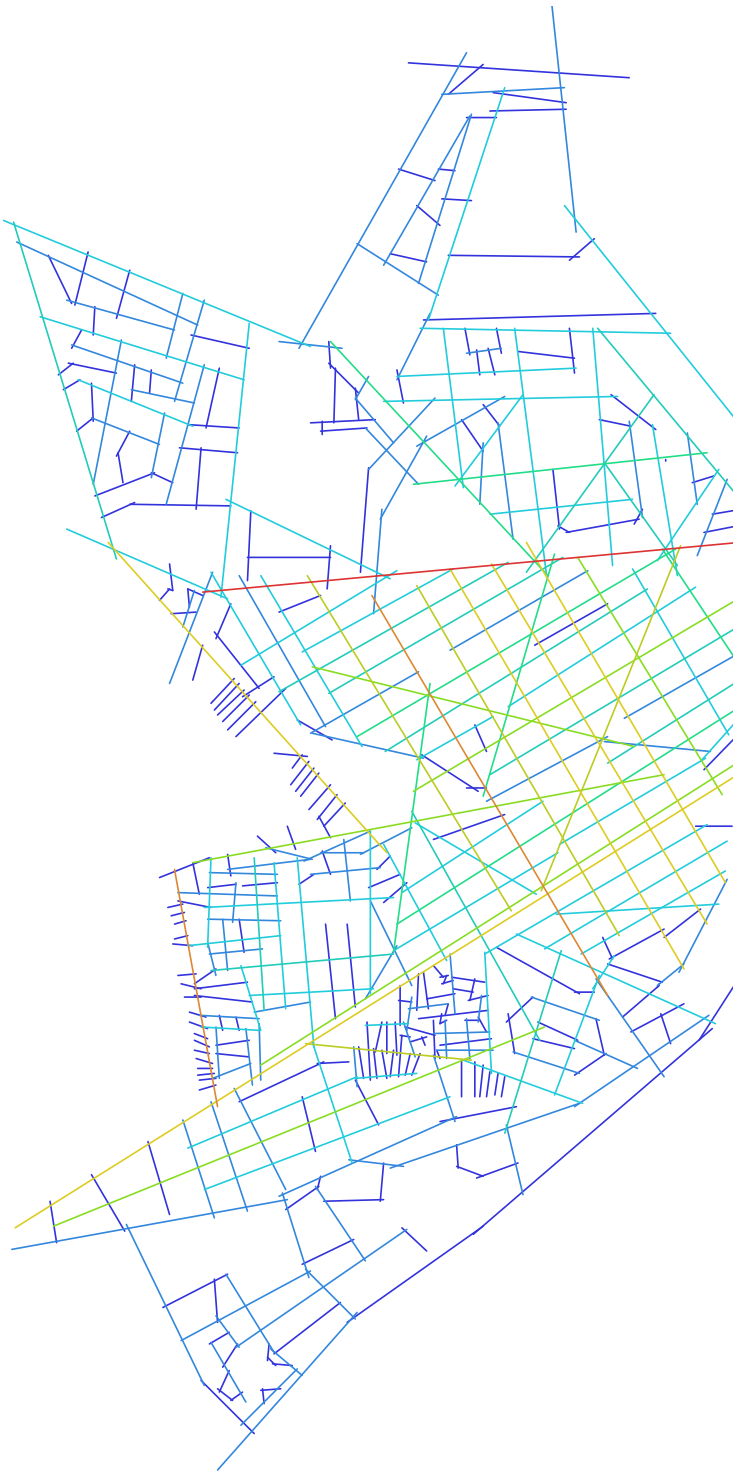

Figure 17. Maadi Connectivity.

Figure 18. Maadi Local integration R3.

Figure 19. Maadi Local integration R5.

Figure 20. Maadi Local integration R7.

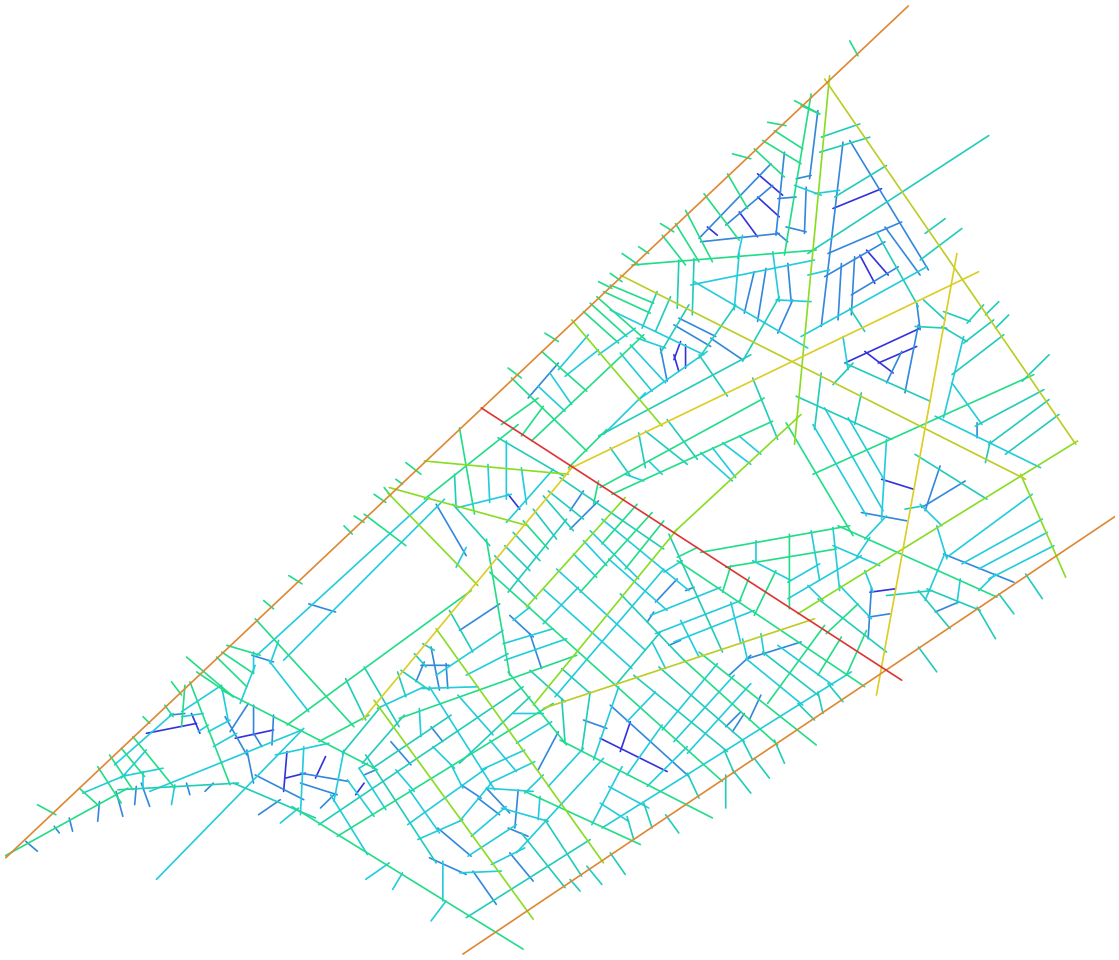

Figure 21. Heliopolis global integration.

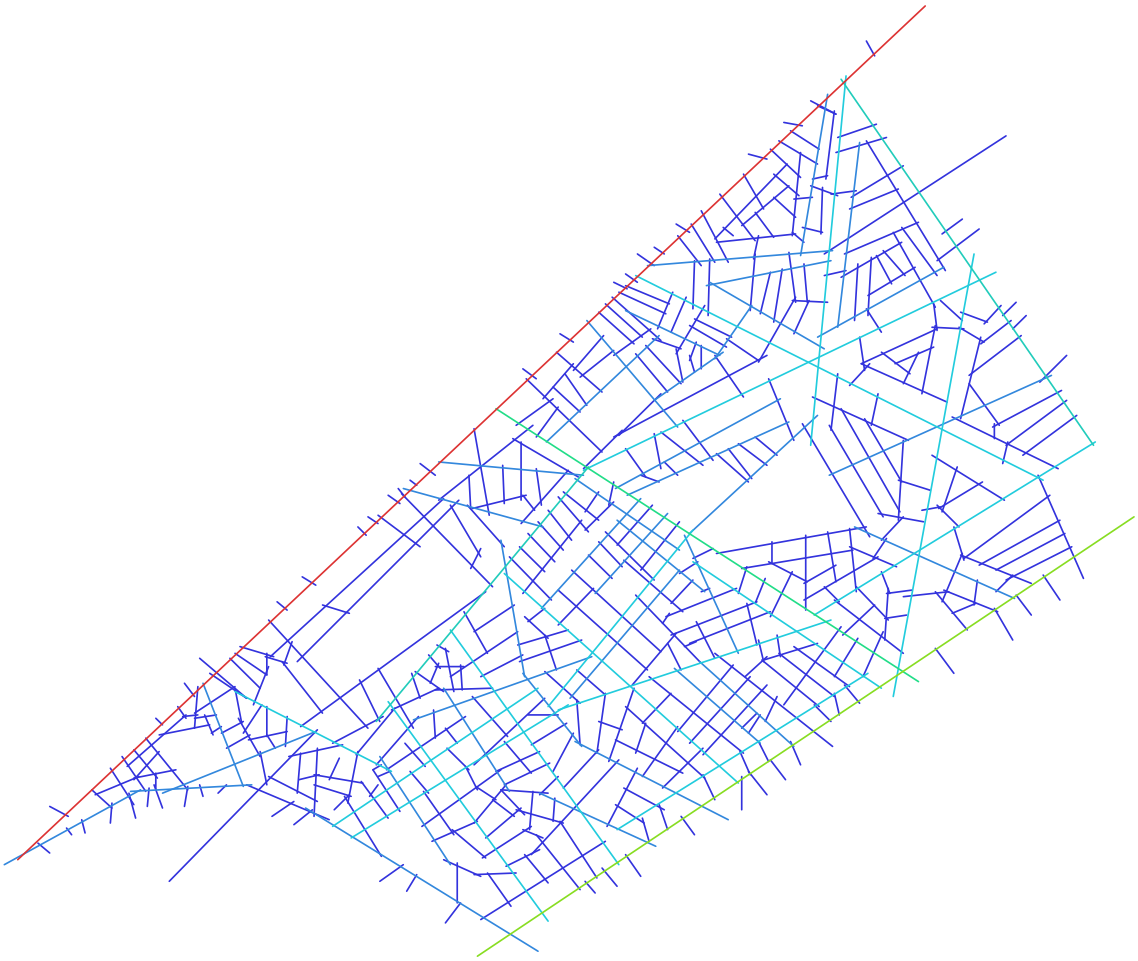

Figure 22. Heliopolis connectivity.

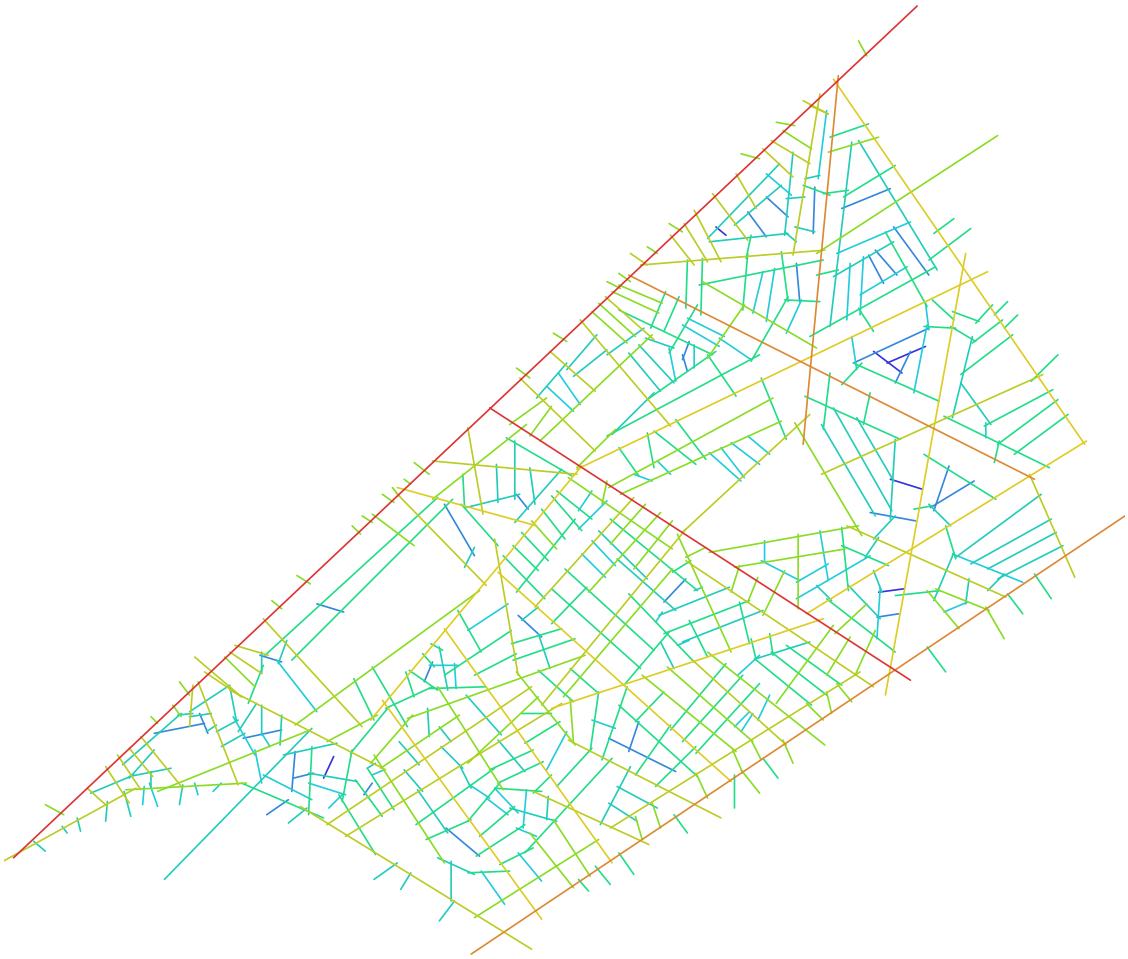

Figure 23. Local integration R 3.

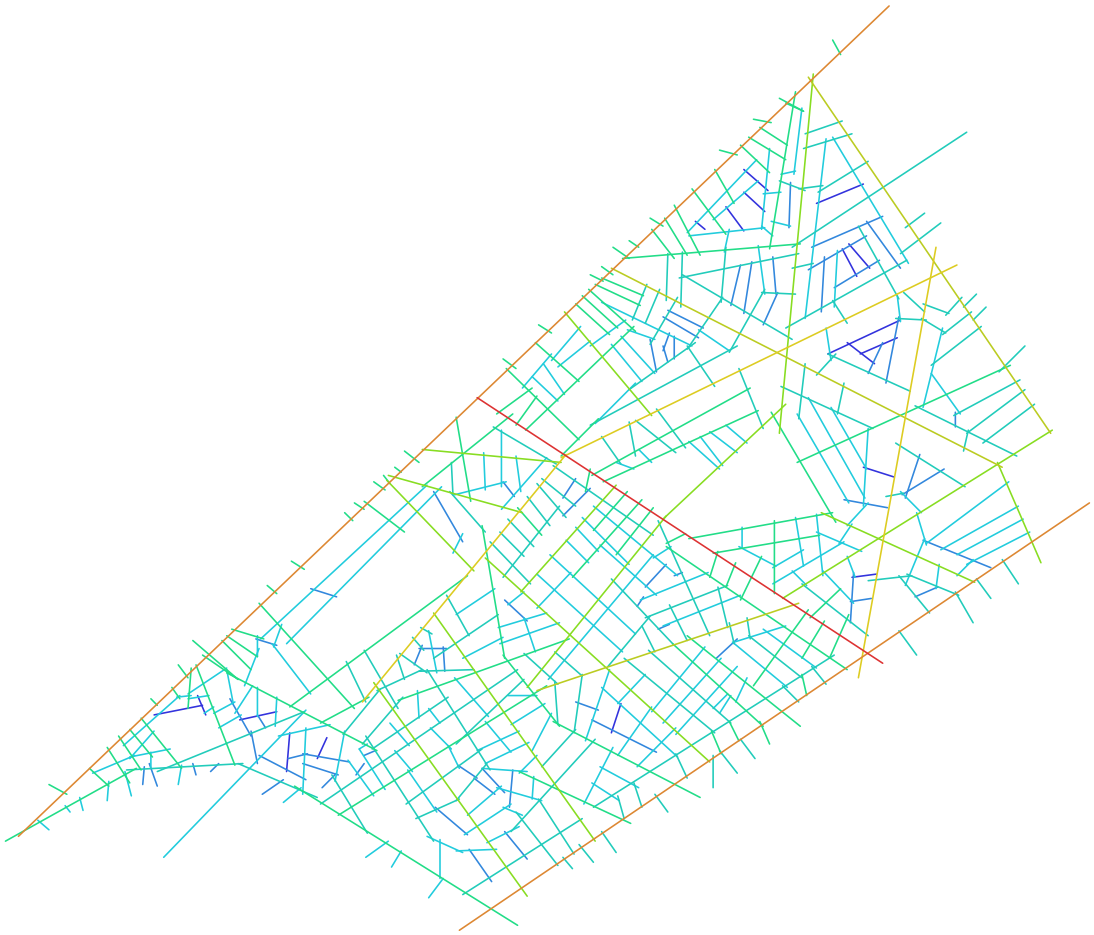

Figure 24. Local integration R 5.

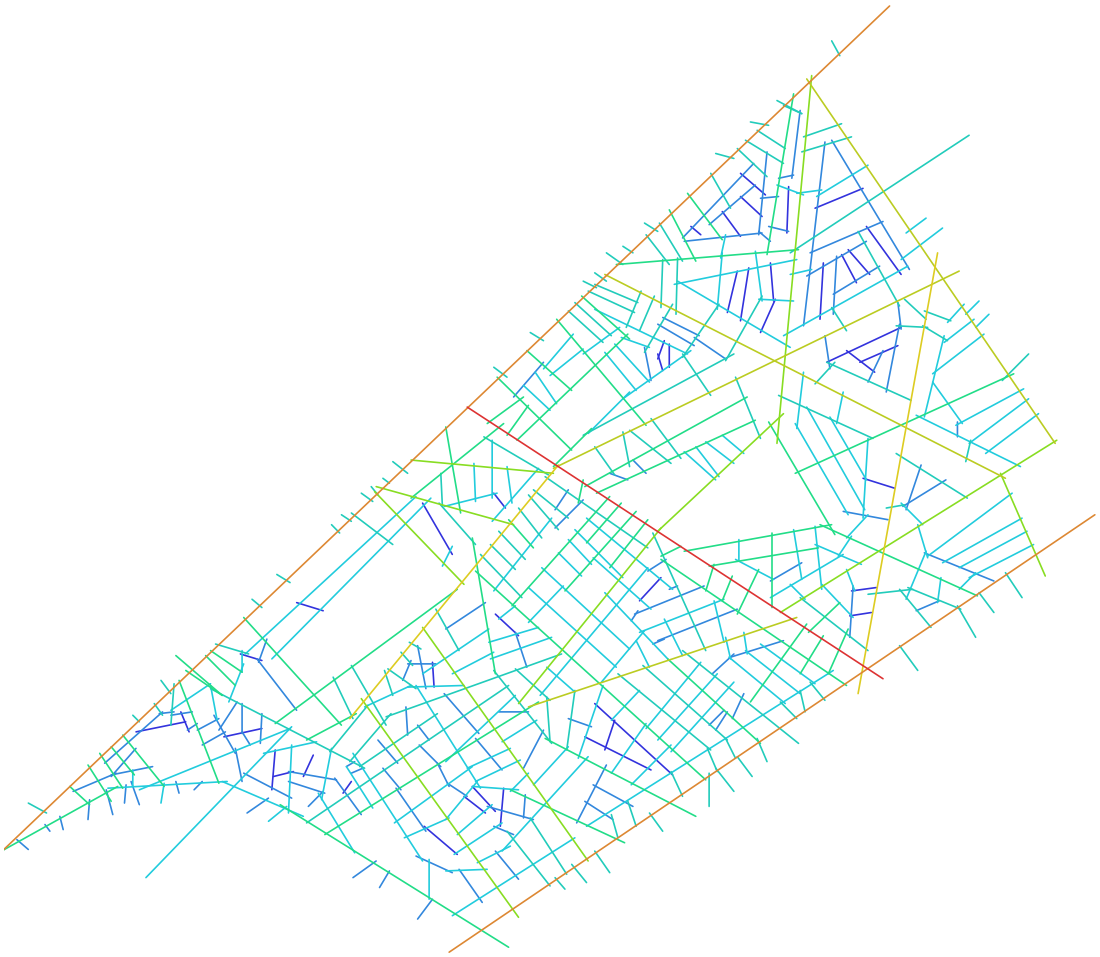

Figure 25. Local integration R 7.

Attribute	Cairo CBD	Maadi	Heliopolis
Global integration	1.34613	1.5835	1.99448
Connectivity	3.60911	4.88143	4.37126
Local integration R3	1.95613	2.2452	2.46953
Integration R5	1.69724	1.8355	2.08381
Integration R7	1.5334	1.6703	1.99651

Table 3. Confgurational values of the three urban layouts.

As can be seen,

- Heliopolis has a good global integration. The most integrated segments are the main streets in the suburb. The most segregated segments are the shortest ones. The association between the integration value and the frequency of recall exists. Fortunately, the most integrated axes appeared in the mental maps. The southern part of the suburb showed global integration values higher than that located in the northern side. This result is matched with the real observed use of spaces, as the southern part contains the core of activities and is rich of distinct elements rather than the northern one. The zone located at

the far north-western end of the suburb showed the most segregated pattern compared to the other parts of the suburb.

- The appearance degree of the streets in the sketch maps is somewhat significantly correlated with their degree of importance in the area regarding to the values of most integrated axes. This means that the spatial syntax of both the sketch maps and the environment are closely related.

- As for Cairo CBD, the major streets showed high integrated values, whereas the minor ones showed low integrated values. The pathways between Cairo CBD buildings are the least integrated roads. These results are matched with Space syntax principle which indicates that longer axes with fewer changes of directions are more integrated than the shorter with many changes of directions.

- The south-eastern part of the area tends to be segregated because of snaky, narrow streets and dead ends which represent a part of the urban fabric of Fatimid Cairo[20].

- The spatial configuration analysis indicates that Heliopolis has the highest integration (Rn) value at 1.9945. After it, come Maadi at 1.5835 and Cairo CBD at 1.3461. Similarly, Maadi has the highest value of connectivity at 4.8814. After it, come Heliopolis and Cairo CBD at 4.3713, 3.6091 respectively (Table 3). In other words, Heliopolis is the most globalised, whereas Maadi is the most localised. The maps of Maadi local and global integration contain many axial lines with high values of integration, which means that those lines are generators of movement and expected to attract more visitors and therefore have commercial uses. But the fact proves that most of these axes are used for residential purposes. Moreover, the daily life in Maadi is full of quietness, low rates of movement. This means that the results obtained by spatial configuration analysis for Maadi are not in the right place and need to be discussed. This conflict will be tackled in the next step of analysis.

4.2.2. Intelligibility and Synergy Values

The degree of intelligibility can be read by a scattergram that shows the relation between global integration and connectivity. Scattergrams of Intelligibility and Synergy values of the three areas are shown in figures (26-31) below.

[20] Fortunately, the results of Cairo CBD analysis were matched with the results of professor Salheen dissertation : Salheen, M., 2001, A comprehensive analysis of pedestrian environment: The case study of Cairo city center, Ph.D. thesis, Heriot-Watt University, Edinburgh College of Art, Faculty of Environmental Studies, School of Architecture.

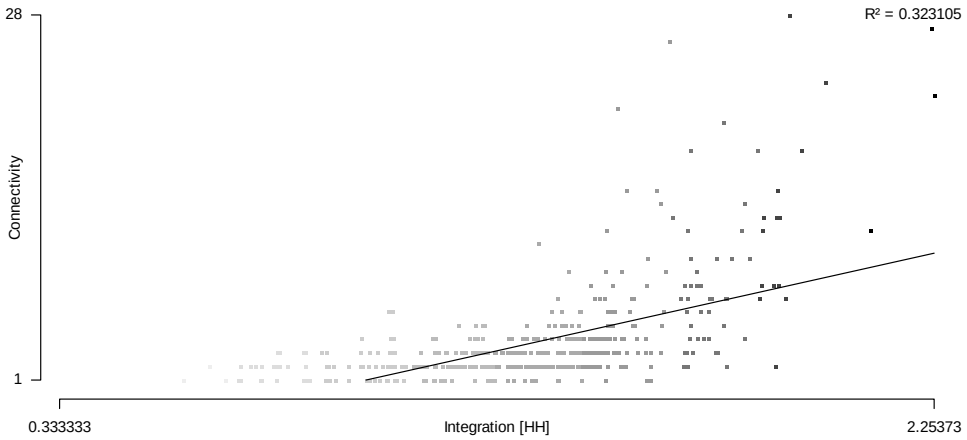

Figure 26. Intelligibility scattergram, Cairo CBD.

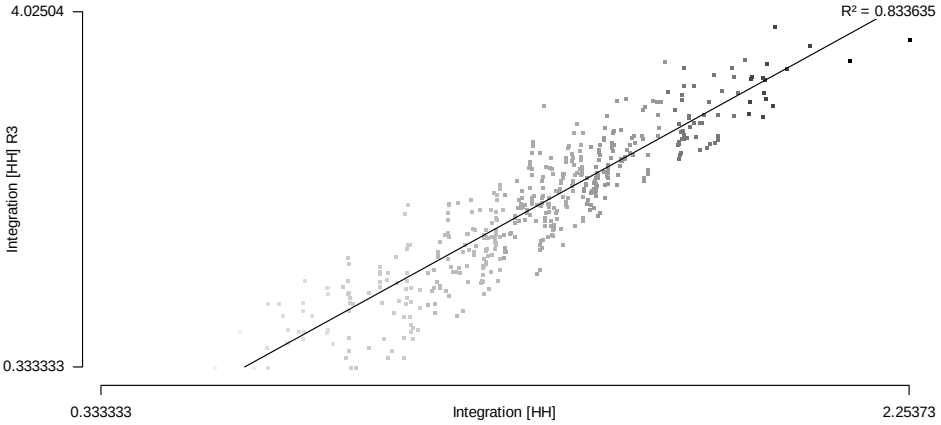

Figure 27. Synergy scattergram, Cairo CBD.

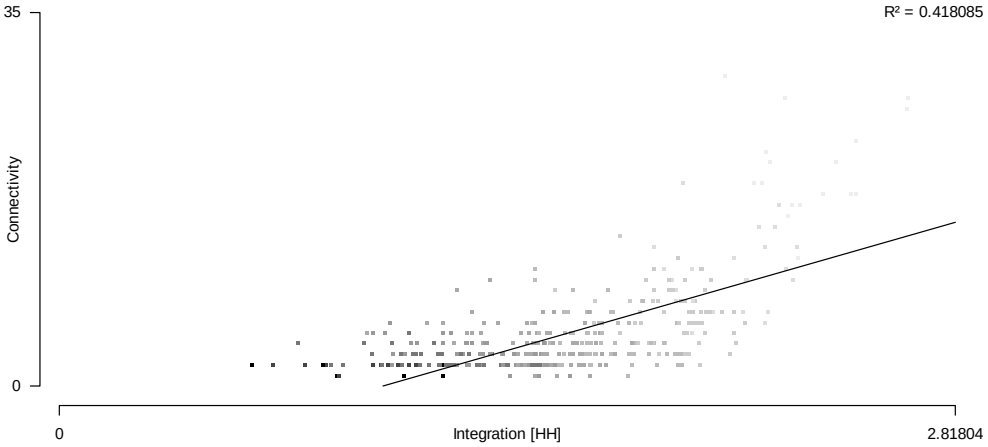

Figure 28. Intelligibility scattergram, Maadi.

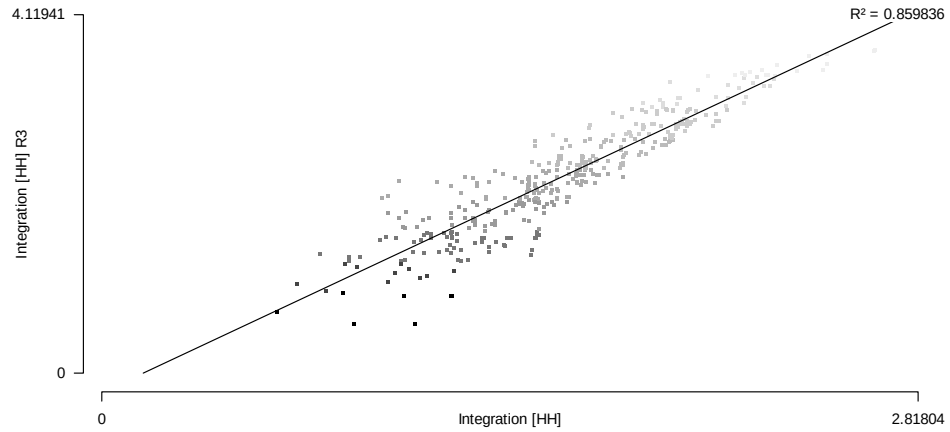

Figure 29. Synergy scattergram, Maadi.

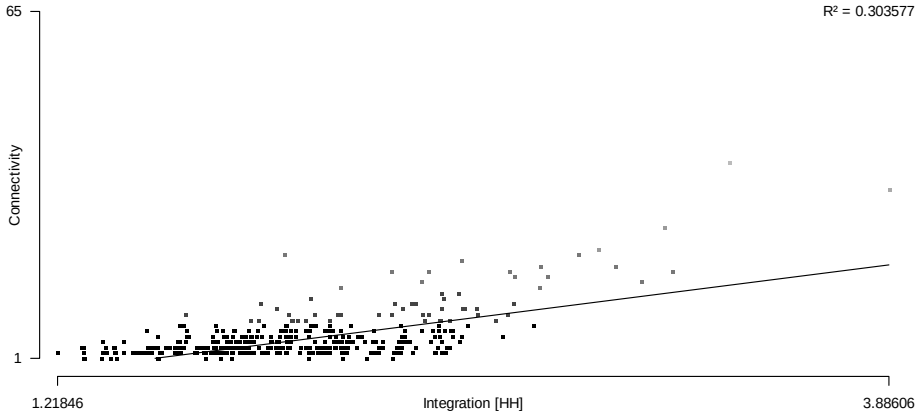

Figure 30. Intelligibility scattergram, Heliopolis.

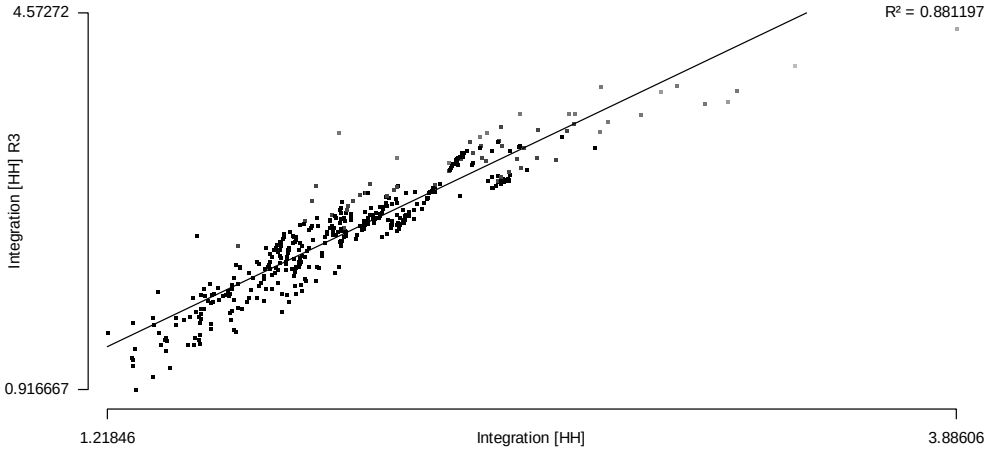

Figure 31. Synergy scattergram, Heliopolis.

Measure	Heliopolis	Maadi	Cairo CBD
Correlation integration n/ integration3 (Synergy)	0.881197	0.859836	0.833635
Correlation integration n/ Connectivity (Intelligibility)	0.303577	0.418085	0.323105

Table 4. Comparing the synergy and intelligibility of the three urban layouts.

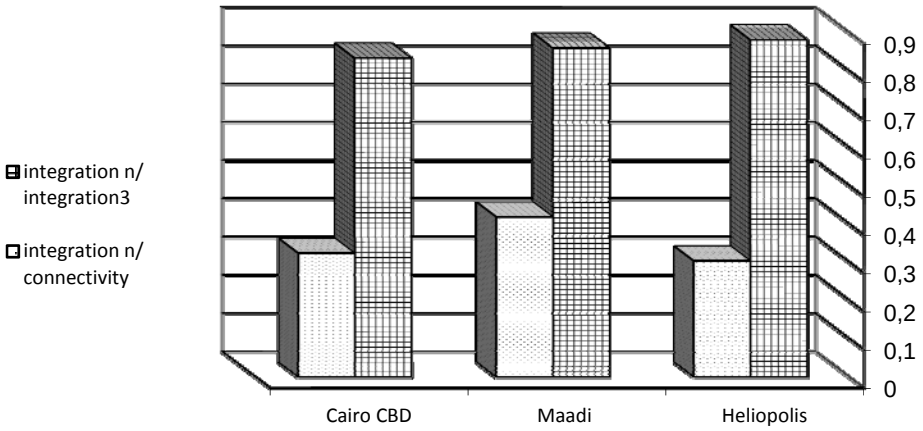

Figure 32. Comparing the intelligibility of the three urban layouts.

The results of the comparison between case studies showed, with high degree of confidence, that there are differences between the three urban layouts. Maadi has showed the highest intelligibility at 0.42, while Heliopolis and Cairo CBD are approximately having the same degree of intelligibility at 0.3.

The initial interpretation indicates that: In the cases we show here, the interesting effect is that the order of synergy for Heliopolis, Maadi, and Cairo CBD is the opposite of the order of intelligibility. This is, on the face of it, surprising and very interesting. There are various possibilities — are we comparing like with like? Are the case studies composed of more or less equal numbers of spaces (correlation coefficients are very affected by the number of data points)? Or is this telling us something more fundamental — the boulevards of Maadi would seem locally well-connected, but are they the same alignments that form the global structure of the whole of Cairo? Is there something more localised about the way Heliopolis is structured?

The axial maps of Heliopolis, Maadi, and Cairo CBD are composed of 501, 443, and 523 lines respectively. Furthermore, Maadi is physically isolated from the whole Cairo, as it is surrounded by strong edges from its sides: the River Nile from the south west; Kobry Shmal Tora and a flash flood from the south east; and Degla desert from the east. Moreover, this beautiful suburb is adjacent to slum areas from the north. So the syntactic sizes of case studies are comparable,[21] and we would seem to have a genuine effect. Maadi is more localised — its boundaries are strongly defined. This means that the system we are analyzing is closer to the complete system. As such, it is not a surprise that Maadi has higher intelligibility than Heliopolis and Cairo CBD.

[21] In cases with different syntactic sizes, Hillier normalizes the measure, to allow comparison, by dividing the relative asymmetry (RA) by a D-value to calculate a different kind of integration called real relative asymmetry, a reciprocal of integration.

4.3. The Juxtaposition Between Legibility And Intelligibility

Evaluating the legibility of the case studies showed that Heliopolis is the most legible. After it, comes Cairo CBD, while Maadi has showed the lowest scores. On the contrary, measuring intelligibility showed that Maadi is the most intelligible, while Heliopolis and Cairo CBD are approximately having the same degree of intelligibility. Definitely, intelligibility and synergy values for Maadi are away from reality, as they are unmatched with the legibility inferred by mental maps. So the question is how to solve this conflict between legibility and intelligibility. In other words, how can we interpret people's wayfinding problems in Maadi: space syntax analysis confirmed that Maadi has higher intelligibility, while sketch mapping and interviews confirmed that it has wayfinding problems and one can not find his destination. We can safely declare that the results of spatial analysis for Maadi look superficial and misleading. But, what's the real reason behind this error in analyzing its morphological structure? In fact, the deviation of Maadi results from reality lies in the constant, narrow width for most of Maadi roads and subways. Although narrower width and absence of road hierarchy —both of main streets and subways have the same width— discourage traffic flow and decrease familiarity and wayfinding ability, the error here is related to axial map itself. Someone may claim that space syntax has nothing to say about road width, especially the issue of road hierarchy. But this is definitely not right, as the axial map does not neglect this— the way in which an axial map is drawn means that longer and more connected lines get through wider streets. Maadi axial map does not subject to this principle, as both of longer lines and shorter ones have the same width. This is absolutely abnormal, so Maadi and the like are odds/ special cases. To conclude, we like to say that space syntax can not predict the degree of intelligibility and wayfinding ability in special cases, such as Maadi and the like which definitely need methods rather than space syntax to interpret and predict wayfinding difficulties within them.

5. CONCLUSION

This paper analyzed legibility according to the Lynchian mapping method. The two maps of the researcher's site observation and the mental map of each area were compared with each other. The difference between the two types of maps predicted the degree of legibility for the case study areas. After that, we compared legibility of case studies. This comparison is crucial to reach the real reasons of wayfinding problems.

In the next section, we analyzed the morphological structure of the case studies according to space syntax technique by using UCL Depthmap software. The values of Local and Global integration, Depth, and Control were measured for each case. In the next part of analysis, the scattergrams of intelligibility and synergy were drawn for each case. Looking at the shape of the scattergrams illustrated the degree of ability to read the whole from the parts.

In the last section, the results of legibility and intelligibility for the three urban layouts were compared with each other; the most surprising outcome is that when main roads and subways have the same width, absence of road hierarchy, the results of analysis will be unmatched with the real world and will need to be refined. This means that cases of morphological characteristics resembling Maadi should be excluded from the rule, and analyzed according to an appropriate technique rather than space syntax. It is worth mentioning that cases like Maadi can conditionally be analyzed using space syntax measurement if we provided the road width of the spatial pattern to the data base, then the principle which adopts that longer lines are wider than shorter ones will not be applied. Consequently, the outcomes will be more accurate and closer to the real world. Finally, it is fair to say that in spite of the criticism obtained through this paper discussion, space syntax is still a source of inspiration for architects and urban designers, especially in

comparing different concepts of design with each other.

6. ABOUT THE AUTHOR

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