

Spatial Digraph at the Room-level of 'Sequina' Slum Area in Alexandria, Egypt

[Ali Essam El Shazly]

Abstract— Geometrical digraph with cross-tabulation extends the social logic of space syntax in the pilot 'Sequina' slum area of Alexandria. The measure of universal distance at the micro level of room survey clarifies the social interface of the discrete spatial system. The essence of irreflexive network facilitates the 'visitor' penetration into the 'inhabitant' rooms. However, the backward direction inverts the relationship with the 'inhabitant' having more choice of interface in shortcuts than the traversable 'visitor' of then a deeper structure. The correlative networks condense at the second-rank to form concentric waves of social domains from the inmost 'visitor' exposure to the outmost 'inhabitant' privacy, with the double-face ring of in-between 'living & kitchen' of semi-domain. Further covariance of cross-tabulation defines negative relationship of 'inhabitant' zones, but changes to positive towards the central 'visitor'. In this regard, the 'bedrooms' are set apart with alternative covariance of either 'living' or 'kitchen', which segregates into zones of 'inhabitant' sub-domains or integrates into an absolute 'inhabitant' when the 'visitor' is absent. Thus, the social logic of digraph compensates the accessible rings of space syntax with interactive spatial networks that changes direction according to the instant situation of social domains.

Keywords—Alexandria, Sequina slum, digraph

I. Introduction

The urban sprawl of slum areas in developing countries represents a universal challenge of massive redevelopment. Despite the disgraceful image, the slum issue demonstrates social aspects of architecture. The slum phenomenon is largely found in Egypt against the building codes and without basic infrastructures [13 & 14]. In particular, the steady migration from rural to urban cities characterizes the Egyptian slums. Job finding clusters fellow migrants in urban slums through social communications. In this respect, each slum area requires a social study to clarify the spatial structure of migrants who are classified by rural zones [6 & 7]. Among the populous slums which have been selected for a detailed building survey is 'Sequina' area in Alexandria, of majority laborer migrants from the nearby 'Behera' rural province. Since the area lacks any census or building documentation, household survey has been conducted on a cluster of building blocks in prior to the stratification of twenty-sample buildings of migration for a detailed survey on the room level "Figs.1-7". The micro-level survey of 'Sequina' slum area in Alexandria with extended scope of analysis blends with the previous studies on slums in Egypt [e.g. 15, 11, 1 & 2].

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The study of social slums addresses the space syntax methodology of spatial structure [4]. The building rooms are represented as justified graphs to perform analytical measurements of space. Meanwhile, the spatial visibility issue adds another dimension of housing decodes [8]. However, the method's topological limitation of not-to-scale abstraction or determinant shape is prospected in this research through the geometrical 'Graph Theory' approach with statistical exploration [e.g. 5, 9 & 12]. Specifically, the digraph of survey rooms measures the universal distance (distances from all spaces to all others) of dynamic circulation in each survey building with their aggregation for the prototype retrieval of shaping layouts. In this regard, the study experiments the space syntax methodology with to-scale digraph measurement, while defines the social dimension for the long-term comprehensive plan strategy of redeveloping slum areas in Alexandria that lacks the social dimension [3].

II. Digraph Analysis

The flow of digraph distances in layouts from one space to the others represents the strength of functional relationships [10 & 12]. Unlike the graph adjacency or incidence, depth is not measured according to yes/no permeability, but the nearer the permeable space the shallower is its rank. Suppose two spaces are permeable to each other, their depth may not be symmetric with respect to an off-centered third permeable space. Based on the distance measurement, each space aligns the room set of digraph depths in an ascending order. The spatial rank of any depth, nevertheless, may be shared if it is equidistant from the starting position. Basically, the argument reviews the space syntax analytical conception, which states: "*....these are the notion of distance; and the notion of location. It is crucial to our approach that neither of these concepts – in spite of their manifest usefulness for the purposes for which they have been applied – appears in the*



Figure 1. Location of Sequina



Figure 2. Sample Buildings

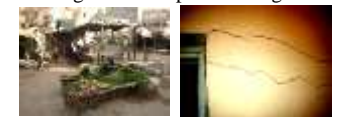


Figure 3. Market

Figure 4. Crack

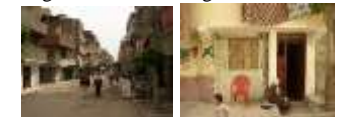


Figure 5. Street

Figure 6. Access



Figure 7. Typical Floor Plans of Survey Buildings in 2015

foundations of 'space syntax'. This is initially distance free, and for the concept of location is substituted the concept of morphology, by which we imply a concern with a whole set of simultaneously existing relations." [4, p. xii] The comparable measurement between the relative spatial depth in the concept of space syntax and the ranked digraph distances raises the research issue. The digraph results format a matrix of survey rooms to list the ordered ranks of measured distances, which is illustrated for the sample 'no. 5' of flow from the 'staircase' position "Table I & Fig. 8". The global interface of rank-1 identifies the matching of room pairs. Although the central space of the 'reception' dominates the rank-1, the backward is not always reflexive. Some spaces such as the 'utilities & bedrooms' have less ranks to the center, which affords an alternative matching options. In this respect, the digraph structure assumes a unique interface of 'visitor-inhabitant' spaces in order to centralize the direction of outflow, while in the meantime decentralizes the way back. The inverse also holds true, where the digraph of the relatively deep rooms from the central space such as the 'reception → toilet' are more shallow in the opposite direction.

The reflexive relation, however, is more maintained within the 'visitor' domain, such as the 'staircase, reception & living' spaces, which have equal interrelationship from the 'reception' space. Nevertheless, the 'reception' space of dominant rank-1 towards and from the 'staircase & living' spaces changes to a

different relationship of the 'staircase ↔ living' spaces, which indicates an intransitive functional relationship. The detailed ranks per room compare their spatial structure at the collective level of the discrete spatial system and the individual layouts as well. The total ranks of '177-points' for the 'reception' space, which increases deeply to '309~390 points' of the other rooms with narrow variance. Since the less the ranking points the more is the global integration of a space, the central space has as twice integration as the other spaces. Among the spatial interface of rank-1 with total 120-frequency, the 'reception' has '80' of them, compared to '42' of the 'living & Kitchen', '28' of the 'stair & bedroom-I', and '22' of the 'toilet & bedroom-II'. These frequencies optimize the 'visitor' domain in equidistant distribution of spatial layout, compared to a half distributive reduction of the 'living & kitchen' rooms, while diminishes in the 'bedrooms & toilet' of more privacy depth. However, the second rank of lengths observes the most stable interface with a range of '23~29 frequency' across the rooms. From the third to sixth ranks of distant encounters, the dense frequencies concern the 'bedrooms & utilities'. Overview of the aggregated social logic structures the central 'visitor' with short links to the 'inhabitant' rooms (which is not happening due to the social norms), but the 'inhabitant' has more choices of shorter distances to overpass a 'visitor' engaged with another 'inhabitant' in house. Both domains, however, balance at the second-rank digraph, with further 'inhabitant' privacy.

TABLE I. Diagraph Matrix of Survey Rooms

Survey Rooms	Stair	Reception	Living	Dining	Kitchen	Toilet	Bedroom-I	Bedroom-II	Bedroom-III
S01		1	3		4	2	6	5	
S02		1	2	1	4	5	2	3	
S03		1	2		4	5	3	6	
S04		1	2		5	6	3	2	4
S05		1	3		2	6	4	5	
S06		1	2		4	5	6	3	
S07		1	3		4	2	2		
S08		1	2		3	5	4	6	
S09		1	2		5	4	3	6	
S10		1	2		1	3	2	4	
S11		1	1	1	3	2	4		
S12		1	1		2	3	4		
S13		1	2		5	6	3	4	
S14		1	2		5	4	3		
S15		1	3		7	4	2	5	6
S16		2	1		1	3	4	5	
S17		1	1		2	4	2	3	
S18		1	2		5	6	3	4	
S19		1	2		1	4	2	3	
S20		1	2		4	6	3	5	
R01	1		1		2	1	4	3	
R02	1		1	1	1	2	1	1	
R03	1		1		1	2	1	1	
R04	1		1		2	3	4	1	1
R05	1		1		1	2	1	1	
R06	1		1		2	3	4	1	
R07	1		1		1	1	1		
R08	1		1		1	2	1	1	
R09	1		1		3	2	1	1	
R10	1		1		1	2	1	3	
R11	1		2	1	4	3	5		
R12	1		1		2	3	4		
R13	1		1		1	2	1	1	
R14	1		1		3	2	1		
R15	1		1		5	2	1	3	4
R16	2		1		1	4	3	5	
R17	1		1		1	2	1	1	
R18	1		1		2	3	1	1	
R19	1		1		1	1	1	1	
R20	1		1		1	2	1	1	
L01	2	1			4	3	1	5	
L02	3	2		2	4	6	1	5	
L03	2	1			3	5	2	4	
L04	2	1			4	5	1	1	3
L05	4	1			5	6	2	3	
L06	3	1			4	5	1	2	
L07	3	1			2	4	3		
L08	3	1			3	4	2	5	
L09	3	1			5	4	2	6	
L10	2	1			1	4	1	5	
L11	1	4		5	2	1	3		
L12	1	1			2	3	4		
L13	2	1			5	6	3	4	
L14	2	1			5	4	3		
L15	4	1			6	2	3	1	5
L16	1	1			1	1	1	1	
L17	1	1			1	2	1	1	
L18	2	1			4	5	2	3	
L19	2	1			1	3	1	4	
L20	2	1			3	5	2	4	
D02	1		1	1	1	2	1	1	
D11	1	1	2		4	3	5		
K01	3	1	4			2	5	1	
K02	4	1	3	1		1	3	2	
K03	4	2	5			1	6	3	
K04	4	2	5			1	6	5	3
K05	2	1	5			1	4	3	
K06	3	2	5			1	6	4	
K07	5	1	2			3	4		
K08	2	1	3			1	4	5	
K09	3	2	4			1	6	5	
K10	1	1	1			2	1	3	
K11	4	5	2	5		3	1		
K12	4	2	2			1	3		
K13	3	1	4			1	5	2	
K14	4	2	5			1	3		
K15	7	3	4			2	6	5	1
K16	1	1	1			1	1	1	
K17	2	1	1			1	3	2	
K18	3	1	4			1	5	2	
K19	1	1	1			1	1	1	
K20	3	1	4			1	5	2	
T01	2	1	5		3		6	4	
T02	5	2	4	2	1		4	3	

T03	4	2	5		1		6	3	
T04	4	2	5		1		6	5	3
T05	3	2	6		1		5	4	
T06	3	2	5		1		6	4	
T07	2	1	5		4		3		
T08	3	2	4		1		5	6	
T09	3	2	4		1		6	5	
T10	4	2	3		2		3	1	
T11	4	5	1	5	2		3		
T12	4	3	3		1		2		
T13	4	2	5		1		6	3	
T14	4	2	5		1		3		
T15	7	1	2		5		6	3	4
T16	2	4	1		1		5	3	
T17	4	2	2		1		5	3	
T18	4	2	5		1		6	3	
T19	4	1	3		1		3	2	
T20	4	2	5		1		6	3	
B101	3	2	1		5	4		6	
B102	3	2	1	2	4	6		5	
B103	3	1	2		5	6		4	
B104	3	2	1		5	6		1	4
B105	3	1	2		4	5		2	
B106	4	2	1		5	6		3	
B107	2	1	4		5	3			
B108	3	1	2		4	6		5	
B109	3	1	2		6	5		4	
B110	2	1	1		1	3		4	
B111	4	5	2	5	1	3			
B112	4	3	3		2	1			
B113	3	1	2		5	6			
B114	5	1	4		3	2			
B115	2	1	3		7	4		5	6
B116	4	2	1		1	5		3	
B117	2	1	1		3	5		4	
B118	3	1	2		5	6		4	
B119	2	1	1		1	3		4	
B120	3	1	2		5	6		4	
BII01	5	2	4		1	3	6		
BII02	5	1	4	1	2	3	4		
BII03	6	1	5		2	3	4		
BII04	2	1	1		4	5	1		3
BII05	5	1	3		4	6	2		
BII06	2	1	3		4	5	6		
BII08	5	1	4		2	6	3		
BII09	6	1	5		3	2	4		
BII10	4	2	3		2	1	3		
BII13	5	1	6		2	3	4		
BII15	5	2	1		7	3	4		6
BII16	5	4	1		1	2	3		
BII17	3	1	1		2	4	5		
BII18	5	1	6		2	4	3		
BII19	4	1	3		1	2	3		
BII20	5	1	6		2	3	4		
BIII04	5	1	4		2	3	6	4	
BIII15	7	3	4		1	2	6	5	

The detailed observation of the second rank clarifies the layout structure with room mapping “Fig. 9”. From the ‘staircase’, dense frequencies map to the ‘living’ more than the ‘bedroom’ spaces. Also the ‘living’ maps to the ‘bedrooms & staircase’ spaces beyond the ‘reception’ ties at the first rank. The ‘kitchen & toilet’ map to the ‘bedroom & staircase’ respectively. Meanwhile, the ‘bedrooms’ map to the ‘living, kitchen & staircase’ in order of density. Further observation of the third rank enforces the mapping of ‘bedrooms’ to other spaces, which continues down to rank-6 with more dispersed frequencies. The longest room mapping of the ‘bedrooms’ suggests a concentric structure beyond the first two ranks. In this regard, the mapping of room distances configures the layout in waves, with the intermediary ring of ‘living, kitchen & staircase’ of semi-domain between the outer ‘bedrooms & toilet’ and the inner ‘reception’ rings. The rank-two mapping of ‘living, kitchen & utilities’ to the ‘bedrooms’ or ‘staircase’, while the ‘bedrooms’ map to all of them indicates the structure of more than one ‘bedroom’ along the outer ring. Thus, the satellite ‘bedrooms’ select a reflexive digraph structure of the middle-ring in shortcuts to dissolve the ‘reception’ centrality.

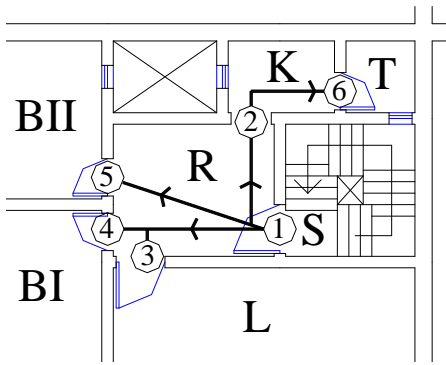


Figure 8. Digraph Sample

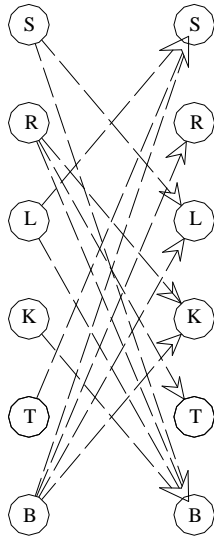


Figure 9. Mapping of Rank-two Distances

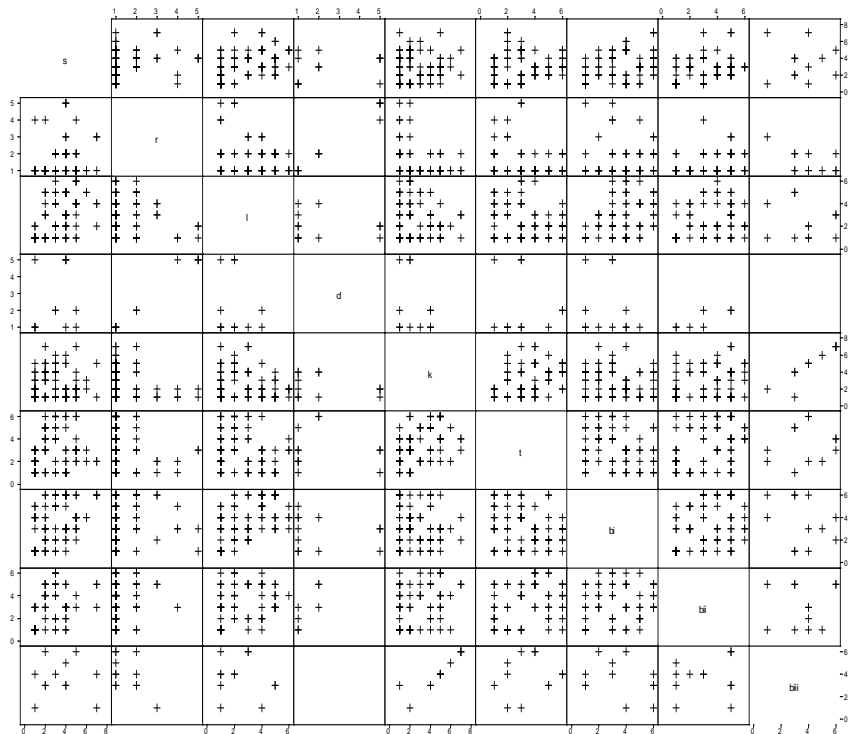


Figure 10. Scatterplot of Digraph Distance Rank

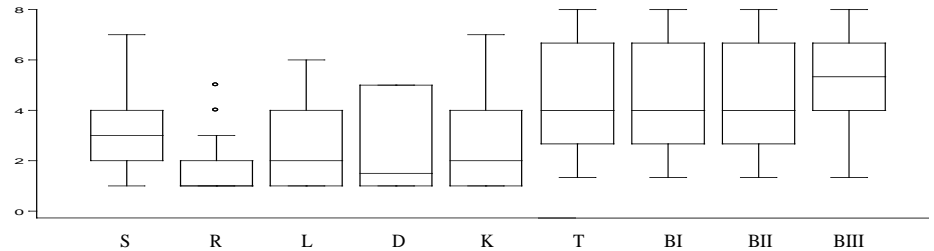


Figure 11. Box-plot of Digraph Distance Rank

The scatterplot observes the cross-tabulation of room pairs in covariance towards the rooms set “Fig. 10”. The positive or negative covariance determines the functional relationships across the room set with matched digraph of spatial clustering. The ‘staircase’ positively covariate with the ‘reception’ in the ‘living’ by a (2,1) respective digraph ranks to form one spatial zone. Another negative covariance occurs with the ‘bedrooms & utilities’ where the far they are from the ‘staircase’ the near to the ‘reception’ they become. The following plot of ‘staircase & living’ covariate towards a close ‘reception’ and distant ‘utilities’ functions. However, a negative covariance occurs whenever the ‘living’ is set closer to the ‘bedroom’. Accordingly, the ‘staircase’ changes the relationship with the ‘living’ to covariate in either ‘visitor’ or ‘inhabitant’ zone. The plot of ‘staircase & kitchen’ has random relationship of neither positive nor negative covariance. The ‘staircase & bedroom’ covariate towards the ‘reception’ with (1,1) digraph ranks. The distant covariance, however, matches the ‘utilities’. Therefore, the ‘staircase’ has a constant covariance of short ranks in the ‘visitor’ zone, but varies towards the ‘inhabitant’ outreach.

The ‘living’ of dense scatterplot has the (1,1) covariance with the ‘staircase, kitchen & bedroom’ in the ‘reception’. Further (2,1) ranks skip the ‘kitchen’ with denser ‘staircase &

bedroom’ covariance. The longer (3,1) ranks reverts to the ‘kitchen’ instead of the ‘bedroom’ zoning. The distant paths of the ‘living’ have a negative covariance with the ‘reception’ towards the ‘utilities’. Therefore, the dynamic ‘living’ room interchanges the ‘visitor or inhabitant’ domain in covariance with the ‘reception’ at different levels of resolution. The shorter covariance functions as a ‘visitor’ space, while the longer covariance becomes an ‘inhabitant’ zone. The plot of ‘living & kitchen’ has several observations. The positive covariance sets both spaces in (1,1) ranks towards the ‘visitor’ zone. But the inverse relationship structures one ‘bedroom’ near to the ‘living’ whenever the other is near to the ‘kitchen’. Therefore, the ‘living & kitchen’ rooms function as ‘visitor’ spaces in covariance with the ‘reception’, while turn into ‘inhabitant’ spaces in alternating covariance with the ‘bedroom’ spaces. This finding enforces the satellite structure of the ‘bedrooms’ to match the digraph with either ‘living’ or ‘kitchen’ spaces in one deep ‘inhabitant’ ring.

The plot of ‘kitchen’ room clarifies the layout structure. Some covariance of the ‘kitchen & staircase’ extends from the first rank up to the fifth with positive sign of nearby ‘visitor’ and distant ‘inhabitant’ zones. However, the ‘kitchen & living’ have a negative covariance with respect to the ‘staircase’. The

'kitchen & bedrooms' compose two opposite covariance of 'kitchen & bedroom' with distant 'living', which contrasts the 'living & bedroom' with distant 'kitchen'. This covariance of digraph not only verifies the 'bedroom' matching phenomenon with 'kitchen & living' but also configures two magnets of 'bedrooms' against the concentric zone of 'visitor' space. The scatterplot of 'bedrooms', which are numbered in clockwise direction, specify their relevant structure. The positive covariance of 'bedroom-I & staircase' has distant ranks of digraph towards the 'toilet, kitchen & bedroom-II' in common. Nevertheless, the first two ranks of 'bedroom-I' correlate with the 'living & reception' spaces, while the 'staircase' lags by one rank than the 'bedroom-I' in common covariance towards the 'living' space. Also the 'bedroom-I' lags one rank behind the 'staircase' in common covariance towards the 'reception' space. Thus, the aggregated cross-tabulation matches the room pairs of 'bedroom-I & living' against 'staircase & reception'. Meanwhile, the digraph correlation of 'reception & living' with (1,1) reflexive rank adheres the spatial structure in cross-section along both 'visitor' and 'inhabitant' concentric rings.

The plot of 'bedroom-II' differ the 'inhabitant' structure. The dense correlation of rank-1 coincides with the 'reception' or 'kitchen', while the second rank is largely dispersed. The distant ranks, nevertheless, have negative covariance of room relationships. Besides, the varied 'kitchen' structure has made the 'bedroom-II' locates close but independent. The difference of segregated 'bedroom-II' with liberated 'kitchen' introduces an access corridor (sometimes along the 'reception' wall) to satisfy both structures in shortcut. The 'kitchen' drags the 'toilet' inwards for sanitary and functional reasons with 'bedroom-II', thus an 'inhabitant' zone of higher privacy. In this regard, the 'corridor' performs another role of adherence comparable to the 'living' of the opposite 'inhabitant' domain, but with difference of privacy level. Overview of digraph structure compares the box-plot of network densities across the room set "Fig. 11". The main observation is the equal densities of 'living & kitchen' networks along the various ranks, with their average of second rank. The 'two-bedrooms & toilet' have equal networks of average fourth rank. The 'reception' concentrates the networks at the first two ranks, while the 'staircase' distributes with total average networks. The outliers of 'dining and bedroom-III' have the least layout encounters with trivial effect on the digraph networking. This box-plot weighing conforms to the digraph logic of interactive spatial rings of in-centric 'visitor' and out-centric 'inhabitant' with the 'living & kitchen' in cross-sectional ringing structure.

III. Conclusion

The digraph of survey rooms in 'Sequina' slum area reveals the logic of social networks as follows:

1. The irreflexive digraph contrasts the 'visitor' of shallow outflow to the 'inhabitant' rooms with inverted inflow of deep 'visitor' from the 'inhabitant' clusters. The mapping of second-rank digraph reflects the concentric structure of overlapping middle ring between the core 'visitor' and the satellite 'inhabitant' ties apart from the space syntax rings. The longer networks set the 'inhabitant' rooms into sub-domains of different structure to self-interact on occasion.

2. The cross-tabulation of the digraph networks covariate the room-set into spatial zones of favorite matching. The logic of alternative interface changes the social domains from one structure to the other. Mainly, the 'living & kitchen' integrate with 'bedroom I & II' in respective 'inhabitant' zones, while match together in common 'reception' zone. Thus, the digraph's simultaneous covariance integrates or segregates the inter-cyclic layout, which negates the ringy space syntax with adaptable social interfacing all the time.

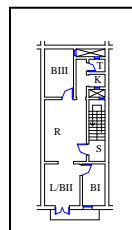
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