CHAPTER THREE
BILL HILLIER MAPPING METHOD:
Basis Of Space Syntax Technique

3.1. INTRODUCTION
How to describe space? How to analyse urban fabric according to objective way? How to predict movement and usage from a spatial structure? How to evaluate the design of an area? How to measure the connection of spaces? How to investigate society-space relation?
These questions will be tackled by extending a coherent family of ideas and analytical techniques: Space syntax.

Space syntax, originated and developed in the 1970s at the Bartlett Unit for Architectural studies, University College, London (Hillier, 1988; Hillier & Hanson; Hillier et al., 1983; 1989a; 1989b;), is a robust technique that can be used to describe and analyse patterns of architectural space both at the building and urban level. It's how to establish an objective way to evaluate and investigate the relationships between the morphological structure of man-made environments and social structures or events. “Space syntax is a set of techniques for the analysis of spatial configurations of all kinds, especially where spatial configuration seems to be a significant aspect of human affairs, as it is in buildings and cities.”¹ Space syntax is also defined as “a family of technique for representing and analysing spatial layout of all kinds”( Hillier 1999: 165). It attempts to explain human behaviors and social activities from a spatial configuration point of view (Hillier, 1997).

¹ space syntax laboratory , retrieve on 7th may 2008, “http://www.spacesyntax.org/introduction/index.asp”
Space syntax has been used in a wide range of research projects. Hillier et al. (1987a) made an analysis of house genotypes. Peponis et al. (1990) looked at the function of morphological structure of buildings in the way finding process. Hanson (1989) described the sociocultural implications of different plans for the rebuilding of London after the great fire. Miller (1989) used space syntax as a tool in the process of urban renewal in a Swedish town. Hillier et al. (1989b) attempted to predict spatial patterns of crime in urban areas, and De Holanda (1989) was concerned with social implications of different ways of structuring city-form in the third world. Mills (1989) showed how the spatial structure of townships acts as a mechanism of control in the apartheid ideology. Last and most important, the relationship between the morphological structure of urban areas and (mostly pedestrian) movement patterns has been researched frequently (Hillier 1988; Hillier and Hanson, 1984; Hillier et al., 1983; 1987b; 1989a; 1990; Peponis et al., 1989).

3.2. THE IMPORTANCE OF ANALYZING THE SPACE

Space is the unit within which all human activities occur. It reflects the social and cultural aspects of the city. The effect of space on people, how they use it and interact with each other within it are all need to be grasped. It is necessary to understand space from a functional perspective in terms of what people do in it. We should think of space not as the background to human activity, as we think of it as a background to objects, but as intrinsic aspect of human beings do (Vaughan, 2007). Space can be described in three geometric ideas: linearly when people move in it, convex space (in which every point can see each other) when they interact within it and finally isovist which from any point of space can be seen as a variably shaped, often

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2 Environment and Planning B; planning and design, 1993 “Space syntax: standardised integration measures and some simulations”
spiky visual field (Benedikt, 1979). All these geometric ideas will be defined in more detail in this chapter.

Figure 3.1. Relation between space and activity: Space is not a background of activity but an intrinsic aspect of it. (source: Vaughan, 2007)

3.3. WHAT IS SPATIAL CONFIGURATION?

It is clearly accepted that city is the container of activities, in its spaces many human behaviors like eating, gathering, interacting and dwelling occur, having their spatial form. There is an expected relation between space and its use lies in the relation between configuration of people and configuration of space. Configuration as defined in Hillier's book *space is the machine* is “a set of interdependent relations in which each is determined by its relation to all the others” (Hillier, 1996: 24). The arrangement of spaces in such a way influences the use of them according to how we relate these spaces to each other. For example, figures 3.2.a and 3.2.b show two different types of spatial configuration, although they seem similar in adjacency and number of cells, they are totally different in underneath topology (Hillier, 1996).

Regarding to the principle of permeability, it is clear that the position of doors in the two figures is quite different, therefore has its influence on the privacy of spaces, that eventually determine the use of space, so spatial configuration needs to be analyzed and understood (Hillier, 1996).
3.4. UNIT OF SPACE SYNTAX TECHNIQUE

Every point in the space has one and two dimensional aspects, the one dimensional is called axially; the other is called convexity:

3.4.1 Axiality

It is to draw the longest and fewest lines that covers the system, the product is called axial map. It offers the most globalizing perspective, as an axial line will extend as long as at least one point is visible and directly accessible (Hillier et al.,1983). Axial lines are used when studying movement.

3.4.2 Convexity

A convex space is defined as “a space that will not contain concave parts” (Hillier et al., 1983). It is an area outlined by a border of straight lines, any
two points in this convex space can be joined by a straight line which doesn't go outside the space.

Convex map consists of the largest and fattest convex spaces that cover the area (Hillier et al., 1983; Szalapaj, 2001). The convex space offers the most localized perspective because any selected point taken within it appearing visible and directly accessible to all other points within that same space (Hillier et al., 1983). Convex spaces are used when studying interaction.

![Convex and Concave Spaces](image)

**Figure 3.3.** Space syntax tools (source: Hillier et al., 1983)

### 3.4.3. Isovist

The key criterion in defining isovist is how far can one see or move from every point in the space. Isovist analysis has been developed in landscape studies and is integral to GIS (Rana, 2002). Benedikt (1979) adopted the term isovist from Tandy (1967) who had used it to describe landscapes. Isovist field is in itself a measure of the morphology of the system, it can be generated automatically by using a software such as **Depthmap** from Turner, **Omnivista** from Dalton. 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). It is the field of view within which the entire space boundaries can be defined through the transportation of observer's eye around 360° without geometric obstacle. The boundary-shape of an isovist is sensitive to location of point of seeing when the space is non-convex, as there would be many isovists with different shapes. It is used when examining complex patterns of behavior.

![Figure 3.4. Isovist.](source: Batty & Rana, 2002)

![Figure 3.4. Isovist.](source: http://wiki.uelceca.net/2007/2008/files/doc+essay.pdf)

**3.5. THE CONCEPT OF DEPTH**

The main interest in space syntax has not been in creating axial lines or maps, but in examining and interpreting relationships between lines that cover such map (Batty & Rana, 2002). Space syntax measures distance between spaces topologically, this topological distance is called depth. Depth means number of intervening lines that must be crossed to get from space to another, the minimum number of steps means shallowness (integration), whereas the maximum number of ones means segregation.

**3.6. INTEGRATION**

**3.6.1. The Correlation Between Integration and Depth**

Integration is the fewer intervening lines which need to be passed through to go from a line to every other line. It's in contrast with mean depth (obtained
by dividing the total depth by \( k \), the number of spaces in the system), the most integrated lines means minimum depth. In other words, integration \( \alpha \) 1/mean Depth so The more segregated spaces means higher depth.

![Diagram of Maximum and Minimum Depth](image)

**Figure 3.5.** Relation between integration and depth (source: Hillier et al., 1983).

### 3.6.2. Measuring Integration

If the axial lines of an area have been drawn, it is possible to choose any line and place all lines that join directly with it on a separate level until we cover the whole system, then the number of levels required to join up all lines in the system can be specified and values of integration, and depth can be calculated (Hillier et al., 1983). As shown in figure 3.6., by starting at line 7, we can see that it is only connected to line 5. Then line 5 is connected to line 6 and 4. By placing each direct connection on a separate level, we find that
for line 7 we need four levels to join up the system. Similarly, for line 4 we can see that it's directly connected to lines 2,3 and 5. then line 5 is connected to line 6 and 7, moreover line 2 is connected to line 1. Continuing as before we see that we need 3 levels to join up all the system, so line 4 is more integrated than line 7 because it needs fewer number of levels(3). To calculate the mean depth of a certain line multiply the number of the lines on a level by the level number, sum across levels and divide by the number of lines( Hillier et al., 1983). An integration value can then be calculated as actual integration value = 1/ mean depth.

Figure 3.6. Simple model of axial lines( source: Hillier et al., 1983)

Space 4 mean depth = ( (3x1) + (3x2) ) / 6 = 1.5
Space 7 mean depth = ( (1x1) + (2x2) + (3x3) ) / 6 = 2.3
Integration value α 1 / mean depth

Figure 3.7. Simple justified graphs. ( source: Hillier et al., 1983)
3.6.3. The Integration Core

Every axial line in the axial map has an integration value that differs from line to another, this integration value reflects its importance and how it relates to all other spaces. If the integration values of lines be sorted and ranked from the highest to the lowest, the lines of highest (25% of high integration lines is recommended for small settlements of less than 100 lines. 10% is the recommended value for the integration core of larger settlement) integration values can then be specified and presented on the map. These most integrated values (10%) is called integration core and can be distinguished on the map by a heavy black lines as shown in figure 3.8. In good systems, the integration core relates to all other areas. This means where ever you are in the system, you are never away from a high integration line (Hillier et al., 1983). The most integrated lines in an urban plan will represent the skeleton of the mental map because those lines are the most familiar to people.

![Figure 3.8](image)

Figure 3.8. Example of axial map analysis according to space syntax technique: Darker lines is the most integrated, while light gray is segregated (source: Kim Y O, 1999).
3.6.3.1. Forms of Integration Core

Hillier (1983) postulated that:

“The core takes a form typical of many types of town or urban area, which we call deformed wheel. A small semi-grid of lines in the heart of the settlement (the hub) is linked in several directions (the spokes) to lines on the periphery of the settlement (the rim), which also form part of the core.” (Hillier et al., 1983: 69)

![Diagram of integration core forms](source: the researcher deriving from Hillier et al., 1983)

3.6.4. Local & Global Integration

The integration value of a line changes according to the number of levels that have been considered in measure; if we count how deep or shallow each line is from all other lines, we call this **global integration**, whereas counting how deep or shallow each line is from all lines up to three levels away is called **radius-3 integration**, if it's only one level away from each line, then we call this **connectivity** of a line (the number of lines that are directly joined with it), so specifying the type of integration depends up on radius–n integration(Hillier, 1997). Connectivity is a property of the line that
can be seen from the line, whereas global integration couldn't be seen from the line, as it requires knowledge of the system as a whole, it considers the relationship between each line and all other lines regardless how far they go, so it's a global measure (Hillier et al., 1983).

- Integration R-3 is used in investigating pedestrian movement, as it has been found out that a pedestrian movement in most predictable pedestrian trips is on average limited to three levels. On the other hand, a typical vehicular trip (vehicular movement) is often limited to ten levels (integration R-10) (Fanek, 1997).

![Figure 3.10](image-url)

**Figure 3.10.** Global and Local integration of Delft, Netherlands: a (left) illustrates Global integration - It is a measurement of the relation of a line towards all other lines in the system, ranked from the most integrated (dark color) to the most segregated (light color) -, while b (right) illustrates Local integration analysis calculated up to three lines away from each line in every direction (source: Bilsen, 2006).
3.6.5. Intelligibility

Intelligibility is a key property of the spatial structure of towns. It's an indicator of the quality of an environment as being easily navigable. Figure 3.11.a. looks like an intelligible when seen from above in two dimension, but it may not be intelligible when one moves about in it, in contrast figure 3.11. b. may be intelligible (Hillier et al., 1983); so the variables affecting intelligibility need to be grasped. The intelligibility 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).

![Image of intelligible and unintelligible patterns](image)

**Figure 3.11.** Example of intelligible and unintelligible patterns.

Intelligibility of space is “a measure of the relationship between the overall urban space and local features” (Szalapaj, 2001: 41). The definition concerns the relation between connectivity of space(local measure) and its global integration, it means how spatial configuration can be read from its parts. In other words, how the observer can be informed about his position within the spatial system as a whole from every location that he potentially occupy “The key to understanding parts and whole is understanding the relation
between the different radii of integration” (Hillier, 1996: 127). The most integrated area will be visited more, thus it will be more familiar, even though integration had no direct effect on familiarity. An intelligible system is one in which well-connected spaces also tend to be well-integrated ones and vice versa. In an intelligible world the correlation between local and global properties of space is perfect, so the whole can be read from the part. Conversely, if the correlation is poor, the product will be unintelligible environment, so the people may lose their way. Later, Hillier (1996) explains this notion using a scattergram that shows the correlation between connectivity and integration. He notes that the degree of intelligibility can be predicted by looking at the form of the scatter. If the points form a straight line rising at 45 degree from bottom left to top right, then this implies a good correlation between local and global integration. Consequently, The system would be highly intelligible (Hillier, 1996). For example, in figure 3.12.a the points form a tighter and linear scatter which indicates a perfect correlation, and therefore a greater intelligibility. On the contrary, figure 3.12.b shows that the scatter is diffused indicating that the correlation is poor. Thus, revealing unintelligible world.

![Figure 3.12.a. Intelligible spatial layout (source: Kim Y O, 1999)](image1)

![Figure 3.12.b. Unintelligible spatial layout (source: Kim Y O, 1999)](image2)
3.6.6. What Is A Synergy Value?
Synergy is simply the correlation between local (radius3) and global integrations. It is a different kind of intelligibility in so much, as it is about the relationship between the local and global structure. Radius 3 is not as local as connectivity, but it is the best correlate, for example, of pedestrian movement rates, and seems to give a good indication of the local pedestrian scale structure of urban areas. Its correlation with the global integration measure is, therefore, perhaps an indication of the relationship between the local economy of neighbourhoods and the whole city economy. Do the routes which connect the whole pass through the same spaces as those which form the heart of the neighbourhood? In the modern city one of the effects of zonal planning and traffic engineering has been to separate the global route structure from the local neighbourhood (in order to speed car traffic), and we would expect this to be shown by a reduction of synergy. We would also expect a reduction of intelligibility, but this would be shown in the scattergram as a small number of the most integrated spaces (the main traffic routes) also being poorly locally connected.

3.6.7. Movement Pattern
It's widely accepted that there is a relation between the spatial configuration and the likelihood of encounters, this relation is called natural movement (Hillier, 1996). Natural movement is “the proportion of movement on each line that is determined by the structure of the urban grid itself rather than by the presence of specific attractors or magnets.” (Hillier, 1996: 120). Even though, integration of an urban plan is purely spatial analysis, it has proved a strong predictor of movement patterns, both pedestrian and vehicular (Hillier, 2004). If the integration values of an area have been measured; and

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3 From a discussion through e-mail between the researcher and both of professor Alan Penn and Dr. Ruth Conroy Dalton.
a street survey of counting the number of people who are passed when an observer walks 100 m/ min. has been carried out, then the usage and pattern of movement can be predicted, as streets from which other streets can be accessed with minimum intervening lines attract more people. Thus, attract retail and other land uses that rely on the volume of pedestrian traffic, and consequently the volumes of both pedestrian and uses are multiplied, as the allocated functions then increase the importance of the location itself and attract other functions, this phenomena is what Hillier has called *Multiplier effect* (Hillier, 1996). This indicates that the pattern of movement is a function of its pattern of integration (Hillier et al., 1983). This principle of predicting movement pattern and usage could be used as an evaluative tool in design and redevelopment of urban areas. Figure 3.13. shows a scattergram between encounters on the horizontal axe against integration on the vertical.

![Figure 3.13. Scattergram between encounters and integration.](image)

3.7. WHAT IS A CONTROL VALUE?
Control is defined as “the degree of choice that each space represent for its immediate neighbours as a space to move to” (Hillier et al., 1983: 237). It is the sum of the reciprocal of the connectivity of its neighbours. It has been determined that each line starts with a control value of 1. Each line will
distribute its initial value of 1 equally to lines with which it intersects. Each line will give and take control values depending on the number of lines that intersect with it, these control values reflect the influence of each line over those intersected with it. Figure 3.14 shows that line 1 intersects with two lines, it will distribute its initial control value equally to line 2 and 6 by giving each a value of 0.5. Similarly, line 3 will give line 2 a value of 0.5 and line 4 will give line 2 a value of 0.333. Consequently, the control value of line 2 equals the sum of 0.5, 0.5 and 0.333, the resulting control value of 1.333 is higher than it had initially. Other lines may get control values less than their initial ones such as line 6 which has control value of 0.833.

![Figure 3.14. Axial lines demonstrating the control value.](image)

### 3.8. AXMAN SOFTWARE

It is a computer aided design program created by Nick Dalton at University College London. By creating an axial map and inserting it into Axman software, all syntax values such as Depth, Connectivity, Integration R=n and Control can be obtained, as Axman applies space syntax methodology using programmed mathematical processes. “Axman constructs a graph of the
configuration of axial lines, interpreting the lines as the graphs nodes and connections between lines as the edge of the graph”⁴. Axman is included in the Macintosh Bundle.

3.9. UCL DEPTHMAP

Depthmap, created by Alasdair Turner at University College London, is an application used in visibility analysis of architectural and urban systems. Axial maps can be entered to the program and analyzed according to Space syntax principles. UCL Depthmap can perform many types of analyses such as the original visibility analysis, generation and analysis of axial maps as well as segment analysis. The program was first written for the Silicon Graphics IRIX operating system as a simple isovist processing program in 1998. It is designed to run on Windows 2000 and XP operating systems⁵.

Figure 3.15. UCL Depthmap interface.

⁵ http://www.spacesyntax.org/software/DepthMap.asp.
3.10. CRITICISM ON SPACE SYNTAX

Although space syntax is widely used and published since few decades, the validity of technique is controversial. The limitations of space syntax can be presented in the following points:

1- Discarding of metric and 3D information: Ratti (2004) argued that space syntax measures the distance between spaces topologically neglecting metric distance and this is hard to be accepted. Hillier (2004) claimed that space syntax is not enough for social behavior interpretation, as it has noting to say about pedestrian choice make, so it need to cooperate with other suitable variables to do so. He argued that there is a conflict between the metric and topological relations, as considering metric distance instead of topological one will always presents the geometric center of the system as most integrated (because it is metrically closer to all other parts of the system) and presents the geometric edges as most segregated, this means that the boundary of the model will be affected by the choice of its position.

Some architects reject the analysis based on space syntax because it is not three dimensional and can not therefore have much to say about visual quality. Consequently, Space syntax ignores the superficial appearance of the environment, including surface colors, textures and patterns. Ratti stated that there are many factors can generate movement such as bus stop and taller building. As space syntax neglect 3D information, then it's hard to differentiate between a pedestrian pavement and an urban highway when counting on axial map.

2- Redundancy and ambiguity of terms used in space syntax: The terms used by Hillier in writing space syntax are complicated and ambiguous. Moreover, some of these terms are similar in the meaning. For instance, both of depth and integration mean the same thing. Thus, this produces redundancy.
3- Lawrence (1990) argued that space syntax technique is inadequate in projecting society's norms. Likewise, Edmund Leach (1978) argued that the generative syntax can not be inferred by just looking to the two dimensional urban pattern of a settlement, and even if we could be sure of what generative syntactic rules have been, nothing could be inferred about the society that makes the use of the resultant settlement. On the contrary, Hillier suggested that social interaction results from the spatial configuration of an urban layout. This claim is impossible to be tested, as our today urban lifestyle is totally different from that existed when Hillier built his thoughts.

4- “The danger of planners using space syntax without understanding of the ideologies behind it which might lead to “other equally important design issues being treated as secondary” (McLeish, 1987:108).

5- Space syntax has nothing to say about many properties of urban layout such as property of shape, and the angular size of the turns. Although axial maps may speculate main and sub roads through lengths of axial lines, it has nothing to say directly about road width. In other words, pattern of axial maps may reveal existence of hierarchy of roads while it is actually not. Hierarchy of roads can not be obscured in wayfinding and orientation issue. This point will be discussed in more detail in the empirical part.

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7 ipid.
3.11. CONCLUSION

In this chapter, we have briefly introduced the basic elements of space syntax. For instance, illustrating the concept of spatial configuration, defining the tools of spaces syntax analysis (convex space and axial line), explaining the notion of depth and integration and how to measure them. We have also mentioned the difference between global and local integration and how the correlation between them can be used as an evaluative tool of good urban areas properties in the light of intelligibility principle. After that, we identified another important term used in space syntax, it is the control value of a line, illustrating its meaning and how can it be calculated manually.

In the last part of this section, the relationship between integration and pattern of movement have been discussed, illustrating how can spatial pattern predicts usage. A scattergram is presented to make better understanding of the correlation between space syntax and spatial behavior.

There are other specialized terms used in space syntax such as centrality and choice have not been mentioned in this research study, as they have little significance for it.

Finally, we have discussed the criticism against space syntax especially the abandon of metric and 3D information, the argument between Hillier and C. Ratti has been discussed in order to support or refute metric and 3D information.