Mahbub Rashid

The Geometry of Urban Layouts

A Global Comparative Study

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To my parents

Acknowledgments

This book originated from an elective seminar course I teach on the morphology of buildings and cities in the departments of architecture and planning at the University of Kansas. For the first few years of the seminar course, the students and I discussed various techniques for describing the morphology of buildings. For the next few years, we discussed how best to represent and analyze cities or city areas for the benefit of urban designers and scientists.

This book is an outcome of the seminars of the later years. Most early versions of the drawings presented here in this book were created by the students. Put alphabetically, these students were Dhirgham Alobaydi, Elizabeth Avenius, Ahmed Bindajam, Adam Brcic, Roberto Castillo, Dominique Coolidge, Vincent Cunigan, Tyler Eighmy, Nick Fratta, Garrett Nicholas Fugate, Zach Holbert, Shareka Iqbal, Faria Islam, Sharmin Kader, Nate Kaylor, Chang Liu, Aubrey Morris, Kayla Pagano, Matthew Ainge Primovic, Pearl Suphakarn, Jesse Walters, Xiaoyun Wang, Jonathan Wilde, and Shiqi Zhang. I am most grateful to each of these students for their diligent work that served as the impetus for this book. I am also grateful to Drs. Shateh Hadi and Nayma Khan, who worked as my graduate research assistants for the seminar course. More specifically, I would like to thank Dr. Hadi for preparing the satellite images needed for the seminars and Dr. Khan for doing the hard work of counting objects on the maps.

My larger intellectual inspiration for writing this book comes from Stanford Anderson, Michael Batty, Bill Hillier, Allan Jacobs, Lionel March, John Peponis, Phil Steadman, Michael Southworth, and the late Douglas Allen—some of whom I have known personally, while the others are known to me only through their publications. It would be extremely gratifying if this book is able to extend some of their ideas.

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Part I
The Geometry of Urban Layouts: A Comparative Study of the Urban Layout Maps of Downtown Areas in Cities Around the World

Chapter 1
Introduction

1.1 What Is This Book About?

This book is about the geometry of urban layouts for all interested in urban form and structure. It presents a compendium of the urban layout maps of 2-mile square downtown areas or central business districts (CBDs) of more than 100 cities in developed and developing countries. Created digitally using high-resolution satellite images, these maps are presented at the same scale for comparative geometric investigations by urban designers and spatial scientists. The book also presents analytic studies on the geometry of these maps using carefully developed metric geometrical, topological (or network), and fractal measures. Using univariate descriptive statistics, these analytic studies identify the ordinaries, extremes, similarities, and differences in the geometry of these urban layout maps. Using bivariate analysis, these studies investigate scaling in the geometry of these urban layout maps. Finally, using multivariate and factor analysis, these studies develop precise descriptive categories, types and indicators for multidimensional comparative studies of the geometry of these urban layout maps.

1.2 Why Do We Need This Book?

The geometric studies of urban layouts, particularly of the kind presented in this book, are needed for several reasons. First, there is a lack of rigorous comparative geometric studies involving intermediate-scale urban areas—areas larger than small-scale environmental spaces such as individual buildings, streets, urban spaces, urban blocks or neighborhoods but smaller than large-scale geographical spaces such as whole cities or metropolitan regions—from cities across different geographic regions of the world. This lack of comparative studies is more noticeable for downtown areas because these areas are generally among the most identifiable,

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imageable, heterogeneous, accessible, and vibrant intermediate-scale areas in most cities. Therefore, studies focusing on the geometric features of urban areas of intermediate scale taking downtown areas as examples are needed.

Second, most urban design-related comparative geometric studies [1–11] have remained focused on small-scale environmental spaces disregarding larger contexts within which smaller areas are located. In contrast, with the exception of a very few studies [12–20], most urban spatial science-related comparative geometric studies [21–35] have remained focused on large-scale geographical spaces disregarding many geometric aspects of architectural and phenomenological importance. As a result, geometric studies of intermediate-scale urban areas that serve the purposes of both urban design and spatial sciences are needed.

Third, most urban spatial science-related comparative geometric studies have remained technical in nature, lacking normative contents for urban designers [21–35]. In contrast, most urban design-related comparative geometric studies have remained normative in nature, lacking technical and analytic contents for urban spatial scientists [1–11]. Therefore, normative studies with more analytic content and analytic studies with more normative content on urban geometry are also needed.

Fourth, aside from a lack of comparative geometric studies of intermediate-scale urban areas, comparative geometric studies of urban layouts of cities across different geographic regions of the world generally have remained surprisingly rare. With a very few exceptions [29, 32, 36, 37], most reported comparative studies have considered one or more cities within the national and cross-national contexts of the developed countries [22, 27, 33, 34, 38–40]. Therefore, comparative geometric studies of urban layouts of cities across different geographic regions of the world are needed as well.

Finally, most of comparative geometric studies of cities are limited in scope concerning the geometric measures they use. So far, the metric, topological, and fractal geometric measures have remained mostly separate in these studies, even though each of the three geometries has proven useful for urban design and spatial sciences. For example, there are those that primarily use metric measures [2, 4, 6–9, 11, 41–45]. Then there are those that primarily use topological or network measures [15, 30, 31, 46–53]. There are also those that primarily use fractal measures [18, 25–27, 35, 54–57]. There are only a few that use any two sets of these geometric measures [13, 36, 38, 40, 58–64], and there are even fewer that use all three sets of measures in the study of urban geometry [13, 14, 58, 65]. Therefore, there is a need for comparative geometric studies of urban layouts of cities across different geographic regions of the world involving measures of all the three geometries.

Concerning the above issues, satellite images offer an unprecedented opportunity. These images are an easily accessible resource that this book uses to create a compendium of maps representing downtown areas of cities in developed and developing countries for normative and analytic studies. This book hopes to strengthen our understanding of the variants and invariants of the geometry of urban layouts of downtown areas in cities around the world by using metric geometrical, topological, and fractal geometric data extracted from these maps in its analytic and comparative studies. This book also hopes to improve the relationship between urban design and spatial sciences because both urban designers and spatial scientists may find the studies of this book on intermediate-scale urban areas equally interesting.

1.3 How Is This Book Going to Affect Urban Design and Science?

Today, the majority of the world's population lives in urban areas in the developing world that do not work too well. The local governments of many of these cities, where dysfunctional urban areas are growing rapidly, often seek help from international experts to alleviate the problems of their cities. A major challenge in this regard is that most international experts simply do not know much about the cities in these countries. Nor do they know how to guide the processes of growth and development of these cities in an optimal way.

Established on western intellectual traditions and experiences, the theories, principles, and practices of urban design and spatial science of developed countries that international experts often use in their deliberations are not very useful for solving today's urban challenges in developing countries. Yet, due to vastly improved transportation, information, and communication technologies, these theories, principles, and practices of urban design and spatial science of developed countries are having more immediate impacts on developing countries. Therefore there is an urgent need for analytic and comparative studies describing the specific and generic geometric characteristics of cities and city areas in developed and developing countries to help guide the present and future academic and professional activities in urban design and spatial science.

The urgency is reinforced by the fact that in many cities of developed countries changes in technology and lifestyles have transformed many traditional urban activities into private activities, diminishing the importance of urbanity as previously understood. In these cities, rampant anti-street sentiments among the middle class often equate streets with noise, lack of privacy, criminal activities, and unsanitary conditions. Using various political and legislative instruments, therefore, streets are being planned out of new urban areas creating superblocks with non-frontal, volumetric, and/or sculptural building mass. As a result, new urban areas in these cities show little or no capacity to generate and facilitate movement and to promote a genuine diversity enhancing social interactions and correlated activities. In such developments, potential users proliferate, but pedestrian density does not occur, and no relationship between buildings and streets is found. This occurs despite the fact that since Camillo Sitte's *City Planning according to Artistic Principles* (1889) [10] there has been no shortage of literature describing the qualities of successful urban areas [1, 50, 66–73].

The urgency is also reinforced by the fact that, despite our best efforts and intentions, we have not been able to create a sense of urbanity in the new urban areas of our cities. Compared to the amount of attention they have received, recent models of urban design and planning including everyday urbanism [74–76], generic urbanism [77], and new urbanism [78–82] have not been able to deliver what they have promised. For example, "There is little urbanity in most new urbanism projects," writes Southworth:

> Like other suburbs, the neotraditional models are essentially anti-urban, sanitized versions of the small town, and they exclude much of what it takes to make a metropolitan region work. Real towns must do much more than house middle-income people; they usually include housing for the less well-off, as well as commercial and industrial space, cemeteries, waste disposal sites, and many other uses that planned suburbs systematically exclude. [They] are rather rigid architectonic visions that offer instant identity and instant community sense by controlling the built form. … In reaction to the anonymous sprawl of suburbia, the tendency has been for designers to superimpose an image on a development before it is even occupied, providing a "scenographic" setting that is fixed and unchangeable and that occupants and users cannot shape over time. Often this image, though strong, is a fraudulent one, like Disneyland, that ignores tradition and context. The fallacy of such thinking is especially glaring in the early stages of development, when true identity and community are minimal. [83, pp. 43–44]

Therefore urban designers and spatial scientists need a new process for generating urban structure and identity in new developments, one that is less superficial and pays more attention to the real tradition of places, the deep structure, rather than merely trying to copy historical styles. According to Southworth [83], that real tradition includes fundamental environmental qualities such as density, scale, grain, compactness, transparency, the relation between buildings and streets, continuity, connectedness, and access, qualities that are often best defined by geometry.

It is in this regard downtown areas in our big cities appear important. They seem to possess all the fundamental qualities of urbanity. They are generally the most easily identifiable physical, mental, and functional entities representing the best of urbanity in almost all big cities. They are also the oldest surviving areas in most cities, and are typically characterized by more compact form and higher density and diversity of use than the other parts of cities [84–87]. Whether grown spontaneously on irregular grids or laid down on more regular grids, most downtowns of big cities are somewhat "natural," for they show complex spatial patterns of interactions, activities, and structures. Along with some residential functions, most downtowns in big cities serve a mix of financial, government, commercial, and/or cultural functions of regional, national, and global significance.

Despite facing numerous difficulties, most downtowns of big cities have managed to maintain their identities and significance over decades, if not centuries. Nowadays, they are increasingly seen as environments to be carefully designed and managed for their value as urban places, on the one hand, and for their financial and economic value in national and global networks, on the other [88]. This tension between global corporate interests and locally rooted urbanity and placeness, however, is not so easily resolved in many downtown areas. Often, global corporate interests seem to win over locally rooted urbanity and placeness in these downtowns.

In order to make meaningful changes to the already existing urbanity of downtowns, it is therefore necessary to pay more attention to the features that make these downtowns different from the other transactional centers supporting comparable functions on the periphery. Most downtowns of big cities still offer a degree of access, sense, vitality, variety, spontaneity, and intensity that cannot be sustained in transactional centers on the periphery. They still offer a degree of social inclusiveness that is not generally seen on the periphery. They still possess a strange ability to update, enliven, and repair themselves that transactional centers on the periphery do not possess. Most of these downtowns are still able to support a model of local economic development based on adding new types of work to old, promoting small businesses, and supporting creative impulses of urban entrepreneurs that Jane Jacobs [70] found so essential for urban liveliness and sustainability.

If the geometric characteristics of downtown areas are important for defining the real tradition or the deep structure of urbanity found in these areas, as claimed by Southworth [83], then the concepts, analytical tools, and procedures of this book offering a clear, rigorous, and explicit description of downtown areas in cities of developing and developed countries may be important. They may provide a foundation for a better understanding of urban geometry in general and may provide effective tools for research and practice in urban design and planning across regions and nations. They may also provide opportunities for more research in an important but less studied area that lie at the intersection of urban design and spatial sciences. Additionally, they may also be used in studies related to the growth and evolution of the city and its areas. Even though the studies of this book involve both manual and automated techniques, it is hoped that its measures and methods would become far more useful and effective for urban design and urban spatial sciences, if and when they are completely automated.

1.4 An Overview of This Book

This book is organized into two parts. Part I of the book includes eight chapters. After this first introductory chapter, Chap. 2 discusses the definitions and significance of urban layouts. Chap. 3 provides a review of the geometric studies of urban layouts in urban design and spatial sciences. The review divides the literature into two broad categories. One of these categories includes studies that have used metric geometry to describe the physical structure of urban layouts. The other category includes studies that have applied new mathematical theories such as sets, groups, graphs, and fractals to describe the configurational structure of urban layouts. Chap. 4 discusses how cities were selected for the studies of this book. It also discusses why and how the study area from each downtown was determined to be a 2-mile square. Additionally, it describes the types of urban layout maps that are used in the studies of the book and how these layout maps of the study area were created using satellite images. Finally, it defines and discusses different geometric measures that are used in the studies of the book.

Using univariate descriptive statistics of the metric geometrical, topological (or syntactic), and fractal measures, the first analytic chapter of the book, Chap. 5, identifies the ordinaries, extremes, spreads, similarities, and differences in urban layouts of the downtown areas of all the cities in the sample and of the cities in developed and developing countries separately. Using bivariate regression models, Chap. 6 studies if rank-size rules and allometry apply to the geometry of urban layouts. To take advantage of all the different measures by using factor analysis—a multivariate technique of statistical analysis—Chap. 7 combines the metric geometrical, topological (or syntactic), and fractal measures to create fewer descriptive indices of urban geometry. This chapter then uses these indices to further understand the similarities and differences of the cities in developed and developing countries. Finally, Chap. 8 discusses the relevance of the findings of the analytic studies of the book to urbanity and discusses what needs to be done next.

Chapter 9 of Part II of the book presents the urban layout maps of the 2-mile square study area of each of the more than 100 cities from the developed and developing countries, with a brief description for each city. The study area of each city is represented by four maps—the street map, the street centerline map, the urban block map, and the axial map. Altogether, more than 400 maps, all drawn at the same scale, are included in this part of the book. It is hoped that this compilation of maps will be an excellent resource for the students of cities providing them with a common frame of reference to compare downtowns along a range of spatial metrics.

Overall, the book takes a close and comprehensive look at the geometry of urban layouts. It would have been hard to conceive of a book like this before the availability of satellite images. This book includes more cities from both developed and developing countries, uses larger study areas, has more drawings of urban layouts, and uses more metric geometrical, fractal, and topological measures in its analytic studies than any previous book on similar topics. As a result, this book is likely to become an invaluable resource for studies on the geometry of urban layouts in urban design and spatial sciences.

References

1. Appleyard D, Gerson S, Lintell M (1982) Livable streets. University of California Press, Los Angeles
2. Childs MC (2006) Squares: a public space design guide for urbanists. University of New Mexico Press, Albuquerque
3. Gatje RF (2010) Great public squares: an architect's selection. Norton, New York
4. Carmona M, Heath T, Oc T, Tiesdell S (2012) Public places–urban spaces. Routledge, New York
5. Hegemann W, Peets E (1922) Civic art: the American Vitruvius. Architectural Book Publishing, New York
6. Jacobs AB (1993) Great streets. MIT Press, Cambridge, MA
7. Jacobs AB, Macdonald E, Rofé Y (2002) The boulevard book: history, evolution, design of multiway boulevards. MIT Press, Cambridge, MA

8. Jenkins EJ (2008) To scale: one hundred urban plans. Routledge, New York
9. Moughtin J (2003) Urban design: street and square. Architectural Press/Elsevier, Burlington
10. Sitte C (1986) City planning according to artistic principles. Rizzoli, New York
11. Zucker P (1959) Town and square: from the agora to the village green. Columbia University Press, New York
12. Cooper J (2005) Assessing urban character: the use of fractal analysis of street edges. Urban Morphol 9(2):95
13. Gil J, Montenegro N, Duarte J (2012) On the discovery of urban typologies: data mining the many dimensions of urban form. Urban Morphol 16:27–40
14. Laskari A, Hanna S, Derix C (2008) Urban identity through quantifiable spatial attributes: coherence and dispersion of local identity through the automated comparative analysis of building block plans. In: Gero JS, Goel AK (eds) Design computing and cognition '08: proceedings of the third international conference on design computing and cognition. Springer, New York, pp 615–634
15. Nophaket N, Fujii A (2004) Syntactic and network pattern structures of city: comparison of grid and meandering street patterns in Kyojima and Honjo. J Asian Archit Build Eng 3(2):349–356
16. Rodin V, Rodina E (2000) The fractal dimension of Tokyo's streets. Fractals 8(4):413–418
17. Steadman P, Evans S, Batty M (2009) Wall area, volume and plan depth in the building stock. Build Res Inf 37(5–6):455–467
18. Thomas I, Frankhauser P (2013) Fractal dimensions of the built-up footprint: buildings versus roads. Fractal evidence from Antwerp (Belgium). Environ Plan B Plan Des 40(2):310–329
19. Vanderhaegen S, Canters F (2010) Developing urban metrics to describe the morphology of urban areas at block level. Int Arch Photogramm Remote Sens Spat Inf Sci 38(4/C7):1–6
20. Yoshida H, Omae M (2005) An approach for analysis of urban morphology: methods to derive morphological properties of city blocks by using an urban landscape model and their interpretations. Comput Environ Urban Syst 29(2):223–247
21. Batty M, Longley PA (1994) Fractal cities: a geometry of form and function. Academic, London
22. Burton E (2002) Measuring urban compactness in UK towns and cities. Environ Plan B 29(2):219–250
23. Chen Y, Zhou Y (2003) The rank-size rule and fractal hierarchies of cities: mathematical models and empirical analyses. Environ Plan B 30(6):799–818
24. Chen Y, Zhou Y (2008) Scaling laws and indications of self-organized criticality in urban systems. Chaos Solitons Fractals 35(1):85–98
25. Frankhauser P (1998) The fractal approach: a new tool for the spatial analysis of urban agglomerations. Popul Engl Sel 10(1):205–240
26. Frankhauser P (1998) Fractal geometry of urban patterns and their morphogenesis. Discret Dyn Nat Soc 2(2):127–145
27. Frankhauser P (2004) Comparing the morphology of urban patterns in Europe: a fractal approach. In: Borsdorf A, Zembri P (eds) European cities: insights on outskirts, vol 2, Report COST Action 10 Urban Civil Engineering. COST Office, Brussels, pp 79–105
28. Herold M, Scepan J, Clarke KC (2002) The use of remote sensing and landscape metrics to describe structures and changes in urban land uses. Environ Plan A Plan Des 34(8):1443–1458
29. Huang J, Lu X, Sellers JM (2007) A global comparative analysis of urban form: applying spatial metrics and remote sensing. Landsc Urban Plan 82(4):184–197
30. Jiang B (2007) A topological pattern of urban street networks: universality and peculiarity. Phys A Stat Mech Appl 384(2):647–655
31. Jiang B, Claramunt C (2004) Topological analysis of urban street networks. Environ Plan B Plan Des 31(1):151–162
32. Schneider A, Woodcock CE (2008) Compact, dispersed, fragmented, extensive? A comparison of urban growth in twenty-five global cities using remotely sensed data, pattern metrics and census information. Urban Stud 45(3):659–692
33. Schwarz N (2010) Urban form revisited: selecting indicators for characterising European cities. Landsc Urban Plan 96(1):29–47

34. Strano E et al (2012) Urban street networks: a comparative analysis of ten European cities. arXiv preprint. http://arxiv.org/pdf/1211.0259.pdf. Accessed 21 Oct 2015
35. Thomas I et al (2010) Clustering patterns of urban built-up areas with curves of fractal scaling behaviour. Environ Plan B Plan Des 37:942–954
36. Chen Y (2010) Characterizing growth and form of fractal cities with allometric scaling exponents. Discrete Dyn Nat Soc Article ID 194715. doi:10.1155/2010/194715
37. Mohajeri N, French JR, Gudmundsson A (2013) Entropy measures of street-network dispersion: analysis of coastal cities in Brazil and Britain. Entropy 15(9):3340–3360
38. Longley PA, Batty M, Shepherd J (1991) The size, shape and dimension of urban settlements. Trans Inst Brit Geogr 16:75–94
39. Samaniego H, Moses ME (2008) Cities as organisms: allometric scaling of urban road networks. J Transp Land Use 1(1):21–39
40. Shpuza E (2007) Urban shapes and urban grids: a comparative study of Adriatic and Ionian coastal cities. In: Kubat AS et al (eds) 6th international space syntax symposium. ITU Faculty of Architecture, Istanbul
41. Cataldi G (2003) From Muratori to Caniggia: the origins and development of the Italian school of design typology. Urban Morphol 7(1):19–34
42. Conzen MRG (1960) Alnwick, Northumberland: a study in town-plan analysis. Transactions and Papers, Institute of British Geographers, no 27
43. Kasprisin R (2011) Urban design: the composition of complexity. Routledge, New York
44. Moudon AV (1986) Built for change: neighborhood architecture in San Francisco. MIT Press, Cambridge, MA
45. Siksna A (1997) The effects of block size and form in North American and Australian city centers. Urban Morphol 1(1):19–33
46. Cardillo A et al (2006) Structural properties of planar graphs of urban street patterns. Phys Rev E 73(6):066107
47. Carvalho R, Penn A (2004) Scaling and universality in the micro-structure of urban space. Phys A Stat Mech Appl 332:539–547
48. Crucitti P, Latora V, Porta S (2006) Centrality measures in spatial networks of urban streets. Phys Rev E 73(3):036125
49. Gudmundsson A, Mohajeri N (2012) Entropy and order in urban street networks. Sci Rep 3:3324. doi:10.1038/srep03324
50. Hillier B (2007) Space is the machine: a configurational theory of architecture. Cambridge University Press, Cambridge
51. Hillier B et al (1993) Natural movement: or, configuration and attraction in urban pedestrian movement. Environ Plan B Plan Des 20:29–66
52. Porta S, Crucitti P, Latora V (2006) The network analysis of urban streets: a dual approach. Phys A Stat Mech Appl 369(2):853–866
53. Xie F, Levinson D (2007) Measuring the structure of road networks. Geogr Anal 39(3):336–356
54. Frankhauser P (2008) Fractal geometry for measuring and modelling urban patterns. In: Albeverio S et al (eds) The dynamics of complex urban systems: an interdisciplinary approach. Physica-Verlag, Heidelberg, pp 213–243
55. Longley PA, Mesev V (2000) On the measurement and generalization of urban form. Environ Plan A 32(3):473–488
56. Tannier C, Pumain D (2005) Fractals in urban geography: a theoretical outline and an empirical example. Cybergeo Eur J Geogr, no 307
57. Tannier C et al (2011) A fractal approach to identifying urban boundaries. Geogr Anal 43(2):211–227
58. Batty M et al (2008) Scaling and allometry in the building geometries of Greater London. Eur Phys J B Condens Matter Complex Syst 63(3):303–314
59. Cook EA (2002) Landscape structure indices for assessing urban ecological networks. Landsc Urban Plan 58(2):269–280

60. Hillier B, Iida S (2005) Network and psychological effects in urban movement. Spat Inf Theory Lect Notes Comput Sci 3693:475–490
61. Hillier B et al (2007) Metric and topo-geometric properties of urban street networks. In: Kubat AS et al (eds) 6th international space syntax symposium. ITU Faculty of Architecture, Istanbul
62. Hillier B et al (2010) Metric and topo-geometric properties of urban street networks: some convergences, divergences and new results. J Space Syntax 1(2):258–279
63. Masucci AP, Stanilov K, Batty M (2013) Limited urban growth: London's street network dynamics since the 18th century. PLoS One 8(8):e69469
64. Peponis J et al (2007) Street connectivity and urban density. In: Kubat AS et al (eds) 6th international space syntax symposium. ITU Faculty of Architecture, Istanbul
65. Smith DA, Crooks AT (2010) From buildings to cities: techniques for the multi-scale analysis of urban form and function. CASA Working Paper No 155. Centre for Advanced Spatial Analysis, University College London, London
66. Alexander C (1965) A city is not a tree. Archit Forum 122(1):58–62
67. Alexander C et al (1987) A new theory of urban design. Oxford University Press, Oxford
68. Anderson S (ed) (1986) On streets. MIT Press, Cambridge, MA
69. Bacon EN (1967) Design of cities. Thames & Hudson, London
70. Jacobs J (1961) The death and life of great American cities. Vintage Books/Random House, New York
71. Lynch K (1981) A theory of good city form. MIT Press, Cambridge, MA
72. Southworth M (2003) Measuring the liveable city. Built Environ 29(4):343–354
73. Jacobs A, Appleyard D (1987) Toward an urban design manifesto. J Am Plan Assoc 53(1):112–120
74. Brown DS, Papadakēs A (1990) Urban concepts. Academy Editions, London
75. Chase J, Crawford M, Kaliski J (2008) Everyday urbanism. Monacelli Press, New York
76. Venturi R, Brown DS, Izenour S (1972) Learning from Las Vegas. MIT Press, Cambridge, MA
77. Koolhaas R, Mau B (1998) In: Sigler J (ed) Small, medium, large, extra-large: Office for Metropolitan Architecture, Rem Koolhaas, and Bruce Mau. Monacelli Press, New York
78. Calthorpe P (1993) The next American metropolis: ecology, community, and the American Dream. Princeton Architectural Press, New York
79. Duany A, Plater-Zyberk E, Alminana R (2003) The new civic art: elements of town planning. Random House, New York
80. Duany A et al (1991) Towns and town making principles. Harvard University Graduate School of Design, Cambridge, MA
81. Duany A, Plater-Zyberk E, Speck J (2010) Suburban nation: the rise of sprawl and the decline of the American Dream. Farrar, Straus & Giroux, New York
82. Kelbaugh D (1989) The pedestrian pocket book: a new suburban design strategy. Princeton Architectural Press in Association with the University of Washington, New York
83. Southworth M (1997) Walkable suburbs? An evaluation of neotraditional communities at the urban edge. J Am Plan Assoc 63(1):28–44
84. Murphy RE, Vance JE (1954) Delimiting the CBD. Econ Geogr 1954:189–222
85. Murphy RE, Vance JE (1954) A comparative study of nine central business districts. Econ Geogr 30:189–222
86. Murphy RE, Vance JE, Epstein BJ (1955) Internal structure of the CBD. Econ Geogr 31:21–46
87. Weaver DC (1969) Changes in the morphology of three American central business districts, 1952–1966. Professional Geogr 21(6):406–410
88. Abbott C (1993) Five downtown strategies: policy discourse and downtown planning since 1945. J Policy Hist 5(1):5–27

Chapter 2
Urban Layout and Its Significance

2.1 Introduction

This book uses different types of urban layout maps for a rigorous and comprehensive exploration of cross-national similarities and differences in the geometry of downtown areas in cities of developed and developing countries. The aim of this chapter is to describe the role of geometry in representing spaces, to define the urban layout as a kind of geometric representation of space, and to describe the significance of the geometry of urban layouts.

2.2 Geometry, Spatial Representation, and Urban Layout

Though this book focuses on the geometry of urban layouts to represent and describe downtown areas, it should be noted that textual (or verbal), pictorial (or image-based), and numeric representations and descriptions of these areas are possible. For example, the cultural anthropologist Hall [1], who categorized space as *fixed-feature space*, *semi-fixed feature space*, and *informal space* based on how permanent things are in space, used both pictorial and verbal descriptions. The sociologist Henry Lefebvre [2], who categorized space as *perceived space*, *conceived space*, and *lived space* to discuss how society produces space, primarily used verbal descriptions. Even in a spatial design field like architecture, geometry may not be the only way to represent and describe space. For example, Norberg-Schulz [3], who presented *pragmatic*, *perceptual*, *existential, cognitive,* and *abstract space*—following and expanding on Piaget [4]—used verbal and pictorial descriptions more than geometric descriptions.

In general, however, spatial design and science fields prefer geometry for spatial representations and descriptions. Surely, they do not always use the same geometry. If they use the same geometry, they do not use it in the same way.

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Spatial categorizations often determine the nature of geometric representations and descriptions in these fields. For example, architects use geometry to describe rooms, buildings, building complexes, and campuses. Urban designers and city planners use geometry to describe campuses, neighborhoods, towns, and cities. Geographers' use of geometry is not limited to the spaces of architects, urban designers, and city planners but extends beyond these spaces to cover regions, countries, and the world. In each of these cases the underlying geometric assumptions may be the same, but geometric representations and descriptions are not.

More recently, geographers working with geographic information systems (GIS) and within geographic information science (GIScience) have used a rather robust categorization of space based on manipulability, locomotion, and size [5]. The spaces in this system of categories include (1) *manipulable object spaces* that include objects smaller than human body that can be held, turned, rotated, and so on, and do not require locomotion to experience them; (2) *non-manipulable object spaces* that include non-manipulable objects that are larger than the human body and smaller than a house and that require locomotion to view all parts of the objects; (3) *panoramic spaces* that are small-to-large spaces that can be viewed from one vantage point by scanning or panning the space; (4) *environmental spaces* that are experienced by locomotion and are learned piecemeal over time, such as the inside of a building, neighborhoods, and city-sized spaces; (5) *geographic spaces* that are very large spaces—such as cities, states, countries, and the universe—that cannot be experienced in their entirety via locomotion; and, finally, (6) *map spaces* that usually include two-dimensional representations of environmental and geographic spaces but that could potentially include the representations of all of the above spaces.

Map space is unique because it easily represents a variety of symbolic contents, hierarchical relations, and structural patterns often found in a given environmental and/or geographic space. Map space is also unique, for it can describe the invisible structures along with the visible structures of environmental and geographic spaces at a two-dimensional level without regard to topography, built form, and land use—factors that can have order and structure on their own, either reinforcing the two-dimensional patterns or running counter to them. The urban layout is an example of map space representing the city or its areas. But how is the urban layout, as used in this book, different from other similar map spaces?

2.3 Urban Layout as Map Space

In geography, the *urban layout* of a city has been called the *town plan* [6], the *ground plan* [7], or the *street plan* [8] of a city. Even though each of these terms refer to map spaces representing cities and city areas, the usage of these terms often implies scale and content differences among these map spaces. Regarding scale, a small English town like Alnwick can easily be represented as a town plan. However, it is difficult and might even be pretentious to talk about the town plan of New York City. In the case of New York City, it may be more appropriate to talk about the ground plan of the city.

Regarding content, both the town plan and the ground plan of a city imply some degree of completeness concerning the information being presented. For geographical purposes, this information may include *land division patterns* showing functionally differentiated and legally protected ownership within a street grid; *land use patterns* showing the proportion, size, shape, and location of specialized use of plots; and *building fabric* showing the type, quality, and quantity of the physical structures needed for specialized use of plots. In contrast, the street plan of a city or any other similar term fails to convey the completeness of the town plan or ground plan of a city. It would appear that in the street plan information such as land division patterns, land use pattern, or building fabric could easily be left out with very little consequence.

Therefore the phrase “urban layout” may be used to refer to an appropriately flexible content and scale of the city that is useful for spatial design fields such as architecture, urban design, landscape architecture, and city planning, as well as for spatial science fields such as geography, cartography, and surveying. At the one end of the scale, it may represent the smallest possible urban conglomeration. At the other end of the scale, it may represent the whole of, or a part of, a very large city, if required. Regarding content, the urban layout may represent any one or more features of the urban landscape—such as street grids, built versus open spaces, public versus private spaces, natural versus manmade objects, land division, land use, or building fabric—depending on the purpose and scale of representation.

2.4 The Significance of Urban Layout

Like many other maps, an urban layout possesses a variety of symbolic contents, hierarchical relations, and structural patterns that have physical, functional, historical, morphological, psychological, and/or sociological significance for a city. The physical significance of the urban layout of a city lies in the fact that it provides a publicly available framework for various forms of spatial practices involving the development, growth, and maintenance of the communities, institutions, and wealth of a city. This framework of urbanization—defined primarily by street grids, urban blocks, and plot patterns—is like a playboard with its own rules for where, when, and how to live, work, and build in the city.

Even though urban layouts represent the most persistent morphological complex of a city, in many respects they are an incomplete historical record of a city. Layout features created in one period are likely to change in another in varying degrees. In this regard, the patterns of land use within urban layouts change most frequently, responding to economic, social, and technological changes. Building fabric is slower to change than land use patterns because new functions in an old area do not necessarily give rise to new forms. As noted by Conzen [6], adaptation rather than replacement of the existing fabric is more likely to occur owing to land use changes over the greater part of a built-up area established in an earlier period. Even when the inherited building fabric is rendered obsolete owing to economic, social, and technological changes, the new fabric rarely disregards the old urban framework of streets, urban blocks, and plots. In a sense, the essential characteristics of an urban layout tend to remain unaltered for a very long time. This is more so for the older, central areas of a city than for its newer peripheral areas.

While a wisely conceived framework can open up a range of choices and opportunities for future development and growth, a poorly conceived framework can do just the opposite in the city [9]. *The Making of Urban America* [10] provides many examples of the early frameworks of urbanization in the United States. In the earliest of these examples, the colonizers conceived the man-made landscape as a unit in which the city and its surrounding arable lands were inseparable. Therefore, in laying out these frameworks the colonizers needed to consider the future capacity of the city—its size, population, buildings, and commerce—that could be supported comfortably by the arable land surrounding the city. These early frameworks have now become the settings for many vigorous American cities. In contrast, many European and English cities originated from their early Roman or medieval, as opposed to colonial, frameworks [11, 12]. These early frameworks were not always preconceived and regular. Some of them grew organically by accretion. Whether preconceived or organic, the historical stages of implementation, functional development, and morphological inertia of the city can be best revealed in the morphogenetic historical studies of urban layouts.

However, the city did not always develop and grow continuously from the framework defined by its initial layout. Sometimes it reinvented itself in the same area where the old historic core used to be. At other times, it reinvented itself in a place next to or even distant from its old historic core when the core was unable to accommodate the changes initiated by physical, social, economic, or political forces. In many European and English towns, most new additions to the dense old medieval cores were regular. In many others, the regular order of the rectilinear towns planted by the Romans became irregular over time owing to changes in land division patterns, land use patterns, and building fabric. In contrast, most modern colonial powers in Africa and Asia often overwhelmed the intricate traditional urban patterns by superimposing on them new grand geometric orders. Any changes in the geometric order of urban layouts always indicate changes in the social order beholden to prior occupation, to long-established conventions of the social contract, or to a string of compromises between individual rights and common interests [13].

In many ways, the functional significance of the urban layout is related to its historical significance described above. As the palimpsest of the city, the urban layout provides the most accurate description of the relationships between the functions and the form of the city. Different structures of function and of spatial interaction patterns of functions in the city often depend on its urban layout, characterized by street systems, land division patterns, land use patterns, building fabric, and such historically defined morphological conditions as urban fringe zones and central business districts (CBDs) [for definitions, see 6, 14, 15]. For example, despite functional similarities, the CBDs of many cities evolved differently because of the geometric differences of the initial grid-like urban layouts. In these cities, small square blocks produced finer-mesh circulation patterns, more potential lot frontage, and more fine-grained continuous urban fabric. In contrast, larger blocks were intensified over time by inserting alleys and subdividing block interiors. Even though larger lots in these blocks were subdivided into orderly patterns in early phases, the subsequent amalgamation of lots occurred in less orderly patterns, creating unpredictable discontinuous urban fabric [16]. These CBDs clearly show that the geometry of urban layouts can affect functional development through its effects on the changeability, continuity, and growth of the city.

In many other ways, the functional significance of the urban layout is also somewhat universal and, therefore, independent of the history of the city. For example, the structures of accessibility—a primary determinant of communication, movement, and activities—are important for the city, regardless of its history. In general, the size and degree of concentration of social, cultural, and economic establishments appear to bear directly upon the costs and ease of intercourse and upon the opportunities for creating new ideas and wealth in the city. So does the clustering of businesses in some areas, such as the central districts, of the city. This clustering process clearly reflects the efforts to increase accessibility among linked establishments, to reduce the distances separating them, and to take advantage of the external economies that clustering generates. That the spatial clustering of different functions in certain areas of the city, in turn, brings in more people with diverse backgrounds who create new opportunities for exchanges of ideas and materials also appears to be relevant to the city in general. The structures of urban layouts are interesting because they affect all the spatial phenomena of a city, including accessibility, land values, land use patterns, population distribution, and density.

The historical and functional significance of the urban layout of a city is generally predicated upon the assumption that the city is a physical artifact immediately and completely verifiable in objective terms. However, this is not how individuals and the public at large see the city. The psychological and sociological significance of the city is evident in its legibility, liveliness, livability, memorability, sensuous delight, meaning, or expressiveness. This list of the attributes of the city is by no means complete. For example, Ewing and Handy [17] identify as many as 51 attributes of the urban street environment that may be psychologically and/or sociologically important. In his examination of 70 urban design plans and studies of 40 towns and cities (and one island), prepared in the United States between 1972 and 1989, Southworth [18] identifies over 250 specific environmental attributes that fall into several clusters (in order of decreasing frequency of mention): "Structure and Legibility," "Form," "Comfort and Convenience," "Accessibility," "Health and Safety," "Historic Conservation," "Vitality," "Natural Conservation," "Diversity," "Congruence or Fit," "Openness," "Sociability," "Equity," "Maintenance," "Adaptability," "Meaning," and "Control." Not all of these attributes are psychological and sociological in nature, but many are.

The psychological and sociological qualities of the city are difficult to describe and explain, not only because there are so many of them, but also because they are associated with individuals and the public who use, design, and/or manage the city, regularly or occasionally. These qualities can be affected as much by the physical