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Voronoi Structure of Space Integration with an Applied Roundabout Network - Part III

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Abstract
Graph properties of embedded networks in voronoi diagram demonstrate new architectural dimensions of intangible space structure. The parametric model correlates the integral criteria of walkability and distributiveness along the layered graph networks in application to the historical conservation of roundabout Cairo. The essence of hamiltonian property globalizes from maximal degree choice to the favored components in eulerian loops. Meanwhile, the least integral asymmetry of distant generators forms the most traversable extent in compensation. However, the global system integration emphasizes the core meeting-point in topologic distributiveness with geometric shortest distance as well. Nevertheless, individual generators swap the topological-geometrical spatial integrity of exchangeable strategy at diverse layers of graph embeds. In this regard, cross-correlative strategies project the virtual graph networks over the existing roundabout Cairo to become interactively dynamic. Overview of voronoi-based graph integrity extends the parametric geometry along topologic networking of artificially intelligent space formation with social functioning, thus all packaged in prospective software architecture.

Keywords: Voronoi Space, Delaunay Graph, Pitteway Graph, RN Graph, EMST Graph, NN Digraph, Network Integration

1. Introduction

Architects are supplied with software developments that enable the design of spaces in digital media. Nevertheless, crossing the border from the drafting toolbox to the artificial intelligence of creating layouts supposes the stepping up from the parametric design of shape-grammar to the level of including social parameters in digital automation of space design. Correlating the geometrical form to the social function requires a computational technique of processing the discursive rules of shaping space in addition to the non-discursive spatial configuration of social integrity to create alternatives of layout connectivity [1]. Setting up the objective parameters of form and function commands the system intelligence to resolve and model the alternative connectivity network of functional form in social and environmental dimensions. In one basic-science method to build upon the whole theory of ‘form follows function,’ the intrinsic phenomenon of voronoi space structure supposes the possibility of combining geometrical form with functional relationships in one diagram [2]. The unique diagram rolls into a dual graph of delaunay network, which extracts further resolutions of embedded graph networks. Meanwhile, the objective graph networking addresses the state-of-the-art computation of graph theory with artificial intelligence beyond the human ability [e.g., 3, 4]. The prospects of voronoi’s dual graph computation extend from being theoretically basic-science to the universal application on space [5, 6], specifically for the logic of social space integration in form and not only function [7, 8] (Fig.1).

The clarity of application upon this study explores the consecutive graph resolutions of the dual delaunay graph of the voronoi diagram representing the historical colony in Cairo. In 1867 the French pioneer Haussmann planned the colony, which formed a new satellite network of roundabouts along the Nile. The linking boulevards were superimposed on old Cairo and extended outwards for socioeconomic development [9]. However, the current problem facilitates the dissolution of the original scheme due to the socioeconomic pressures of redevelopment [10]. Nevertheless, the conservation act enforces the visual renovation with the cross-cultural values of social dimensions [e.g., 11, 12, 13, 14]. In this regard, objective conservation of the conceptual space integration demonstrates the parametric geometry and topology of voronoi structure along the dual graph resolutions for virtual reality of future strategy.

2. Methods

The spatial structure of voronoi diagram extracts hierarchal graph networks from its dual delaunay graph with extendable knowledge on the intangible layout. The voronoi phenomenon is largely applied to the computer software of parametric design such as the architectural grasshopper and the geographic informatics. Nevertheless, the software application provides the designer with the toolbox of creating calculative shapes and forms of voronoi units with their interrelationships. The dual graph network and its further embeds are less applied though, although they demonstrate a rich material on the algorithmic properties of the created object through the parametric byproduct of the voronoi convex-hull. One embedded property of importance to the designer is the intangible issue of spatial integration, which is largely applied in the methodologies of social studies on architectural space design. The profound method of space syntax builds the main theory on investigating the quantitative spatial integration of architectural design to qualify the social logic behind. In process, the social method constructs the topologic graph of layout upon the human principles of visibility and permeability of space for the social interaction to be extracted [15, 16, 17, 18]. Nevertheless, the topologic objective for the social logic of space integration is hardly synchronized with the parametric toolbox of architectural and urban software drafting [19, 20].

However, the gap of software toolbox between the architectural form and the social function has been considered in recent innovations among the symposia of space syntax in relationship to shape-grammar of architectural design [e.g., 21, 22, 23, 24, 25]. Meanwhile, innovative shape-grammar incorporates the graph properties and algorithms to compute units of designing forms [e.g., 26, 27, 28, 29]. In this regard, the common theme of graph adaptation as a basic-science denotes the key factor of synthesizing form and function in combination. While the graph theory is relative in scope and application, it affords an unlimited virtual media of research on objective problem solving. Also, with reference to the innate voronoi geometry of space structure, it affords an encapsulated knowledge of the dual graph network at different layering of embedded resolutions. From this perspective, the prospected method further investigates the graph potential of voronoi convex-hull in exploring the relationship between form and function of space integration in one virtual toolbox of architectural design for software development. The application traces the voronoi of roundabout Cairo with the dual graph connectivity at the subsequent criteria of; 1) delaunay, 2) pitteway, 3) relative neighbor, 4) euclidian minimum spanning tree and 5) nearest neighbor, with the computational tools of mathematical graph automation in artificial intelligence [e.g., 30]. The modeling of integral parameters ranges from geometrical distancing to the topologic traverse and distributive structure of space. The correlative graph results attempt to verify the integral strategy of future space structuring as of the Cairo application.

3. Results

3.1. As-built Graph

The process of voronoi diagram constructs the convex hull of distributed points in space. The coverage of each cell of the convex hull belongs to its geometric centroid of generative point. In process, the bisector line to the one joining each pair of neighboring generators defines the fibre-process of voronoi diagram. This voronoi process has been automated in Mathematica programming of Wolfram language. The syntax is specified as; *DensityPlot*[*First*[*nf*[{*x, y*}]], {*x*, -5, 5}, {*y*, -5, 5}, PlotPoints -> 100] for a given point process in space [31]. Applying this string of voronoi command on the roundabout case realizes its geometric convex hull of encapsulated cognitive findings to unfold (Figs. 2 & 3 and Table 1). The convex hull on its own defines the geometric territories of each roundabout in terms of land-use and building blocks, distances and pathways, demographics and economies to imagine regardless of the administrative subdivision. Brief contents of what falls within each of the roundabout cells demonstrate the conceptive planning of royal quarter along the Nile promenade (generators 1, 2, 11 & 12), administrative and commercial quarter towards the railway station (generators 5, 6, 7, 8 & 15), residential suburbs open to agriculture (generators 9 & 10), old Cairo differentiated (generators 13 & 14), with the whole centered by the royal palace in symbolic overwhelm (generators 3 & 4), in addition to the royal workshops at the periphery (generator 11). Defined voronoi functions of roundabouts attempts to synchronize with the cognitive structure of theoretical town planning realm in time and space.

The circulation network stretches from one voronoi cell of roundabout to the other. The main boulevards connect the roundabouts to form the as-built geometry of graph network. Meanwhile, the dual voronoi diagram of delaunay graph in the next section represents the virtual reality of roundabout connectivity in comparison to the as-built real one. Amidst this and that there exist numerous boulevards, alleys and passages cutting through building blocks, which may optimize shortcuts of virtual pedestrian connectivity into the future. Otherwise extensive change of urban tissue paves new paths but counted as infeasible though. The graph of existing geo-network measures various properties of graph theory such as eulerian, traversable, hamiltonian [e.g., 5], in addition to the universal distance from anyone generator to all others in top-up manner of network connection [e.g., 32]. The eulerian property specifies a connected graph of even number of edges for each of the graph vertices [5, p.55]. Satisfying the eulerian condition allows each of the graph edges to be crossed once in a circuit up to the starting point. The majority, however, of Haussmannn's network have odd degree of vertices of global eulerian dissatisfaction. The local context, nevertheless, of the connected generators 2, 3 & 10 have the highest even degree of 4-edges each. This graph minor determines the most dynamic network of integrating the layout in cyclic eularian excursion. Meanwhile, standalone generator-6 of a similar high degree displays a global eulerian role of integrating old with new Cairo in self-centered looping point.

Further traversable property identifies a single graph-trail crossing all edges once along the network. In the cyclic condition, the connected graph should have exactly two odd vertices [5, p.58]. Although roundabout Cairo is neither eulerian nor traversable along any cycle or trail, the most isolated generators 13 & 15 have the most traversable trails of 13-edges long in compensation. Another hamiltonian path verifies if it is possible to cross all vertices once in sequence [5, p.69]. While this path is not found asbuilt in roundabout Cairo, the same generators 13 & 15 add generator-8 in expanded hamiltonian choice of 12-vertices along 11-edges path to prove their cross subsidy with the awkward eulerian networking. Meanwhile, the metric universal distance (UD) property qualifies generastor-4 to be the shortest in network integration against generator-13 of longest distance. Functional interpretation proves the royal palace symbolism of allover shallow reaching out, while distancing irregular old Cairo from the regular new. Viewing the same as-built graph from the space syntax's topologic point of view determines the relative asymmetry measure of spatial integrity in a graph network as; Relative asymmetry (RA) = $\frac{2\,(\mathrm{MD}-1)}{\mathrm{K}-2}$, where 'MD' is the mean depth of a space and 'K' is the number of spaces in the spatial system [15, p. 108]. Resulted measurement identifies generators 3 & 4 as the most integrative of the layout in contrast to generators 13 & 15 of the least layout integrity. Overview of space structure cross-correlates geometric and topologic integrity of roundabout-4 and the detaching roundabout-13 as well.

3.2. Delaunay Graph

Shifting the real situation to the virtual realm investigates roundabout Cairo in graph autonomy upon the voronoi process. In this regard, generative pairs sharing a voronoi line connect in dual delaunay graph network. This phenomenon is automated in Wolfram language by stringing; *pts = RandomReal[{-1, 1}, {5, 1}]; then pts = RandomReal[{-1, 1}, {50, 2}]; then; R = DelaunayMesh[pts]; then; HighlightMesh[R, Style[0, Black]]* [33]. The resulted graph is highly connected in comparison to the built, which opens new doors of roundabout connectivity. All of the delaunay vertices have loops to bypass or connect any of the roundabouts at different global resolutions. The cyclic global system overcomes the restricted eulerian circuiting or passing due to odd-degree vertices of almost half of the graph order. The highest even degree of 6-edges qualifies generators 4 & 6 as the most eulerian networking spots in cyclic system integration. On the other, generator-9 of highest degree integrates the surrounding with maximal 7-loops of cyclic space. Less eulerian degree of 4-edges per generators 1, 3, 5 & 14 enforce the linkage excursion with variety of choice in cycles, especially for the detached old Cairo. Opposite detachment of generator-15 becomes more integrated to the vicinity by more degree-5 links, although non-eulerian terminal. In another, the opposite generators 7 & 11 of the least odd-edges benefit from being along the densest loops along their horizontal axis. Least degree-2 of generator-13, however, capitalizes on the eulerian circuit with generators 12 & 14 towards global cycling perspective.

Traversable disability in the delaunay graph of roundabout Cairo is met with extended trails of over twothirds of the 34-links in total. All graph vertices satisfy the long-trail observation as per the dense delaunay connectivity. Interactive trails of the global system tolerate the freezing of some links on the expense of others as convenient and without affecting each other. The freeze of extra links in any extended one trail may end up the graph being traversable at each position in foremost satisfaction. Converting the constraint into opportunity widens the local scope of traversal choice instead of global restriction. Extreme satisfying is observed at the level of hamiltonian property where the delaunay graph proves true in circuit and not only path for each vertex. In Wolfram the string of true or false hamiltonian is computed as; *HamiltonianGraphQ*[%] [34]. Meanwhile, the universal distance determines generator-9 to have the shortest length of connecting the whole system. Also, generator-13 continues the segregation of old from new Cairo in farthest reach of the layout extent. Wolfram computes the distance as; *GraphDistance [g, s, t],* to measure the length from vertex-s to -t in graph-g. Moreover, the universal distance from one-vertex to all others of a graph follows the string; *GraphDistance [g, s].* Parallel to the geometry of delaunay graph, the topologic integrity of the same graph qualifies generator-9 as the most integrating vertex versus generator-13 of the least layout integrity, thus the direct geometrictopologic correlation [35]. In fact, the delaunay graph not only turned the as-built geometry from dissatisfying to satisfying properties, but doubled the average topological integrity of the layout as well.

3.3. Pitteway Graph

Shaping-up the pitteway graph only considers the delaunay link crossing the voronoi edge of respective generators. Wolfram program may process the precedent delaunay down to pitteway graph in progress. The resulted graph enhances the connectivity in direct relationships of the spatial system to function. The vertices of odd degrees keep at average graph order with the even ones having higher degrees. The graph observes more emphasis on the even vertices to facilitate the linking properties of trajectories. This contrasts with the predecessor delaunay network of higher ratio of odd links to the even, but denser in choice. The pitteway graph continues to be non-eulerian to tour all links in one circuit or path sequence. The reduction of pitteway links, nevertheless, preserves the high-ratio of possible longest traversable trails of more than two-third of the total 22-edges allover. For example, starting from generator-9 it is possible to follow a longest trail of '9-4-3-2-12-1-2-10-11-1-10-9-8-7-6-5-4-14-13' of 18-links out of the 22-total. Another generator-13 may follow the longest trail of '13-14-12-1-11-10-2-1-10-9-3-4-5-6-7-8-94-14' also of 18-links out of the 22-total and so on. Longer trails can be tracked as of generator-4 along the path '4-3-9-10-11-1-10-2-12-1-2-3-4-5-6-7-8-9-4-14-13' of 20-links close to the full eulerian and so traversable network. Programming all possible paths may help to compute the layout variations in comparison. The long pitteway trails of Cairo count on the spread of inner cyclic spaces everywhere with only two tail vertices at the graph tips.

Graph minor explores embedded dimensions of the pitteway connectivity. In application, contracting some vertices of systematic relationship may prove useful in network supposition. Suppose each cycle space is contracted as one vertex in connection to others, the result shifts the graph tails along the horizontal axis for old Cairo to revitalize in shared maximal cycle. Another dimension contracts the tail vertices into the one connected to end up of even degree, thus more traversable at the global level. Many other graph minors of cyclic criteria have potential programming for the whole system to retreat. The pitteway graph without minoring strategies is non-circuit, in addition to conditional true hamiltonian path. There is no choice but to start and end at the two tail vertices otherwise the pitteway is non-hamiltonian. It gives unique privilege to the tail against all cyclic spaces, or getting contracted in minor graph for the whole system to be true hamiltonian. When contracted, nevertheless, the pitteway allows a single looping of hamiltonian path on either side of each vertex. Less freedom of pitteway excursion extends the universal distance with generator-4 measuring the least distance in comparison to the longest generator-13 as usual. Meanwhile, the integral measure of space syntax favors generator-9 of the least RA-value in highest layout integrity, whereas the most disintegrating is generator-15. Therefore, in cross-correlation the integral pitteway ties with the delaunay graph but disintegrates same as in the as-built, whereas the universal proximity matches the as-built and becomes distant along with both the as-built and delaunay graphs. Thus, the pitteway itself has topologic-geometric diversity of layout bonds.

3.4. Relative Neighbor Graph

Narrowing the scope down to the relative neighbor graph (RNG) approves the pitteway links that connect each pair of generators in shortest distance than any other of both. The resulted graph increases the geometrical relationships among generators in tuned network. The only cyclic space is found halfway to connect generators 3, 4, 5, 8 & 9 from which elongates graph tails in all directions. The absolute focus on a single cycle represents minor graph integrity for the whole layout. Critical generator-3 joins the longest branching graph-tail to the cycle in a cut-vertex of extreme weight as never before. Opposite generator-5 compares a similar tail joint to the graph-cycle in less weight. All path types are defined according to the two knotting cycle-tail generators. Dissatisfied eulerian, traversable and hamiltonian paths combine into one property of finding the longest trail possible in common extent. Found path shifts the emphasis from the central cycle with its heavy joints of tails towards the very end tailing vertices. Anyone tail-end starts a journey that lasts after crossing 11-vertices along 10-edges in longest trail up to another tail-end. Rethinking the nearest neighbor graph geometry adds a global structure to the just local context of neighboring distance objective. Each vertex becomes critical in defining a path, cycle or minor graph to explore in extra cut vertices. Homogenous graph-tailing dissolves geometric and topologic differences of generators in unified network. Meanwhile, the longest trail of vertices and edges sustains a two-third ratio of the relative graph system without loss of as-built, delaunay, pitteway and relative-neighbor generality.

One minor graph may contract each tail of the RNG in connection to the central cycle. Compact graph only requires 5-edges to cross from end to end. Conversely, the cycle contraction minimizes the now treegraph in only 8-edges to connect the farthest ends. Looking at the graph as neighborhood division justifies some vertices of enlarged relationships and others to be self-contained. The cycle maximizes those neighboring ties as one entity regardless of its generators being neighbors due to shortcuts of two-way accessibility. Tails, nevertheless, vary from one generator to the other depending on the degree of links. Generator-2 has the top rank neighborhood by degree-three links of tree branches. The centralized generator qualifies itself as the shortcut to its neighbors, especially in connection to the cyclic entity. Comparable connectivity of generator-6, nevertheless, is seen as an ordinary tree vertex of degree-two in linear rather than radial centrality of shortcut. This is numerically proved by generator-2 of almost double layout integrity with much less universal distance than the neighboring tree vertices and the comparable generator-6 as well.

Above all, generator-3 demonstrates the extreme neighborhood capacity not by degree-3 as others, but by being neighbor to both the boosting generator-2 and its own cycle. Similarly proves as of the highest value in layout integration and the shortest universal distance of no other. Comparable structure, however, of generator-5 proves idle due to the weak neighbor-tree of generator-6 and being the farthest cyclic vertex from generator-2. The same observation is emphasized by this cyclic generator-5 of less layout integrity and more universal distance than the tailing generator-2 for the first and the last critique of the unique cycle in RNG network. Besides, the equity of tree-graph shares the least layout integrity and the longest universal distance by the two opposite generators 15 & 13 respectively.

3.5. EMST Graph

Reaching up to euclidian-minimum-spanning-tree (EMST) connects the graph in shortest distance. The new graph deletes just one previous RNG link in extreme isomorphic percentage, but of major network change. Expired cycle sacrifices one cyclic link of the most integral generator-3 on the expense of acyclic space. The integral reduction with longer distances of this particular vertex further flattens the differences among the layout by more homogenous properties. Minimal graph branching extends the traversable path up to 10-vertices along 9-edges of exact two-third of the total layout in line with predecessor graphs. Meanwhile, the graph emphasis shifts to the two branching vertices 2 & 5 of similar structure. It justifies the contraction of the EMST graph into these two generators in connection. Despite being too abstract, the graph minor represents two connected poles of attraction in connection to all others contracted. This is the simplest and only linear structure for a tree graph to verify as eulerian, traversable and hamiltonian. Also, of close resemblance to reality in the form of zigzagging network along the horizontal axis with radial ends of vertical axis coverage.

Instead of the branching vertices, switching the system of graph minor by contracted tree-segments ends up as two connected vertices with each branching into another two vertices. Although turns non-traversable or hamiltonian, the graph system enforces the global structure of radial two poles. In this regard, the pole connectivity of EMST graph adds more potential to generators 3 & 4 for all layout properties. Any path should pass through them in central cut vertex of layout's highest distribution property. Each of both connects to either pole in same color property, where precisely generator-3 maximizes its distributiveness with the active pole of richer branching tails than the other. Contracting this line-segment of pole connectivity changes the whole layout structure into pure radial network for the first time of roundabout Cairo graph. Therefore, the crucial pole connectivity of EMST replaces the RNG ring in different but correlative graph network structure. Nevertheless, most affected generator-9 suddenly changes from distributive ringing to non-distributive tailing end of lost layout role.

In calculative terms of layout proof, the most integral space of EMST graph is generator-3 by both least RA value and least UD travel to reassure its previous RNG's dominance role. The second rank of close measurements to the top is shared by generators 2 & 4 having exactly the same RA value with relatively marginal difference of UD in favor of the later over the former if to be considered when ranking. Rival generator-5 occupies the third rank by higher RA value and more UD travelling to prove some decrease in layout integrity. So far, the top-tier generators of integrating the EMST layout correspond to the same critical path of graph polarity in minimal variance except generator-5 of relatively widest margin to count as dummy-like vertex of network flow.

Flipping the graph measurement at the bottom-tier identifies generators 1, 9, 13 & 15 as the most disintegrating of the EMST layout. While 13 & 15 vertices normalize the layout in least integrity, the other two are new to the scenery. Generator-9, specifically, exhibits the absolute swap of most integrative delaunay and pitteway layouts with the EMST least category. Similar contrast extends to the most isomorphic RNG graph of doubled integrity in both terms of RA and UD measures of the same generator. Further opposition extends to the as-built graph from real top to virtual bottom stratum of layout solidarity. The prolonged contrast to all graphs can be interpreted in several dimensions under the same title of 'catalyst' generator, which may be introduced to integrate the whole layout or removed without effect. Generator-1 follows suit but to a less extent of average integrity elsewhere in comparison to the EMST drop without distinction. The narrow variance among all tiers of the EMST graph measurements endorses the homogeneity of the layout tree after all.

3.6. Nearest Neighbor Digraph

Arriving at the nearest neighbor digraph (NND) represents a standalone graph besides being delivered by descendants. This unique graph is directed in nature to find the nearest couple of all generators. In process, each generator selects the nearest neighbor to direct its arrow without necessarily receiving the same directed connectivity. The resulted digraph is disconnected on the layout level but of extensive observations on the local context of each connected component. The center of attention moves to the revitalized generator-5 that connects with generator-6 in directed graph to each other. They attract more directed graphs from further two-generators in sequence to each of the couple. The total graph component of order-6 is the largest found at the NND layer. Being directed, all arrows point to this deep twin structure of magnified centralization in analogical graph minor to the whole disconnected digraph. The top rank of digraph distance emphasizes the same primary couple as closest to each other among the rest. The remaining vertices connect in couples of minor graph components. Meanwhile, vulnerable longest distance of couple generators 2 & 10 in bottom rank allow the single generator-12 to join direction with more distraction of loose ties. All other matches share intermediate distance of middle rank with little variance, including the isolated generators 13 & 14 of old Cairo in cut-off structure. Possible graph contraction reduces each couple as one to form minor minor-graph components and restructures the NND network. Accordingly, the graph reconnects into curious two-poles of typical components with one new couple found at each. Here the contracted 1 & 11 with 2 & 10 form one couple at one pole, while the contracted 5 & 6 with generator-8 form the other. Meanwhile, the cut-off couple of 13 & 14 contracts in directed arrow to the nearest generator-12, thus the twin component isomorphism.

4. Discussion

Discussion of diverse computation on geometrical graph layers embeds many strategies within one strategy of voronoi-delaunay triangulation. Graph geometry allows topological measurements to be adhered, whereas the inverse undertakes theoretical intervention for holding true. Autonomous voronoi of scaled distance measures, in addition to the measurable topologic length in geometric graph, restructures the spatial integration in universal dimensions. While this spatial study selects some basic graph properties to resolve, still the door is open for limitless algorithms by virtue of both geometric and topologic graph theory applications. Fortunately, the human limitation is met with unlimited advancement of artificial intelligence to prove powerful in calculated strategy of existing space structure or to create new. Through the limited apparatus attempted by this study, the issue of spatial integrity in computable media of geometric graph shifts the real world into virtual realm to be further explored. Unbiased computation rolls from one graph layer to the other of programmed properties with integral outcomes in correlation to each other. Common theme of interchangeable matching of generator integrity adapts, simultaneously, to change in layout strategy at embedded sub-graph so as minor-graph perspective.

5. Conclusions

Cognitive space of voronoi analysis imagines the philosophic integral structure in virtual-graph-reality. Such a metaphysical approach materializes in graph perspective of spatial measurements by privileged geometric dimensions beyond the abstract topology. Parametric layers of interdependent geometric graph correlate the networking integral properties of path finding in universal distancing and relative asymmetry analyses, thus the multidiscipline method stretch. In one verified application of voronoi's analytical graph on the historical case of roundabout Cairo determines the strategy of future conservation as follows:

1. Interactive traversable trails invest more in satisfying the hamiltonian path of touring all roundabouts in one excursion, while changes the eulerian strategy of choosing links. Tuned hamiltonain paths define the longest universal distances in uni-direction at NNG and EMST layers and changes strategy of total hamiltonian circuiting in shortest universal distance by variety of path choice at the delaunay level. Meanwhile, the pitteway layer holds hamiltonian path but not circuit, with considerable amount of path choice in moderate strategy. This extends the as-built layer to more possible linking strategies of achieving any of the virtual network inter-correlation through various embedded graph layers.
2. Symbolic system of graph layers changes strategy of graph-minor from contracting cyclic spaces at the delaunay and pitteway layers to the contraction of tree segments or special cycle at the NNG and EMST layers, in addition to the NND layer of disconnected but isomorphic polar components of coupled generators when contracted. Each of which switches the whole integral structure from one static to another dynamic distributiveness as convenient. Similar potential of cross-correlation adds to the as-built graph with extreme adjustment of changeable spatial integrity to revitalize or suffice a specific generator in favor of the whole layout strategy in real dimension and not only symbolism.
3. Roundabout role proves to be plural and not only single as-built. Top-tier integrity of distributive generators in shortest universality flips the script by one change of graph layer. In one application, generator-9 changes from being distributed and nearest to all in delaunay and pitteway layers into one of the most segregating and distant one at the EMST layer, but again shows medium layout integrity for the NNG layer. Also, generators 13 & 15 of absolute distancing in opposite directions alternate their role of being the most disintegrating generator from one graph layer to another. Besides, numerous variances are observed for each generator in each layer of changed minor or major strategy as required. This can only be realized through programming graph strategies of artificial intelligence.

Declaration of Interests
The research paper declares to have no known competing financial interests or personal relationships that could have appeared to influence the work reported.

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Appendix of Table

Gen.	As-built		Delaunay		Pitteway		Relative Neighbor		EMST	
	RA	UD (Km)	RA	UD	RA	UD	RA	UD	RA	UD
1	0.340659	21.48356	0.153846	17.51139	0.252747	18.23933	0.626374	27.21483	0.67033	28.12894
2	0.252747	18.16189	0.120879	14.61644	0.21978	15.82222	0.263736	16.65833	0.307692	17.57244
3	0.175824	15.80639	0.131868	13.62844	0.186813	14.13972	0.252747	16.32183	0.296703	17.23594
4	0.175824	15.62222	0.098901	14.93678	0.164835	13.8855	0.296703	17.21411	0.307692	17.48867
5	0.21978	16.88117	0.142857	14.33078	0.21978	15.23639	0.340659	18.78333	0.340659	18.78333
6	0.197802	16.24628	0.142857	15.02039	0.318681	16.67939	0.43956	20.22633	0.43956	20.22633
7	0.318681	20.91228	0.175824	18.41089	0.307692	19.67839	0.56044	22.92139	0.56044	22.92139
8	0.318681	22.9525	0.131868	14.44222	0.208791	15.3425	0.373626	20.20011	0.461538	21.273
9	0.208791	16.44478	0.087912	13.16567	0.153846	14.16061	0.32967	18.95672	0.604396	25.47128
10	0.252747	19.32539	0.131868	15.81094	0.208791	16.58111	0.362637	19.77633	0.406593	20.69044
11	0.340659	22.0825	0.186813	18.69	0.307692	19.66594	0.483516	23.88178	0.527473	24.79589
12	0.395604	27.86161	0.120879	18.63289	0.263736	21.16994	0.362637	22.57883	0.406593	23.49294
13	0.461538	40.59194	0.21978	33.81644	0.362637	33.90011	0.626374	44.37494	0.67033	45.28906
14	0.318681	36.18133	0.142857	28.29956	0.21978	29.4895	0.483516	39.96433	0.527473	40.87844
15	0.461538	32.38983	0.142857	26.09172	0.450549	30.953	0.703297	36.35317	0.703297	36.35317
Av.	0.295971	22.86291	0.142125	18.49364	0.25641	19.66291	0.4337	24.36176	0.482051	25.37342

Table 1: Graph Measures of Roundabout

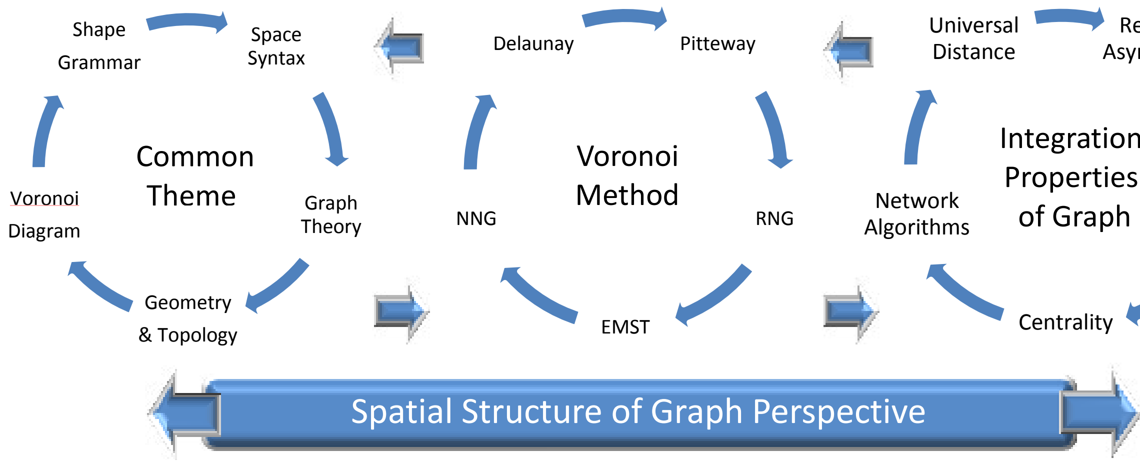

Figure 1: Graph Processing of Space

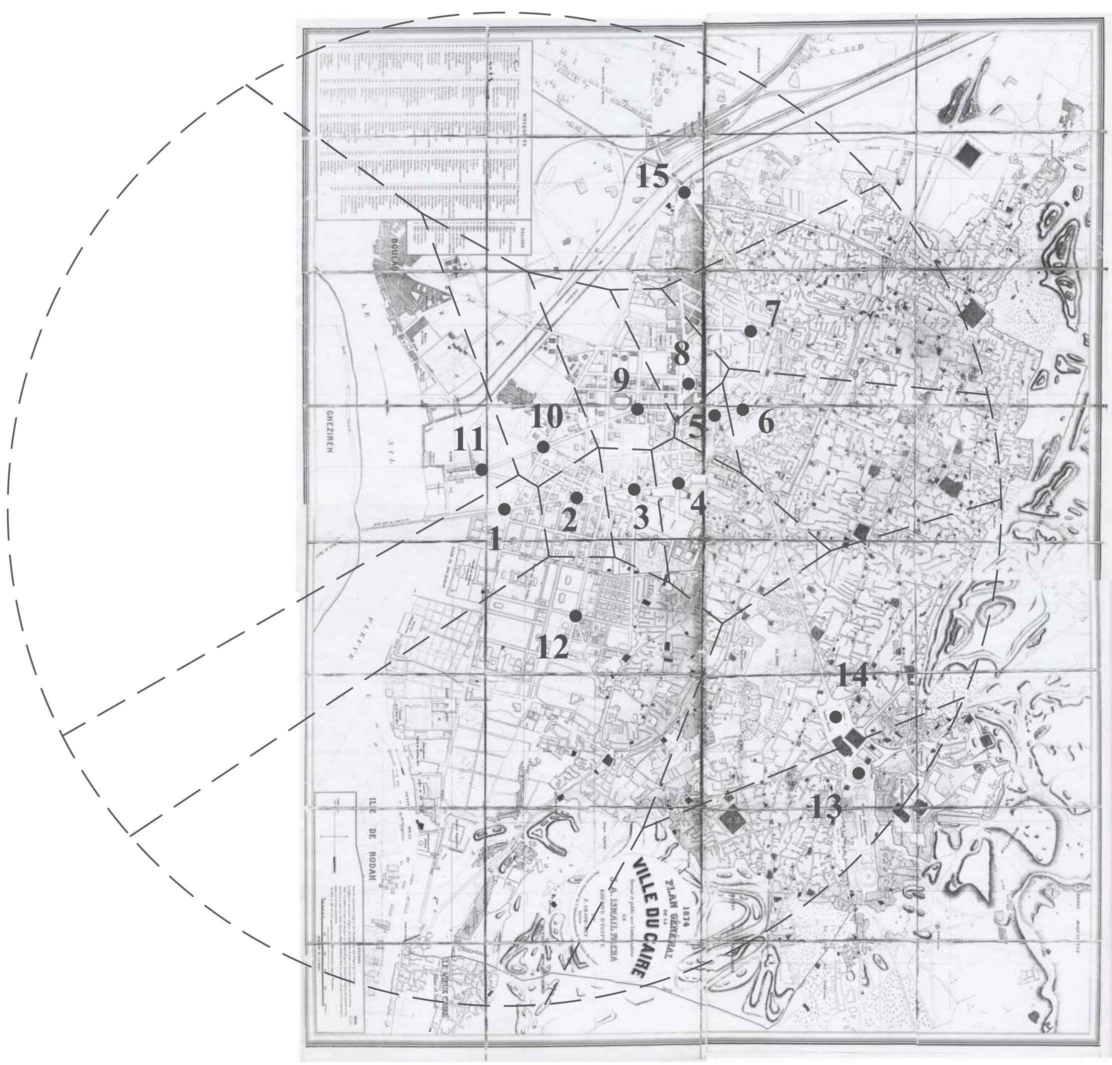

Figure 2: Voronoi of Roundabout Cairo
(Source of Basemap: copy from the Survey Department, Cairo)

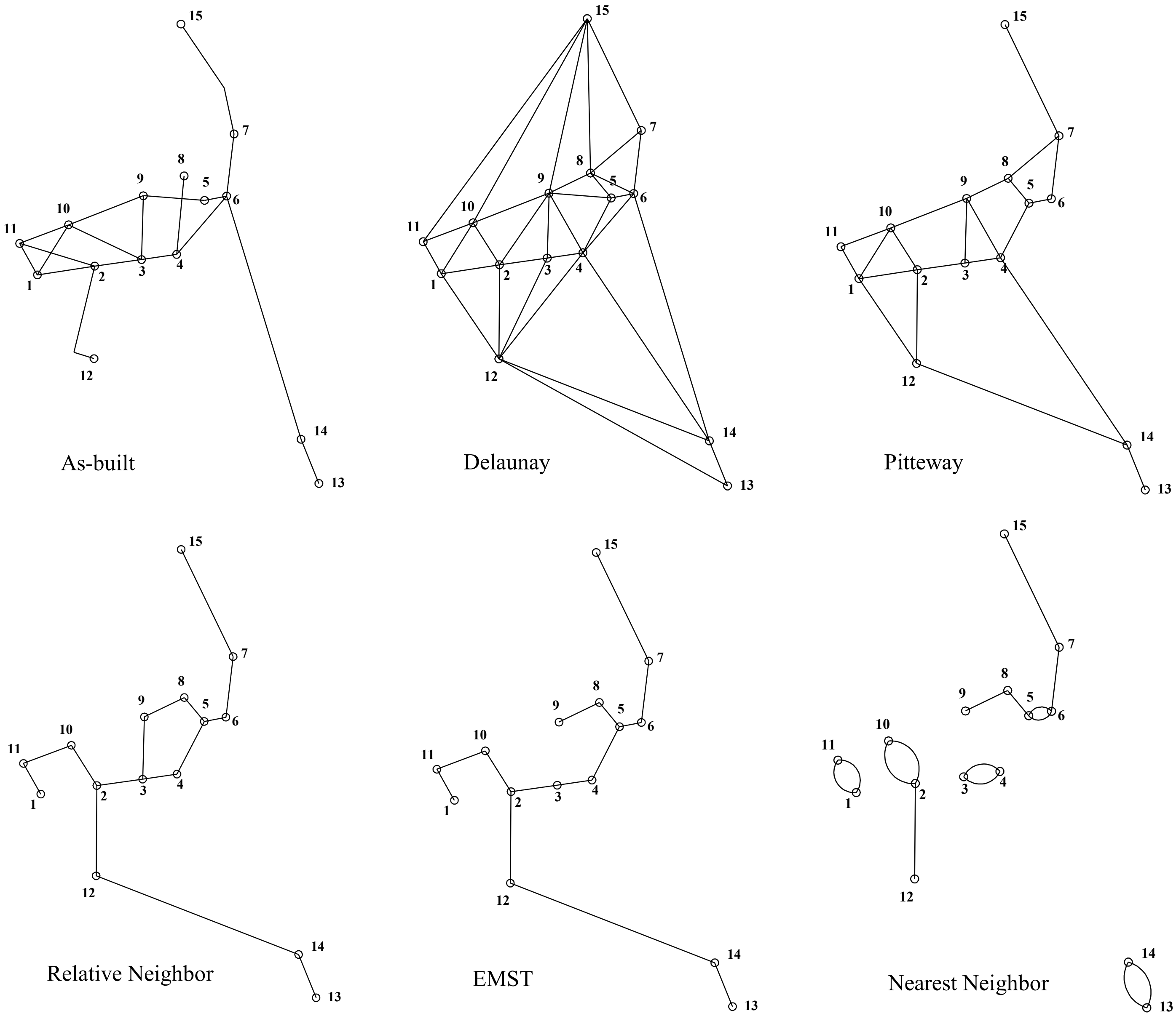

Figure 3: To-Scale Graph of Roundabout Cairo