

## A new concept of adaptive complexity

Hassan A. Al-Guesbi

Dept. of Architecture, University of Babylon

---

### ABSTRACT

Animate systems can organize their complexities to stay alive. They run in easiest ways within specific boundaries to keep their existence and to maintain highest levels of interaction with their surrounding environments. They are (living) systems of emergent (adaptive) and evolved (survived) complexities. The focus here will be on adaptive complexities of their flexible structures. Man-made systems, like cities, are constructed and shaped by instant and accumulative human decisions. Metaphorical questions about the possibility of these systems to behave alike are re-raised. It is argued that their emergent (generative) processes according to optimal combinations of physical and visual connections would enhance their adaptivity. A different method, derived from space syntax, provides a new tool for detecting and estimating these adaptive complexities. It provides measurable dimensions, as sensitive indicators, of adaptive complexities and explains how their continual and generative (size-dependence) processes emerge. In (2D) systems, it is found that organized complexities have adaptive dimensions of fractal values approach to ( $D_A \approx 1-2$ ). Also, from results on the grounds, each existing urban fabric has a structure with a specific and comparable local and global adaptive dimension. More supportive researches and applications in various (2D) and (3D) systems are needed to develop the concept.

**Keywords:** Adaptive complexity, Self-organizing, Size-dependence, Space syntax, Adaptive dimension ( $D_A$ )

---

### Corresponding Author:

Author Name, Hassan A. Al-Guesbi  
Departement, Department of Architecture  
University, University of Babylon  
Address, Hillah, Babel, Iraq  
E-mail: hassanalguesbi@uobabylon.edu.iq

---

### 1. Introduction

A unified theory for living patterns is targeted. It depends on new integrated concepts of both adaptive (energy-preserving) and survived (information-maintaining) complexities. Adaptive complexity and its emergent inner-organizing structures are discussed here. While survived complexity, which reflects the evolving outer-occupying structures, was presented elsewhere in other parallel paper. Natural, sustained and healthy systems have living patterns of optimal (adaptive and survived) complexities. These systems, with suitable mechanisms, react and respond to different stimuli. They try to seek, conceive and organize their complexities according to the same rules of contraction and relaxation that govern all living systems around. Rationally, they are all considered to be economic ordered structures that connect to each other compactively. The continual and emergent patterns' processes reflect deep implications of the society as a whole. Christopher Alexander had defined the "pattern" as a solution space for recurring architectural and urban solutions. He claimed that similar solutions embody invariant patterns at different times and in different cultures. Also, he referred to structures with higher degrees of wholeness as living structures. Wholeness is defined mathematically as a flexible and recursive structure, and it exists in space and matter physically and reflects in our minds and cognition psychologically [1]. A related question about having adaptive structures with acceptable amounts of self-organized complexities similar to those of organisms and human living qualities is under discussion.

Systems are adaptive only if they have specific mixtures of internal and peripheral connections. Otherwise, they are merely assemblages of components. Adaptive complex structures are geometrically and topologically coherent because of their preserving potentialities and their correlated information in and across their different sizes. Life in the built systems depends greatly upon compactivity and connectivity, with all possible number of connections between components, and with the overall gained information. Separation instead of integration between physical and visual connections kills living systems.

It is argued that our common sensation of complex structural configurations can be detected and estimated by mathematical formulas that testifies structures in relevant to existing, living and natural, ones. The research is

limited to (2D) structural configurations of theoretical drawings and vector images of existing and well-known adaptive patterns. The results are approximated to fracture numbers of three digits to make the calculations and comparison. They offer a mechanism to calculate the degree of self-organized complexity of any (2D) structure under scanning. Also, these measured degrees of complexities can be compared with other degrees of peer (existing) living structures. In naturally growing structures, spatial components react to different stimuli to economically preserve their powers. They altogether seek for self-interweaving and well-compacting at each generative process to keep their energies. The trend is to abstractly mimic the generative processes according to simple analogical rules. Most adaptive systems have flexible self-organized structures. Wondering about how to erect and organize these structures in man-made systems, in relevant to that of living systems, is the big issue. Man-made environments are considered to be means of human communications that reflect and combine the brains' structures of the designers with those of the observers. The complexity of urban systems is intimately related to their structures' adaptivity. Living cities have systems with flexible structures that feed their organized complexities with the daily human-scaled activities. They are defined as "fine scales characterized by the human body and its surroundings... Scales that are directly visible, touchable, and appreciable in a person's daily life" [2]. So, they are inevitably affected by architectural environment. Also, they will be in continual and emergent self-organizing of their complexities accordingly. Generating similar adaptive structures in human networks is a suitable approach to guarantee desired complexities and to testify such premises. Like organisms, complex systems promote human life with dynamic images. They solve similar problems by generating adaptive processes and movements [3, 4]. Unfortunately, people are forced every day to live with contemporary architecture and urbanism in opposed to their traditional human values. From one hand, losing older buildings of instinctive style and timeless values is unforgettable. On the other hand, gaps at the levels of small human (size-dependence) processes, would destroy urban coherence.

## 2. Method

### 2.1. Patterns and adaptivity

Human adaptive patterns are sustainable solutions to different problems across time, culture and climate. They reflect an essential relationship between geometry and human actions. They embody systems of continual self-rearranging and re-organizing structures that correspond to various inner and outer effects. These flexible structures depend greatly upon initial conditions, emergent generative processes and continual changes. They would be developed organically, in the opposite approach from generic, industrial design, to have both physical and human characteristics[5]. Most adaptive patterns had been intuitively used and re-produced by different people for their efficiencies. Any system that respond to human beings has specific geometrical and topological properties of connectivity and compactivity. Each component in their structures tries to connect physically and visually to each other in shortest ways, as a natural tendency, to preserve its existence in a coherent whole. They, optimally, organize physical and visual information to prevent randomness and sensory overload. These patterns are sustainable versus the anti-patterns of inhuman solutions that destroy the built and the natural environment. The resultant self-organizing structures reflect specific combinations of geometrical and morphological properties accordingly. The morphogenesis of the embryo, for example, implies quantitative processes and qualitative products together. From one hand, it makes a gradient in the system's energy resulting from self-organizing wholeness of its spatial structure by compactive arrangement in given conditions. On the other hand, it reflects a general tendency toward simple connections' rules to maintain and guarantee the flow of information. 'If the cells in the embryo "know" where and when to change shape, contract, or move, then it begins to be possible to envisage a program for the development of form" [6]. The varied adaptation of many elements in a complex system is related to compactive and connective tendencies of their structures. Cities are, basically, dynamic systems with different patterns of continual, generative and emergent, processes. When all of their structural components are related to each other, in a way enhancing human needs and utilities, the resultant urban fabrics would have adaptive structures that truly reflect these needs. Physical and visual aspects in their (2D) networks' structures would be at a balanced state of compression and tension respectively. They try to keep their (steady-state) of equilibrium while emerging or fracturing across multi-sizes (size-dependence). Their components are of piecemeal growth. Accordingly, they try to generate something new that is related to their initial conditions or to restore their previous equilibrium when they imposed to external interventions. Any fabricated living networks or urban systems imply genetic programs of all probable and adaptive processes. They reveal adaptive structures that reflect their, physically and visually, self-organized spaces. This could be searched, defined and used mathematically according to multi (size-scanned) regions of their complexities. We need to bridge the gap between geometrical and topological properties that applied to urban fabrics by using axial and visual maps together in a new interpretive syntax of spaces generated by sustainable processes for the

purpose of adaptivity. Each emergent step or process should interact with that already exists and with the previous ones. By time, traditional urban paths had produced successful fabrics that obey human scale. Designing according to such generative codes would guarantee having adaptive environments. Most effective choices of adaptive solutions in living urban fabrics are made by local people who live there. A systematic germination by designs accelerate the transformation of the present (mutations) to possible futures. According to [3, 7], it is called futurecraft that empower people to make better choices about where they live. Synthesis of adaptive patterns produces uniqueness of the great genuine works. Traditional architecture emphasizes generative processes that introduce variety just as in natural environments.

**2.1.1. A new interpretative space syntax**

Space-syntax can analyze structures of different systems according to their geometries and topologies. The common definition of this term is related intuitively to the notions of shortest paths with least angles direction changes and higher levels of integration. They both indicate preserving principles of highest degrees of potentialities. Sustainability of different adaptive systems rely on their emergent and continual processes to create networks of harmonious whole. Spatially existing (physical) connections between structural components tend to integrate with all possible (visual) connections in a way that preserve and keep the whole system in a (compression-tension) equilibrium. Shortest physical connections with the fewest changing in direction versus largest visual connections are adopted as representations of adaptivity. A curve line shape, for example, can be constructed by approximate straight segments of connected lines with specific lengths. Larger-sizes with visually rich structures might reveal new topologies that differ from their origins. Within space syntax, precedence is given to linear features such as streets, in contrast to points that approximate locations [8]. Total length of effective links (physical and visual connections) within specific areas are important factors to understand geometrical and topological characteristics. Figure (1) illustrates a simple (axial-visual) map of a (2D) mono growth model. It explains how the total number of both, physical links (*segments/S*) and visual axes connections (*V*), work and relate in artificial (2D) dynamic structures of piecemeal growths with their all probable configurations.

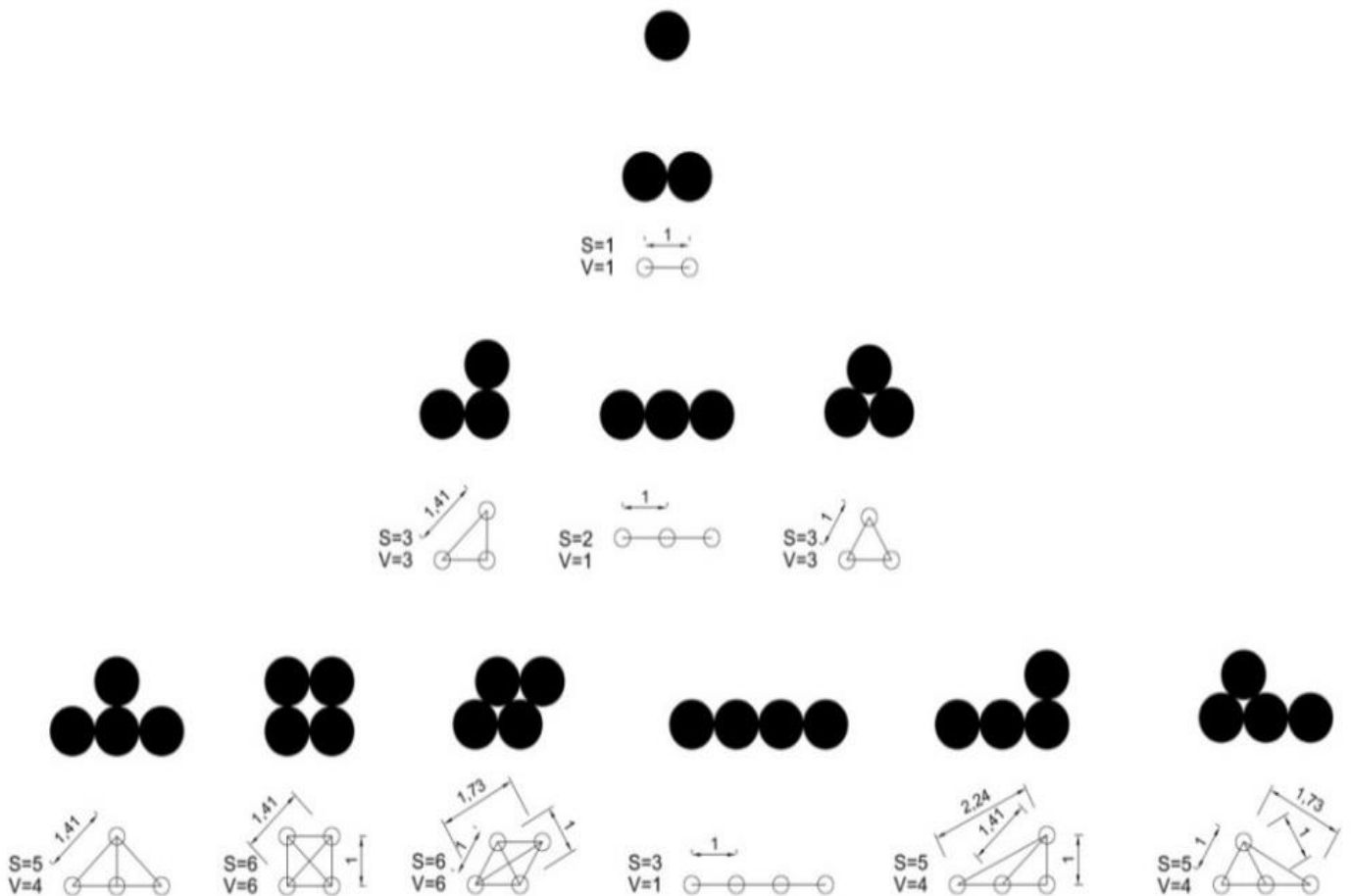


Figure 1. A simple (axial-visual) map of a (2D) mono-growth model with all probable structural configurations

In practice, the research provides another tool to measure geometrical and morphological properties together by a new syntax of spaces. This tool produces new adaptive dimensions ( $D_A$ ) for (2D) structures that can detect, explain and control their behaviors. In my opinion, it differs from fractal dimensions ( $D_F$ ) which detect self-similarities and assume suitable behaviors across multi scales without the ability of specifying, firstly, whether these scales imply healthy or living processes, or how or why? In addition, there is no need for more than one level of magnification to make the calculations with these new adaptive dimensions. Each instant tiny process reflects distinctive shape with specific geometrical properties (like: area ( $A$ ), perimeter ( $P$ ), number of vertices...) and topological properties (like: number and length of physical and visual connections ( $N$ ), total length connections ( $L$ )...). It determines whether each, emergent and generative, process is properly configured and shaped according to suitable adaptive dimensions in relevant to comparative desired structures. Hence, the focus would be on (size-dependence) living processes which are acting at the same level of magnification instead of their fractal properties (scale-dependence). Real actions and behaviors in urban networks start with nodes (vertices or junctions) and then facilitate paths formation. Junctions are placed so as to be physically accessible and the connective networks link all these junctions together in a way that makes life more joyful. Configurations of spatial structures can simplify reality. In space syntax, the focus is on lines, not points, streets or corridors, or the junctions that anchor them in a two-dimensional space[9, 10]. Street networks with more people attract more activities to be located along them. "They are considered to be one significant component of urban structures and serve different urban functions for sustainable development, including commercial, traffic, industry and landscape-based functions"[11]. These paths reflect networks that connect urban spaces by multi efficient choices. The more activities to be located along urban paths, the more they attract people. In modern cities, paths in grid-iron patterns provide more fragmented physical links (*segments/ S*) than extended visual straight axes ( $V$ ). One visual axis with specific length might compose of infinite number of physical segments ( $S$ ) with decreasing lengths. Space syntax makes it possible to develop a set of theories about how urban spaces networks are related in general to the social, economic and cognitive factors which shape them, and how they are affected by them. Jacobs (1961) argued that the pedestrian activities on the street are the most significant indicators of cities' life [12]. It is possible to analyze systems of past networks patterns using historical maps and correlates the results with recent patterns of networks that still alive and work. "Configurational analysis represented by the method of space syntax allows the modeling of a city that link intuition and science, and it can be used for designing and planning cities, as well as in research" [13]. Integration of networks embodies wide-range of quantitative and qualitative determinants of the whole urban life.

### 2.1.2. Adaptivity and self-organized complexities

Daily *living* human-scaled activities feed generative (*adaptive*) processes and evolved (*survived*) solutions. Each system needs suitable and piecemeal self-organized complexities to hold its own structure, to run and work *adaptively*. Adaptive systems have different degrees of self-organized complexities as indicators of potential energies. The acceptable and required complexity is neither of excessive simplicity nor randomness. Rationally, when each structural component is suitably connected to the rest components, they can all cause the whole system to be adaptive. Hierarchies of different, shortest physical and largest visual, connections link up inner structure within itself and with the outer surrounding environment. "Life is the transformation of energy into information. Organisms developed means of preserving their discovered (evolved) structure by means of genetic (emergent) information" [14]. The focus will be on structures that tend to manage *physical* and *visual* differentiations successfully to keep and to preserve their richness and energies within high levels of self-organizing. Natural sustained systems pass time-tested challenges successfully. They have proper self-organized complexities in relevant to suitable surviving tendencies. It is important to know how to qualify the degree of complexity in a structure to calculate the amount of energies and how they are distributed. Tightly-self-organized complexities are coherent because of the ordered structures they have which reflect large internally coordinated and preserved energies. The continual generative processes of natural and living systems entails a reorganization of their spatial structures, including the emergent rational hierarchy of *physical* and *visual* connections. Different configurations of these connections on all sizes could be optimally perceived as a coherent whole. The usual step-by-step generative processes method for studying any natural or complex adaptive systems are adopted by:

1. Depicting and observing their instant and piecemeal structures.
2. Analyzing and evaluating their present behaviors whether they are healthy or pathologically diseased.
3. Estimating their overall general-state and predicting their future behaviors.

4. Deciding and intervening, whether to change the position of some specific components or remove them or replace them, to create healthy structures, instead. We as humans belong to nature. Our life permits energy to flow optimally by well-organizing of system's complexity. In other words, we give energy to life processes [15]. Systems die when their structures are no longer capable of organizing themselves properly to preserve their energies or to guarantee the flow of information. Adaptation generates useful complexities through feedback from the environment. "Energy cycles driving living processes actually fit within a very different complex geometry adapted to people's needs" [14]. When actions and behaviors melt together without any neglecting or dissipating of each energy, proper self-organized complexities are achieved. It is just like the recycling metabolism in organism to get rid of weak components and unused residuals. For architects, the challenge is how to manage adaptive and survived complexities to respond to different real limitations on many different sizes and scales. Humans prefer straight-line connections because they naturally try to save their energies by reducing bodies efforts to the minimum. Visual symmetries optimize energies exhaustions according to human brains [13]. Each adaptive system appears totally distinct on the surface when it has a structure of a high level of tight organization. Accretion or reduction of subtle bifurcations to those structures affects their complexities. That depends on the tendency of a process to realize the most possible and optimal state. Suitable self-organized complexities should compromise between easiest ways to access and direct axes to reach. Theoretically, matching between physical and visual axes ensures more effective and functional design. Furthermore, having optimal combinations of both, physical and visual connections, can keep structures adaptive, see figure (2).

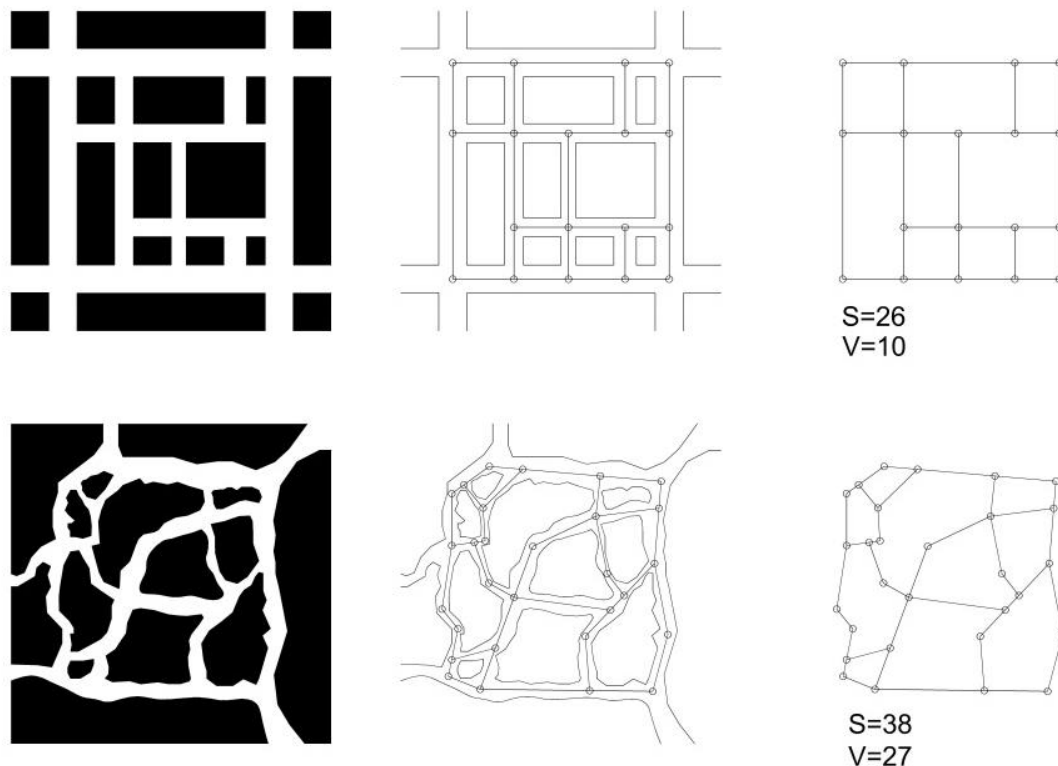


Figure 2. Grid-iron and irregular artificial patterns of the same bounded areas might be of different interpretive space syntax

Adaptive systems would behave properly to organize their structures. Space syntax analysis in an urban fabric can express and identify the deeply interwoven spatial form of self-organizing processes with the people's day life behaviors and choices[16]. From one hand, cities are profound systems to be controlled because of their living characteristics, as organisms, that respond continually to different stimuli. On the other hand, they are not simple machines or inanimate entities that are entirely controlled by external forces. So, their living structures should come from both, adaptive and survived patterns of behavior, that need to be unified. These patterns' methods are adopted to manipulate, explain and understand spatial structures. Cities are formed by individuals' generative and adaptive processes that try to keep their self-organized complexities. Adaptive structures have

emergent properties that are created by partially breaking up large self-organized segments to generate smaller components due to different forces. All the time, fractality and cellular automata generate new well self-organized complexities[17]. One might wonder about the ability of having mathematical formulas to explain the relationship between geometrical and topological characteristics in a specific urban area. "Street-level urban functions contain both physical characteristics and socioeconomic information that serve human activities" [10]Traditional human-scaled environments with the same basic urban generative codes of networks provide adaptive patterns of livable solutions.

**2.2. Field of influence (the visual field)**

Living systems, whether natural or artificial, declare themselves as adaptive and survived structures in equilibrium. They are in a balanced state of tightly physical and expansively visual connections. Examining enormous number of all probable small connections is of great help selecting the optimal organization. Visual connections instantly connect local to global components. When components are split, merged or aggregated, they would behave differently within their bounded areas (fields) of influence. Opposing forces acting in these fields, starting from the two adjacent (pair) nodes (vertices) up to series of straight connected ones, keep the whole distinct system in balance. Visually concluded parameters have crucial inter-correlations with different implied and internal behaviors. People always try to orientate themselves through their built environments. Designing according to visual connections, that integrate with the shortest and minimum number of changing directions, is a reliable approach to have whole and coherent complex structures of similar behaviors. Urban fabrics try to fix, keep and preserve their existence. After reaching specific limits of compactness, they tend to extend either horizontally or vertically according to different determinants. Horizontal diffusion is almost preceding vertical extension to achieve optimal compromising of adaptation. Each (2D) system has its own field of influence (visual field) according to its own structural configuration. Usually, extensive visual connections (edges) between border nodes (vertices) would frame and define a specific bounded field of influence. Each visual field has its own geometrical properties (like area (A), perimeter (P), number of components (N), number of physical segments (S)). Also it has topological properties (like visual (V) connections and total length of connections (L)). The new method is based on the notion of how to combine and formulate these variables altogether mathematically. The organized complexity of the resultant flexible structures could be scrutinizingly analyzed. Visual field might be extended linearly, be porous or irregular and fractal. Figure (3) explains what is meant by visual fields according to peripheral, visual and bounded connections between border components that contain and hold all other components.

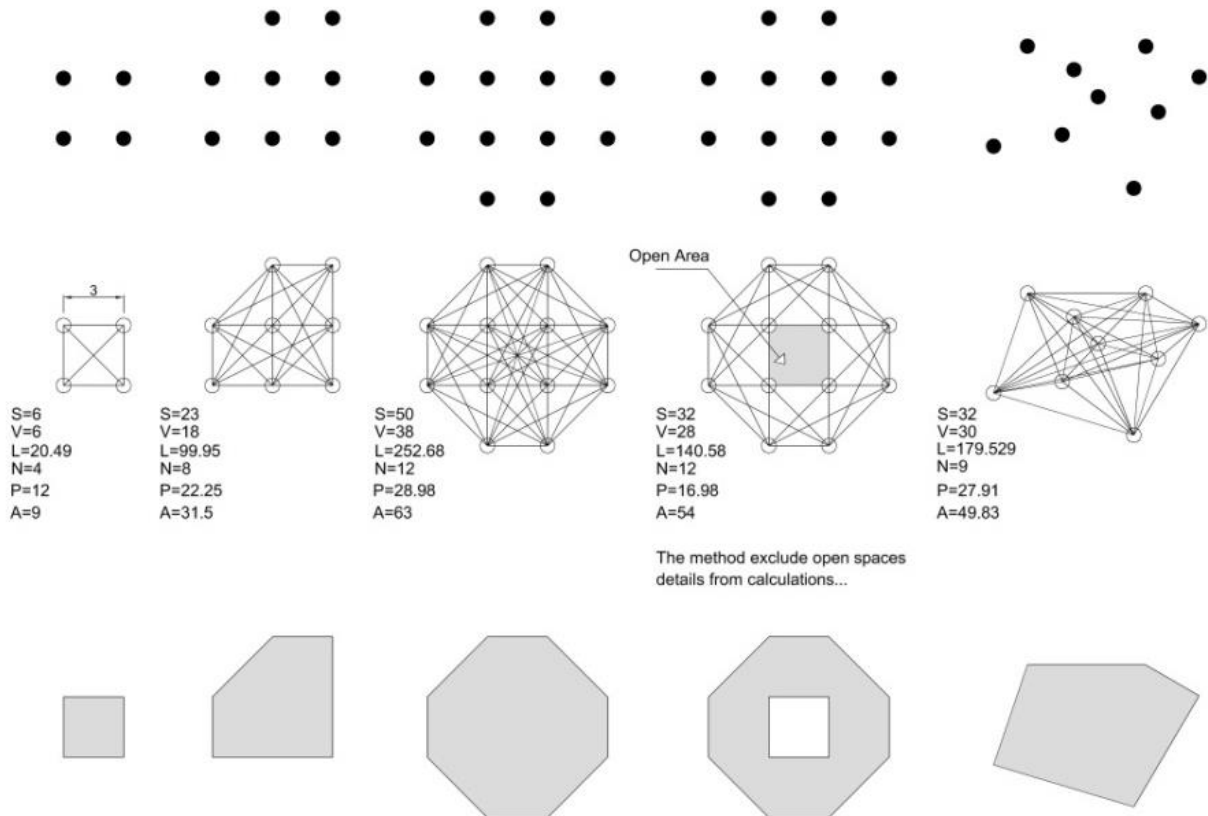


Figure 3. Various visual field of different (2D) structures

Let's propose that we have accumulated, aggregated or proliferated polyominoes of (mono-cell) square unit's configurations. Every single component of an adaptive structure tends to connect to each other in shortest ways. They will interact and shape a field of influence with distinct geometrical and topological qualities. The overall visual field and its bounded area might have internal voids (open-spaces) that would be excluded from the calculations. According to the three basic plane symmetries (reflectional, translational and rotational), a step-by-step model is developed to describe all probable generative processes in relative to an initial (mono-cell) unit. Figure (4) shows a series of probable (mono-cell) aggregation levels in a (2D) model with their topological and morphological qualities. The question is about having spatially alike properties and behaviors across different adaptive fields of influence (visual fields).

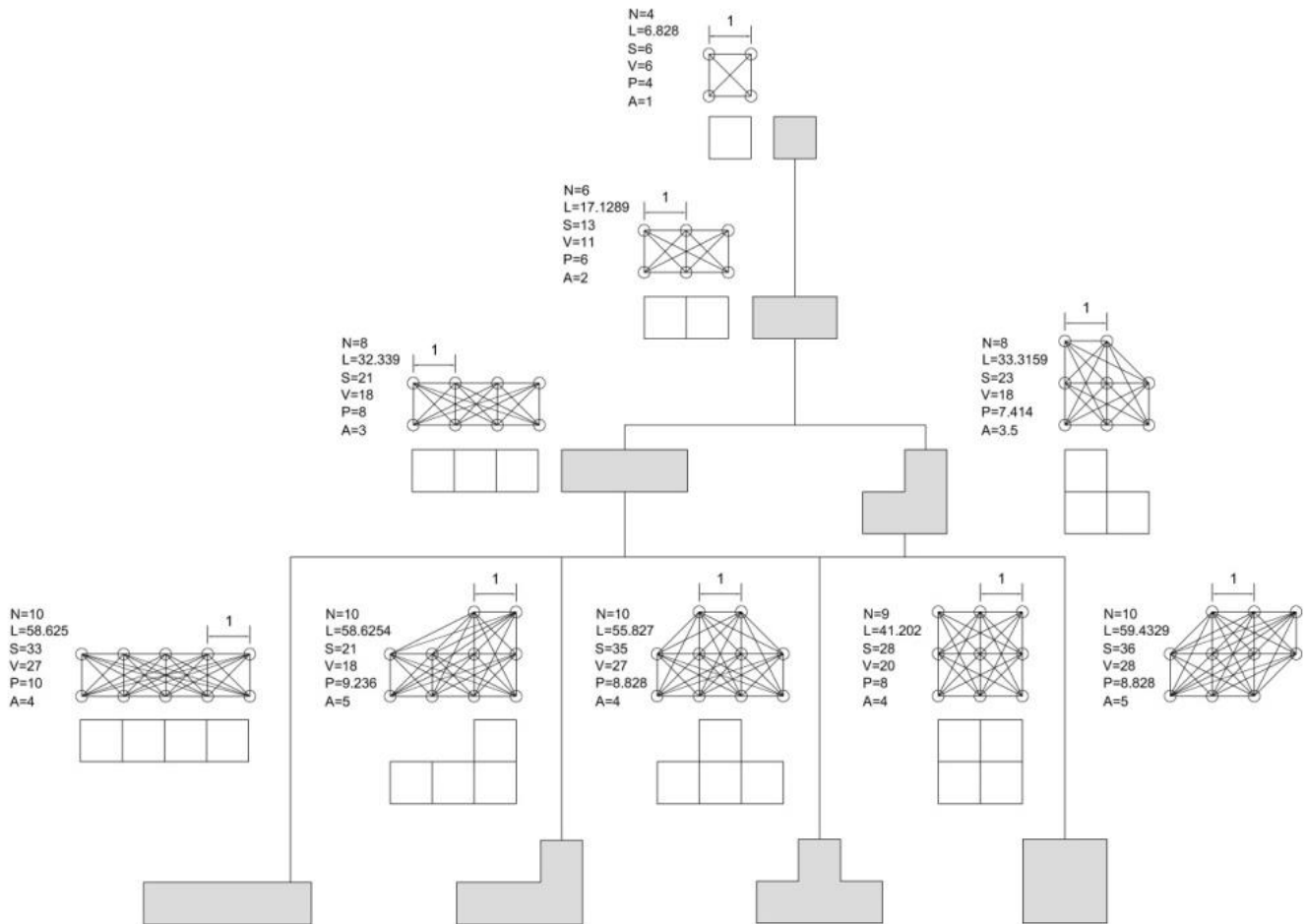


Figure 4. A (2D) model of consequent aggregated polyominoes with all probable configurations

### 3. Results and discussions

#### 3.1. Calculating adaptive dimensions ( $D_A$ )

All the time, human beings develop physical and visual modes of adaptation. They respond to different stimuli physically (by movement) and visually (by interaction). Physical actions and visual information are of mutual interactions. It is necessary to explain how these systems react and respond adaptively. Living complex structures are plausibly of continual re-organizing and managing of themselves. Each of their components is linked directly and indirectly to each other's. Their total number of components ( $N$ ) and total length of connections ( $L$ ) change accordingly. Direct connections between two adjacent points in axial maps are defined as physical connections. Other straight connections, which might sensibly extend and pass across two or more components, are presented as visual connections. Hence, they compose of one or more segments of physical connections. Intuitively, a visual field is determined, framed and specified by peripheral connections whether they are existing (physical) or perceivable (visual) connections. Normally, outer configurations are sensitive to inner behaviors. They are both affected by physically compressed and visually tensioned connections. It seems that each field of influence gathers all components, pieces and segments with different connections' lengths in one visually tight unit. They are hold together to define a specific visual field with a unique combination of compact area ( $A$ ) and single tensioned perimeter ( $P$ ). It is claimed to have a new calculable adaptive dimension

( $D_A$ ) to estimate related geometrical and topological properties. The new method of calculation depends greatly upon analyzing (2D) shapes according to their (physical-visual) connections in relevant to their different (peripheral-internal) behaviors. Each distinctive structure has a unique configuration of a specific adaptive dimension ( $D_A$ ). Intuitively, adaptive systems' complexities are flexible structures that try to keep and preserve their existence. They try to maximize their compactness (shortest physical connections with minimum number of changing directions (depths)). Also, they tend to maintain and increase their potentialities of connecting and sprawl to their maximum extension (largest visual connections with maximum number of changing directions). Summation of these physical and visual connections ( $S+V$ ) is used as a crucial new variable that affects self-organizing of (2D) structures. Also, multiplying the total accumulated lengths of all physical and visual connections ( $L$ ) by the total number of components (nodes or vertices/ $N$ ) are used as ( $L \times N$ ) for the same purpose. The new syntax method of spaces uses geometrical and topological characteristics together in a new mathematical set. Combining these inter-correlated variables in one formula provides a more sensitive parameter with more realistic and unique explanations. It presents a method of quantifying systems according to both, their geometrical and topological aspects. The concept depends mainly on having a parametric motif segment ( $\frac{L \times N}{S+V}$ ) that distinguish each (2D) structure. It differs from the arbitrary chosen segment that used normally in space syntax as an initial or a starting segment to begin with. This rational fracture is considered to be a new system's fingerprint, see figure (5). It is rationally proposed that this detective variable is related simply (linearly) to the trend of the bounded perimeters ( $P$ ) to extend, while it is in a planar (quadratic) relation with the trend of the actual areas ( $A$ ) to compact. Accordingly, a resultant logarithmic formula, which provides a new adaptive dimension ( $D_A$ ) of (2D) structures, is calculated as:

$$D_A \left( \log \left( \frac{LN}{S+V} \right)^2 - \log A \right) + \left( \log P - \log \left( \frac{LN}{S+V} \right) \right)$$

- $N$ : Total number of vertices within the whole visual field.
- $L$ : Summation of total, physical and visual connections, lengths (excluding those surrounding solids or penetrating internal open spaces holes).
- $S$ : Number of all probable direct (physical) segments' connections that link vertices altogether (excluding those surrounding solids or penetrating internal open spaces holes).
- $V$ : Number of all probable extended (visual) connections that link vertices altogether (excluding those surrounding solids or penetrating internal open spaces holes).
- $P$ : The surrounding perimeter length of the whole visual field (excluding those surrounding solids or penetrating internal open spaces holes).
- $A$ : Total area of the whole visual field.
- $D_A$ : The adaptive dimension.

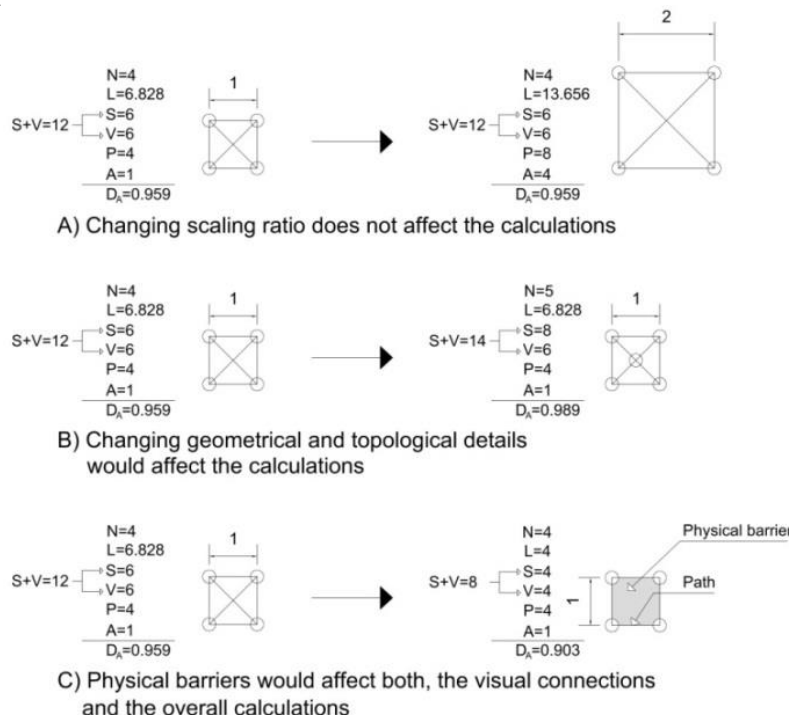


Figure 5. New different fingerprints for (2D) structures with different limitations.



Dense spatial structures within specific areas have more adaptive abilities depending upon their organized complexities. The rougher and fractured structures, the more complex they are. The more (2D) structures' fractality, the more degree of complexity, occupancy and entropy they have [9, 18-20]. Figure (6) shows how the adaptive dimensions of real constructional trusses can detect their self-organizing complexities comparably.

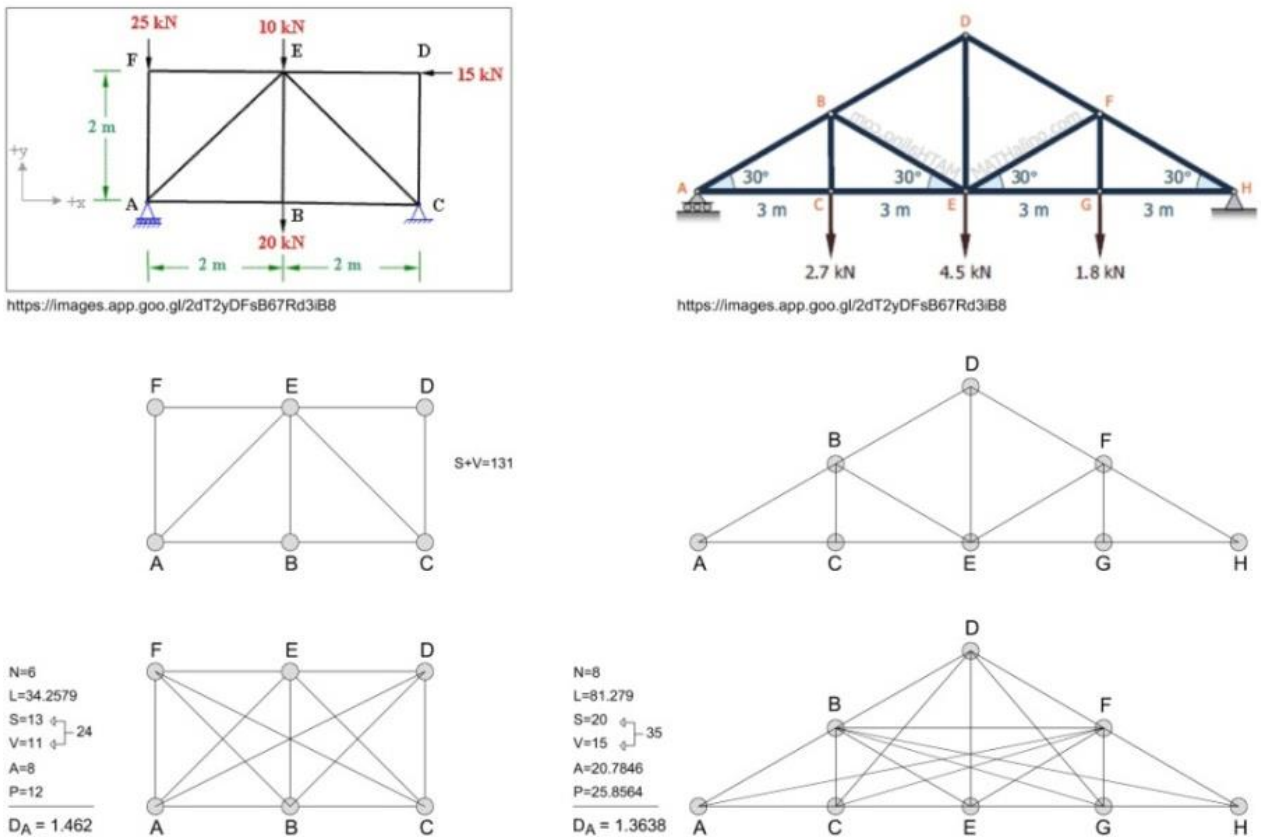


Figure 6. Adaptive dimensions of real constructional trusses

Any accretion or reduction of components or connections to existing structures affects their whole organizations. Figure (7) presents a theoretical model to show that the resultant complexities could be adaptive (not random) when suitable processes of self-organizing are followed.

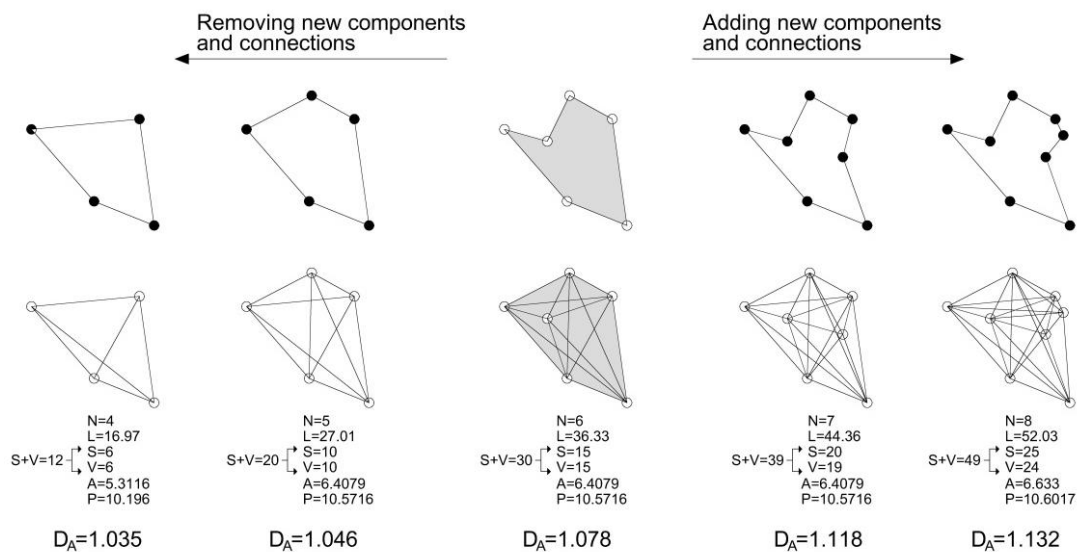


Figure 7. Adding or removing components affects systems' adaptive dimensions

Similar ways of calculations to estimate the adaptive dimensions of other livable (2D) systems can be adopted for the same purpose of comparison. For example, regarding heart normal ECG complex shown in figure (8), it is possible to recognize healthy patterns by these dimensions. This would be of great help diagnosing different heart disorders.

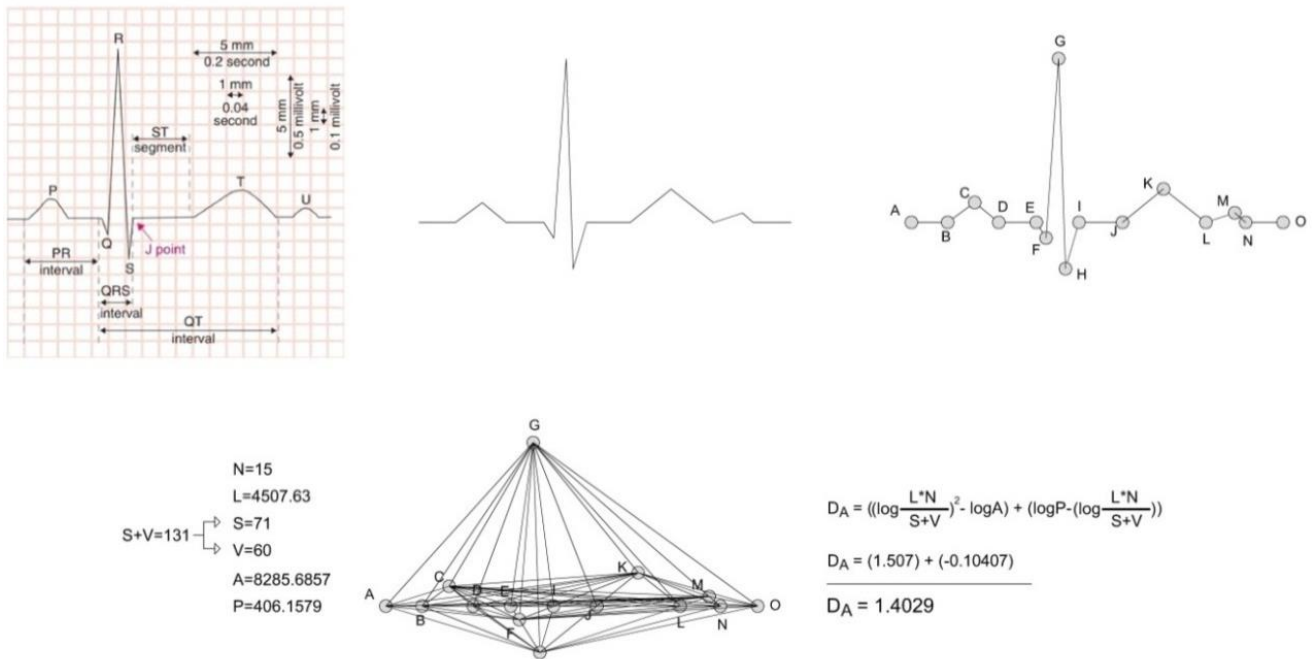


Figure 8. Incription of a normal electrocardiogram (ECG) reveals a specific adaptive dimension of ( $D_A=1.4$ ) [21]

Wonders of music are livable signals of life. They reveal harmonious, integrated and coherent wholeness of their patterns with similar adaptive dimensions. Legendary musicians can feel this rhythm spontaneously. Figure (9) determine how these similar adaptive behaviors of the great Beethoven symphony act in harmony.

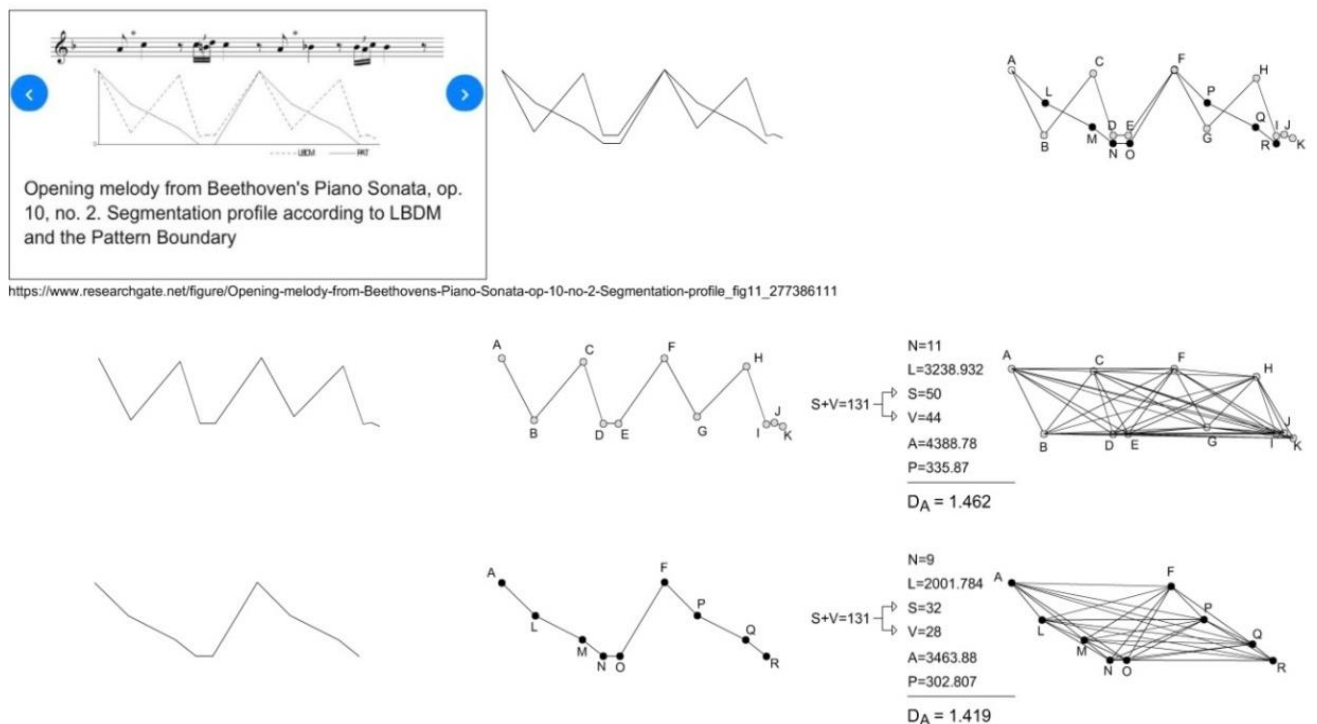


Figure 9. Flowing patterns of livable music act similarly according to their adaptive dimensions

On the urban scale, deliberately elimination of existing structures, by imposing ideal shapes or creating large-scale symmetries without self-organizing, would destroy any urban fabric. Some urban fabrics die out, whereas others become popular because of the adaptive tendencies of their inhabitants' needs and the survived qualities of their responses to coexist with their surroundings. Self-organizing of human movement requires both, linear and curved, urban paths connections to achieve overall coherence like traditional urban fabrics of irregular patterns. While, grid-iron modern cities lack these integrations because of their distinctive straight paths connections. In other words, adaptive systems are integrated when their physical and visual connections are combined according to these new geometrical and topological rules. The new adaptive dimensions have values of ( $D_A$ ) that approach to ( $D_A \approx 1-2$ ). They can detect and estimate adaptive tendencies of different (2D) systems. One can observe and compare these dimensions with the dimensions of peer successful systems to make suitable decisions and actions.

### 3.2. Urban fabric scanning

Fabricated urban structures have proper self-organized complexities if they were generated and guided by suitable adaptive dimensions ( $D_A$ ) in comparably. Imposing abstracted geometrical shapes, as essential geometries, have catastrophic consequences for individual buildings and urban fabrics. Instead, it is better to seek flexible structures with rich information of suitable self-organized complexities. Adaptive complexities in architecture and urban design imply selecting according to local climate, culture, materials... in addition to human needs. They refer to fitting the human being's responses and behaviors with familiar healthy examples according to a specific range of adaptive dimensions ( $D_A \approx 1-2$ ). Urban systems depend greatly upon adaptive patterns, as sets of fundamental human behaviors, that shape buildings and spaces accordingly. Most modern city planners imposed simple shapes while ignored inherited patterns of proven solutions. They reduced the richness of urban complexity by imposing simplistic geometries on urban fabrics deliberately or ignorantly. They, blindly, replaced essential living patterns by empty died suburbia and giant buildings which ran improperly and failed to recognize or match with the adaptive complexities of past cities. Batty argued that the future city is not predictable since the city is a complex, intricate, and indirect organism that grows primarily based on spontaneous bottom-up processes, but is invented by the individuals of the contemporary society [22]. We need to discover scientific reasons for city shapes, processes, and behaviors in order to understand how things work. One might wonder: what makes a particular piece of urban fabric healthy? Are there any specific apparent qualities concerning its spatial structure that might be helpful? The focus here would be on "design by image". In other words, visual-design approach would be an implication of tremendous geometrical and topological complexities of other variables like: socio-geometric, emotional, cultural forces... The adaptive dimensions of the resultant urban fabrics, reflect their behaviors within the built up physical and visual spaces. First, it is important to specify pathological paths and ill-fabrics spots. Then, we have to think of possible changes and transformations in their structures to fix the problem. Suitable interventions can be the healing treatment. This might require something to be destroyed to erect new different things, like functioning urban nodes that concentrate paths connections and keep them alive. In this case, we can help by sacrificing the unhealthy parts to repair the urban fabric. Wasting human energy and fossil fuels by bad designed and distributed urban network connecting would produce dysfunctional because the essence of urban life are not facilitated by the geometry of the built environment [23, 24]. We also need to learn from organic growth of traditional architecture and vernacular settlements. They were innately built to follow biologically-based and emergent rules. Human-scaled environments depend mainly on the continuous and piecemeal daily life activities. Can and Heath (2016) propose that social interactions are highly reliant on the connectivity of the streets, and the in-between spaces are crucial for the presence of the interactions[25]. Over time, desired qualities in urban fabrics could be improved by applying these adaptive tiny details. "Human-scale living convenience, or convenience of living, is a perceptual quality of life. It mainly refers to a fine scale related to the human body and human behaviors, which people can see, touch, and perceive in their daily lives"[2, 4]. Sometimes, imposing aesthetic mega structures that violate living cities might destroy instead of treat existing ill fabrics. Each urban structure tries to adapt itself to human physical and visual satisfactions within an acceptable range of organized complexity. Cities are sustained by connections and interactions of their transports and networks. They are considered to be distinct collections of actions and information. Size-dependence properties of cities could be presented by axial and visual maps of streets networks. Urban paths and spaces are tested in network cities for their functional tendencies to connect and to preserve the existence of urban life. Through their location and design, urban paths and plazaz can optimally compromise between physical and visual connections. Decomposing a city into equally complex components is useful for better understanding of urban forms and

functions. Results, from existing urban fabrics on the ground, prove that it is possible to compare between two fabrics according to computable values of their adaptive dimensions. These sensitive dimensions detect and guide interventional actions correctly. Figure (10) provides a sample test to decrease the value of the adaptive dimension from ( $D_A=1.215$ ) in a grid-iron pattern. It matches a theoretically desired value of ( $D_A=1.16$ ), which is similar to that of a healthy postulated irregular pattern, by suggesting a suitable urban open space.

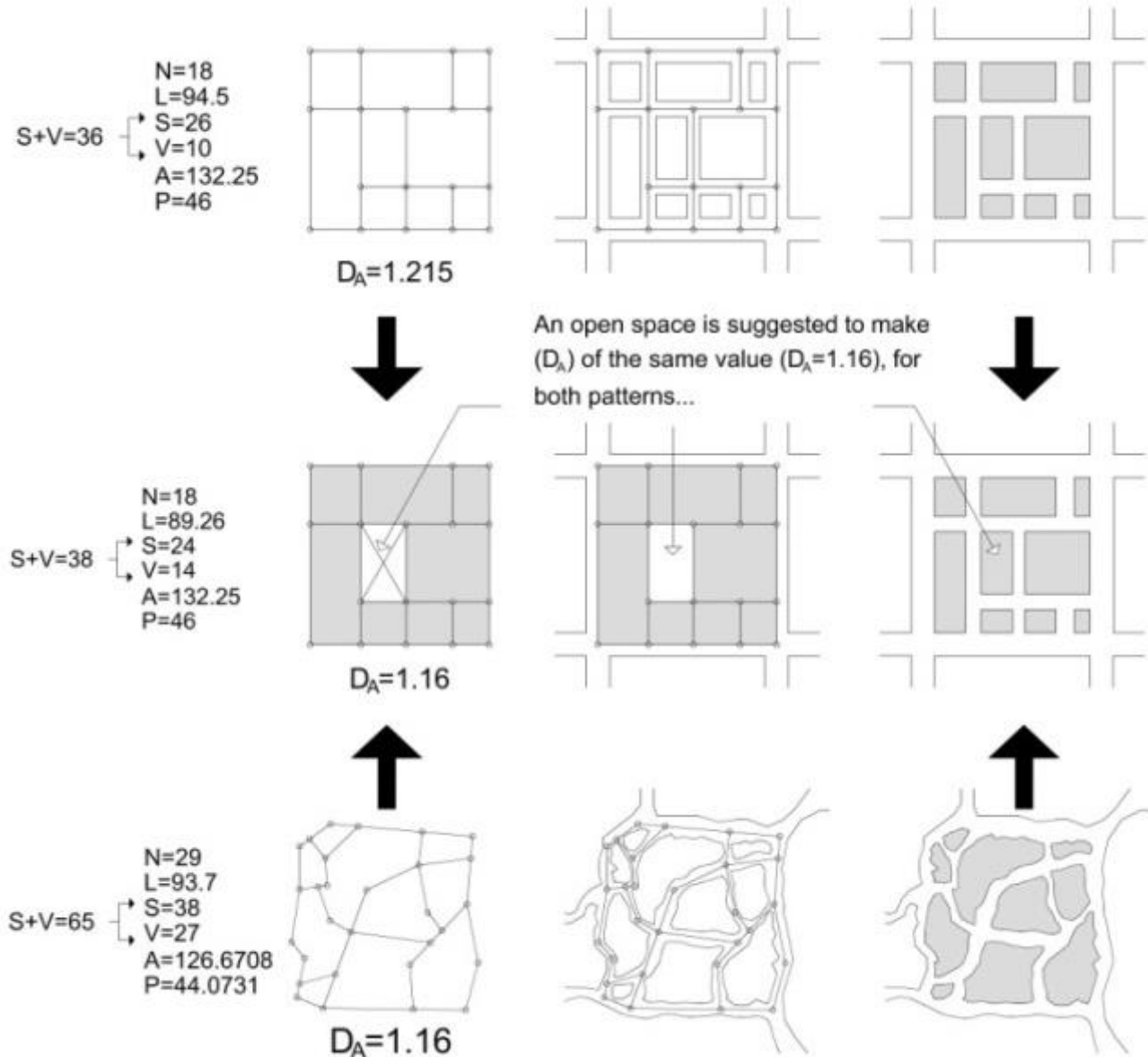


Figure 10. A postulated sample test of a desired intervention depends upon ( $D_A$ ) as an indicator of adaptive complexity

The new method of calculations provides a mathematical tool to examine existing fabrics. It can depict their peripheral and internal behaviors together. Intimately, adaptive dimensions of urban structures indicate their self-organized complexities. Urban fabrics are coherent combinations of *physical* and *visual* connections. Like ornaments and decorations, they show different complexities across many local and global (size-dependence) scanning. They could be used in pointing and orienting user's actions to proper sizes correctly. Natural growth and generative processes of urban structures try to keep their self-similar behaviors. They tend to have the same geometrical and topological properties at many different sizes. In such cases, cities networks connections are presented by high number of shortest lines and low number of longest ones. According to figure (11), which is based on the work of [7], we can distinguish different urban structures with different sizes according to their adaptive dimensions. This is useful to determine where, when and how to interfere for better living aspects comparably.

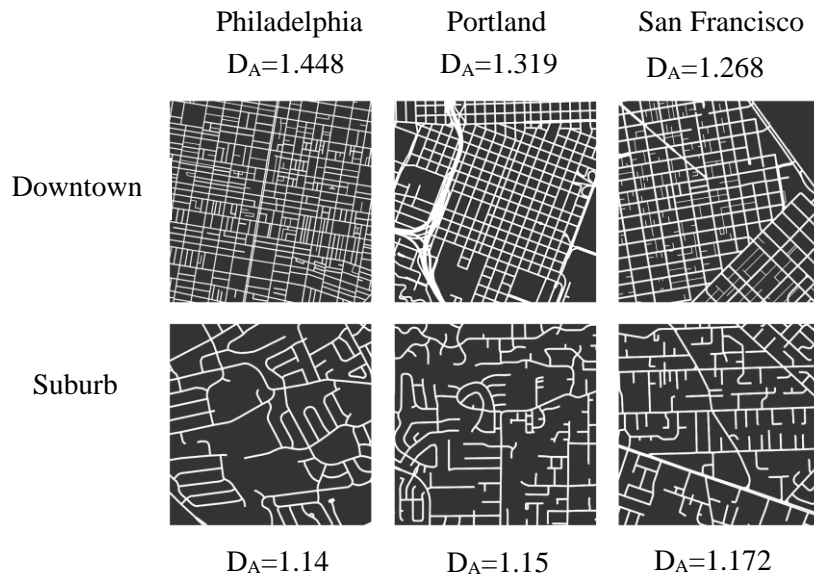


Figure 11. Calculating adaptive dimensions ( $D_A$ ) for different American cities, based on the work of (Boeing, 2017)

#### 4. Conclusions

(2D) systems are livable only when they achieve both adaptive and survived complexities. The focus would be on adaptive complexities while survived complexities are presented elsewhere in another separate paper. Sustained and living systems can express their lives by their structural configurations. Each adaptive (2D) structure imply a specific self-organized complexity which properly optimizes human uses and needs. These adaptive structures respond to changes by similar behaviors across continual, emergent and generative processes. Their dynamically self-organized processes can be depicted and mathematically estimated by new adaptive dimensions ( $D_A$ ). They are considered to be sensitive detectors of systems' behaviors under different conditions and stimuli. Endless changes of life could be of further interpretations and predictions in more promising methods. From one hand, it is found that different systems of different structures might be of similar responses and have equivalent adaptive dimensions. On the other hand, other systems might be of similar structures and have remarkably different responses to the same stimuli with other adaptive dimensions. We can sustain our lives by preserving our adaptive complexities and maintaining our survived ones with correct and desired interventions. These new findings need to be of more investigations in future (2D) and (3D) systems researches.

#### References

- [1] B. Jiang, "Spatial heterogeneity, scale, data character and sustainable transport in the big data era," ed: Multidisciplinary Digital Publishing Institute, 2018.
- [2] Y. Long and Y. Ye, "Measuring human-scale urban form and its performance," ed: Elsevier, 2019.
- [3] C. Ratti and M. Claudel, *The city of tomorrow: Sensors, networks, hackers, and the future of urban life*. Yale University Press, 2016.
- [4] H. Tuama, H. Abbas, N. S. Alseelawi, H. T. S. J. P. o. E. ALRikabi, and N. Sciences, "Bordering a set of energy criteria for the contributing in the transition level to sustainable energy in electrical Iraqi Projects," vol. 8, no. 1, pp. 516-525, 2020.
- [5] M. Dudzińska *et al.*, "Directions for land management in rural areas," 2014: Croatian Information Technology Society, GIS Forum.
- [6] B. S. J. U. D. I. Hakim, "Generative processes for revitalizing historic towns or heritage districts," vol. 12, no. 2, pp. 87-99, 2007.
- [7] H. F. Khazaal, H. T. S. Alrikabi, F. T. Abed, S. I. J. P. o. E. Kadhm, and N. Sciences, "Water desalination and purification using desalination units powered by solar panels," vol. 7, no. 3, pp. 1373-1382, 2019.

- 
- [8] G. J. C. Boeing, Environment and U. Systems, "OSMnx: New methods for acquiring, constructing, analyzing, and visualizing complex street networks," vol. 65, pp. 126-139, 2017.
- [9] A. W. Aidoo, "The impact of access to credit on process innovation", Heritage and Sustainable Development, vol. 1, no. 2, pp. 48-63, 2019.
- [10] H. Xing, Y. J. C. Meng, Environment, and U. Systems, "Integrating landscape metrics and socioeconomic features for urban functional region classification," vol. 72, pp. 134-145, 2018.
- [11] D. Zhu, N. Wang, L. Wu, and Y. J. A. G. Liu, "Street as a big geo-data assembly and analysis unit in urban studies: A case study using Beijing taxi data," vol. 86, pp. 152-164, 2017.
- [12] H. Sung, S. J. T. R. P. D. T. Lee, and Environment, "Residential built environment and walking activity: Empirical evidence of Jane Jacobs' urban vitality," vol. 41, pp. 318-329, 2015.
- [13] B. Hillier, "The genetic code for cities: is it simpler than we think?," in *Complexity theories of cities have come of age*: Springer, 2012, pp. 129-152.
- [14] N. A. J. O. J. Salingeros, "Complexity in architecture and design," vol. 36, no. 1, pp. 18-25, 2014.
- [16] B. Hillier, "The now and future of Space Syntax: From structures and models to theory," in *Proceedings of the Ninth International Space Syntax Symposium Seoul*, 2013.
- [17] M. Batty, *The new science of cities*. MIT press, 2013.
- [18] H. T. S. Al-Rikabi, *Enhancement of the MIMO-OFDM Technologies*. California State University, Fullerton, 2013.
- [19] N. S. Alseelawi, E. K. Adnan, H. T. Hazim, H. Alrikabi, and K. Nasser, "Design and Implementation of an E-learning Platform Using N-Tier Architecture," 2020.
- [20] I. Al-Barazanchi, S. A. Shawkat, M. H. Hameed, and K. S. L. Al-Badri, "Modified RSA-based algorithm: A double secure approach," *Telkomnika (Telecommunication Comput. Electron. Control.*, vol. 17, no. 6, pp. 2818–2825, 2019.
- [21] T. Quinn *et al.*, "Effects of prehospital 12-lead ECG on processes of care and mortality in acute coronary syndrome: a linked cohort study from the Myocardial Ischaemia National Audit Project," vol. 100, no. 12, pp. 944-950, 2014.
- [22] M. Batty, *Inventing future cities*. MIT press, 2018.
- [23] M. Mehaffy and N. A. Salingeros, *Design for a living planet: Settlement, science, & the human future*. Sustasis Press, 2017.
- [24] M. A. a. Roa'a, I. A. Aljazeera, S. K. Al\_Dulaimi, H. T. S. J. B. o. E. E. Alrikabi, and Informatics, "Generation of High Dynamic Range for Enhancing the Panorama Environment," vol. 10, no. 1, 2020.
- [25] I. Can, T. J. J. o. H. Heath, and t. B. Environment, "In-between spaces and social interaction: a morphological analysis of Izmir using space syntax," vol. 31, no. 1, pp. 31-49, 2016.