

Human city and physical city: connecting the two by generating syntax-based urban configurations

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Published online: 30 April 2015
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Abstract Cities are complex entities, and their studies are interdisciplinary. Some hunt for finding urban variables; others say a few variables can little capture the essence of urbanization. The reason is urbanization is not only a global phenomenon of physical and cultural restructuring; it has itself become a spatial effect of the distributed networks of communication, resources, finance, and migration that characterize contemporary city life. In this fight, the key question of urbanization has remained unanswered: Are there scientific reasons behind the development of a human city that well exists within its physical form? This paper develops a discussion explaining how a human city interacts with its physical form by revisiting the meaning of city configurations with the help of a newly developed syntax-based accessibility analysis model known as unit-segment model. The discussion also points out that, with current increases in computational power, the unit-segment model can contribute to the field further by answering a fascinating question that syntax configurational studies have helped to frame: What makes a city complex entity while dealing with its behavior and, therefore, the reasoning of its formation?

Keywords Unit-segment analysis · Space syntax · City configuration · Urbanization · Urban variables · Space–people relationship · Human city

1 Background

Urbanization is no longer a global phenomenon of physical and cultural restructuring. It has itself become a spatial effect of the distributed networks of communication, resources, finance, and migration that characterize urban life. The emergence of this global urban culture has had real and complex social, aesthetic, economic, physical, and political effects. Many of these effects, on account of explaining the functioning urban variables that reflect the key attributes of a human city—human interaction and healthy habitation—are still little understood (Paul 2011a; Downton 2009). Because of this, some basic questions of city design have remained unanswered.

Where is the human city (Hillier 2005) behind a well-planned physical city? Or, how can one gain a deeper understanding of the human city from the process of urbanization itself? Can the planners and policy makers assure with substantial data evidence (Paul 2012a) that the urban development and revitalization schemes, which they come up with their knowledge and years of experience would truly enhance city living and retrofit suburbs aiming a successful sustainable development in longer terms? In order to answer these questions, what seems to be needed is to synthesize a common spatial language of urbanization (Hillier 1999a)—a kind of urban representation—that is sensitive to capturing the functioning of various urban variables at the local levels for the purpose of gaining a clear and comprehensive understanding of the global urban environments, cities, in which the local structures remain syntactically embedded.

2 Review exegesis and statement of rationale

A well-known technique for understanding the functioning of urban variables through a common spatial language has turned out to be the syntax axial-line model in the recent

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past (Hillier and Hanson 1984). Its contribution to the study of urban movement has been found pertinent to observing the urban phenomena from the morphological stance. By bringing the axial configurational measures of city structures and by observing their relationships with the patterns of urban space use and movement, pedestrian movement by and large (see Paul 2013) however, it has become possible to understand how people navigate urban grids (see Major 1996; Hillier 1999a; Penn et al. 1998). Subsequently, this has also helped to underpin the perception of how cities, large physical objects, are animated and driven by human behavior (Hillier 2005; Hillier and Iida 2005). Essentially, what one needs to ask here is: Does the syntax axial-line model also become sensitive to capturing the functioning of urban variables by utilizing its abilities of generating configurations at both local and global levels, especially for the cities that take personally owned vehicles as the prime mode of transportation?

In space syntax, urban trip makers' forward-facing fields (Penn 2003) or roadway spaces are represented by axial lines. And then, by using the syntax network-analysis method, which lines are closely (or distantly) accessible from the other lines of a given city structure or layout is determined. This measure of accessibility is typically expressed through a numerical value called integration. That is, an integrated line is closely accessible from the other lines, and one that is not is termed segregated line (see Paul 2011c for further details). Studies suggest that axial integrations are related to urban movement, which alone has a major effect on the key attributes of a human city describing the city's architecture, society, policy, and culture (numerous study examples in support of this argument can be found in Hillier et al. 1987a; Dawson 2003; Hillier 2003; Griz and Amorim 2005; Mahdzar 2003; Petit and Pullar 2004; Al-Sayyed 2003; Peponis et al. 1989, etc.).

Now, according to Fricker and Whitford (2004), nearly 70 % of the urban movement of the North American cities is made by personally owned vehicles. These cities have also grown and changed in the recent past bringing out the fact that urbanism is no longer exclusively associated with dense city centers (Hillier 1999b; Peponis et al. 1989) but has become a global phenomenon of physical and cultural restructuring. Now, because the prime factor of accessing extensively spread urban facilities (attractors) in these cities is vehicular movement (Chang 2006), city configurations that are intensely found to relate to their vehicular movement networks must have a substantial influence on the functioning of urban variables, that shapes and characterizes contemporary city life (Hillier et al. 1987a). According to Hillier et al. (1993, pp. 31–32):

The argument is that configuration is the primary generator, and without understanding it, we cannot

understand either [urban movement], or the distribution of attractors or indeed the morphology of the urban grid itself.

However, the literature in the field is vast and also reports that the idea of treating axial lines as a set of forward-facing roadway spaces went under scrutiny in the early 1990s (Hillier et al. 1987b; Kruger 1989; Peponis et al. 1989; Teklenburg et al. 1993) when distinct procedures were tested without much success. Nor did the axial-line model seem to gain much popularity within the contemporary urban planning and design community (Turner 2007, p. 540; Penn 2003, p. 62) in terms of describing how urban configurations relate to movement networks particularly while dealing with the cities that take personally owned vehicles as the prime mode of transportation.

The main problem was that a long axial line was found to gain configurational centrality (refer to Hillier 1999b and Paul 2011c for further explanation on configurational centrality) for being well connected to its incident lines. Fragmenting a long axial line resulted in weakening it—in centrality terms—but also in generating a locally oriented model. For instance, it was found that the syntax axial-line analysis of the city of Lubbock in West Texas (Paul 2013) was unable to capture the configuration–movement relationship with a reasonable level of acceptability as the overall post-diction of vehicular flows from street to street of the city remained noticeably weak. The *r*-squared depicting the axial configuration–movement relationship was found as low as 0.18 at $p < 0.01$.

However, recent investigations in the field have helped to solve the problem of configurational centrality by developing a new syntax-based accessibility analysis model known as unit-segment model (see Paul 2012b for further details). While capturing the configuration–movement relationships of the cities that take personally owned vehicles as the prime mode of transportation, this new model has turned out to be more sensitive to the local urban structures than the traditional axial-line model. The *r*-squared describing the unit-segment configuration–movement relationship of a residential neighborhood of Lubbock at a local level has been found to reach 0.49. On the contrary, the same derived from the axial-line model has not been seen to rise above 0.03. Also, when the unit-segment model has been applied to analyze the global structure of the entire city of Lubbock (Paul 2011b, also refer to Fig. 1)—within which the local neighborhood structure is embedded—a significant increase in the sensitivity has also been observed from the same derived from the axial-line model as reported before. The *r*-squared obtained from the unit-segment model has been found to reach 0.63 at $p < 0.01$.

The distinction between the axial-line model and the unit-segment model is simple. The former purely deals with the topological distances (Ratti 2004) between axial lines or

forward-facing roadway spaces, which trip makers are typically presumed to consider in selecting trip routes. The latter also takes the topological distances between unit segments but additionally considers the mobility characteristics of these segments (such as freeways, arteries) in order to understand how speedily they can be used for travel.

3 Analysis framework

In view of the statistical evidence produced by the unit-segment model, it is argued that this new model is consistently expected to develop stronger configuration–

movement relationships (in terms of space–people relationships) than the traditional axial-line model particularly while dealing with the city structures that take personally owned vehicles as the prime mode of transportation. Application wise, these relationships are expected to provide data support or evidence in order to facilitate planners in making policy recommendations with substantial accuracy while determining the functioning of urban variables (described in Fig. 3) that directly or indirectly relate to urban vehicular movement.

The overall framework, shown in Fig. 2, details out how the configuration–movement relationship of a city—as a common spatial language of urbanization—facilitates in optimizing the city’s space–people relationship and, therefore, in explaining how a human city interacts with its physical form.

4 Policy development tool

Realities of the cities are always important considerations in any planning models, and such models need to be verified against real-world variables. The unit-segment model, in support of this argument, generates a common platform and can be considered to act as a tool to comprehend the notion of urbanization that itself has had the real and complex effects on account of the functioning of urban variables. In the study of cities, the unit-segment model can be vastly used in order to capture the functioning of many such variables at both local and global levels (as previously studied with the other syntax models; see Campos and Golka 2005; Caria et al. 2003; Choi et al. 2005; Eisenberg

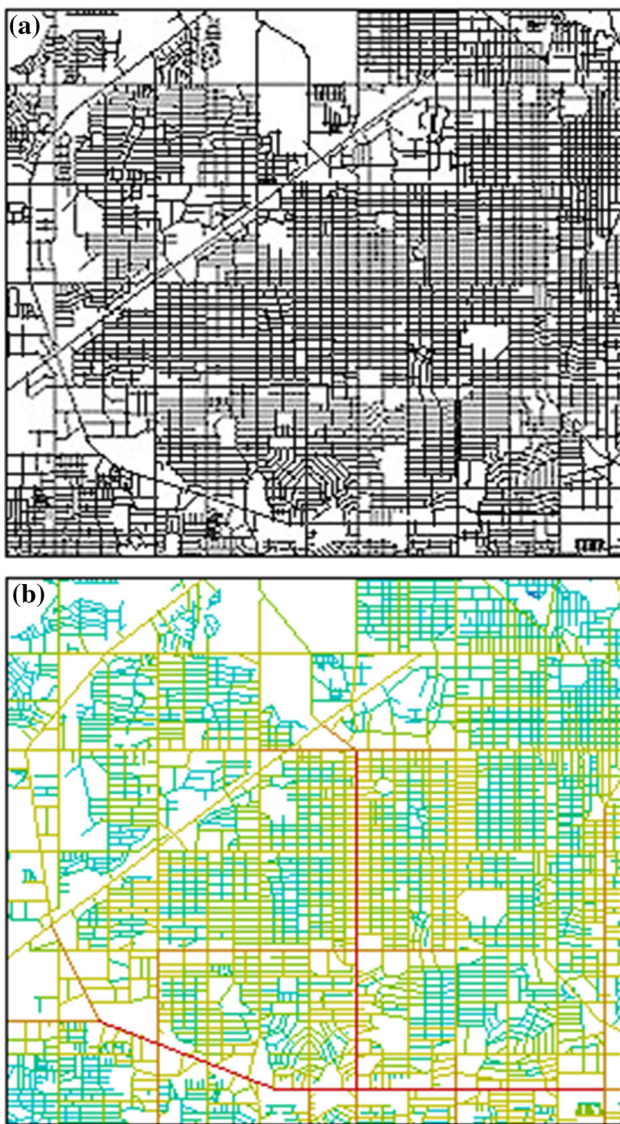


Fig. 1 Unit-segment configuration of Lubbock, West Texas. **a**, **b** describe the before and after scenarios of the configurational analysis. Configurational measure reduces as the color of the lines changes from red to blue (color online)

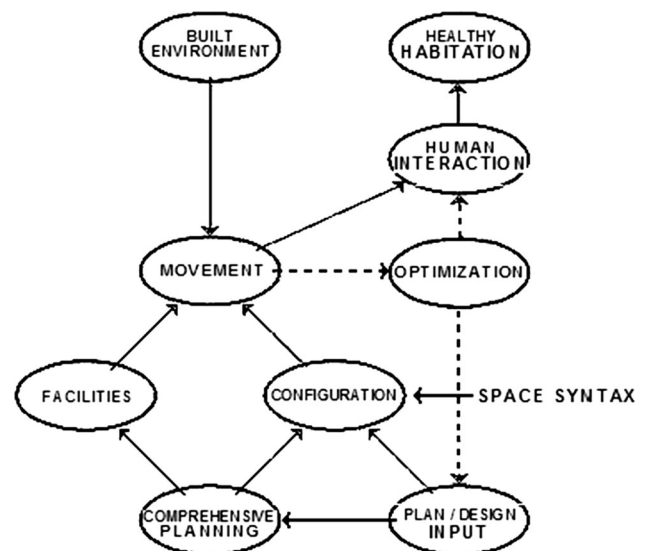


Fig. 2 Study framework showing the optimization process of a configuration–movement relationship (source: Paul 2011b)

2005; Griz and Amorim 2005; Howsley 2003, etc.). Below are some suggested cases.

4.1 Urban transportation

It is not unusual that a freeway with a high flow capacity is occasionally seen to carry much lesser traffic than one with a low flow capacity but located at a well-developed area. For instance, consider a four-lane highway at a suburban area for the former case and a two-lane street at a CBD area for the latter. The basis behind this anomaly has been explained by Penn et al. (1998, pp. 74–75):

... however integrated you make an area, average flows through it will never rise far above those at capacity. Equally, however wide you make a street segment the flows through it depend on how it is embedded in the network and whether it is in demand as a through movement space.

Penn et al. (1998) have also pointed out that the construction and calibration of traffic models is a costly procedure, in which the cost is related to the resolution with which the origin–destination trip data are gathered and the size of the model measured in terms of the number of nodes and links represented in the network (p. 59). It is, therefore, apparent that contemporary traffic-assignment models are seldom constructed to represent the finest scale structure of the street network, and their performance at this scale is not well understood.

On the other hand, studies suggest that the unit-segment model is capable of making vehicular traffic perditions even at the very finest scale of an urban structure (see Paul 2012b) without using costly origin–destination trip data. Therefore, it can be envisaged that unit-segment configurations can offer much efficient transportation planning policy solutions for the purpose of

- (a) controlling flow congestion of city roads and intersection delays,
- (b) enhancing transportation safety,
- (c) creating infrastructure and economic development opportunities,
- (d) controlling environment air quality, and
- (e) managing transportation assets and allocated investments.

4.2 Urban evacuation

Hurricanes Rita, Katrina, and Sandy are the commendable recent instances that have highlighted the challenges associated with evacuating major American cities as well as strengths and weaknesses in state, local, and private

evacuation plans (Governor’s Task Force on Evacuation of Texas 2006, Vitetta et al. 2008). The challenge here is: How can the evacuation planning and execution techniques be further improved to better protect city residents in the events of future emergencies? Essentially, what is needed here is to devise a handy tool—a planning model—that can be used for quick simulations of road maps (Batty et al. 1998; Jiang et al. 1999) with predicted evacuation flows. These simulations are expected to guide planners in recognizing major transportation links (also see Sheffi et al. 1982) for carrying evacuees to rehabilitation shelters and in identifying possible alternative routes in case gridlock (blockage of route) occurs during evacuation.

By using unit-segment configurations, mass evacuation policy aims are expected to be met without even using historical data. Historical data—typically used in developing evacuation plans—are the previously surveyed trip data that do not often portray real flow conditions during emergencies. Moreover, because surveyed data are not required to perform a unit-segment analysis, the evacuation planning process itself can be effectively expedited at the time when time management itself becomes a critical concern for the decision makers in order to avoid major losses (Murray-Tuite and Mahmassani 2003). In summation, with the help of scenario simulations that the unit-segment model is capable of generating, urban evacuation challenges are expected to be met by

- (a) identifying major transportation evacuation links,
- (b) making quick responses with data support in order to control traffic flows before and after emergency warnings,
- (c) identifying alternative routes when gridlock occurs,
- (d) optimizing the preparedness at both policy and infrastructure development levels to cope with any future emergencies,
- (e) developing efficient traffic flow management plans well in advance before an emergency strikes, and finally
- (f) optimizing the utilization of allocated evacuation funds.

4.3 Urban design

Stroll through any city ... observe the variety of smells, noises, and activities of its residents. Now imagine a city without any people. Would the city still have the same smells, sounds, and hubbub of vibrant human interaction?

The above is a well-known argument made by Jacobs (1961) that urban designers often use while justifying the essence of their design schemes. But is this truly possible to predict the usefulness of an urban design scheme without

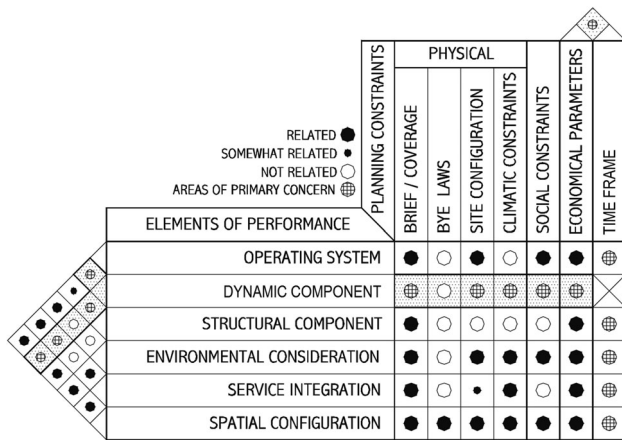


Fig. 3 Schematic relationships showing interactions between spatial elements of performance and urban variables depicting planning and design constraints. The dynamic part of the diagram allocates the room for growth, change, and obsolescence of urban structures within a time frame (source: Paul 2011b)

producing any evidence (Paul 2012a) whatsoever while dealing with the interactive relationships that space and people develop? Urban design is a process and an outcome (Lynch 1960) of building healthy and environment-friendly habitations, in which people live and engage with each other and with the physical places around (Dalton and Dalton 2005).

Therefore, while meaningfully understanding the iconic argument of Jacobs, it becomes important in recognizing the fact that the ways, and perhaps the only ways, space and people can interact with each other are by making direct and indirect interactions in order to facilitate the usual people-to-people interactions for which spatial arrangements are required.

While dealing with the functioning of urban variables, Fig. 3 describes how the above two space–people interactions can be perceived and then controlled by using unit-segment configurations. Subsequently, these configurations are expected to lead policy makers in making design recommendations with substantial evidence for the purpose of building healthy and environment-friendly cities.

5 Conclusions

The study of urbanization is interdisciplinary and deals with the functioning of a number of urban variables. No matter how complex an urban environment turns out to be, the need of a common spatial language that helps to explain how an urban configuration integrates with the functioning of a variety of urban variables cannot be ignored. Without controlling the functioning of these variables, one indeed cannot measure their effects on contemporary city life (Hillier 1999a). Therefore, the

instinctive question that comes into view is: Are there scientific reasons behind the development of a human city that well exists within a physical city? Recent investigations in the area have resulted in the emergence of the unit-segment model, which, in modeling movement networks—especially for the cities that take the personally owned vehicles as the prime mode of transportation—has turned out to be very sensitive to capturing the functioning urban variables and, therefore, has helped to throw a deeper insight into the argument of how a human city interacts with its physical form.

Acknowledgments This paper has been developed to emphasize the need of Princeton-Mellon Initiative in Architecture, Urbanism, and Humanities on the issue of Cities of the Americas: Architecture, Society, Policy, and Culture. Thanks to the organizers of this initiative for bringing up this research problem into light and for posting their viewpoints, some of which have been used in this paper. Also, thanks to the anonymous reviewers of *Environment, Systems and Decisions* and others for their comments, which have also helped in developing this paper.

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