The Space Syntax Methodology: Fits and Misfits

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Abstract

The corner stone of the space syntax methodology is a simple mathematical/graph theory procedure intended to analyze nodal diagrams of plans to arrive at cultural norms behind the morphology of buildings. Beside giving credit to the technique, this paper discusses, with examples, its major shortcomings: the Western cultural element in the calculation of the shortest path; the limitation of the inherent binary coding; and the inability of the method to stand by itself, hence the necessity to complement its findings with socio-cultural research.

Résumé

La méthode de la syntaxe spatiale consiste en une simple procédure mathématico-graphique dans laquelle des diagrammes nodaux de plans sont examinés pour cerner les normes culturelles qui soustendent la morphologie des bâtiments. L'article formule une appréciation de cette technique, y compris de ses limites: l'influence de la culture occidentale sur les calculs; les restrictions posées par son codage binaire; et le fait que la méthode ne peut être utilisée seule puisque ses résultats doivent être complétés par une recherche de type socio-culturel.

1. Introduction

The space syntax (Hillier and Hanson 1984 & 1987) is a theory and method for investigating society-space relation. The main theoretical argument is founded on the authors' assertion that building forms are embodied in social norms of societies. Thus, according to its authors, analyzing and interpreting spatial qualities of artifacts would reveal the social rules that regulate the interface among people. The analytical procedure is based on graphic representation, nodes and links, of traditional architectural floor plans and the qualification of graph properties using mathematical formulae. Although the analytical procedure of the method is simple, objective, and replicable, the interpretation process of the numerical results remains complex, subjective, and so controversial. In other words, the method does not seem to yield much of the full scope of interpretation outlined by the pioneers, that is the unraveling of social norms behind the morphology of buildings. On the contrary, wrong interpretations, sometimes departing far from reality, might arise, as this paper will demonstrate. Moreover, applying space syntax, while overlooking social and psychological aspects of people, lead researchers to speculate and generalize about social rules that produce shared design features.

The space syntax offers a significant contribution to the advancement of research in the field of environmental design. Most important, it is the first research method in the field that allows researchers to rely on objective concepts instead of on those offered by the social sciences. Yet, in this paper we argue that regardless of the advantages gained by applying space syntax, there are limitations to the method which question its findings and interpretations. For instance, the way the shortest path between any two internal nodes — which is essential for the derivation of the main syntactic integration parameters — is calculated, makes the method inappropriate for the analysis of non-western houses. Also, the use of binary coding, one for the direct connection between a pair of spaces and zero for the absence of direct connectivity, leaves out various types of spatial, visual, auditory, and olfactory connectivity which in reality can exist between two spaces. These limitations among others are the subject of discussion in this paper. Furthermore, the paper proposes alternative ways to rectify the shortcomings of the method and supplement its procedures.

2. The Space Syntax

In "The Social Logic of Space," Bill Hillier and Julienne Hanson (1984) argue for the considerable influence of socio-cultural norms on the spatial organization of buildings. The authors (see also 1987) present an analytical method, "space syntax", for reading, quantifying, describing, and comparing morphological patterns of buildings for the purpose of projecting the social norms of their inhabitants. The basic analytical procedure of the space syntax method is composed of the following two steps.

First, traditional scaled architectural floor plans are transformed to a dimension-less form of permeability diagrams or graph representation. Every habitable space in a plan is to be subdivided into the largest and fewest convex spaces. The resulting convex spaces, known as the convex map, which may or may not correspond to the way in which the building is actually conceptualized, are represented by nodes and the connection between them by lines. Nodes are then aligned above a "root" node — that usually represents the outside space of a building — in levels, according to the number of spaces to be crossed to reach each convex space from the outside, or the reverse.

Second, from the permeability diagram, the basic syntactic parameters — integration, connectivity, and control — are quantified. Values for all space syntax measurements are calculated manually for simple graphs or generated by a computer program for complex ones. Input to the computer is given as a matrix of connections based on permeability diagrams. The key syntactic properties measured following this procedure are the depth, shortest path, and the degree of ringiness. The shortest path between a pair of nodes in a graph is defined as the minimum number of steps taken to reach one node from the other, while the degree of ringiness or distributedness is a measure of the existence of alternative routes between any pair of nodes. These two properties are combined to develop a quantitative mathematical measurement known as the integration or relative asymmetry value (RA). RA values are then adjusted between theoretical and empirical limits to allow direct comparisons across patterns regardless of their size. The adjusted integration measurement is known as the Real Relative Asymmetry (RRA). Integration values range from 0 to 1. Low values indicate integration and high values indicate segregation (for the definitions and mathematical formulae of these syntactic measurements, consult Appendix I).

3. The Advantages of the Space Syntax

There are numerous benefits to be gained from the abstraction of architectural floor plans into graphs of nodes and connections as suggested by the method. Among them, the procedure offers easy, and well defined steps for the analysis, description, and hence the comparison of buildings — though in a two dimensional form — and their spatial qualities. Using space syntax procedure, it is easy to analyze floor plans of buildings to reveal their underlying morphological structure. Subsequently, prominent physical qualities that may dictate the use of buildings in certain ways might be deduced. Furthermore, the method provides an opportunity "to switch problems from one naturally-occurring mode to another where solutions may be more easily obtained," write Haggett and Chorley (1969: 7). By transforming building plans into graphs, environmental design researchers are able to utilize the powerful resources of graph theory and matrix algebra to tackle various problems with great flexibility. Last, but not least, it is a credit to the pioneers that space syntax has opened the door to promising modification and development effort that will enhance and thus strengthen the method's analytical and interpretation procedures; this paper aims to contribute in this effort.

4. The Limitations of the Space Syntax

Presently, more than a decade since space syntax was first published,[1] and after being widely used in the analysis of various types of building patterns, the validity of the

[1] The most inclusive publication that presents the full theoretical argument as well as the analytical procedure of the space syntax is the "Social Logic of Space," by Hillier and Hanson, published in 1984. Before that, Bill Hillier and his

technique still remains controversial, not having yet been fully investigated by architectural researchers. The most noted review,[2] by an architect, is the criticism of Lawrence (1990) which briefly outlines the inadequacy of the technique, as it exists, in projecting society's norms. Similar remarks were made by some social science researchers. Edmund Leach (1978: 397), for example, argues:

"From my point of view the syntactic argument is meaningful and interesting, but I do not believe that one can immediately infer the generative syntax simply by looking at the lay-out of settlement patterns on the ground, and even if one could be sure of what the generative syntactic rules have been, one cannot infer anything at all about the society that makes use of the resultant settlement."

The authors here, in agreement with both Lawrence and Leach, believe that "without knowing the facts," a two-dimensional floor plan is an insufficient source for inferring social dimensions of societies. This paper goes a further step beyond the criticism of other researchers in pointing out some problems associated with the technique and with the mechanics of its application, and in proposing some remedies.

4.1. The cross-cultural invalidity of the method

The theory of the space syntax defines a building, abstractly, as

"a certain ordering of categories, to which is added a certain system of controls, the two conjointly constructing an interface between the inhabitants of the social knowledge embedded in the categories and the visitors whose relations with them are controlled by the building," (Hillier and Hanson, 1984: 147).

Based on the above argument, the configuration of any building is conceptualized by the theory of the space syntax as the relationship among the inner spaces of that building and its immediate external vicinity — the outside space. Consequently, an outside space, the root to any building, is an integral part of its spatial pattern; at the same time the relationship between any space inside a building with the root is a vital factor in the syntactic analysis, particularly the computation of the shortest path.

In many of the examples published by the pioneers of space syntax (Hillier and Hanson, 1984 & 1987) the outside node of a building is its front yard. As shown in Figure 1, this node is not only one of the constituents of a building configuration, but also one of its spaces, the front yard. Therefore, it is possible to connect any pair of spaces, for instance space (c) and space (d) in Figure 1, inside a building through the outside node, space (1). This type of relationship between an outside node of a house

partners presented their epistemology in articles in a variety of periodicals. For instance, Hillier and Leman (1973); Hillier and Leman (1974); Hillier, Leman, Stansall, and Bedford (1976); Hanson and Hillier (1982).

2 Walker (1986) reviewed the "Social Logic of Space" and presented his views in an article that emphasizes some similarities between the theoretical concept of the space syntax and other environment-behavior theories.

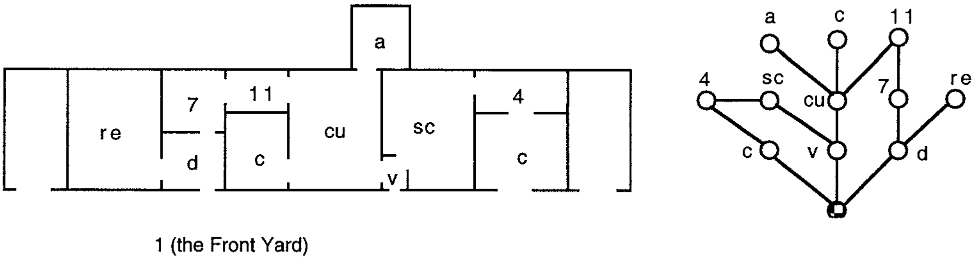

Fig. 1. A Floor Plan of a Western European House (French) and its Permeability Graph; from Hillier and Hanson (1987, 370)

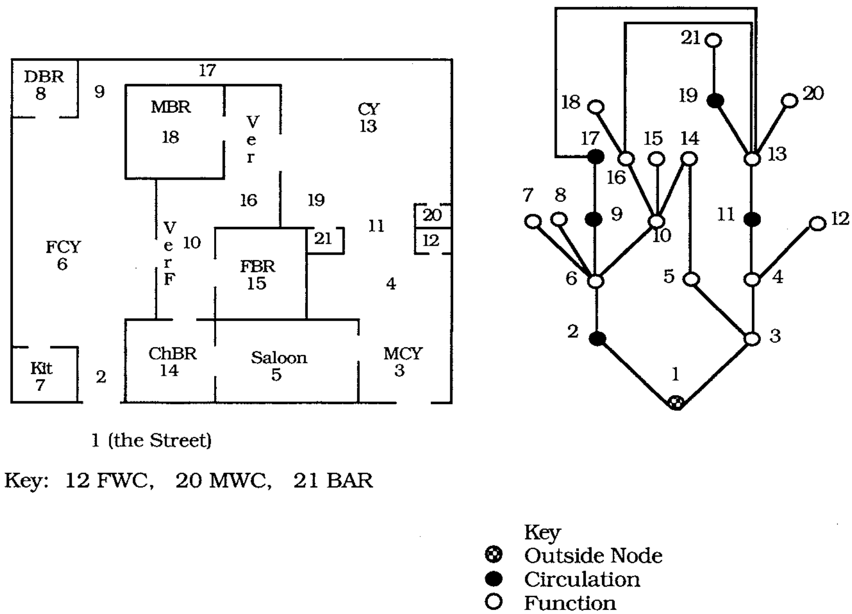

Fig. 2. A Floor Plan of a Non-western House (Sudanese) and its Permeability Graphs

Note: For space abbreviations, see Appendix II.

walls that conceal the built form and courtyards of a house from the public domain. Connectivity to the street is through gates positioned in the boundary walls, see Figure 2. In such a situation, an outside node is a part of the spatial pattern but not and its inner spaces is observed mainly in Western contexts. In other cultures, particularly Islamic and Middle-Eastern, where the open spaces, the courtyards, are part of the functional areas of a house, an outside node of a building is always the street or the public domain.[3] In these cultures, houses are surrounded by boundary the

3 The relationship between the private space of a building, particularly housing, and the public domain differs with the variation of culture (Rapoport, 1969 & 1977). In western cultures, single family houses--which provide suitable ground for

building itself. Thus, it is inconceivable to consider a shortest path that connects two spaces, say space (3) and space (6) in Figure 2, within the boundary of a building through the street, space (1). This cultural variation in the conceptualization of the outside node, hence the computation of the shortest path between any two nodes in a setting, clearly shows the misfit of the space syntax concepts, as they exist, for the analysis of non-Western buildings. To overcome such a misfit, a recursive[4] computer program which is capable of performing the shortest path analysis, and hence the other syntactic measurements as suggested both by the space syntax pioneers and by this paper, is developed by the authors. In the added capacity of the program, the shortest path between any two internal nodes in a network is computed with the exclusion of any route that passes through the outside node. This feature, essential for the analysis of the connected graphs of non-Western houses as explained before, is not available in preexisting software packages which are specially designed to handle space syntax procedures.

To illustrate the difference between the analytical approach of the space syntax (for Western houses) and the modified computer program (for non-Western houses) suggested in this paper, the example of a Sudanese house[5] presented in Figure 2 is analyzed using both techniques. The data[6] generated by applying the two programs is given in Table 1 and Table 2. From Table 1, it is clear that the medium depth (md) and integration (RA) values obtained by the two programs are different for some of the nodes. For these nodes, the modified algorithm gives higher medium-depth values and hence higher integration values than those of the Space Syntax. In other words, the Space Syntax program reflects shallower and more integrated spaces relative to those indicated by the modified program.

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comparison with compound houses of some Islamic societies--are normally surrounded by a front and/or back yard, a semi-private transitional zone, that demarcates the boundary of a plot and relates the building to the neighboring private plots and to the public domain, the street (Goffman, 1959; Cherayeff & Alexander, 1963). In non-western cultures, in particular Islamic and middle-eastern, the built form of a house may be composed of several units that are connected to each other by courtyard(s). Unlike in the west--where only a few domestic tasks take place beyond the roofed space--courtyards, in these cultures, are part of the living quarters of the house and many domestic activities can be performed in the open air (Rapoport, 1969). Thus, an outside node of this type of setting is not the front yard of the building, but the street or public domain.

4 A computer program that has at least one procedure which calls itself many times in the execution phase.

5 The Sudanese house example is extracted from a large sample collected by the author, K. M. Osman, in a field research in 1991; for the results of this survey, see Osman (1993).

6 Since the two techniques result in two different sets of mean depth values, then only the syntactic parameters dependent on the shortest path values, particularly the RA and the RRA, are subject to change by the modified program. The RA parameter is chosen here over the RRA for presentation and discussion because it can compare spaces within, and not across, systems.

Table 1
Space Syntax and the Modified Program Integration (RA) Values of a Sudanese House (Fig. 2)

Node fl	Depth fl	Space Syntax Values		Modified Program Values	
		md	RA	md	RA
1	0	3.300	0.242	3.300	0.242
2*	1	3.100	0.221	3.650	0.279
3*	1	3.100	0.221	3.450	0.258
4*	2	3.100	0.221	3.400	0.253
5*	2	3.350	0.247	3.400	0.253
6*	2	2.650	0.174	2.800	0.189
7*	3	3.600	0.274	3.750	0.289
8*	3	3.600	0.274	3.750	0.289
9*	3	2.900	0.200	2.950	0.205
10	3	2.450	0.153	2.450	0.153
11*	3	2.900	0.200	2.950	0.205
12*	3	4.050	0.321	4.350	0.353
13	4	2.500	0.158	2.500	0.158
14	3	2.950	0.205	2.950	0.205
15	4	3.400	0.253	3.400	0.253
16	4	2.500	0.158	2.500	0.158
17	4	2.900	0.200	2.900	0.200
18	5	3.450	0.258	3.450	0.258
19	5	3.350	0.247	3.350	0.247
20	5	3.450	0.258	3.450	0.258
21	6	4.300	0.347	4.300	0.347

Note: The * indicates a variation between the results of the two programs in the corresponding row.

Table 2
Order of Spaces by Ascending (Lowest--Highest) Integration (RA) Values

(i) Space Syntax Values

Node #	10	6	14	3	5	15	18	20	7	12	21
Space	VerF	FCY	ChBR	MCY	Saloon	FBR	MBR	FWC	Kit	MWC	BAR
RA Value	0.153 <	0.174 <	0.205 <	0.222 <	0.247 <	0.253 <	0.258 =	0.258 <	0.274 <	0.321 <	0.347

(ii) Modified Program Values

Node #	10	6	14	5	15	3	20	18	7	21	12
Space	VerF	FCY	ChBR	Saloon	FBR	MCY	FWC	MBR	Kit	BAR	MWC
RA Value	0.153 <	0.189 <	0.205 <	0.253 =	0.253 <	0.258 =	0.258 =	0.258 <	0.289 <	0.347 <	0.353

Note: For space abbreviations consult Appendix II.

The data obtained also detect a shift in the syntactic quality of some spaces as shown by the results of the two techniques. For instance, according to the Space Syntax results, the male courtyard (MCY) is more integrating than the saloon and the female bedroom (FBR). The opposite is true in the data obtained by the modified program: the saloon and the female bedroom are more integrated in the setting than the male courtyard. Also, whereas the most segregated space by the Space Syntax values is the bathroom (BAR), it is the male toilet (MWC) according to the modified program. In reality, based on a personal observation of that particular house, the male toilet is isolated from other spaces because of the limitation of its use, while the bathroom is positioned in such a way to serve both male and female domains.[7] Generally, the interpretation of the results of the modified program for Sudanese houses — the example presented here being one of many — corresponds with the observed conclusions, while that of the original program departs, in extreme cases, away from reality. As a special case, it is fair to note that the two methods yield the same results for single-gate houses, western or not, since the outside node has no influence whatsoever in the calculation of the shortest path between nodes inside.

4.2. The inherent binary coding

One of the problems associated with the application of the space syntax and graph theory in general stems from the fact that these methods use a binary coding, of zero and one, to express the link between a pair of spaces for the purpose of drawing graphs and generating the quantitative measurements associated with the method. Such an approach equates all types of connectivity which may exist between adjacent spaces; also those between non-adjacent spaces — spaces linked to each other through a third common space. Specifically, the space syntax method perceives connectivity through doors as equivalent to connectivity through archways, and equates short corridors that link two non-adjacent spaces with lengthy ones in a similar position. For instance, in Figure 3, it is clear by observation that the corresponding nodal diagrams of plans (a-c) are alike; hence, as shown in Table 3, all the syntactic properties of these plans are the same. Similarly, Figure 4 (a-c) and Table 4 show identical graphs and similar sets of RA values for all three plans, respectively, regardless of the variation of the size and shape of space (4) in all of them. In reality, the spatial and visual continuity between two adjacent and non-adjacent spaces depends on two variables: i) the type of plane — continuous, discontinuous, freestanding, portable, etc. — and ii) the nature of the space — a long or short corridor, dominant, equivalent, etc. — that connects or separates between two spaces (Chang, 1979).

The application of the space syntax method is particularly difficult in modern open floor plans where the boundaries between spaces are set by function and furniture rather than by physical barriers, and in compound-type dwellings where courtyards are constituent parts of the living space. In such situations, before drawing the graphs associated with each floor plan, a researcher has to weigh hard and subjective options in order to divide an open roofed or unroofed space into its constituent convex spaces, as shown in Figure 5, prior to drawing permeability graphs and quantifying the syntactic parameters. The connectivity between such artificially broken spaces, which are actually one unit, is regarded by the method as equivalent to the connectivity between spaces which are physically separated. For example, in Figure 5 the connectivity between space (18) and space (20), both in fact represent one unit,

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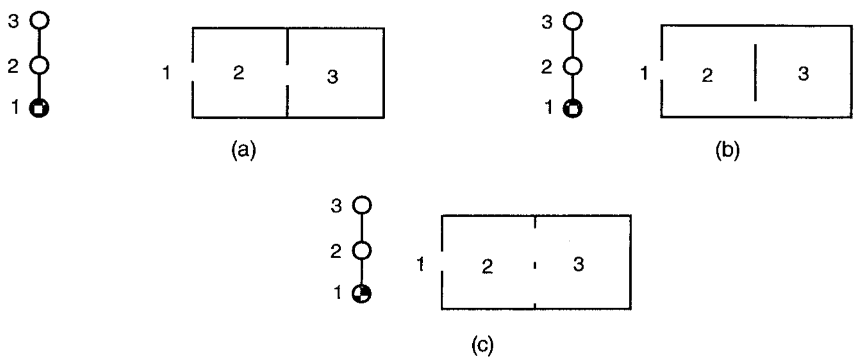
7 As described by Karrar (1981) and Lee (1977), the traditional Sudanese house is generally divided into two domains. The front, the least sacred part, is exclusively for men. The back and the most secluded part of the house is for women.

is assumed equivalent to the connectivity between space (18) and space (19) which are separated by a physical barrier.



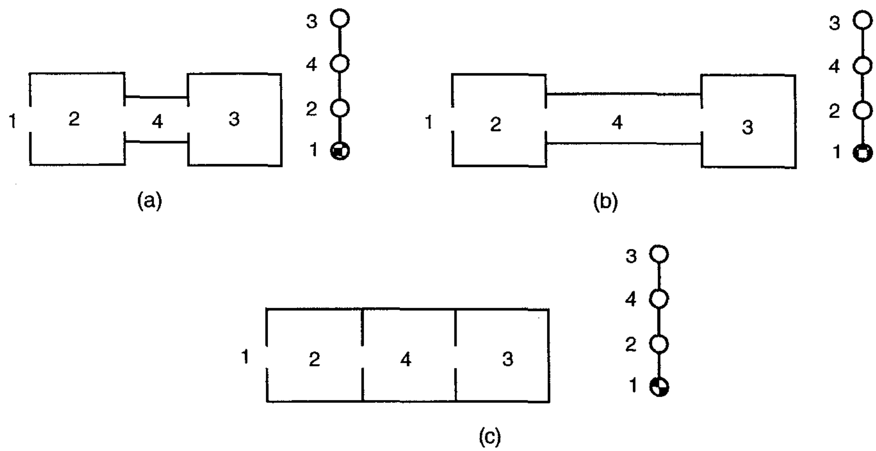
a) a Door in a Continuous Plane;
b) Two Openings in a Free Standing Plane;
c) a Discontinuous Plane

Fig.3. Three Examples Illustrating Some of the Types of Connectivity that may Exist Between Two Adjacent Spaces.

Table 3
Integration (RA) Values for Plans (a-c) of Figure 3

Plan #	Space	Depth	RA
a	1	0	1
	2	1	0
	3	2	1
b	1	0	1
	2	1	0
	3	2	1
c	1	0	1
	2	1	0
	3	2	1

Thus, these analytical procedures result in misleading interpretations since they do not induce values that reflect the actual building fabric. Consequently, coming up with adjusted connectivity values generated by a fuzzy, rather than a binary, coding system that would consider all type of connections existing between a pair of spaces, and the development of a computer program that performs all the corresponding syntactic functions — on a fuzzy logic base — is of significant importance for the upgrading and the development of the space syntax method and hence for future research in the field.



a) Short Corridor; b) Long Corridor; c) a Third Functional Space

Fig. 4. Three Examples Illustrating Some of the Types of Connectivity that may Exist Between Two Non-Adjacent Spaces.

Table 4
Integration (RA) Values for Plans (a-c) of Figure 4

Plan #	Space	Depth	RA
a	1	0	1.000
	2	1	0.333
	3	3	1.000
	4	2	0.333
b	1	0	1.000
	2	1	0.333
	3	3	1.000
	4	2	0.333
c	1	0	1.000
	2	1	0.333
	3	3	1.000
	4	2	0.333

4.3. The intotality of the cultural interpretation of the measurements

The approach of the morphological interpretation of buildings provides a systematic method of analysis. Using the space syntax, diverse types of buildings may be described and compared by projecting their underlying configuration and interpreting their syntactic properties, i.e. property of depth, integration, control, and connectivity. However, as Lawrence (1990: 75) writes "the mere act of transforming the two dimensional representation of a building from a traditional scale drawing to a graph does not yield any information about psychological, social, cultural, or temporal issues."

Furthermore, the meaning and use of space as well as the interaction among the users are not solely dependant on the building form (Rapoport, 1969 and Lawrence, 1990).

Thus, to pursue the study of cultural context of buildings by the mere analysis of its configuration, is quite unreasonable.

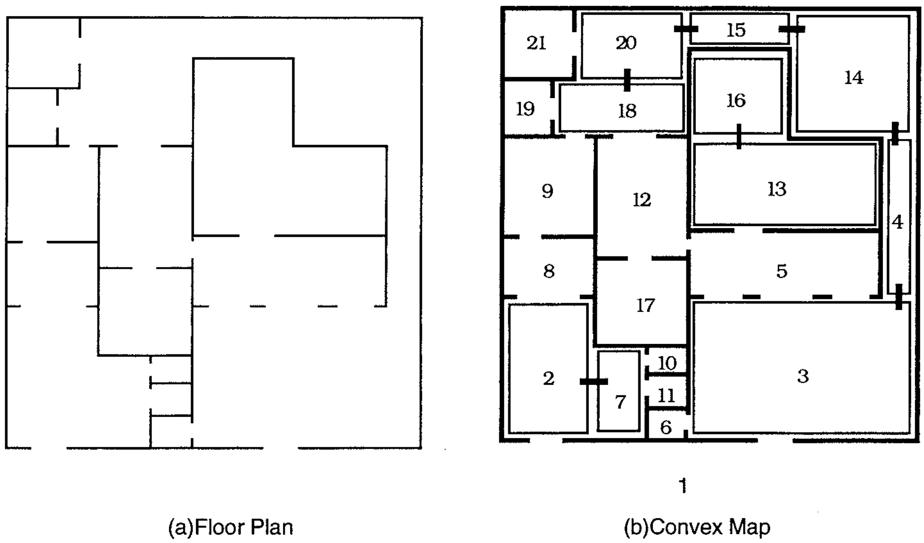


Fig. 5. An Example of a Compound Type Dwelling.

The space syntax method intends to deduce formal physical properties of buildings that inhibit or encourage personal contacts among the user — individuals or social groups — as dictated by their culture. According to the syntactic interpretations of the method, low integration values mean segregation and privacy, while high integration means high connectivity and less privacy. To rely totally on such analysis and to accept their interpretations, means to agree that the degree of physical segmentation and division of space in buildings is an indication of the social and cultural norms that govern the relationships among the user. This may be true to a certain extent, but, as explained below, a growing number of studies has shown that the degree of segmentation and division of building space is not indicative of the degree of the interface among the inhabitants.[8]

For illustration, some cultural groups — the Berber of north Africa (Bourdieu, 1973, 1977), the Bari of the Amazon forest (Jaulin, 1971), the Betsilo of Madagascar (Kus & Raharijaona, 1990) among others — inhabit dwellings which have no internal physical division, i.e. the whole living space is one open unit. If we apply the space syntax method, the graphical representation of such homes, as shown by Figures 6-7, are all composed of two nodes — one is the outside node and the other represents the internal built form. Following the space syntax interpretations, it is easy to conclude

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8 Gans (1968) in his famous book "People and Plans," drew the attention to the difference between the induced, "potential," use of the built environment implied by the design and the actual, "effective," use dictated by the norms of inhabitants.

that the cultural norms that govern the interaction among the members of each of these three groups are similar since the houses of the three groups have the same morphology. However, the ethnographic analysis of Bourdieu (1973 and 1977), Jaulin (1971), and Kus and Raharijaona (1990) reveal that each of these cultural groups has a distinct set of rules which is used to divide the internal space and regulate the relationship among its members. As a result, to avoid such misleading interpretations, the space syntax approach must be supplemented by the analysis of all the variables — social, cultural, and others — implicated in the production of the built environment.

In a study of Sudanese houses (Osman 1993), the modified procedure of the spaces syntax, mentioned earlier, coupled with socio-demographic analysis,[9] proved to be indispensable for eliciting cultural variables behind spatial settings. The results obtained by the application of one method of analysis complement and hence solidify those obtained by the other. For instance, the ethnographic study reveals the gender division in the conduct of activities and the use of space, whereas the spatial analysis highlight the morphological pattern of segregation in the Sudanese house. In other words, the two methods, in combination, indicate that the traditional Sudanese house not only is divided into male/female quarters, but also that these quarters are spatially segregated. Such comprehensive findings cannot be reached if only one of these two methods, the modified space syntax and the ethnographic research, is employed.

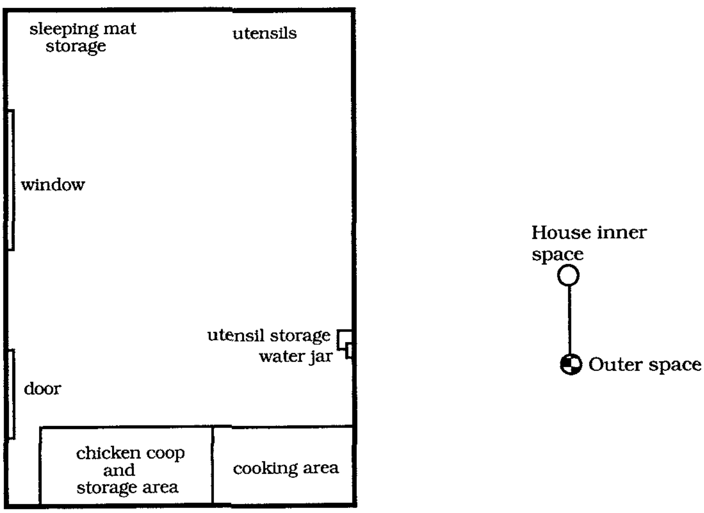

Fig. 6. A Floor Plan of a One Room Betsileo House and its Respective Permeability Graph; from Kus (1990, 25)

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9 This approach is based on a concurrent investigation of both spatial and aspatial features of housing (Osman, 1993). It is in line with the arguments presented by Foley (1964), Barker (1968), and Rapoport (1980; 1989 & 1990).

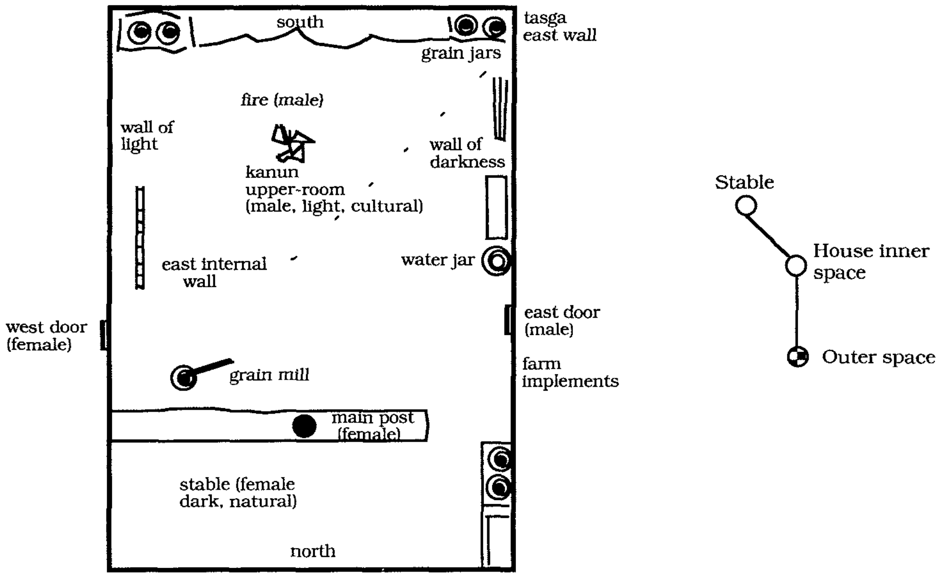

Fig. 7. A Floor Plan of a Kabylie Berber House and its Permeability Graph; from Oliver (1971, 162)

5. Conclusion

Around a decade since space syntax was first published, it still remains a controversial technique. Many of its critics, few of them architects, have questioned the validity of the method in interpreting the social norms of inhabitants. They claim that the existing analytical procedure falls short of fulfilling the complex goals set by the pioneers.

This paper goes an extra step beyond the published criticism to outline the fits and misfits of the technique and to propose some solutions. It argues, with illustrations, that regardless of the advantages of the space syntax, there are limitations to the method which hamper its findings and, subsequently, their interpretation. First, the possibility of including the outside node in the shortest path calculation for any internal pair of nodes does not fit non-Western houses where the outside node represents the public domain. Hence, a modified approach for the calculation of the shortest path is proposed. Second, the analytical procedure, as it exists, does not generate data that describe built-forms as seen in reality because of the limitation of the binary coding. To project reality, weighted or fuzzy connectivity, instead of binary, has to be considered. Third, the space syntax methodology alone is incapable of eliciting the cultural norms of societies governing the use of building. It should be supplemented by social science methods; they are much more equipped for such a purpose.

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Appendices

Appendix I

Space Syntax Selected Mathematical Formulae

Mean depth (md) = $1/(K-1) \cdot \sum$ (all depth values between a point & all other points in a graph) (1)

The depth value between two points in a graph is equal to the minimum number of connections that must be taken to reach from one point to the other (the shortest path).

K is the total number of nodes in a graph, including the outside node.

Relative Asymmetry (RA) = $2(md - 1)/(K - 2)$ (2)

Real Relative Asymmetry (RRA) = RA/ X (3)

where $X = \{ 6.644K \cdot \log_{10}(K+2) - 5.17K + 2 \} / (K^2 - 3K + 2)$

Control Value = $\sum_{D(a,b)=1} 1/Val(b)$ (4)

where D(a,b) represents the connectivity (shortest path) between points (a & b), and Val(b) is the number of direct connections for point (b). So the control value for any point (a) is calculated by summing the reciprocal of the number of connections for each point directly connected to (a).

Note: For further elaboration on these measurements and others, consult Hillier (1984 & 1987) and Peponis (1985).

Appendix II

Space Abbreviations

Abbreviation	Meaning
BAR	Bathroom
ChBR	Children Bedroom
CY	Courtyard
DBR	Dependant Bedroom
FBR	Female Bedroom
FCY	Female Courtyard
FWC	Female Toilet
Kit	Kitchen
MBR	Master Bedroom
MCY	Male Courtyard
MWC	Male Toilet
Ver	Veranda
VerF	Female Veranda