Understanding the Generative Process in Traditional Urbanism:

An Application Using Pattern and Form Languages

by

Ngoc Hong Nguyen

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved March 2015 by the
Graduate Supervisory Committee:

Emily Talen, Chair
Liling Huang
David Pijawka

ARIZONA STATE UNIVERSITY

May 2015

ABSTRACT

Scholars have called for better understanding of the generative process, a process underlying the creation of urban form that often has positive qualities such as coherence, human scale, flexibility, and adaptability. The generative process is incremental and continually refined, producing urban settlements that respond to feedback. Redefining the pattern language as a system of knowledge generation, and a method to acquire essential information and re-create historical contexts, this dissertation aims to provide a comprehensive understanding of the generative process and the corresponding urban codes of traditional cities. The dissertation consists of three complete yet interconnecting articles. The first article examines the structural components of the generative process—place-based norms and urban codes—and their roles in generative development. Two traditions of urbanism with distinctive and coherent forms and different levels of imposed regulations were investigated: medieval European and Arabic-Islamic. The study finds that place-based norms are the core of any generative process. Whenever written codes do not control urban space, these norms emerge to operationalize the building process. The second article investigates the generative process through the operationality of patterns, properties, and a sequence in the creation of the traditional form of the town of Hoian, Vietnam. The recurrence of each property and the pattern of its repetition in urban elements are investigated to assess the impact of generative forces on the urban form of Hoian. Fifteen of Alexander's properties and ten of Lynch's qualities were also combined into a set of twenty properties of urban elements. Finally, the third article observes and then explores the unfolding of the generative process using the virtual online platform OpenSim, thereby verifying the operationality of the generative process revealed in the

previous two articles. The paper substantiates the proposition that the generative system includes patterns and urban properties that can serve as rules for directing urban growth. These rules build diverse and unified urban settlements.

DEDICATION

To my Family

ACKNOWLEDGMENTS

This dissertation cannot be accomplished without the assistance and inspiration of numerous people. I want to first thank Emily Talen, the chair of my committee, for her tremendous support throughout my graduate years at ASU. I feel especially lucky to have had a chance to work under her gentle and effective leadership. Her professional attitude and her thoughtful insights have shed the light on my research. Without her tolerance, patience, and support to allow me to explore every corners of the generative world, this dissertation would not be finished. Second, I would like to thank Dr. David Pijawka and Dr. Huang Liling, my committee members, for their extremely helpful comments and insights. Together they have guided me through the dissertation process.

I am grateful to the School of Geographical Sciences and Urban Planning for financial support, which made my studies in the doctoral program and research possible. The same gratefulness goes to the ASU's Graduate Completion Fellowship program that directly supported me to write this dissertation. Thanks to Dr. Elizabeth Larson for much helps in-and-out of the schools during my term as a teaching assistant, Laura Grosso and Jennifer May, the school's coordinators who always let me know how to navigate through the maze of the doctoral program.

Thanks to Michael Mehaffy for his mentorship and friendship. I gained tremendous understanding about the generative method and Christopher Alexander's world. I am grateful for advice and feedback from Besim Hakim and professor Nikos Salingaros. Thanks to the participants from Danang University for taking part in this dissertation's simulation. This project would have never been completed without their

time and energy contributions. I especially want to thank Ly Ngoc Son for being such a resourceful expert.

I am indebted to my dear family. Thanks to my wife, Lê thị Minh Hằng, for her love and courage in solving all matters at home during my endless times away from home in the last five years. I feel so grateful for her support and love. My two sons, Nguyễn Lê Anh Quân and Nguyễn Lê An Phúc, have been the joys in my life. The desire to have them nearby have pushed me toward the goal of finishing this dissertation. The Vietnamese often say, “Công cha như núi Thái Sơn, nghĩa mẹ như nước trong nguồn chảy ra" (“The effort of a father is like a tall mountain, and the caring of a mother is like a flowing spring.") The efforts and carrying of my parent have transformed into the motivation for me to pursue this education path. My father, Nguyễn Ngọc Diệp, who is my role model and who shows me the wonderful world of computer and poetry—I cannot surpass him. His poem about Hoian is the best poem about the Town that I have ever read. My mother, Nguyễn thị Hồng Luyện, for always believing in me, even though my education has been so long and arduous. I thank my brother, Nguyễn Trung Dũng, for being the dearest friend and helping me to realize that I wanted to be a teacher, twenty years ago. I owe intellectual debts to my uncle, Nguyên Ngọc, the writer, for his wisdom and courage both in life and in his writing. He has been my hero since the childhood. Thanks must go to my parents-in law, Lê Minh Châu and Đinh thị Xuân Nhật for their love and support. My brothers and sisters-in law, Lê Minh Chính, Lê Minh Chuyên, Lê Minh Chuân, and Lê thị Minh Hảo—the big family that makes me feel great to hang around. They always provide assistance when I need it.

TABLE OF CONTENTS

Page

CHAPTER Page

CHAPTER Page

APPENDIX Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

Figure Page

CHAPTER 1

Introduction

Phố có vui không
Ai về tôi nhắn Phố

Bữa tôi đi Phố buồn biết mấy
Đường Phố mưa Phố ướt dầm dề
Ai đến Phố cũng lây sầu với Phố

Mái nhà nâu sẫm sầu hun khói
Kéo guốc người đi mấy vĩa hè
Phố lặng nhìn tôi lòng ủ dột
Phồn hoa son phấn Phố lơ là

Is the Town merry?
Anyone comes home please send Her my words

How sad She was the day I departed
Rain falling on, the Town got soaked
Deep sorrow infected the passersby

Rooftops turned color as boredom permeated
Clogs dragged along the sidewalks
Sullenly, the Town observed me
She: the vanity, the cosmetics, the negligence

(Nguyễn Ngọc Diệp 2008)

1.1 Introduction

This dissertation is motivated by a desire to better understand the processes that shape traditional vs. modern cities. How did people build such soul-nourishing cities in the past—Hoian, Venice, Siena, Florence, Savannah, or Kyoto, and why do modern cities, in comparison, seem to lack these qualities? Could planners and designers rebuild these towns under today's social and political constraints using modern technology? Can

we reshape cities today so that they become equal to or better than these famous cities built in the past?

The key issues lie in understanding the mechanism inside the "clock" of the so-called generative process (GP) and its derivatives, the generative system (GS), the generative method (GM), and the generative codes (GCs). Understanding them means revealing the secret of successful traditional cities—catching the operational mechanisms or the DNA of traditional cities. This dissertation seeks to then learn from this DNA to devise a new tool to better understand the operationality of urban form in both traditional and contemporary cities. The dissertation has two overarching goals. First, it aims to understand the operational mechanisms underlying the generative process. In so doing, the study adds to the literature of urban form and its relationship to building regulations. Second, this study aims to understand the cultural and social norms that contribute to the urban form. These place-based norms (PBNs)—a term coined by Eran Ben-Joseph (2005)—operate in every tradition of urbanism and it is needed to be thoroughly understood.

The three main articles that comprise this dissertation examine the mechanism of the generative process. The articles are related to one another, but each is a complete study of the GP from different angles: a) the components of the GP and their roles and relationships in generative development; b) the operational elements of a GP and the revision and restructuring of Alexander's generative method, and c) simulating the GP in an immersive environment, thereby verifying the operationality of the GP's elements.

1.2 Problem Statement

The enigmatic charms of medieval European and Arabic-Islamic towns have been studied by scholars for generations, beginning with Leon Battista Alberti and Camilo Sitte (1889) and continuing with Braunfels (1988), Saalman, H. (1968) and Spiro Kostoff (1991). However, many of these studies are descriptive and seemed unable to penetrate the outer layer of description to the mechanisms that run beneath the surface of architectural or urban typologies of traditional cities. This job is difficult, particularly the task of understanding the overall principles that shape traditional cities regardless of differences in cultures or geography. Nevertheless, there are some hints by Lewis Mumford (1960) when he mentions organic planning principles of the medieval cities. Besim Hakim (1994, 2008, and 2014) recently presented extensive work on the mechanism of form-determinants in Arabic-Islamic cities. This dissertation aims to develop a comprehensive understanding of the general principles of the GP, different operational elements in the GP, its relationship with the so-called generative codes, and its potential applicability in today's context. For these purposes, this dissertation examines three traditions of urbanism: medieval European, Arabic-Islamic, and pre-colonial Vietnamese.

The GP in this context refers to incremental development goals that produce a coherently built environment, not unlike the process-oriented paradigm that Jane Jacobs (1961) promoted. Rejecting the idea of a master plan as a frozen image of future built environments, a GP instead adheres to a "stepwise process by which a form might emerge from the evolutionary action of a group of collaborators" (Mehaffy 2008, 57). Scholars have argued for the GP in traditional cities based on its virtue of coherence, its

operation on a human scale, and the flexibility and adaptability of the environments under its influence.

1.3 Research Questions

In this dissertation, I answer one overarching question and three sub-questions relating to the GP and its derivatives, the generative method and generative codes. The three sub-questions are answered in three articles.

What are the general principles of the generative process and how does the generative process operate as form-givers regardless of cultural and geographical differences?

1) What are the roles of place-based norms and written codes in the generative process?

2) How can planners uncover the forces that form a traditional city—a product of the generative process—using an operational approach? Consequently, how can the generative method be effectively restructured based on newly acquired knowledge regarding the GP?

3) How do the operational elements of the generative process actually unfold in a simulated environment? What insight a virtual environment—the OpenSim—can offer into the generative process and generative method?

1.4 Dissertation Structure

To answer the overarching question about the general mechanism that shapes traditional cities, my dissertation investigates the GP through three different perspectives. The first perspective examines place-based norms (PBNs) and explicit written regulations

as two components of the GP. They are structural components and the aforementioned approach is termed structural. The second approach implements three elements of the GP: patterns (in a pattern language), properties of urban elements (in the form language), and a sequence (i.e., an engine or a generator for the emergence of sequentially adaptive patterns based on local conditions) to uncover forces that shape traditional urban form. These three elements comprise what I term the operational approach of the GP. The third approach employs a virtual environment and simulation to gain insight into the GP and to verify conclusions from the other two approaches. These three approaches are related and support one another. The articles employ these approaches to develop an in-depth understanding of different aspects of the GP.

Based on the insights gained from chapters 3, 4, and 5, in chapter 6, I provide qualitative formulas describing urban form. These formulas suggest a preliminary fusion of form-based codes and generative components.

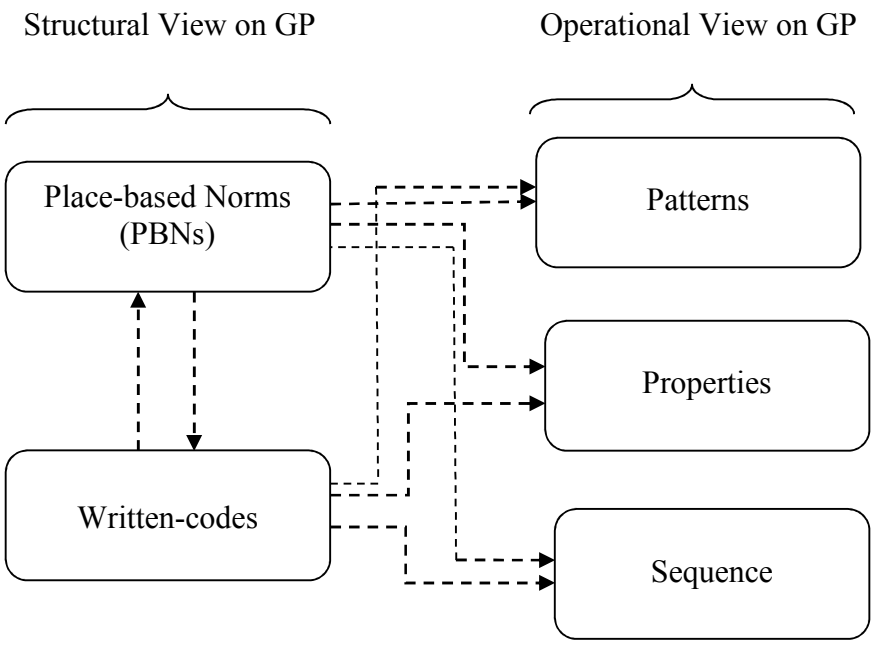


Figure 1.1: Structural and Operational Views of the GP.

The first article (chapter 3) provides a structural view of the GP by examining the two components: PBNs and written codes. Two traditions of urbanism—medieval European and Arabic-Islamic cities—are compared and analyzed from the structural perspective to obtain insight regarding the GP. As shown in figure 1.1, these structural components are related to elements of the operational perspective. Norms are patterns when they satisfy communities' demands. In other words, they provide spatial and social solutions for communities. On the other side of the diagram, the properties of a form language and the developmental sequence are the intertwined results of both PBNs and written codes. In addition, although scholars invest heavily in studying the myriad expressions of traditional urban form, from detailed architecture to urban typologies, the relationship between GCs and the GP is not clearly defined. Chapter 3 also delineates a clear relationship between these two related categories, helping urban designers to understand the DNA of traditional urban form.

Chapter 4 (the second article) examines the GP through the operationality of Alexandrian elements (i.e., patterns, properties, and a sequence) in the creation of traditional urban form. These operational elements are reexamined and reorganized in applicable order for studying the forces that shape the form of traditional cities. In chapter 4, I also rebuild the properties of urban elements based on the fifteen properties outlined by Alexander and the ten qualities proposed by Kevin Lynch.

Looking at the actual unfolding of the GP through the lens of a virtual environment, chapter 5 investigates the unfolding of the patterns, their associated properties, and the developmental sequence for the town of Hoian. The chapter also

reveals new capacities for using the simulation as a tool for public participation in urban design and for testing zoning codes.

Chapter 6 contributes to the literature of urban form by proposing qualitative formulas for extracting the DNA of different urban forms. Through these formulas, researchers can qualitatively gauge the roles of the elements that affect urban form: patterns, codes, and market forces.

This dissertation suggests further research on the combination of form-based codes (FBCs) and GCs in which generative modules are provided for the SmartCode—a transect-based FBC. Through a combination of these two types of code, I expect to bring flexibility and predictability, the two most in-demand qualities, to urban codes.

1.5 Methods

This dissertation employs different methods: *historical analysis, a pattern language, and simulation* to study the GP. These methods are used in different articles to provide an in-depth understanding of the process.

1.5.1 Article 1

Under the overall framework of a historical analysis, the first paper uses pattern and form languages to investigate two components in the GP: PBNs and written codes. The pattern language was originally seen as a design solution. Nevertheless, applications of the pattern language to education (Yinger 1987; Tabak 2005), computer programming (Gabriel 1996), management (Jessop 2004), and other fields show that a pattern language can and should be looked at as a method of organizing information. It allows for putting together information in an organized and logical order. A pattern language has the

capacity to capture nuances while ignoring trivial information. Therefore, a pattern language is used in article 1 as a system of knowledge generation. Form language with its properties on the other hand provides the specific shape to a pattern. Implementing pattern and form languages provides a thorough and essential picture of the norms and codes that shape the built environment. Thus, each pattern carries in itself norms, written codes or both. Using this approach, I identify only the codes and norms that affect urban form. Thus, I can assess the role of each structural component of the GP.

1.5.2 Article 2

Under the overarching archival research method and based on Alexander's writing and practice, three operational elements of the GP emerge: patterns, properties, and a sequence. These elements are reorganized and redefined to provide a deployable method for studying forces that shape urban form. I redefined the elements as follows: i) patterns as social and spatial solutions serving in a pattern language and ii) properties of urban elements (i.e., edges, nodes, paths, landmarks, and districts) serving in a form language. Accompanying the patterns, these properties are the shape-givers. The final element is iii) a sequence as an engine or a generator of emerging patterns. A sequence makes a pattern happen; it improves an existing pattern to give it a new shape or to provide dormant conditions for future patterns.

1.5.3 Article 3

Article 3 approaches the GP from the perspective of simulation. Twenty-two participants participated in the open-source platform OpenSim to rebuild the virtual town of Hoian between the 17th and 19th centuries. These participants were divided into three groups and followed instructions in a manual that I developed. At each step of the

rebuilding, groups were required to build a pattern accompanied by appropriate properties based on the results of the second article. A sequence of patterns was also provided. At the end of the simulation process, the results of the three virtual towns were compared to provide an in-depth understanding of the GP. This human-based simulation enhanced the method that Alexander and his colleagues (1987) implemented in their wood and cardboard simulation.

1.6 Summary

The three articles in this dissertation provide different but related views on the GP of traditional cities. On the one hand, the structural view investigates the two components, place-based norms and written codes, and their roles in the GP. The operational view, on the other hand, delves into the operationality of the GP by showing three elements: patterns, properties, and a sequence. The first view answers the question of what the GP comprises. The second answers the question of how the GP works.

The simulation of the growth of Hoian provides a near-realistic picture of the transformation of the patterns and properties of the GP and therefore provides a deeper understanding of the process. Finally, by systematizing the knowledge gained regarding the GP, I built qualitative formulas expressing the underlying mechanism – the DNA of the generative development. This is the first step in addressing qualities such as flexibility and predictability in urban coding.

CHAPTER 2

An Overview to the Key Concepts of the Generative Process

This chapter provides an overview of the key mutually related concepts in the GP. Although scholars have extensively described the GP, there is no common understanding of GCs, rendering them an obscure topic. This chapter also provides an overview of the concepts of the GP: centers, wholeness, patterns, properties, and sequences.

2.1 The Generative Process versus Generative Codes

The distinction between a GP and the so-called generative codes is unclear. Much of the academic discussion centers around the GP. Thus, the GP is better defined. The GCs, however, have received various interpretations.

A GP is an underlying mechanism that creates urban forms with qualities such as coherence, human scale, flexibility, and adaptability of the built environment under its influence (Alexander 2002; Hakim 2008). “The generative process” in this context refers to incremental development goals to produce a coherently built environment based on feedback and continuing refinement.

Therefore, the GP is about sequential development, setting priorities for steps in growth, and the continuing improvement of settlements based on collaborative work. Although GPs are nearly identical in academic thinking regarding the generative system, knowledge regarding GCs is obscure. GCs are poorly defined and have been assigned various meanings by various scholars. Alexander (CES 2006) defines a generative code as follows:

> "… a system of unfolding steps that enable people in a community to create a wholesome and healthy neighborhood. The steps are governed by rules of unfolding that are not rigid, but depend on context, and on what came before. The rules work in a way that is similar to the rules that nature follows to unfold an organism or a natural landscape, much as genetic codes unfold embryos. But these rules unfold a neighborhood and its buildings from the whole, and lead to a unique result for each particular place. The rules tell you how to take specific steps, in a certain way that allows unfolding to proceed."

Alexander's definition reveals that the GCs are sequential procedures or instructions on how to build wholeness for a community. For example, in the generative code[1] for the Strood community, Alexander discussed at length the steps necessary to lay out the physical arrangement for the community and the procurements and management of this process. In his view, a total overhaul of the current planning practice and management systems is needed. Another example is Alexander's proposal for an independent project manager who works for the community and who is in charge of the entire planning and construction process. This is, of course, innovative in design and planning but far from the reality of the planning process. An observer may recall in *The Battle* (2013), the newest book by Alexander and his colleagues, a school project that Alexander and his team designed and built in Japan. In this project, he established a new system that runs counter to the conventional methods employed by the planning and construction industries. The results were mixed and compromised. However, the most important factor as Salingaros et al. (2006) show, is the impossibility of replicating the model that Alexander desires. Instead, Salingaros et al. support a program that can work within an existing system. In short, what Alexander calls generative codes are more like *instructions* than legally binding rules, and they resemble procedures of the GP more than building codes.

[1] Most of Alexander's proposals for GCs are in a draft state.

The case of Arabic-Islamic codes is interesting because it provides a different viewpoint regarding GCs. The codes that regulate Islamic built environments are similar to adaptive rules. For example, a code protects a homeowner's view to the sea illustrates this point. If an existing homeowner complains that a new house blocks the view to the sea and if the distance between these houses is less than 100 feet, then the new house must be changed, either by relocating it or by changing its building mass so that the objects that obstruct the view are removed. Another example is the stipulation regarding the protection of visual privacy, i.e., it is the responsibility of the homeowner to protect the visual privacy of his or her neighbors. If the potential exists for the homeowner's view to look directly into a neighbor's inner space from his flat roof, for example, the homeowner must build a parapet to block the direct view. There are many such rules in the Islamic tradition. Although he does not directly mention Islamic cities, Mehaffy's perspective on GCs generally aligns with Islamic adaptive codes. He defines GCs as "a set of rules for responding to a previous set of conditions" and "each builder will have requirements for responding to previous builders in a much more contextual way" (Mehaffy, n.d., 6). Therefore, GCs in the Islamic tradition are like adaptive codes — the codes specified for conditions and what-if-scenarios. GCs are based on before and after situations in the following format: if preexisting conditions of a settlement are these, then the new structures must follow those stipulations. This type of GC differs from that proposed by Alexander and his colleagues.

Chapters 3 and 4 show that the GP in traditional cities is more important than written codes. The coherence of traditional settlement forms is possible without the involvement of GCs. As shown in chapter 3 (article 1) and chapter 4 (article 2), the cases

of medieval European cities and Hoian offer proof of this assertion: few rules dictated the form of these cities and PBNs were the main determinants of their forms.

An urban observer can tell that rules that are devoid of norms are meaningless and even harmful. An example is computer-based generative rules. Lacking cultural and social values, these rules produce interesting forms, but they can be alienating. Therefore, as shown in chapters 3 and 4 code reformers should incorporate patterns and properties that carry cultural and social values.

To conclude, traditional urban form can operate with and without adaptive rules. However, as chapter 3 (article 1) and chapter 4 (article 2) reveal, PBNs operate as an underlying mechanism forming traditional cities. Therefore, norms are of utmost importance.

Adaptive rules do not necessarily support the GP, but the generative instructions in Alexander's schema do. However, these instructions are not legally binding. Planners are faced with a dilemma. On the one hand, they have codes that they are not sure will support the GP. On the other hand, they have procedures or instructions that clearly support the GP but that are not legal codes. This dilemma can be solved by making the procedure legally binding, but this has never been implemented. One can see that Alexander's "generative codes" have never been adopted by a community. Another procedure that has become popular recently is based on progressive legal reform, working within an existing system such as FBCs. Various types of FBCs have been adopted by communities throughout the U.S., and these codes promise further development. However, to ensure that adaptation and flexibility can still be incorporated

into the codes, patterns should be brought into the equation. Chapter 6 will sketch out how this incorporation can occur.

2.2 The Structural View: Place-Based Norms versus Written Codes

PBNs are activities originating in cultural, social, and religious values. The relationship between written codes and the GP is interesting. Because some rules appear to support the GP, such as conditional adaptive rules in Islamic cultures (e.g., protection of visual privacy or protection of a view to the sea), other rules appear do not have causal relationships to a generative program.

Hakim contributes to the study of building codes in traditional urbanism by distinguishing two types of codes: proscriptive vs. prescriptive. A proscriptive rule stipulates what should not be done. Its mandate is equivalent to "thou shalt not" (Hakim 2014, 99). By contrast, a prescriptive rule outlines what should follow. Its formula is "thou shalt." As Hakim states:

> "*Proscription* is an imposed restraint synonymous with prohibition as in 'Thou shalt not', for example, you are free to design and manipulate your property provided you do not create damage on adjacent properties. *Prescription* is laying down of authoritative directions as in 'Thou shalt', for example, you shall setback from your front boundary by (x) meters, and from your side boundaries by (y) meters regardless of side conditions.

This distinction has important implications for researching the GP. Because proscriptive rules provide communities with room for interpretation, favorable conditions for the GP are created when builders and other parties act adaptively based on norms and local conditions. Therefore, Hakim states that a generative system should include many proscriptive rules and few prescriptions.

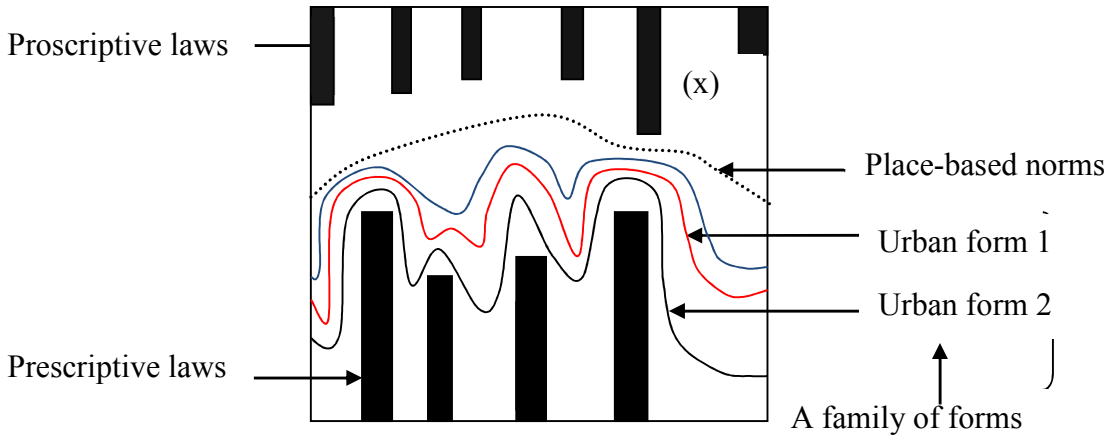


Figure 2.1: The Relationship between Laws and Norms. Urban forms are the products of negotiation among place-based norms versus proscriptive and prescriptive laws. As a result, a family of forms exists among these constraints. Note that when a proscriptive rule (x) is more restrictive than the norms, the norms must bend, thus generating an effect on the family of forms.

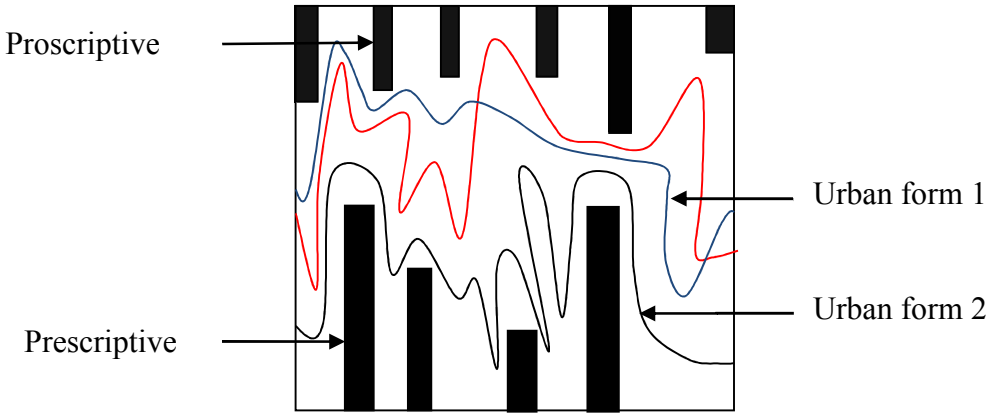


Figure 2.2: A Hypothetical Case When Norms Does Not Exist. In this hypothetical case, urban forms fluctuate without norms. No family of forms survived despite the presence of proscriptive and prescriptive laws. The result is a chaotic environment.

The diagrams in Figures 2.1 and 2.2 illustrate cases in which the cities developed with and without norms (hypothetical). In Figure 2.1, we have both proscriptive and prescriptive rules that are further constrained by norms. The result is a family of forms with diverse but unified qualities. Without norms, as in Figure 2.2, no family of forms can exist; only a chaotic environment develops, even in the presence of regulations. An important conclusion: norms are the basis of any GP.

It is also noted that norms and codes do not always differ from one another. Some norms become codes. For example, the code protecting visual privacy in Islamic cities clearly originated from the value that Muslims place on the privacy of homeowners. It is also possible for codes to become norms. We can determine when a code that has been applied for a period of time becomes a norm even after the code has become obsolete and is no longer being applied. One of the examples can be the code that stipulates the width of the street that should be enough for the passing of two horses or camels. Even when this law became obsolete, residents still maintain the habit of building streets based on minimum width.

In summary, the GP of the traditional urbanism is based primarily on norms *not* codes. The levels of intervention of written rules depend on the social fitness of patterns. Healthier patterns in term of human scales, compactness, and mixed use in the GP are associated with less control from written regulations, and vice versa.

From now on, I will use the term adaptive codes with clearer connotations to discuss codes that create scenarios for new structures adapted to preexisting conditions. Whenever I use the term "generative codes," I will specify it as either Alexander's instructions or procedures regarding the GP or as adaptive codes along Hakim's line of thinking. When mentioning codes that do not support the GP or that have ambiguous effects on it, I use the term "written codes."

2.3 The Operational View: Patterns, Properties, and a Sequence

2.3.1 Pattern Language

Pattern language has an established history in urban design. Alexander and colleagues (1977) argued that architecture and urban elements are generated by patterns, or spatial and social solutions to design and planning problems. Patterns are organized in an interconnected and hierarchical system that allows for infinite combination. A collection of entities in this type of order—a pattern language—has the capacity to adapt to local conditions. In addition, a pattern language is based on the induction and observation of successful urban traditions; therefore, it reflects humans' shared knowledge of built environments. A pattern language supports the virtues of organic planning in that collective efforts produce a highly coherent structure based on sequential development.

Surprisingly, researchers outside of the field of design and planning are often the individuals who best understand the values of a pattern language. For example, Werner Ulrich (2006) described patterns as follows**:**

> "It is important to realize, according to Alexander, that patterns are not arbitrary design ideas but can and need to be identified and verified through careful observation. Furthermore, patterns *become meaningful only within a hierarchy of interdependent* patterns, in which each pattern helps to *complete* larger (more generic) patterns within which it is contained, and in turn is *further completed by smaller* (more specific) patterns that it contains. *Each pattern has a well-defined place in the overall network of patterns*; together, they constitute a *pattern language,* a vocabulary of design that consists not just of words but of mental design images" (my emphasis).

Nonetheless, pattern language has also been fiercely critiqued by planners and designers. One of the most common criticisms of Alexander's patterns is that he imposes patterns with universal implications. Cuthbert (2007, 206), for example, wrote "[o]ne of

the major problems with the patterns is their claims to be archetypes, and of having crosscultural application, which is clearly not the case." My argument is that this critique missed the following point: Alexander mentioned that his patterns are hypotheses that require additional verification and that these patterns will be applied through a process of trial and error. In particular, Alexander stated that "if you like, each pattern may be looked upon as a hypothesis like one of the hypotheses of science. In this sense, each pattern represents our current best guess as to what arrangement of the physical environment will work to solve the problem presented and are therefore all tentative, all *free to evolve under the impact of new experience and observation*" (my emphasis).

Another noteworthy consideration is that patterns in a pattern language are discovered by people. No restriction to only 253 patterns is imposed; instead, the number of patterns is unlimited. Whenever builders build a community or a building, they must develop their own patterns, although they can and should use the aforementioned 253 patterns as a valuable reference. It appears that the pattern language method is ignored because the development of patterns for builders requires careful observation and skills. This requirement may be the most irksome aspect of this method for pattern language opponents, who seem to ignore the power of observation and inductive knowledge. Critics of Alexander also ignore the fact that pattern language has been successfully applied in other fields, such as computer science, education, archaeology, and management. Researchers have utilized pattern language-based approaches to advance their methodology and practices. A notable success in this regard is the application of pattern language to object-oriented programming (Gabriel 1996; Gamma et al. 1998).

Another critique of pattern language is that it is not appropriate for the conditions of contemporary societies and that what Alexander proposes is a "totalitarian moral framework." Rabeneck (1979, 20) wrote:

> "Alexander and his colleagues have created a totalitarian moral framework into which their prescriptions slot so neatly. But today with close regulation of the economy and freedom of individual morality, a positive initiative like the pattern language stands little chance…it is a treasure trove of esoteric evidence brought to the support of firmly held personal prejudices."

This critique again failed to account for the principle that patterns should first be discovered and established and then adapted to the conditions of modern society. Nevertheless, pattern language also seeks to address values to which humans aspire, such as human scaling, mixed uses, walkability, and connectivity. These values have been verified and proven through myriad research (for example, Jacobs 1961; Bardill, Karamanoglu and Herd 2005; Ewing and Handy 2009; Gehl 2010; Ewing and Clemente 2013). Among critiques of the pattern language approach, the criticism that this method ignores current conditions of planning and regulation practices may be the most reasonable concern. Buchanan stated:

> "The reasons for the neglect of Alexander's pattern language are obvious. Though it purports to be a working tool outlining a process to a better environment, it is hopelessly impractical. It ignores and cannot even accommodate such basic constraints as planning controls and building regulations. There is no word on finance; and modern tools, materials and conveniences are shunned. The world it implies is paradoxically both too primitive and too utopian. It smacks of a shaggy; idealistic and unsustainable hippiedom (Buchanan 1979, 21).

Aside from repeated, worn-out critiques regarding Alexander's pattern language, such as criticisms of its "utopian" nature and "unsustainable hippiedom," the issues of control and building regulations and scale of economy are the real problems that preclude

the use of pattern languages in urban design. In his later works, Alexander recognized and attempted to address these issues. Other scholars and practitioners have also adopted the ideas of pattern language and attempted to mold pattern language into a usable framework for contemporary cities. For instance, Andrés Duany and Jeff Speck (2010) provided 148 principles for smart growth development in their *Smart Growth Manual*. These principles are actually patterns.

This dissertation explores an approach to address the aforementioned issues. Through imparting an in-depth understanding of the generative process and urban codes in traditional cities, I seek to provide a solid foundation for applying the generative method (including pattern language) in contemporary cities.

2.3.1.1 Wholeness

The concepts of wholeness, the center, and process are mutually related. In a GP, i.e., an incremental development wherein process-oriented evolution or "organic development" occurs, a performance quality called "wholeness" emerges (Alexander *et al.* 1987). Alexander emphasizes the importance of the process in which participants collectively and sequentially enhance the coherence or wholeness of the built environment. Alexander's wholeness implies a global connection between a structure and other entities while maintaining a high level of order and coherence within the structure (Alexander 2002).

Using a quantitative approach and a concept he termed architectural life, Salingaros (2008) conducted a study in which he calculated the architectural life (L) of an architectural structure using two parameters that he called architectural temperature (T)

and harmony (H). This architectural life in nature is similar to the quality of coherence or wholeness that Alexander proposed.

Salingaros defined architectural life (L) as the mathematical product of T and H:

$$L = TH \tag{2.1}$$

T is the sum of geometrical substructures and color in a building.

$$T = T_1 + T_2 + T_3 + T_4 + T_5 \tag{2.2}$$

Each T_i is assigned a value from 0 to 2 based on a human assessment. Little or no presence of quality = 0, some =1, considerable =2.

Salingaros explained,

a) *T_1 is the level of intensity of perceivable details*. This quality expresses the capacity to perceive architectural details or differentiation in the material's texture at arm's length (approximately 1 m).

b) *T_2 is the density of differentiations.* This quality measures how much substructure and variety is apparent to observers.

c) *T_3 is the expression of curvature of lines and forms.* This quality measures the "smallness of the radius of curvature of lines and forms" (Salingaros 2008, 108).

d) *T_4 is the intensity of color hue.* This quality measures the depth of color. Vivid or intense coloring receives a score of 2 and dull or grayish coloring receives values of 0 or 1.

e) *T_5 is the contrast among color hues.* This quality measures the interaction among several distinct colors, e.g., yellow and violet or orange and blue.

Salingaros defines architectural harmony (H) as follows:

$$H = H_1 + H_2 + H_3 + H_4 + H5 \tag{2.3}$$

Architectural harmony (H) is also expressed as one of three values: 0 for little harmony, 1 for some harmony, and 2 for considerable harmony. Architectural harmony (H) is based on the measurement of symmetries, contrast, and the relationship among architectural elements.

a) *H_1 is the reflection symmetries on all scales*. This quality measures the presence of symmetries on all scales, not just the largest scales.

b) *H_2 is the measurement of translational symmetries.*

c) *H_3 is the degree to which distinct forms have similar shapes.* This quality measures self-similarity by scaling up the same shapes to different sizes.

d) *H_4 is the degree to which forms are connected geometrically one to another.* This quality measures the presence of geometrical connections. The connection can manifest in many ways, including connecting lines or transitional regions.

e) *H_5 is the measurement of color harmony.*

Table 2.1 shows Salingaros's calculations for several well-known buildings, from ancient to contemporary.

Table 2.1: The Calculation of Architectural Life (L = Th) for Twenty-Five Buildings by Salingaros. Source: Salingaros 2008.

	Building	Place	Date	T	H	L
1	Parthenon	Athens	-5C	7	8	56
2	Hagia Sophia	Istanbul	6C	10	8	80
3	Dome of the Rock	Jerusalem	7C	9	9	81
4	Palatin Chapel	Aachen	9C	7	9	63
5	Phoenix Hall	Kyoto	11C	7	9	63
6	Konarak Temple	Orissa	13C	8	8	64
7	Cathedral	Salisbury	13C	7	9	63
8	Baptistry	Pisa	11/14C	7	8	56
9	Alhambra	Granada	14C	10	9	90
10	St. Peter's	Rome	16/17C	9	6	54
11	Taj Mahal	Delhi	17C	10	9	90
12	Grand Palace	Brussels	1700	9	7	63
13	Maison Horta	Brussels	1898	8	7	56
14	Carson, Pirie, Scott	Chicago	1899	7	8	56
15	Casa Batlló	Barcelona	1906	8	5	40
16	Fallingwater	Bear Run	1936	4	5	20
17	Watts Towers	Los Angeles	1954	10	4	40
18	Corbusier Chapel	Ronchamp	1955	3	2	6
19	Seagram Building	New York	1958	1	8	8
20	TWA Terminal	New York	1961	3	4	12
21	Salk Institute	San Diego	1965	1	6	6
22	Opera House	Sydney	1973	4	5	20
23	Medical Faculty	Brussels	1974	7	4	28
24	Pompidou Center	Paris	1977	6	4	24
25	Foster Bank	Hong Kong	1986	3	7	21

2.3.1.2 Center

A center as proposed by Alexander (2002) is a relational and organized zone, a type of interrelated field of forces that act throughout space. Each center has an adequate level of internal homogeneity and coherence that is typically shaped by a defined boundary. According to Alexander, a center has four key characteristics: i) a center by itself has life; ii) a center helps other centers, i.e., the wholeness of one center supports the wholeness of other centers; iii) centers are made of centers; iv) a structure gets its life according to the density and intensity of other centers that have been formed within it. Alexander uses the term “life” to denote essential characteristics in spatial, natural, or

man-made structures that heighten human feeling. This concept bears similarities to several traditions of thought, such as those developed by Johann Wolfgang von Goethe (in Bortoft 1996) or Henry Bergson (1998). I argue that using the term "wholeness" is more appropriate when assessing architectural and urban structures.

In Alexander's schema, centers have recursive relationships and are field-like forces: *"[c]enter are always made of other centers*. A center is not a point, *not* a perceived center of gravity. It is rather a field of organized forces in an object or part of an object which makes that object or part exhibit centrality" (2002, 118) (emphasized by Alexander). Each center, therefore, is not a primitive element but by definition a composite. According to Alexander, centers can be roughly defined as spatial structures that are often bounded, connected, convex, symmetric, and differentiated from the spaces next to them.

Additional scholars have explored and recognized the concept of center. Though expressed in different terms, these propositions are not unlike Alexander's. For example, in physics, Geoffrey Chew (1970) states that there are no ultimate entities and every particle should be defined with regard to other particles. According to Rudolf Arnheim (1982), an art historian, centers are also fundamental building blocks of wholeness in works of art. Nevertheless, the correlations between Alexander and Alfred North Whitehead's ideas are the strongest.

The concept of centers is closely aligned with that of 'actual entities'—building blocks of reality, which, according to Whitehead (1979, 18), "are the final real things of which the world is made up." Whitehead's actual entities (or actual occasions) are in a state of constant change through the prehension, or grasping, of other entities. This idea

parallels Alexander's thinking regarding the continuous improvement of the wholeness of built structure—property that was built upon the hierarchical centers embedded in one another. The wholeness implies a global connection to other entities while maintaining a high level of internal order and coherence for a structure itself (Alexander 2002).

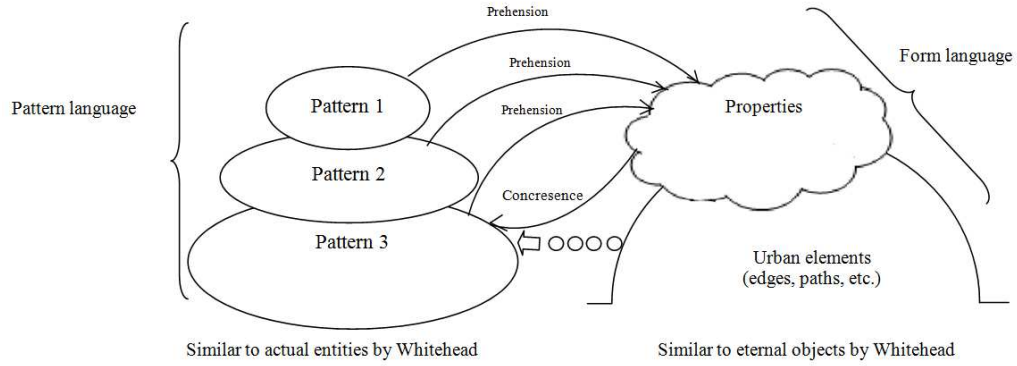


Figure 2.3: The Relationship between Pattern and Form Languages, and Urban Elements.

In Alexander's schema, a pattern as a social and spatial organization is also a center—a field-effect zone that plays a significant role in organizing the urban structure or architecture. As mentioned above, there is an analogy between Alexander's centers and Whitehead's actual entities.

Figure 2.3 further explains relationships between patterns/actual entities and urban elements/eternal objects. On the right of the diagram are urban elements, which include edges, paths, nodes, districts, and landmarks, as Lynch identified. These elements are carrying bodies or containers of properties. They are the abstraction of urban patterns. Whitehead's view can help: urban elements are similar to what Whitehead calls eternal objects. The term used here does not have religious or honorific meaning (Mesle 2008); it just means that the eternal objects are "pure possibilities" or potential events that are ready to become Whitehead's actual entities. Thus, a pattern is similar to an actual entity.

A pattern will enhance its coherence (or novelty, to use Whitehead's term) through the process of grasping a form's properties. This process is, to some degree, equivalent to what Whitehead calls *prehension*. A collection of patterns creates a pattern language, which is similar to a collection of actual entities that Whitehead called a nexus (or a society, in Whitehead's lingo). A form language includes properties that reside in urban elements.

2.3.2 Form Language and Properties

2.3.2.1 Form language

Alexander (2002) proposed that to build a true living environment, it is essential to have a language that cooperates with the pattern language: form language. Closely aligned with Alexander's approach, Salingaros (2008) defined form language as the "particular and practical conception of tectonic and surface geometry" (221), or more simply, the set of geometric rules that govern a type of architecture. It is through the spatial and surfaced components of form language that a building most directly conveys its informational and emotional content to human beings. Each unique form language is the product of evolution through trial-and-error in construction, and it must rely on local context (e.g., materials, practical needs, and climate) to create form. Form language in traditional architecture is "rich, complete, and technically advanced" (Salingaros 2008, 221).

2.3.2.2 Urban elements and their properties

In the 1960s, Alexander and colleagues performed experiments to prove the objectivity of the concept of wholeness/coherence. They asked participants to rank-order strips of seven 1 cm x 1 cm squares, including four black and three white squares. They

used 35 strips for the ranking experiment (Figure 2.4). Sets of two to four squares that are symmetrical and connected to one another, such as sub-strips 1 and 2 in Figure 2.5, are called subsymmetries. The results of the experiment indicated that the strips with more subsymmetries were ranked higher in terms of coherence by participants. Alexander called these substructures local symmetries. This experiment and other follow-up experiments by Alexander indicated that coherence, as a quality of local symmetries, is objective. In his experiment with strips of black and white squares, the only property present was local symmetries.

The *Level of Scale* property is well calculated and has been verified by Salingaros (2008). In his research, he argued that architecture should have definite size thresholds. Salingaros states, "the small scale is connected to the large scale through a linked hierarchy of intermediate scales with a scaling ratio approximately equal to $e \approx 2.7$" (2008, 36). Alexander, however, suggests a more flexible range, stating that the scaling factor should be from 2 to 5 (2002). Both agree, however, that in a composition, elements should have sizes with defined and discernible thresholds.

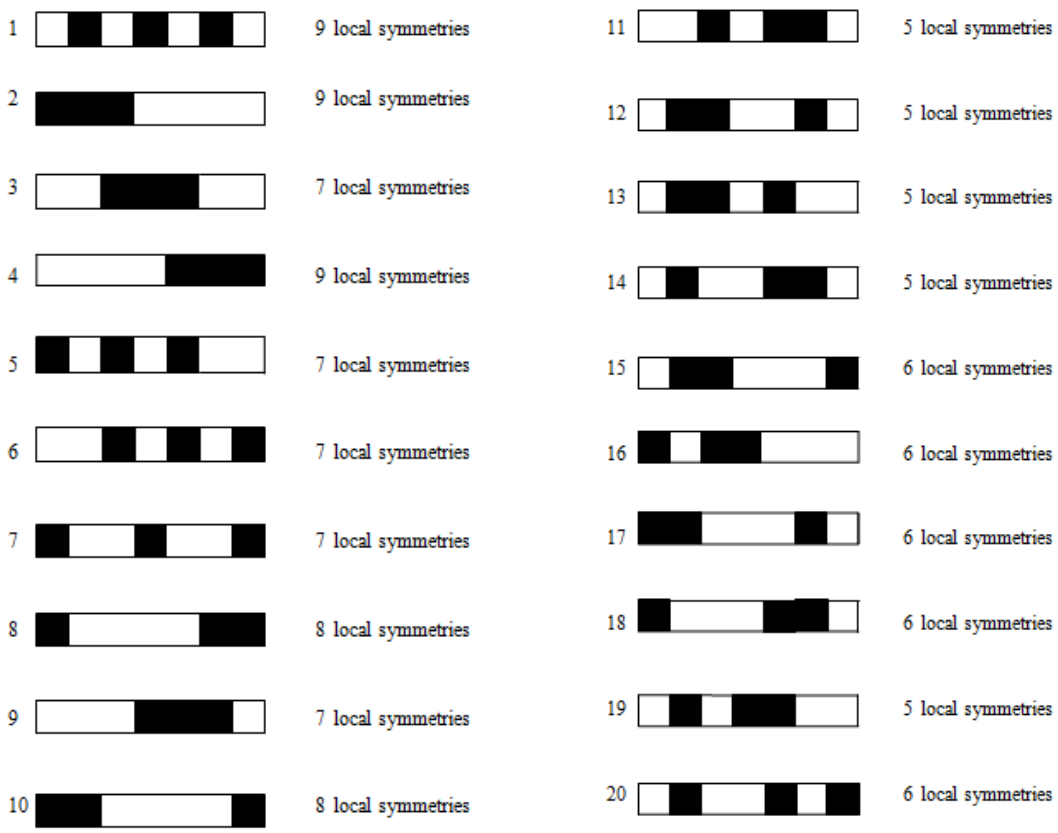


Figure 2.4: Strips Include Three Black and Four White Squares in Alexander's Experiment. These twenty strips represent the highest local symmetries and lowest local symmetries.

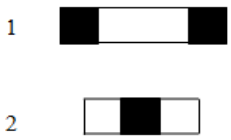


Figure 2.5: Example of Subsymmetries in Alexander's Experiment.

Discovering other properties is more complicated. Nevertheless, Alexander developed a unique method to objectively capture the essence of properties in architectural and urban structures. In Alexander's Mirror-of-the-Self method, participants are shown pictures of two comparable structures—two objects, two buildings or two urban structures. Alexander then asked participants an unusual question: "*If you had to*

choose one of these two objects, as a picture of your own self, then which one of the two would you choose?" He would continue, explaining, "*In case you find it hard to ask the question, let me clarify by asking you to choose the one* which seems better able to represent your whole being, the essence of yourself, good and bad, all that is human in you (in Gabriel 1996, 83; Alexander emphasized). At first, the question seems odd to the participants, who are universally surprised by this question. After several trials, however, they feel comfortable with the question and provide consistent responses to the structures with higher levels of coherence. Gabriel (1996), also confirm the consistency of responses to structures with higher levels of coherence. Therefore, by determining which structure has more life or more wholeness using the Mirror-of-the-Self method, Alexander identified thousands of structures with higher levels of coherence. He has applied this method to determine which structures have higher levels of coherence for more than twenty years in his search for the fifteen properties that I will mention in the following paragraphs. Therefore, it is arguable that the fifteen properties developed by Alexander are objective.

From a different perspective, David Seamon (2007) argued that Alexander's method is a phenomenological approach and that each of the properties he identified is the careful interpretation of human experience. The goal is to identify "underlying lived structure common to many specific experienced instances of the phenomenon" (10). Stephen Grabow (1993) also proposes that Alexander's approach is phenomenological. He said, "the discovery that the sense of being completely alive has a clear phenomenological counterpart in space—a particular quality in space that one can actually see as well as feel" (66-67).

I posit that Alexander's and Lynch's theories about properties (discussed in the following paragraphs) express both scientific and phenomenological approaches and do not conflict with one another. In fact, they support one another because one approach is based on facts and the other on values. These values are extracted from individual and group feelings, intuition, and experience and they are as a valid as measurable facts.

In *The Nature of Order,* Alexander (2002) proposes the use of fifteen properties to express the quality of a built environment's form. These properties are an indicator of the wholeness of a form language. In general, the more properties that exist in an urban element, the higher the wholeness of that element is. Nevertheless, as analyzed in Figure 2.3, urban elements are eternal objects waiting to become concrete actual entities—patterns. Therefore, a pattern with a high number of properties is a pattern that has a higher level of wholeness or coherence. In chapter 4, Alexander's fifteen properties are re-evaluated to determine their applicability at the urban level.

While Alexander's properties in a form language are useful for assessing architectural form, their applicability is limited at the urban scale, particularly when dealing with movement in city. Fortunately, Lynch five urban elements shape human perception (i.e., paths, edges, nodes, districts, and landmarks) can complement. These elements accompanied with their qualities constitute the physical representation of the city form.

In *The Image of The City*, Lynch (1961) discussed qualities of urban elements. He coined the terms: *Singularity, Form Simplicity, Continuity, Dominance, Clarity of Joint, Directional Differentiation, Visual Scope, Motion Awareness, Time Series,* and *Name and Meaning.* His qualities of urban elements are valuable for the assessment of the city on a

large scale. Alexander's properties, on the other hand, allow for assessing the level of coherence on smaller scales. Combining Lynch's qualities and Alexander's properties helps to understand and evaluate city form at every scale from small to large. In chapter 4, I analyze these properties and qualities so that they represent the entire spectrum of urban form.

A note regarding Lynch's urban elements, particularly with respect to critiques of *The Image of the City*: these urban elements were confirmed in research by Aragones and Arredondo (1985), although these researchers stated that the urban element *Edge* appears to require additional exploration and confirmation. In my research, I extract the qualities of urban elements with the objective of providing a better framework for the generative process.

2.3.3 The Sequence

In a generative system, the sequence of steps acts like an engine for the operationality of patterns and properties. Alexander (CES 2006) terms this sequence *unfolding,* saying, '[w]hether in the evolution of a neighborhood or in the evolution of a building, each unfolding is an operation which gets you from one stage or moment of development (whether conceptual or physical), to the next moment of development. A sequence not only complements patterns and properties in a GP, but it is also an essential element and creates the needed transformation.

Table 2.2: The Revised Set of Urban Properties. A complete urban properties are listed in Appendix B.

No	**Form qualities**	**Description**
1	Singularity and Contrast	A coherent and balanced structure usually has a high degree of contrast that creates a sense of differentiation and emphasizes contrasting elements.
4	Dominance	A dominant feature in the urban context, accompanied by sub-elements.
5	Clarity of Joint	The 'high visibility of joints and seams', i.e., clear relation and interconnection.
6	Directional Differentiation and Gradient	Directional ′asymmetries' and 'gradients'—slow and incremental changes throughout the overall structure.
10	Level of Scale	Structures comprise components of different sizes: a few large, several medium-sized, and many small components.
11	Strong Centre	A center is an object with a prominent shape or position within a structure. It must support the centers around it, inside it and that contain it.
12	Boundary	A thick boundary focuses attention on the center.
16	Local Symmetry	A structure should have symmetry at many local scales to create a balanced distribution of forms without global rigidity.

CHAPTER 3

The Generative Process vs. the Urban Code: Comparing two traditions of urbanism

About this chapter

This chapter is the first of the three articles about the generative process. It makes a contribution to the literature of urban form by investigating the generative processes and urban codes used in the creation of medieval European and Arabic-Islamic cities. Using pattern and form languages to uncover principles that are common between these processes and codes, the study finds that a generative process is the product of both place-based norms and written codes. Whenever written codes leave gaps in how urban space should be controlled, place-based norms emerge to fill these gaps in the operationality of the building process. Different norms build distinctive forms in the cultures explored. The article will be submitted to the Journal of Urban Design International.

3.1 Introduction

Although much of the research on code reform focuses on form-based codes (FBCs)—codes that "use physical form, rather than separation of land uses, as their organizing principle" and "foster predictable results in the built environment and a high quality public realm" (Form-Based Codes Institute, n.d.)—the relationship between the generative process and regulatory codes is understudied. "The generative process" (GP)

in this context refers to incremental development goals to produce a coherently built environment.

Although many scholars (Ben-Joseph 2005; Hakim 2008a; Mehaffy 2008; Talen 2012) agree on the importance and prospects of the GP and its relationship with code reform via the principles of flexibility, adaptability, and citizen participation, a thorough study of this relationship has not been conducted. Despite the lack of attention of urban designers, the GP and associated codes have a long history in traditional urbanism. Historical cities from various cultures express some degree of "organic planning" —a Mumford's (1961, 302) term for the generative process. Traditional urban forms were shaped not only by written codes but also by unwritten customs that influenced the form of traditional cities. These customs are defined in a variety of terms; for example, what Emily Talen (2012) refers to as cultural norms is described by Besim Hakim (1994, 2008a) as *urf* in Islamic urbanism, and Ben Joseph mentions place-based norms. The roles of these norms and their relationship with written codes in the GP remain poorly understood.

Christopher Alexander and Besim Hakim are two scholars who have studied the GP extensively. Alexander defined a generative process as incremental development wherein process-oriented evolution or "organic development" occurs. As a result, a performance quality called "wholeness" emerges (Alexander *et al.* 1987). He emphasizes the importance of the process in which participants collectively and sequentially enhance the coherence or wholeness of the built environment. Alexander's wholeness implies a global connection between a structure and other entities while maintaining a high level of order and coherence within the structure (Alexander 2002).

Studying Arabic-Islamic codes using a historical approach, Hakim has written extensively on built regulations in Islamic culture. He (2007, 2008a) argued that a generative system of Islamic cities includes the following: i) general principles based on the religious values of Islamic societies, ii) acknowledgement of the inevitability of change, iii) the fair distribution of rights and responsibilities between public and private parties, iii) respect for local customs, and iv) rules. Hakim noted that although some parts of Islamic rules relating to the built environment derive from Sharia law, others are based on customary laws (2008a).

Apart from the research by Alexander, Hakim and other scholars, the GP and urban codes have not been comprehensively studied in different geographical regions and cultures. In addition, the role of norms in the GP is not clearly understood. To address this gap, the research presented here aims to determine the roles and operational mechanism of norms in the generative process. The study aims to answer two questions: What general principles of the generative process and urban codes apply, regardless of cultural geographical differences? What are the structural components that comprise the GP, and what are the roles of these components?

Based on the quality of urban design, the organic nature, the distinctive form, and the level of presence of written codes, two traditions of urbanism are investigated: medieval European and Arabic-Islamic. A comparative analysis of norms in these cultures will give planners a better understanding of the generative process.

3.2 Background

The study of the generative process has only recently begun, mostly through the writings of Alexander and Hakim. Alexander and colleagues (1987) defined a generative method in urban design as incremental steps to development in which parties (e.g., builders, ordinary people, and developers) collectively build architectural or urban structures with the objective of improving wholeness. Adopting a different approach, Hakim explored Islamic traditions based on a historical analysis. He defined generative codes (GCs) as imposed regulations on public and private realms that respect change, local customs, interdependence between neighbours, and that allow the urban form to evolve "naturally" as a "self-regulating and adaptive system" (Hakim and Ahmed 2006, 19).

3.2.1 The Generative Process vs. Generative Codes

The distinction between a GP and so-called GCs is blurred. As mentioned above, the GP is about sequential development, prioritizing steps in the growth and continuing improvement of a settlement based on collaborative work. While scholars have reached a consensus regarding GP, the concept of GCs has not yet been clearly defined and remains obscure. As chapter 2 discussed what Alexander calls GCs are more *instructions* than legally binding rules. They resemble procedures of the generative process rather than building codes.

Salingaros, for example, defined GCs as rules that instruct and lead to sequential growth. He mentions that "…There is a way to lay these [i.e., organic complexity and adaptive character] out sequentially, iteratively, according to a simple series of rules, as the generative codes propose to do (Salingaros et al, 2006, 22).

The case of Arabic-Islamic codes is interesting because it provides a different viewpoint on GCs. The codes are named as conditional adaptive codes. Although not directly mentioning Islamic cities, Mehaffy's thought on GCs in general is aligned with the Islamic adaptive codes. He defines GCs as "a set of rules for responding to a previous set of condition" and "each builder will have requirements for responding to previous builders in a much more contextual way" (Mehaffy, n.d., 6). Therefore, the GCs in the Islamic tradition are more like adaptive codes—the codes specified for conditions and what-if-scenarios. GCs are based on before and after situations in the following format: if preexisting conditions of a settlement are these, then the new structures must follow those stipulations. This type of GCs differs from that proposed by Alexander and his colleagues.

Adaptive rules do not necessary contribute to the GP, but the generative instructions in Alexander's model certainly do. However, instructions are not legally binding. Therefore, scholars face a dilemma. On the one hand, we have codes may or may not support the GP. On the other hand, we have generative procedures/instructions that clearly support the GP but are not legal codes. One solution is the legislating the procedure, thereby making it legally binding. However, that strategy is typically unsuccessful.[1] Later in the chapter, I demonstrate that GP does not always embody a code. In general, the GP can function with limited regulations or even without a code (as in the case of Hoian[2]).

1 Alexander's GCs have not been adopted by any communities.
[2] Chapter 4 discusses the generative process in Hoian, in which the urban form is not based on strong regulatory traditions. Instead, the town's form was dictated by place-based norms.

3.2.2 Using Pattern and Form Languages to Understand the Generative Process

Pattern language has an established history in urban design. Alexander and colleagues (1977) argued that architecture and urban elements are generated by patterns, or spatial and social solutions to design and planning problems. Patterns are organized in an interconnected and hierarchical system that allows for infinite combination. A collection of entities in this type of order—a pattern language—has the capacity to adapt to local conditions. A pattern language supports the virtues of organic planning in that collective efforts produce a highly coherent structure based on sequential growth.

In his magnum opus *The Nature of Order,* Alexander developed a set of fifteen properties indicating the features of wholeness that a structure should possess[1]. Closely aligned with Alexander's approach, Nikos Salingaros (2008) stated that these properties are the main components of a form language. He defined form language as the "particular and practical conception of tectonic and surface geometry" (Salingaros 2008, 221). Both pattern and form languages must seamlessly connect to one another to build a coherent structure. In chapter 4, I have argued that Lynch's (1960) paths, edges, nodes, districts, and landmarks should be combined with Alexander's properties to create a new set of twenty properties that describe the form language of urban elements.

Using the framework of historical analysis, this paper *investigates the GP through pattern language.* Pattern language has typically been regarded as a design solution. Nevertheless, the application of pattern language in education (Yinger 1987; Tabak 2005), computer programming (Gabriel 1996), management (Jessop 2004) and other fields demonstrates that it can and should be viewed as a *way to organize information*.

[1] Appendix A provides an explanation of these fifteen properties.

Pattern language allows for the consolidation of information in an organized and logical order. A pattern language has the capacity to capture nuance while ignoring trivial information *Therefore, in this paper, pattern language is used as a system of knowledge generation.* As illustrated in Figure 3.1, each pattern carries within itself norms, written codes, or both, and using pattern language provides a thorough and essential picture of the norms and codes that shape the built environment. Using this approach, I discuss only the codes and norms that affect the urban form. Similarly, form language is also employed to demonstrate the effect that codes/norms have on the form of a city.

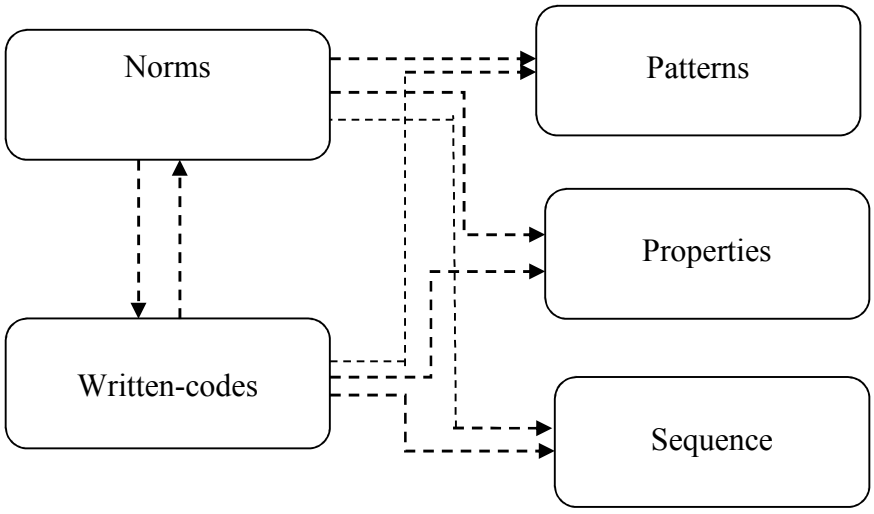


Figure 3.1: Relationship between Patterns, Properties, Norms, and Written Codes in the GP.

Finally, for each type of urbanism, I investigate its *developmental sequence* to determine the impacts of norms and codes on the urban form. In a generative system, the sequence of steps acts like an engine for the operationality of patterns and properties. Alexander (CES, 2006) defines this sequence as *unfolding*,'[w]hether in the evolution of a neighborhood or in the evolution of a building, each unfolding is an operation which gets you from one stage or moment of development (whether conceptual or physical), to the next moment of development.' Salingaros et al. (2006) argue that a sequence is the

origin of 'the emergence of an adaptive form' and that 'a living design' is 'generated by a sequence in which each step depends upon all the previous steps' (p. 19). For example, he and his colleagues specify the sequence of development in favelas as follows: Specifying the Main Street space → Determining the urban space → Establishing side streets that feed the Main streets → Locating house positions → Designing house plans → Building patio or garden spaces → Demarcating the lots on a map (23). In short, a sequence not only complements patterns and properties in a GP but also is an essential element that creates the needed transformation.

This paper employed archival research to document major facts regarding organic cities in two traditions of urbanism: medieval European and Arabic-Islamic. These traditions of urbanism were selected based on the high quality of their urban forms (i.e., human scales, mixed land uses, compact and walkable) and based on the different levels of involvement of written codes in the built environment. As shown in a subsequent part, the physical form of Islamic cities demonstrates the strong involvement of written regulations, whereas written codes were found to be less tangible in medieval cities. Based on Alexander's approach (1987, 2002a, 2002b), the two GPs are investigated in the following format: i) patterns are defined as steps in a transformational sequence; ii) in each pattern, certain properties are manifested; and iii) a sequence of patterns reflects process-oriented development. In Alexander's model of the GP, the sequence[1] must enhance the wholeness of the structure. Nevertheless, Alexander's notion of enhancing the wholeness of structure in traditional cities was not based on the facts that actually occurred 'on the ground'; therefore, this study aims to address this limitation by

1 Alexander (2002b, 51) coins the term "structure-preservation transformation" to describe this sequence.

recreating the GP based on historical facts—i.e., exploring the patterns that actually transformed traditional cities.

3.3 Using Pattern Language to Explore the Generative Process in Medieval European cities

3.3.1 Pattern Language

A medieval city was an outgrowth of cultural and religious institutions, often originating from a monastery and providing protection from thieves, plunderers, and a retreat from the prevailing chaos and confusion after the fall of Rome. Several laws with direct effects on the built environment are analysed.

- Prochiron Legum was promulgated in Calabria, Italia, under the reign of Byzantine Emperor Basil II (976-1025). Hakim (2014) grouped 59 articles of Legum into two categories: i) the right of ownership and responsibilities and ii) rules for land use, buildings, and access.
- Las Sietes Partidas was written under the reign of Alfonso X in the later part of the 13th century (Hakim 2014) and was concerned with issues such as usages and customs, land use considerations, and servitude.

Pattern #1

The Seeding Monastery[1]

A monastery provided order, serenity, and a place of inner retreat—"a citadel of the soul"—in the midst of the turbulence of the post-Roman period (Mumford 1961,

1 For the sake of clarity, the name of each pattern will be written in *italic and underline*, and the name of each Properties will be in *italics.*

246). Most monasteries at the beginning of the Middle Ages had walls to protect against the encroachment of thieves and bandits. Subsequently, these walls were expanded to surround merchant neighbourhoods, eventually embracing the entire city.

Pattern #2

Marketplace

In some cases, the marketplace was only an open area where burghers brought goods to trade, but in some cases, it was roofed. Although the shapes of markets were diverse, they were often convex and irregular (Mumford 1961; Pounds 2005). The form of markets was the result of the negotiation between public and private rights, but as Mumford argued, private rights had precedence, and as Pounds stated, public rights were honoured only after instances of violation were brought before the courts (Pounds 2005). This tendency recalls the impacts of customs in medieval cities over rules. Market stalls were located either in front of the cathedral or flanking it to form an irregularly shaped square.

Pattern #3

Small Square

A square was also the nucleus of a precinct when it was surrounded by churches, guildhalls, and major shops. Although the medieval square had no design, there were rules related to the architecture of the square. In Siena in 1297, houses or palaces facing the Piazza del Campo were to "be built with windows divided by colonettes, and have no overhanging structures" (Hakim 2014, 187). Similarly, no balconies should be constructed facing the Campo. In Florence, houses facing Piazza San Giovanni must shut their doors based on proposals by the Merchant Guild (2014). Given these constraints,

medieval squares were the result of the consensus between private rights and public powers.

Pattern #4

Guild and Guild Halls

"[T]he Church and the guild were based on fellowship, common works, and a common faith" (Mumford 1961, 269). The guild fulfilled other necessities that the church could not; it brought economic and social security, although it never lost its religious influence (1961). The guild provided a material foundation on which the city could prosper: "the guilds were only the city in its economic aspect as the city was the guilds in their social and political aspect" (Mumford 1961, 272).

Pattern #5

City Nucleus

The archetypal centre of the medieval city included a cathedral, a city hall, guildhalls, and a marketplace. The vibrant marketplace often had a roof, sometimes with arcades providing shade and temporary shelter from unfavourable conditions. At the heart of the city was a central square that sometimes had a convex form and was either paved or unpaved. In Venice, the most beautiful square was actually a remnant of the meat market.

Pattern #6

Row Houses

The row house was the most common type of land use for living and working. The first floor was dedicated to a shop or a workshop, and the second level provided living space (the hall) for the master and apprentices (Mumford 1961; Pounds 2005). In

England, the backyard was spacious and given over to large burgage plots (15x60 m or 5 x 12 perches) (Slater 1981). In northern Milan, houses were allowed to abut onto one another if there were no windows in the party walls (Hakim 2014). These rules assisted in building street frontage continuity. The public space shaped by houses was a product of both customary laws and explicit regulations grouped into the following categories:

- *Party walls*: Article 16 of the Legum prohibited building ovens in party walls (Hakim 2014). The Legum also provided rules for digging holes or wells and for planting trees in abutting lots (2014).
- *Views*: Article 31 of the Alarif of Toledo[1] prohibited views overlooking a neighbour's private realms (Hakim 2014). Similarly, the article restricted the construction of doors directly opposite a neighbour's pre-existing doors (2014).

Row house lots are flexible. Even when the houses "planned" by landlords were transferred to building sites, they were always in a state of change, shifting and adjusting based on the realities of the surrounding landforms. This modification process was framed by numerous constraints of public power and cultural norms as a typical demonstration of the "association and obligatory participation" endemic to the Middle Ages (Mumford 1961).

Pattern #7

City Walls

The Pious Skyline of each city needed to be cemented throughout its walls. From the wall-protected cloisters, the city wall extended to surround merchants' quarters; subsequently, it was expanded to surround the entire city (Mumford 1961). In addition to

1 Alarif institution allows experts in civil engineering and laws to provide judgment by order of the judge (Hakim 2014).

providing protection for the city, the wall itself conveyed symbolic meaning. The wall created solidarity among the citizenry within its bounds—inside the wall was freedom and peace in the midst of a chaotic era after the fall of the Roman Empire. Gradually, the wall blended into the city skyline and fulfilled and reflected its purpose of protection and stability. Finally, as Mumford argued, the wall became a type of *magnet* attracting merchants from the outside through its only connection to the world—the gate (Mumford 1961).

Pattern # 8

Parish Churches

At the heart of the neighbourhood, a parish church provided religious services in the daily lives of the area's inhabitants. Parish churches were typically established by rich merchants or by well-known guilds (Saalman 1968; Pounds 2005). These churches became the centres of religious life and the community (Mumford 1961). Parish churches served as dining halls, stages, forums for religious rhetoric contests, and places to store safe-deposit vaults.

Pattern # 9

Vibrant Street

Most of the daily activities of burghers were accessible and within walking distance. In organic planning, this accessibility was the most important factor contributing to the vibrancy of streets.

Although "city air makes you free" was an emancipation perspective of medieval times, this air nurtured new freedom by filling the streets with a vibrancy of sights and sounds. Apparently, the market spread throughout the city in all its activities, from trade

and bargaining to selling produce. The typical shapes of streets: i) were narrow and crooked, ii) were fronted by row houses with shop fronts, and iii) contributed to both commercial and residential functions because urban medieval houses afforded a space for both living and working. As Alberti famously wrote, "…it will be handsomer not to have them strait, but winding about several ways, backwards and forward, like the course of a river…they will add to the idea of the greatness of the town" (in Mumford 1961, 309).

These picturesque and vivacious streets were the products of two mechanisms—cultural norms and explicit written regulations—which expressed the negotiation between the top-down power of a city and its residents' culturally embedded habits. Certain rules concerning public safety, fire, and traffic had direct effects on urban form:

- Maintenance of streets: In medieval Italy, responsibility for the maintenance of public space was assigned to adjacent owners (Hakim 2014). For instance, each homeowner in Bologna had the responsibility to maintain clean pavements on the adjacent streets at their own expense (Hakim 2014). For safety, article 45 of the Alarif Rules of the city of Córdoba banned the digging of holes on streets, squares, and marketplaces (Hakim 2014), and the Legum prohibited ploughs on public streets (2014).
- Traffic and street encroachment: The stipulation of street width was addressed in both proscriptive and prescriptive ways. Typically, the protrusions were eaves, porticos, balconies, or merely house facades. The local ordinances of Parma prohibited eaves that projected so far as to reduce the distance from two opposite houses to less than one *braccio* and a half (approximately 80 cm, according to Hakim 2014). Article 24 of the Alarif Rules in Toledo, Spain, stipulated that the projection of balconies must not exceed more than one-fourth of a street's width (2014). In a prescriptive way, the

Prochiron Legum required that the minimum street width be 12 ft (approximately 3.7 m) (Hakim 2014). Even public buildings were required to be set back from the main street (Zahringer Foundation in Talen 2008).

- Architectural elements facing public space: The *Prochiros Legum* restricted the construction of a window when the distance between opposite houses was less than 10 feet. However, the owner could build a six-foot-high window for lighting purposes (Hakim 2014).
- Merchandise on streets: Article 13 of the Alarif Rules required that outdoors vending must occur within a width of four feet or the width of a balcony (Hakim 2014).

Pattern #10

Identifiable Precincts

Each precinct was typically occupied by a guild subject to city government regulations (Pounds 2005). Some land uses, such as taverns and inns, were not allowed in certain neighbourhoods (Hakim 2014). In addition to merchant and trading quarters, the city had other precincts, such as those devoted to the activities of the monastery or university. As Mumford (1961) also observed, each neighbourhood adopted a nearby village, thereby forming a relationship with the village under its patronage.

Pattern #11

The Cathedral

The Pious Skyline was nearly identical to the cathedral, as the pinnacle of its skyline was shaped by the cathedral's spires. A cathedral is a sacred place that represents the physical convergence of all spiritual activities in a city—the place where spiritual energy reached its apex. A cathedral also functioned as the stage and setting for important

ceremonies. Inside the splendid architecture of cathedrals and their meaning to burghers, the emotional inclination towards the Christian kingdom reached its highest point. Arched domes with murals and light filtering through coloured glass rendered cathedral interiors places of heightened sacred feeling.

Pattern #12

Pious Skyline

The church played an extraordinary role in medieval life. It was the air burghers breathed; they were born in it and died in it. As Mumford succinctly described, "its spires were the first object the traveller saw on the horizon and its cross was the last symbol held before the eyes of the dying" (Mumford 1961, 266). This engraved skyline was enhanced by the symbolic images of monasteries and parish churches that were found everywhere within medieval cities (Pounds 2005). The pious skyline of prominent cities not only attracted pilgrims but also contributed to developing the omnipotent presence of the Church; it was thus the heart of every burgher's life.

Pattern #13

Universities

Universities were called grammar schools where students learned Latin and theology. During this time, the university was closely connected to a cloistered monastery. Subsequently, patricians and craft guilds established schools where students learned practical skills, such as accounting and double-entry bookkeeping, as well as Latin, which was not limited to liturgical education from religious institutions (Pounds 2005). Mumford referred to this new institution as an "active cloister" where the

university worked as a place of "cultural storage, dissemination and interchange, and creative addition" (Mumford 1961, 276).

Pattern #14

Faubourg

If merchants, peasants, or travellers could not reach the city by the time that the city gate closed, they had to stay the night outside the wall or in inns or taverns until the next day. To serve these people, other services were developed, such as money lending, workshops, and small marketplaces. A new precinct was developed surrounding the gate: the *faubourg.* After several generations, when the settlement became sufficiently large for tax purposes, a new section wall was built to enclose the faubourg, granting it privileges and security. Some faubourgs, such as Zurich, Trier, and Reims, were built across from a river; they could connect to the main city through a bridge or a ferry (Saalman 1968).

Pattern #15

City Gate

The city gate was the origin of the faubourg. Physically, the city gate was the nexus of converging streets. Beyond serving as a connection to the outside world, the city gate was considered holy, as is explicitly expressed in article 15 of Las Siete Partidas (Hakim 2014). The burghers proudly proclaimed the city's identity through the motifs decorating the gate or the towers, sometimes far exceeding the city's defensive needs, that rose from it (Pound 2005).

3.3.2. Form Language

The form language of a city was based on the incorporation of properties into Lynch's urban elements: paths (i.e., connections between origins and destinations), edges

(i.e., distinct boundaries), nodes (i.e., junctions and centres of activity), landmarks (i.e., architecture serving as points of reference), and districts (i.e., identifiable quarters) (Lynch 1960). Appendix D details the properties of each pattern of medieval cities.

The Seeding Monastery (11 properties): Strong Center, Singularity and Contrast, Dominance, Visual Scope, Name and Meaning, Level of Scale, Thick Boundary, Positive Space, Good Shape, Local Symmetries, and *The Void.*

Marketplace (7): Strong Centre, Singularity and Contrast, Simplicity, Visual Scope, Positive Space, Interlocking, and *Roughness.*

Small Square (10): Strong Centre, Singularity and Contrast, Simplicity, Clarity of Joint, Visual Scope, Positive Space, Good Shape, Roughness, Interlocking, and *The Void.*

Guild Halls (6): Strong Centers, Singularity and Contrast, Simplicity, Dominance, Name and Meaning, and *Good Shape.*

City Nucleus (12): Strong Centre, Singularity and Contrast, Dominance, Directional Differentiation, Visual Scope, Motion Awareness, Name and Meaning, Level of Scale, Positive Space, Local Symmetries, Interlocking, and *Roughness.*

Row Houses (8): Strong Centre, Simplicity, Continuity, Good Shape, Local Symmetries, Interlocking, Roughness, and *Echoes.*

City Wall (9): Strong Centre, Singularity and Contrast, Dominance, Continuity, Clarity of Joint, Thick Boundary, Good Shape, Roughness, and *Echoes.*

Parish Churches (8): Strong Centre, Singularity and Contrast, Simplicity, Level of Scale, Good Shape, Local Symmetries, Interlocking, and *Roughness.*

Vibrant Street (10): *Strong Centre, Simplicity, Continuity, Directional Differentiation, Visual Scope, Name and Meaning, Positive Space, Local Symmetries, Interlocking,* and *Roughness.*

Identifiable Precinct (8): *Strong Centre, Singularity and Contrast, Visual Scope, Motion Awareness, Name and Meaning, Positive Space, Interlocking,* and *Roughness*

The Cathedral (9): *Strong Centre, Singularity and Contrast, Dominance, Clarity of Joint, Name and Meaning, Level of Scale, Alternating Repetition, Positive Space,* and *Good Shape.*

Pious Skyline (6): *Center, Singularity and Contrast, Dominance, Continuity, Good shape,* and *Echoes.*

Universities (9): *Strong Centre, Singularity and Contrast, Visual Scope, Name and Meaning, Level of Scale, Positive Space, Good Shape, Echoes,* and *The Void.*

Faubourg (6): *Strong Centre, Singularity and Contrast, Clarity of Joint, Visual Scope, Name and Meaning,* and *Roughness.*

City Gate (8): *Strong Centre, Singularity and Contrast, Dominance, Clarity of Joint, Name and Meaning, Alternating Repetition, Good Shape,* and *Echoes.*

Table 3.1: The Distribution of Properties in the Medieval European Urban Form.

	Patterns	Properties																				Sum
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	Seeding Monastery																					11
2	Market Place																					7
3	Small Square																					10
4	Guild Halls																					8
5	City Nucleus																					12
6	Row Houses																					8
7	City Wall																					9
8	Parish Churches																					8
9	Vibrant Streets																					10
10	Identifiable Precincts																					8
11	Cathedral																					9
12	Pious Skyline																					6
13	University																					9
14	Faubourgs																					6
15	City Gates																					8
Sum		15	12	6	6	4	5	2	8	2	9	6	2	2	8	10	6	8	10	5	3	**8.60**

3.3.3. The Sequence

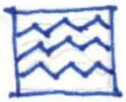
One of the three mechanisms of the generative process is its sequence. The sequence is the incremental development patterns based on geographical and social contexts. From the original monastery and its protective wall, the city emerged with different types of businesses and needed space; therefore, the new medieval town included a marketplace with nearby squares and guildhalls. These elements formed a city nucleus with residential areas in the background. Over time, different precincts were established. When a population significantly increased, a new wall extension was needed. This new wall could be built before or after the establishment of other elements, such as *Parish Churches*, *Cathedral*s, or *The Pious Skyline*. To maintain a successful connection to the outside world, a city needed city gates. From the city gates, other establishments, such as storage places and inns, emerged. Finally, the *Faubourg* as a new precinct developed surrounding the gate.

The following sequence and flowchart show the possible evolutionary path that a medieval city could take. The paths of different cities could differ slightly, but this process includes the basic steps that a medieval city might have taken.

A symbol for each property is also shown in Table 3.1 to facilitate understanding of the GP in medieval cities. A complete symbols of properties are listed in Appendix C.

The operationality of place-based norms depended on their particular patterns, sequences, and properties. In medieval cities, the norms were based on religion and driven by the economy. The primary factors influencing the growth and building of organic medieval cities were religion, craft, trade, and protection, which evolved and appeared in patterns such as *The Seeding Monastery*, *Small Square*, *Row Houses*, *Vibrant Streets*, *Identifiable Precincts*, and *City Gates*.

Table 3.2: Symbols of Properties.

	Symbols of properties
1. Centre	
2. Singularity and Contrast	
12. Boundary	
13. Alternating Repetition	
14. Positive Space	
16. Good Shape	
17. Interlocking	
18. Roughness	
19. Echoes	
20. The Void	

Symbols of Lynch's urban elements

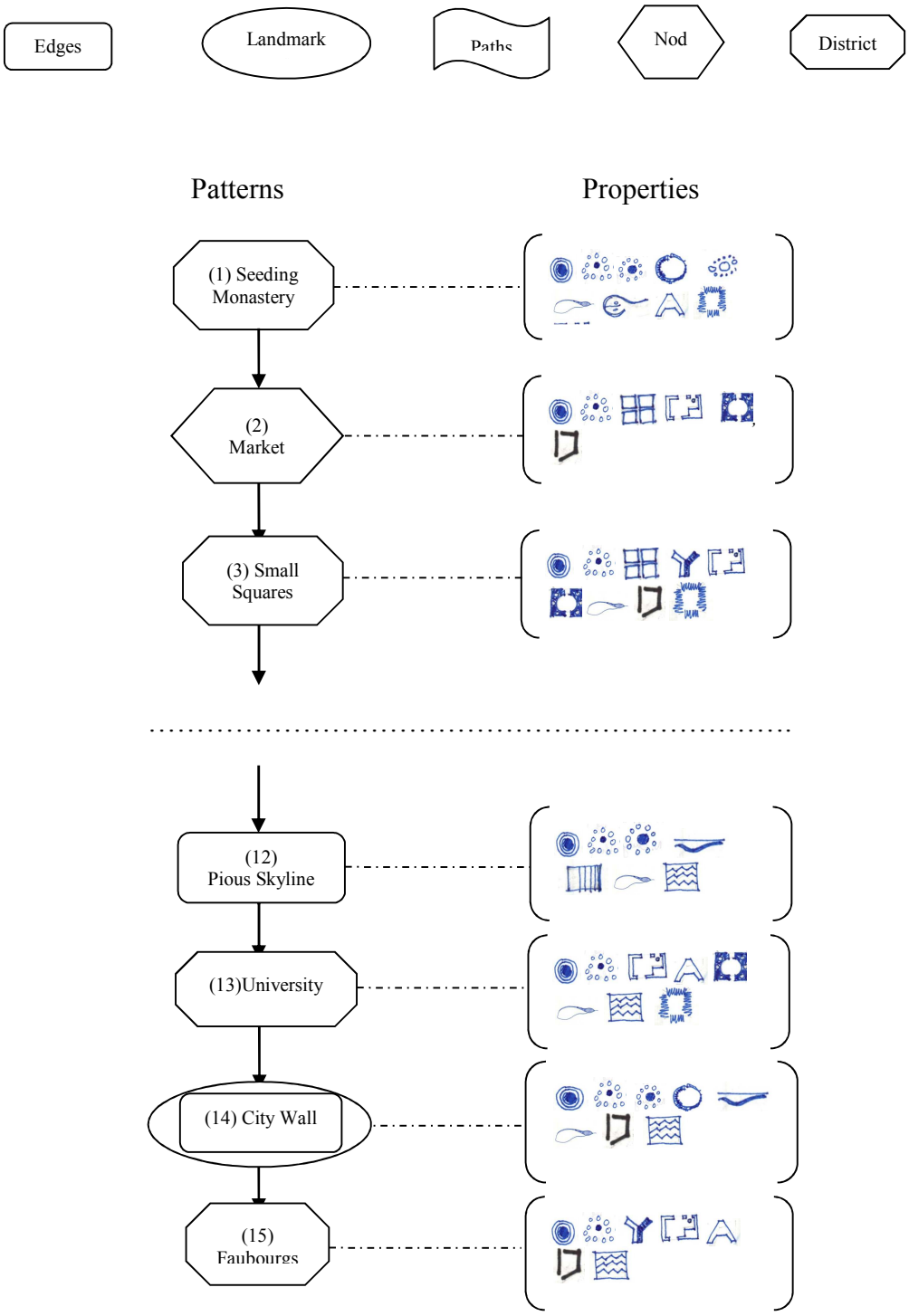


Figure 3.2: Excerpt of Sequential Patterns of Medieval Cities and Their Properties. The complete sequence is listed in Appendix D.

3.4 The Generative Process in Arabic-Islamic Cities

Hakim shows that the built environment in the Arabic-Islamic region was the result of fiqh and urf (or local traditions) (Hakim 2008a). The former is the mechanism of interpreting and applying the value system of Islamic law in the building and planning process (2008a). Among the most well-known schools of law that had a direct effect on the built environment was the treatise of Julian of Ascalon. The treatise addressed places for workshops in housing areas, solutions to structural problems, planting, and the distribution of expenses among co-owners (2008a). The fusion of fiqh and urf generated spatial solutions that constitute a pattern language.

3.4.1 The Pattern Language

Pattern #1

City Mosque (Masjid al-jami).

This pattern is similar to a monastery or cathedral (Hakim 2008a). The mosque was the seed of other urban elements. The structure was often located at the centre of a planned or newly conquered city. The form was usually a reproduction of the Mosque in Medina. The city mosque in Tunis was a typical building type that included a large courtyard and that was surrounded by shops on two sides (2008a). Courtyards provided a sense of tranquillity in contrast to the bustling streets outside.

Figure 3.3: Mosque in Tunis Surrounded by Shops. Source: Profburp.com n.d.

Pattern #2

Khutba Mosques

Khutba mosques were equivalent to parish churches in medieval cities. These mosques often had narrow U-shaped surroundings and covered praying areas. In Tunis, nineteen Khutba mosques were located in the centre of the city, all close to the city mosque.

Pattern #3

The Citadel (Kasbah or Kasaba)

This fortified town typically occupied strategic locations, such as on the top of a hill or a place that had access to a waterway. The citadel was an independent settlement from the city and provided protection for governors (Hakim 2008a). The Kasbah had all

the functions of a city centre: small squares, a governor's palace, mosques, money lending services, barracks, baths, prisons, and markets (Hakim 2008a).

Figure 3.4: The Citadel in Le Kef, Tunisia. Source: Profburp.com n.d.

Pattern #4

City Wall (Sur) and Gate (Bab)

A city wall included gates (babs) and defensive towers (burjs). A typical wall had a thickness of 2 metres and a height of 6 metres. Generally, city gates had machicoulis and half-rounded towers for defensive purposes. The gates were often located at the convergence of main streets, which then connected to roads leading to nearby villages (Hakim 2008a).

Figure 3.5: The City Gate in Tunis. Source: Profburp.com n.d.

Pattern #5

Streets (Shar' or Tarik Nafid)

The street network connected main gates to the city centre, where the city mosque and the adjacent vaulted commercial complex (or suq) were located (Hakim 2008a). Similar to medieval towns, a street in an Islamic city was subject to a number of rules. Generally, a street needed to allow for two fully loaded camels to pass through; therefore, the minimum street width and height were seven cubits (3.23 to 3.5 m) (Hakim 2008a).[1] Other requirements were similar to medieval towns; for example, the rules prohibited the obstruction of streets, the planting of trees, the construction of columns, and storage on the street.

One of the distinctive features of streets in Islamic countries was the recognition of fina, which refers to the space in which a street borders a house. The owner could use

1 One cubit = 46-50 cm (Hakim 2014).

this space for several purposes: sitting, parking horses or camels, and selling from mobile stalls. Nevertheless, the owner could not incorporate the fina into his or her own property (Hakim 2008a). The width of a fina was typically 4-6 shibers (1 to 1.5 metres).

Figure 3.6: A Street in Kairwan, Tunisia. Source: Library of Congress n.d.

Pattern #6

Squares (Bat'ha)

A square was typically located at the junction of three streets forming T or Y shapes. The square, as a centre of a mahalla (a neighbourhood), was the location of neighbourhood facilities, such as bakeries, grocery shops, and a *mesjid* (facilities for daily prayer). In some cases, squares had geometrical, regulated shapes in front of major buildings in the city centre. Squares in the quarters outside of the city centre (Rabat) could be used for weekly open markets.

Figure 3.7: A Square in Tunis. Source: Library of Congress ca. 1899.

Pattern #7

House (dar)

Essential architectural elements in houses in Muslim cities were subject to several requirements: the protection of visual privacy, the interdependence between neighbours on the rights and uses of party walls, and the control of rain and wastewater. The importance of visual privacy in Mohamed's teaching was paramount. This requirement, coupled with climatic conditions, created the architectural type of inner courtyards and flat roofs with parapets exemplifying Islamic architecture (Hakim 2008a). The house layout also prevented direct views from the outside with one or two *skifas* (entrance rooms). The interdependence between neighbours on the rights of using walls generated the organisational characteristics of housing quarters in Islamic cities (Hakim 2008a). The application of servitude—"the 'real' right of acquiring partial authority over an alien

property for the benefit of a person of another property" (Hakim 2014, 113)—emphasised the interdependence between proximate houses.

Pattern # 8

Sabat and Vault

A sabat was a room bridging a street or a cul-de-sac (Hakim 2008a). The application of sabat principles in continuous conditions could sometimes create a tunnel effect on streets. Muslim customary laws approved the right to build over public rights of way—an owner could build over an adjoining street if the sabat did not obstruct traffic. The law elaborates on different scenarios in determining when and how a sabat could be used. For example, with the consent of his neighbour across the street, the former owner could use his neighbour's wall for construction purposes.

Pattern #9

Mesjed (Local Prayer Facilities)

Serving local residents in their five daily prayers (Hakim 2008a), a mesjed provides a room for a small group of people to pray together and receive water for ablution. The facilities ranged in size from small rooms to the Jami-like edifices. They were located within walking distance to local houses (in Tunis, the distance was less than 150 metres from any mesjed) (Hakim 2008a).

Pattern #10

Madrasa (College or Schools)

A madrasa is a higher education institution where students learn science and medicine. Such a building typically included a skifa (main entrance lobby), an area for ablution, classrooms, and prayer rooms. Similar to other public institutions, a madrasa

included a courtyard with surrounding arcades. A madrasa could be a structure from one to two stories with different degrees of decoration in the courtyard (2008a).

Pattern #11

Monastery and Religious School (zawiya)

Religious schools served several purposes: providing an education and providing a lodging place for *sufis* (devout men following the mystic tradition of Islam). The teaching curriculum included the Arabic alphabet and shortened surahs of the Koran at the elementary level. At a higher level, students learned Islamic law (fiqh), theology, Arabic grammar, and applied mathematics. The architecture of such institutions often included a room for prayer; the mausoleum of a Sharifan saint; a room for Koran recitation; and rooms for pilgrims, travellers, and students (Hakim 2008a).

Pattern #12

Commercial Streets (Suq or Bazaar)

Commercials streets, or suqs, were one of the three essential elements of a city (Hakim 2008a). Hakim categorized five different types of suqs: i) a suq surrounding a major city mosque; it was a single-story structure with covered vaults, and the area was sometimes gated; ii) a linear continuous and typical vaulting covered suq; this commercial area often connected the main gates with the city centre; iii) a suq located near the main gates on both sides of a city wall; iv) a weekly or seasonal market; and v) neighbourhood shops (suwaiqas) grouped within a neighbourhood's centre. The location of shops in relation to the city mosque was based on the types of services provided.

Figure 3.8: A Suq in Tunis. Source: Library of Congress ca.1899

Pattern #13

Wekala

A wekala encompassed the commercial covered galleries encircling a courtyard. Two types of wekala existed. The merchant's wekala was a two-story building whose ground floor was used for storing merchants' products and whose spacious upper part was used for other business activities. This type of wekala was often integrated into the suq system. By contrast, a workers' wekala, which accommodated immigrant workers from other regions or villages, was not integrated into the suq system and was located outside of the city centre (Hakim 2008a).

Pattern #14

Palace (ksar)

Ksars served as residential and working places for princes, rulers, high court officials, and army chiefs. Palaces were often located in a large area. Their architecture

often included several courtyards and richly decorated internal spaces, sometimes with walled gardens (Hakim 2008a).

Pattern #15

Funduk (or Fondouk)

A two-storey funduk is an inn or hostel for non-muslim merchants to display and sell products. A funduk usually has a courtyard with large gates that allowed fully loaded carriages to enter. The ground was used to accommodate merchants' animals and commodities, whereas the upper floors were used as a living space for merchants. Funduks used for storage or for work were located in industrial or trading quarters, while funduks used as hostels were located near the city's main gate (Hakim 2008).

Figure 3.9: A Funduk in Tunis. Source: Profburp.com n.d.

Pattern #16

Public bath (Hammam)

As a social space within a neighborhood, a public bath is an essential component of a complete urban settlement —people from all ranks of society came to hammams to

rest and bathe (Hakim 2008). The construction method used of hypocausts and heating pipes in the walls was applied. The functional sequence of hammam includes dressing, resting, warm, and hot rooms.

3.4.2 The Form Language

The Islamic urban form is characterized by inward orientation. Whereas the façades of buildings did not appear to be highly decorated, an inner space was typically covered with plentiful ornament. Table 3.3 illustrates properties for in each pattern. Many patterns are characterized by *Interlocking, Roughness, Boundary,* and *Positive Space* properties. See Appendix D for more details.

City Mosque (12): Strong Centre, Singularity and Contrast, Dominance, Motion Awareness, Name and Meaning, Level of Scale, Thick Boundary, Positive Space, Good Shape, Interlocking, Echoes, and *The Void.*

The Citadel (7): Strong Centre, Singularity and Contrast, Dominance, Clarity of Joint, Directional Differentiation and Gradients, Visual Scope, and *Name and Meaning,*

Palace (ksar) (11): *Strong Centre, Singularity and Contrast, Name and Meaning, Level of Scale, Boundary, Alternating Repetition, Positive Space, Good Shape, Interlocking, Echoes,* and *The Void.*

House (dar) (8): Strong Center, Simplicity, Continuity, Positive Space, Interlocking, Roughness, Echoes, and *The Void.*

Streets (Shar' or Tarik Nafid) (9): Strong Centre, Simplicity, Continuity, Visual Scope, Positive Space, Local Symmetry, Deep Interlocking, Roughness, and *Echoes.*

Sabat and Vault (6): Strong Centre, Singularity and Contrast, Simplicity, Interlocking, Roughness, and *Echoes.*

Public bath (Hammam) (4): *Strong Centre, Simplicity, Interlocking,* and *Roughness.*

Khutba Mosques (9): *Strong Center, Simplicity, Visual Scope, Level of Scale, Thick Boundary, Alternating Repetition, Positive Space, Good Shape,* and *Interlocking.*

Mesjed (Local Prayering facilities) (4): *Strong Centre, Simplicity, Deep Interlocking,* and *Roughness.*

Squares (Bat'ha) (8): *Strong Centre, Simplicity, Clarity of Joint, Visual Scope, Positive Space, Deep Interlocking, Roughness,* and *The Void.*

Commercial streets (Suq or Bazzar) (8): *Strong Centre, Singularity and Contrast, Simplicity, Continuity, Visual Scope, Interlocking, Roughness,* and *Echoes.*

City Wall (Sur) and Gate (Bab) (10): *Strong Center, Singularity and Contrast, Dominance, Continuity, Directional Differentiation and Gradients, Name and Meaning, Thick Boundary, Alternating Repetition, Good Shape,* and *Echoes.*

Monastery and Religious School (Zawiya) (7): *Strong Centre, Level of Scale, Thick Boundary, Alternating Repetition, Positive Space, Interlocking,* and *The Void.*

College or Schools (Madrasa) (8): *Strong Centre, Level of Scale, Thick Boundary, Alternating Repetition, Positive Space, Good Shape, Interlocking,* and *The Void.*

Wekala (6): *Strong Centre, Thick Boundary, Alternating Repetition, Positive Space, Good Shape,* and *Interlocking.*

Funduk (or Fondouk) (7): *Strong Centre, Simplicity, Thick Boundary, Positive Space, Roughness,* and *Interlocking.*

Table 3.3: The Distribution of Properties in the Arabic-Islamic Urban Form.

	Patterns	Properties																				Sum
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	City Mosque	●	●	●						●	●	●	●		●	●		●		●	●	12
2	Citadel	●	●	●			●	●	●		●											7
3	Palace	●	●								●	●	●	●	●	●		●		●	●	11
4	Houses	●			●	●									●			●	●	●	●	8
5	Streets	●			●	●			●						●		●	●	●	●		9
6	Sabats & Vaults	●	●		●													●	●	●		6
7	Public Baths	●			●													●	●			4
8	Khutba Mosques	●			●				●			●	●	●	●	●		●				9
9	Mesjeds	●			●													●	●			4
10	Squares	●			●		●		●						●			●	●		●	8
11	Suq	●	●		●	●			●									●	●	●		8
12	City Walls & Gates	●	●	●		●		●			●		●	●		●				●		10
13	Zawiya	●										●	●	●	●			●			●	7
14	Madrasa	●										●	●	●	●	●		●			●	8
15	Wekala	●											●	●	●	●		●				6
16	Funduk	●			●								●		●			●	●			6
Sum		16	6	3	9	4	2	2	5	1	4	5	8	6	10	6	1	14	8	7	6	7.69

3.4.3. The Sequence

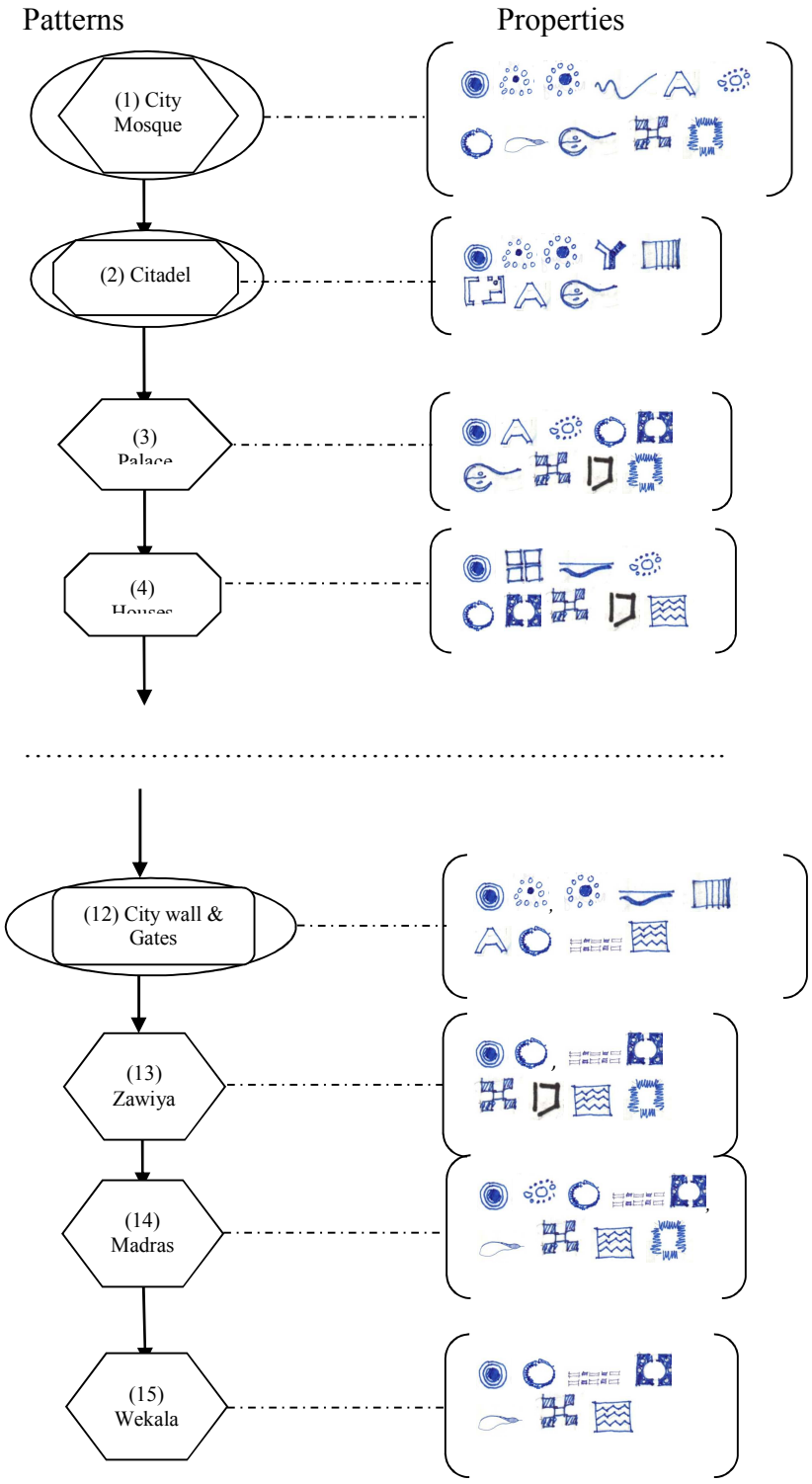


Figure 3.10: The Sequence of Islamic Urban Patterns.

As in a medieval city, the city mosque was the heart of an Islamic town. With its various facilities, the citadel generated different types of land use: palaces, houses, and streets. From that space, *Sabats*, *Khutba*, and *Mesjeds* were sequentially created. In time, a city wall with gates and towers would be built. Subsequently, other structures, such as *Zawiya*, *Madrasa*, and *Wekala*, were added to give the city a complete set of functions.

In Islamic cities, norms are strongly shaped by religious demands and motivated by commercial activities. The urban form has an inward-oriented development that expresses the Islamic concept of beauty without arrogance (i.e., plain on the exterior but highly decorated inside, especially the façades of courtyards) (Hakim 2014). Other characteristics of urban form are *Positive space* (e.g., manifested in courtyards) or strong connections to surrounding environments and the *Roughness* property.

3.5 Cultural Norms vs. Written Rules

Researching Islamic cities, Hakim argued that the generative system in Islamic tradition is based on fiqh (regulations) and urf (local customs). The latter was also recognized as a source of law by the Hanbali and Maliki schools (Hakim 2008b, 79). However, the causes of orderly and coherent urban forms in other cultures, such as medieval cities, could not—without strong imposition of explicit codes—be explained solely based on written regulations.

This study uses pattern language as a tool to understand the GP and its codes. As Jane Jacobs emphasized the importance of "unaverage" clues in planning, the patterns in this study represent these unaverages of the two traditions of urbanism in question. Furthermore, a pattern language acts as a system of knowledge generation, thereby

enabling the capture of critical information from local norms and filtering out nonessentials. Implementing pattern language helps to provide a thorough and essential picture of the norms that affect the built environment. The formula for studying the GPs in each urban tradition includes patterns, form properties, and sequences.

Islamic written codes are largely based on *religious values, the acceptance of change, and a desire to bring fairness to parties involved in the building process.* By contrast, the regulations of medieval cities were *more secular and direct with the aim of protecting public rights and safety*. The building regulations in the two traditions share common purposes with different levels of intention and enforcement. *Such regulations aim to protect public safety (e.g., fire or sanitation), public rights (e.g., traffic requirements or view protection) and the recognition of private rights in real estate.* Scholars recognize the importance of norms in shaping the built environment (Ben-Joseph 2005; Hakim 1994, 2008a; Talen 2009, 2014). These norms function as mechanisms generating the urban form behind the scenes of written codes. *When written regulations are less strongly imposed, as in the case of medieval cities, place-based norms assume the lead*. *As the study of these two cultures of urbanism reveals, these place-based norms or local customs are in fact social-based and spatial-based configurations—they are patterns*. Therefore, organic urban form is the product of both written codes and norms.

The performance of norms is dependent on their specific patterns, sequences, and properties. *Different norms build distinctive forms for each culture*. The norms in medieval cities are based largely on religious protection, solidarity between different

professional groups, and trade, whereas the construction norms in Islamic cities include religious devotion and the segregation of residential precincts from other precincts.

Hakim contributed to the study of building codes in traditional urbanism by distinguishing between two types of codes: proscriptive vs. prescriptive. A proscriptive rule stipulates what should not be done. Its mandate is equivalent to "thou shalt not" (Hakim 2014, 99). In contrast, a prescriptive rule outlines what should be followed. Its formula is "thou shalt". This distinction has important implications for researching GPs.

Although prescriptive laws explicitly determine the form of the built environment, proscriptive codes leave much room for the interpretation of local customs. In traditional urbanism, local customs operate when no rules exist or when rules were not explicitly stated. Even in Islamic cities with a stronger dependence on Islamic jurisprudence, with stipulations that are more detailed than those governing medieval cities, beyond the priority concerns for privacy, fairness, public safety (primarily traffic), and servitude, other issues relating to the built environment were not determined by written codes. Local customs would be involved in interpretation and negotiation, thereby generating specific urban forms. Accompanying the law, urf directed the daily works of form-building business. This observation is even more appropriate for medieval cities. In cultures without strong legal traditions of regulating the built environment, cultural norms and traditional building techniques operated to fill the space between written codes. Therefore, the norms in cooperating with top-down regulations are the true form-givers in traditional cities.

As the diagrams in Figures 2.1 and 2.2 in chapter 2 illustrate cases with and without norms. Both proscriptive and prescriptive rules add constraints to urban form by

norms. The result is a family of forms with diverse but unified qualities. Without norms (Figure 2.3) no families of forms can exist; only a chaotic environment is presented, even in the presence of regulations. An important conclusion: norms are the basis of any GP.

In summary, the GP is based primarily on norms *not* codes. This research has implications for contemporary urban coding. The GP is the production of patterns, their sequence, and urban properties. The constraints that cities had to endure and the commonalities between them can be captured by patterns. Therefore, pattern languages can be built in contemporary cities to express the needs and demands of different involved parties. These shared languages can be used in the GP to build urban codes. The following framework for a GP applies in every culture: i) cultural norms and explicitly written rules are incorporated in the form of patterns, ii) the sequence that makes patterns emerge, and iii) the properties of each pattern are a representation of architectural and urban form. The levels of intervention of written rules depend on the social fitness of patterns. *Healthier patterns in term of human scales, compacted, and mixed use in the GP are associated with less control from written regulations, and vice versa.* Code-writers need to recognize this relationship and create a subtle balance based on their understanding of norms in society.

3.6 Conclusion

This research aims to uncover general principles of the GP and the roles of written codes and norms. Discussing the role of local customs or urf in Islamic society, Hakim referred to “a mechanism of societal behavior, and was thus accepted as one of the sources for the law” (Hakim 1994, 108). He recognized that urf and fiqh generate

diversity and unity and therefore give shape to the form of a city. Additionally, Ben-Joseph (2005) stated that the implementation of Islamic laws related to the built environment "depended more on customs of the town than on the role of officialdom" (2005, 16). Furthermore, he argued that "place-based norms are critical for neighborhoods to prosper and for development to be sustainable" (2005, 24). Similarly, Talen also noted the importance of norms: contemporary reformed codes should replace "place-based norms" or "or at least the mechanism through which they occur" (2009, 157). This research not only furthers these scholars' position in arguing that the GP is the product of place-based norms and written codes but also states that norms are the basis of any GP and GCs could not exist without norms.

When written codes leave gaps in the control of urban space, cultural and social norms emerge to fill these gaps in the operationality of the building process. These norms must be an integral part of the GP of shaping the form of cities. The task of discovering norms should be performed based on a pattern language. The interplay between written codes and norms is the primary mechanism behind any GPs. Two comparative diagrams are provided to illustrate roles of norms. This study finds that the norms shared by these two cultures are based on religion and driven by the economy. In the case of medieval urbanism, solidarity between professional groups is notable, whereas the norms in Islamic cities involved religious devotion and the separation of residential precincts from other precincts. The lists of norms of traditional cities will clearly undergo expansion because many more traditions of urbanism remain to be discovered.

CHAPTER 4

The Generative Process from an Operational Perspective: the case of Hoian, Vietnam

About this chapter

This chapter is the second of three articles about the generative process. The paper aims to examine the generative process through the operationality of Alexandrian elements — patterns, properties, and a sequence — in the creation of traditional urban form. These operational elements are reexamined and reorganized as an applicable package for studying the forces that shape the form of traditional cities.The pattern language for a traditional city and a new set of twenty properties of urban elements are developed to provide a framework for understanding urban form. These properties are synthesised from the fifteen properties outlined by Alexander and the ten qualities proposed by Kevin Lynch. The recurrence of each property and the pattern of its repetition in urban elements are investigated to assess the impact of generative forces on the urban form of the ancient quarter of Hoian, Vietnam. This article was submitted to the *Journal of Urbanism.*

4.1 Introduction

There are challenges to understanding what gives rise to the form of a city in general and to a traditional city in particular (i.e. the compact form of mixed land uses and walkable development that has been seen all over the world before the first half of the 20th century). Although Camilo Sitte (1889), Lewis Mumford (1961), Spiro Kostoff

(1999), Besim Hakim (2008) and other researchers have evaluated traditional cities or have suggested different methods for understanding their form, knowledge of why a city took a particular form and how that form functions is still difficult to ascertain. Kevin Lynch provided the most insight into this endeavour. In *Good City Form* (1981, 327), he offered a compendium of functional theories for describing how cities are formed, arguing that a city is '… a story, a pattern of relations between human groups, a production and distribution space, a field of physical forces, a set of linked decisions, or an arena of conflict' (38). He argued for the development of a functional theory based on established and complete values, dynamism, environmental quality, and individual use that can help scholars better understand how a city develops a particular form.

Subsequently, Reza Banai and Melanie Rapino (2009) presented an excellent review of the functional theories of the city form since Lynch. They concluded that such theories are still fragmented and that despite the progress made, there is no dominant theory that offers a grand narrative for explaining the form of all city types.

Nevertheless, the functional views of urban forms have been taken up at an unprecedented level in recent years, mostly because of advanced computational technology and new understanding of the so-called *emergence* phenomenon. Michael Batty (2013a) developed models of the city based on the algorithmic bottom-up process that forms a self-organising system by tools such as agent-based modelling and cellular automata. Then, there was a new wave of technology; the availability of Big Data—gigantic collections of data on cities that are often streamed from sensors—added new opportunities such as real-time decision-making and the ability to plan at different time horizons (Batty 2013b). Nevertheless, some researchers raised concerns regarding issues

such as privacy or cyber terrorism (Mattern 2013,) or spurious correlations (Taleb 2013). Bettencourt (2013) argues that the Big Data view more or less regards at the city as a machine even the view has its place in certain conditions. He also turns attention from urban scaling issues, i.e., the size of the city in relation to its economic and social patterns, towards social networks as embodiments of city functions. Underlying these scholars' works is the normative view of urban form—the theory of what urban form should be or the guiding principles by which urban organisation and space become functional and beautiful. The point that Lynch (1980) strongly upholds. Later, Talen and Ellis (2002) argued for the need to research good city form beyond the field of urban design. They also broadened the theoretical base for the normative view by embracing new development in fields outside of planning and design.

This paper continues to this normative tradition by exploring the generative process— the incremental development generates qualities such as coherence and wholeness for an urban settlement. The study aims to examine the generative process through the operationality of Alexandrian elements (i.e., patterns, properties, and a sequence) in the creation of traditional urban form. These operational elements are reexamined and reorganized in applicable order for studying the forces that shape the form of traditional cities. This approach for studying the GP is termed operational. Alexander (2002) defines the generative process as an incremental development in creating the coherence of urban structures based on feedback and continuing refinement. To support the investigation of form language, Lynch's city image theory is also implemented. This research contributes to the normative approach when it looks for forces that shape traditional urban form, which then gives a better answer to the question

what urban form should be. In this study, I ask: How to uncover the forces that shape form of a traditional city — a product of the generative process — using an operational approach? Consequently, how can the generative method be effectively restructured based on newly acquired knowledge regarding the GP?

There are three reasons to select Alexander's generative method and Lynch's urban qualities to study urban form. First, the generative method provides a systematic framework to understand traditional urban form. The patterns, by their nature, are social and spatial organisations embedded in hierarchical interconnections. The pattern builders build patterns based on social and cultural factors that they acquired from historical accounts. They locate these patterns in a network based on the logic of hierarchy. Each pattern contributes to the big picture of the historical settlements. The patterns are added to the network until a complete picture of the settlement imaginatively emerges (Alexander 1978). Therefore, the pattern language captures subtleties that have important impacts on urban form. With the coming of new information, the patterns' builders adjust the language by adding, modifying, or even deleting specific patterns to reflect new situations based on one condition: the new piece of information must contribute to the pattern language of the town; otherwise, this piece of information is trivial and should be discarded.

Second, utilising Alfred North Whitehead's (1979) process-relational view, the ontological aspect of physical form is better comprehended. According to Alexander, a pattern as a social and spatial organisation is also a centre—the field-effect zone that plays significant roles in organising urban structure or architecture. Alexander (2002) mentioned the analogy between his centres and Whitehead's building blocks of reality—

actual entities, which, according to Whitehead (18), "are the final real things of which the world is made up." Therefore, pattern language is a fine way to represent the reality of urban form.

Third, according to Alexander (1978), a pattern language must work with form language—geometrical solutions to design problems—to produce good urban environments (i.e., the normative view). Nevertheless, while Alexander's properties in a form language are useful for assessing architectural form, their applicability is limited at the urban scale, particularly when dealing with movement in city. Fortunately, Lynch five urban elements shape human perception (i.e. paths, edges, nodes, districts, and landmarks) can complement. These elements accompanied with their qualities constitute the physical representation of the city form. In this study, fifteen of Alexander's properties and ten of Lynch's qualities are combined into a new set of properties of urban elements.

This research suggests an alternative approach to distilling valuable lessons from traditional cities. Using the ancient quarter of Hoian, Vietnam as a case study, this study investigates the pattern and form languages of the town between the 17th and 19th centuries. The selection of the ancient quarter of the city of Hoian, Vietnam, for this case study was based on the following criteria: (1) the quarter is small but dense with historical buildings, cultural artefacts, and a unique traditional pattern of street networks; (2) despite a chequered history, the town was and continues to be a vibrant environment; and (3) Hoian's unique history and multiethnic background provides an unprecedented opportunity to study the effect of cultural ethnicity on city form development.

4.2 Pattern Language and Form Language

Pattern language has an established history in urban design. Alexander et al. (1977) argue that architecture and urban elements are generated by patterns, or spatial and social solutions to design and planning problems. Pattern language has three characteristics. First, pattern language has the ability to generate an unlimited number of unique combinations. Second, it is a generative system that, like human language, allows normal people to compose elements and create architectural and urban 'sentences' or systems of patterns that are adapted to a local context. Therefore, in addition to being a successful design instrument, pattern language is engendered to meet social and cultural demands. Third, a pattern language is a collective language reflecting shared knowledge.

Alexander (2002) proposed that, to build a true living environment, it is essential to have a language that cooperates with pattern language: form language. Nikos Salingaros (2008, 221) comments that form language is a 'particular and practical conception of tectonic and surface geometry', or a set of geometric rules that shape a physical environment. The built environment communicates its information and emotional content to human beings through spatial and surface components of form language.

Salingaros (2008) analogises the relationship between pattern and form language with the relationship between verbal and nonverbal language. Pattern language, like non-verbal language that offers semantic clues, is required for coherent and functional structures. Form language, being visible and tangible, is similar to verbal language, which provides clear and concrete communication signals. Form alone cannot fully

communicate without a connection to pattern, just as verbal and non-verbal languages are needed for successful communication. Salingaros (2008, 237) argues that 'a *form language* must tie in seamlessly to a *pattern language*'. The two languages form a generative process—an incremental development creating coherence of the design, enhanced through feedback and continuing refinement (Alexander, 2002).

4.3 Urban Elements and Their Properties

In *The Nature of Order,* Alexander (2002) proposes the use of fifteen properties to express the quality of a built environment's form. Although Salingaros (2008) states explicitly that 'a form language must tie in seamlessly to a pattern language' (237), the question of how it *ties in* remains unanswered. It is argued that the issue of cohesiveness of these two languages becomes a conundrum because at urban level, these two languages need *carrying bodies* — urban elements that are essential for understanding city form. Lynch (1981) proposed five such elements: *Paths* (connections between identifiable origins and destinations), *Edges* (distinct lateral boundaries), *Districts* (identifiable quarters), *Nodes* (junctions and centres of activity), and *Landmarks* (architecture that provides a point of reference). These elements are the carrying bodies of city form, and create what individuals perceive as the city's image.

In this study, Alexander's fifteen properties are re-evaluated to determine their applicability at the urban level. They are: *Level of scale, Strong center, Thick boundary, Alternating repetition, Positive space, Good shape, Local symmetries, Deep interlocking and ambiguity, Contrast, Gradient, Roughness, Echoes, The void, Simplicity and inner*

calm, and *Not separateness* (main features of these properties are summarized in the Appendix A.)

However, some properties focus on the architectural scale and are likely insufficient for assessing urban form. Overshadowed by his famous urban elements and buried in the middle of his dense *The Image of The City*, Lynch's qualities of urban elements appear in only several pages of his magnum opus and are typically overlooked. They are *Singularity, Form Simplicity, Continuity, Dominance, Clarity of Joint, Directional Differentiation, Visual Scope, Motion Awareness, Time Series,* and *Name and Meaning*. These qualities can complement Alexander's properties**.** The Appendix A lists the main features of the discussed qualities.

Lynch's qualities allow for the assessment of the city on a large scale—the perception of the city in its movement and through time. In addition, Alexander's properties offer criteria for assessing the level of coherence, especially when the study focuses on small-scale elements such as buildings. To understand and evaluate city form at every scale from small to large, we need to combine these properties into a useful set. Furthermore, an analysis of the qualities proposed by Lynch and Alexander reveals redundancy and overlap. Below is the evaluation of Alexander and Lynch's overlapping properties:

- Lynch focuses on the intelligibility and the simplicity of form, whereas Alexander gives *Simplicity* a quality of calmness from which redundant elements have been removed. Both authors understand the necessity of ornamentation and define the term *Simplicity* similarly.

- *Directional Differentiation* is a more inclusive concept than *Gradient*, which describes only non-directional gradation. However, they have similar nuances and can be combined to form a new quality, termed *Directional Differentiation and Gradient*.
- Although the qualities of *Singularity* and *Contrast* are roughly comparable concepts, Lynch's emphasis on 'figure-background clarity', 'the sharpness of boundaries', and 'closure' is more appropriate for analysing urban space. Therefore, the combination of these terms to form *Singularity and Contrast* creates a concept that focuses adequately on the urban context while maintaining the importance of contrast quality.

A revised set of the qualities proposed in Lynch's and Alexander's works is provided below (see Table 4.1).

Table 4.1: Revised Set of Urban Properties based on Alexander and Lynch's works. A complete description of the revised properties is listed in Appendix B.

No	Form qualities	Description
1	Singularity and Contrast	A coherent and balanced structure usually has a high degree of contrast that creates a sense of differentiation and emphasises contrasting elements.
2	Simplicity	The intelligibility and simplicity of form. Unnecessary and distracting parts are removed.
5	Clarity of Joint	The 'high visibility of joints and seams', i.e., clear relation and interconnection.
6	Directional Differentiation and Gradient	Directional ′asymmetries' and 'gradients'—slow and incremental changes throughout the overall structure.
7	Visual Scope	The capacity to increase the 'range and penetration' of vision.
8	Motion Awareness	The ability to perceive 'form in motion' as it relates to spatial concepts such as distance or direction.
9	Name and Meaning	The quality attached to urban elements through meaning, stories, and history.
10	Level of Scale	Structures comprise components of different sizes: a few large, several medium-sized, and many small components.
11	Strong Centre	A centre is an object with a prominent shape or position within a structure. It must support the centres around it, inside it and that contain it.
12	Boundary	A thick boundary focuses attention on the centre.
13	Alternating Repetition	Once the alternating rhythm of the centres emerges, the repetitive centres amplify one another.
15	Good Shape	A good shape is easy to comprehend and is usually symmetric.
16	Local Symmetry	A structure should have symmetry at many local scales to create a balanced distribution of forms without global rigidity.
18	Roughness	Roughness as irregularity and non-geometrical rigidness describes a focus on the most important elements while ignoring unimportant elements.
19	Echoes	Similar forms exist at different scales and within a single scale but at a distance.
20	The Void	The stillness, calm, and empty space in the centre that alleviates the noise of surrounding centres.

To facilitate the assessment of form quality, symbols are also created to properties (See Appendix C).

4.4 The Case of Hoian

Mumford (1961) coined the term 'organic city' to describe a city without a predefined plan. An organic city evolves and opportunistically advances its own social and economic position. The result is a unified and coherent urban structure not less than result of any planned city.

Likewise, there was no predefined plan for Hoian[1]. The city evolved over time, advanced its needs, seized opportunities, and adapted to new circumstances. Hoian flourished during a period of international trade in Southeast Asia between the 16th and 17th centuries and survived the devastating civil wars of the late 18th century. The recorded history of the port city began when the Japanese community purchased a piece of land on the northern bank of the Thu Bon River to build a town. As late as 1617, the Japanese settled in Hoian (Dang Truong 2013)[2].

The successful community was short-lived; a ban on travel and living overseas was issued by Japanese Shogun Tokugawa Iemitsu in 1635. Upon succeeding the Japanese town in 1635, the Chinese town thrived until the 1773 Tay Son rebellion. In addition to the Japanese and the Chinese, Hoian attracted other foreigners, including

[1] Prior to the 20th century, foreigners referred to Hoian by several names: Faifo, Fayfo, or Facfo. I use the name Hoian when the city is discussed from a Vietnamese perspective and the name Faifo when it is being viewed from a foreigner's perspective.

[2] To accommodate both conventional citation styles and Vietnamese culture, Vietnamese authors who names are written with the surname last (i.e., Truong Dang) in the cited publication will be cited in this paper in the same style. However, the preferences of Vietnamese authors who use the Vietnamese surname-first style (i.e., Dang Truong) will be honored.

merchants from the Dutch East India Company (Vereenigde Oostindische Compagnie or VOC), trade agents from Portuguese Macao, and sailors from Batavia, Ayutthaya, Cambodia, and other regions (Chinho 1973; Tana 1998). In 1775, the adversarial Trinh army occupied Hoian and razed almost all the buildings. In 1801, King Gia Long (1801–1820) ended the century-long north-south division and unified the country as Dai Viet. However, he also imposed strict Confucian ideology and terminated the open-trade policy (Nguyen Dinh Dau 1991). During that time, Thu Bon River changed its course and became shallow while De Vong, a river channel connecting Hoian to Danang (or Turon), filled up and the later took over commercial role during French colonisation. These events were key contributors to Hoian's recession during the 19th and 20th centuries (Vu Van Phai and Dang Van Bao 1991).

Figure 4.1: Touranne or Turon (now Danang) and Hoian. This map by Le Floch de la Carrière's shows the De Vong channel as a "bras de mer" ("an arm of the sea") connecting Hoian and Touranne. Source: Le Floch de la Carrière 1745.

Today, Hoian is a charming town with one- and two-story houses lining the streets from the Japanese Bridge to Chaozhou Assembly Hall. The cityscape is dotted with attractive temples, assembly halls, and front shophouses. Hoian was recognised as a World Heritage Site by UNESCO in 1999. Not only providing valuable lessons about urban design, Hoian also kept the secret of its resilience — the ability to survive, adapt, and emerge from the ashes of war. Pattern language and form language can be partly used to uncover this secret.

4.5 Hoian's Pattern Language

To uncover the forces that shape the urban form of Hoian, the generative method that includes pattern language and form language is implemented. A pattern language is used to uncover 'organic planning' principles of a town[1]. Twelve patterns of Hoian between the 17th and 19th centuries are developed and featured in this section. Each pattern could be understood as a sub-rule within a large set of 'organic planning' principles. While some prominent patterns emerged from studying historical materials, other patterns were derivative of the development of other patterns.

Pattern #1

Thanh Chiem Palace

Thanh Chiem Palace had a strategic location in the Thu Bon Delta. The Palace had many roles: a residential compound for the prince, a garrison to protect and control Hoian and the Mandarin road, and a place to meet ambassadors or trade agents from Japan, Portugal, the VOC, and the British East India Company.

[1] I uses Mumford's words when discussing the organic city.

Pattern #2

The Japanese Town

To accommodate Japanese merchants' needs to stay during unfavourable wind season, Nguyen Hoang allowed them to purchase 20 *mau*[1] (approximately 9.9 hectares) in the Hoa Pho and An My villages (Do Bang 2011). He allowed them to choose their own town chief and to follow Japanese custom and their own laws. Seiichi (2011) estimates that 1617 is the latest date at which the Japanese could have settled in Hoian. Based on the schema of Tung Ban Pagoda, a spiritual centre of the Japanese community, I argued that the location east of the Japanese Bridge and north of Tran Phu Street was the site of the Japanese town. Its focal point was near Duong Thuong Hoi Quan (the Chinese Assembly Hall). The main structure of the town is a street approximately 320 meters in length, which its space was shaped by stores and shophouses on both sides.

Figure 4.2: The Japanese Town as Depicted in the Chayashin Roku Family's. *Source*: Nguyen Chi Trung 2009b.

[1] One *mau* is equivalent to approximately 4970 square meters. Therefore, 20 *mau* is approximately 99,400 square meters (9.9 hectares).

Pattern #3

The Origin and Expansion of the Chinese Town

The Chinese arrived the Hoian region sporadically beginning in the 16th century. Various accounts state that the Chinese settled in the Hoian area between 1602 and 1613 (Chinho 1973; Do Bang 1996; Nguyen Dinh Dau 2011).

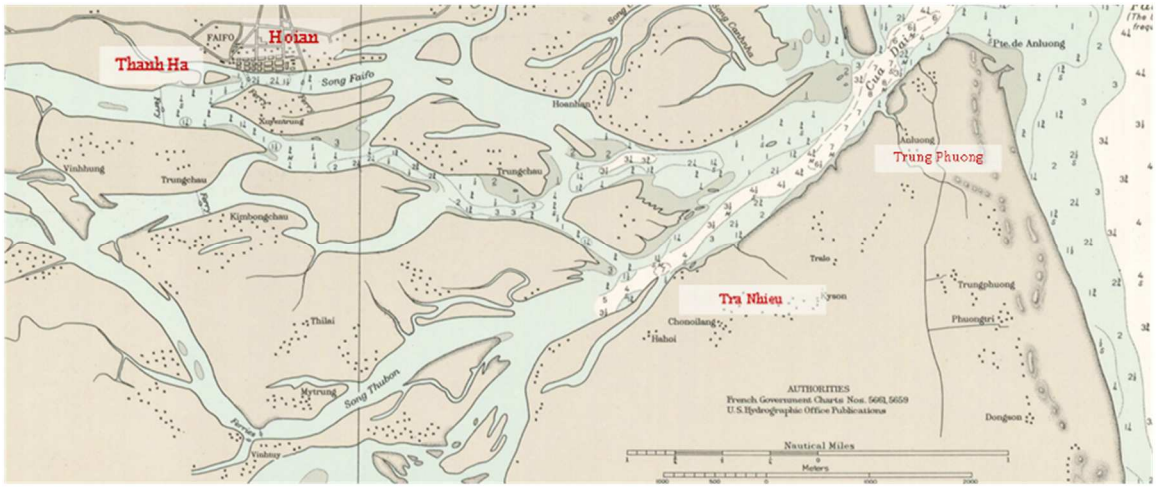


Figure 4.3: Successive Relocation of the Chinese Community in the Hoian Area: Tra Nhieu or Trung Phuong → Thanh Ha → Hoian. S*ource*: Based on Hydrographic Office 1913.

The first location in which the Chinese settled, according to Chaya's illustration and the archaeological evidence, was most likely in Trung Phuong or Tra Nhieu (Quang Van Cay 2008; Seiichi 2010). In addition, Ogura Sadao (in Kunyie 2011) argues that the Chinese village depicted in Chaya's Sea Trading Map consisted of three rows of thatched houses on the southern bank of the Thu Bon River. According to a description engraved on stele at Ba Mu pagoda, the community relocated to Thanh Ha (Nguyen Boi Lien 2008). They later settled permanently to the west of Hoian in Cam Pho village, likely west of the Japanese bridge. Therefore, the Chinese community in Hoian settled, in chronological order, in Trung Phuong or Tra Nhieu, then moved to Thanh Ha, then to Cam Pho, and finally to Hoian.

The Shogun's sudden recall of the Japanese to Japan in 1635 provided a favourable opportunity for the Chinese to thrive in the former Japanese quarter (Nguyen Ngoc Chung 2008). In 1695, when Shi Dashan (in Chinho 1973, 16) arrived in Hoian, he found a complete and vibrant town built primarily by people of Fujian origin.

> Hoian is a traffic junction for the trader and goods gathering from various countries. A straight street by the river with a length of 3 or 4 li (leagues) with two continuous rows of shops is called Ta-'ang-Chieh (Great T'ang Street) whose inhabitants are all Min (i.e., Fukien) people...At the end of the street is the Nhat Ban Kieu (Japanese bridge), across the bridge is (the village of) Cam-pho; on the opposite side of the river is (the village of) Tra-nhieu where the ocean-going vessels anchor. The town is densely populated, abundant in seafood, vegetables, and fresh fruits, which make the street always in a constant pandemonium.

Pattern #4

The 19th Century Expansion

Over the course of two hundred years, the northern bank of the Thu Bon River shifted more than a dozen meters from Main Street. In 1841 and 1872 two important streets were added. They were named as the Rue Cantonaise and Quai Phuoc Kien, Quai Hai Nam, and Quai Trieu Chau by the French. This expansion greatly contributed to the landscape of Hoian by ending the slim T-shape and developing the town along both its East-West and North-South axes.

Pattern #5

The Japanese Bridge

Initially built to serve transportation needs, the bridge had a simple uncovered design and did not bear the symbolic significance it now does. Only after the Japanese settled and built essential structures did they enhance the bridge with a tile roof. Later,

the Chinese attached a small temple to its northern side. Over time, the bridge became a prominent landmark because of its unique shape and religious meaning.

Pattern #6

Central Market

According to the Vietnamese maxim, '*First, close to a market; second, close to the river*', a market should occupy a prime location next to a wharf. The Central Market was uncovered, and sellers covered their stalls with parasols, as depicted in Chaya's Map. The initial location of the market was likely not far from its current location.

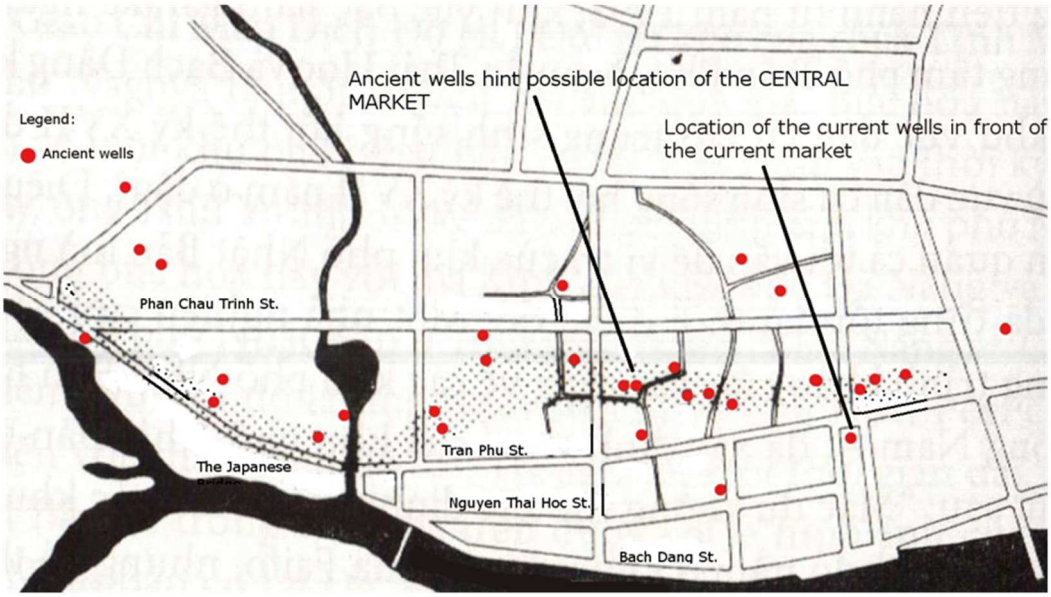


Figure 4.4: Potential Location of an Ancient Well Fronting the *Central Market*. The well is located near the intersection of Tran Phu and Hoang Van Thu streets, which was the former junction of *Main Street* and the street to the Vietnamese village. *Source:* Adapted from Seiichi 2010.

Pattern #7

Assembly Halls

Groups from various Chinese provinces built meeting halls for worshiping their tutelary deities, discussing business, educating younger generations, and organising

cultural activities. These halls constituted the economic and social centre of the Chinese town. A typical assembly hall was composed of two or three brickyards, a front building, a back building, and the main building in which the tutelary deity was worshiped (Dang Truong 2013).

Pattern #8

The Lagoon-Type Estuary and Water Elements

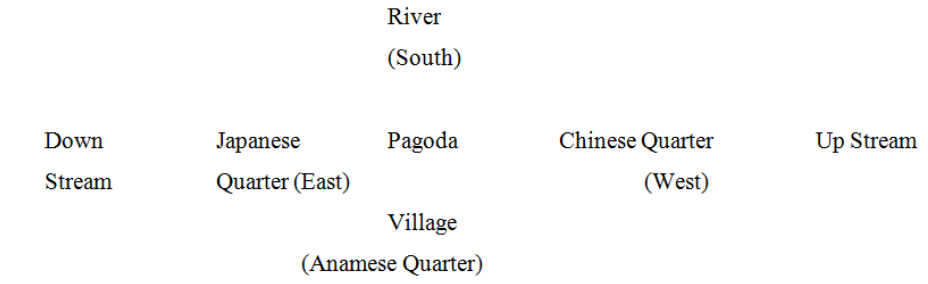
Water element presents everywhere in Hoian from ponds, swamps, rivulets, to major rivers of the region. The Thu Bon lagoon-type estuary was favourable to the establishment of a port-city with a naval base, shipyards, and logistic areas. Hoian was located at the intersection of major east-west and north-south routes: the Thu Bon River brought goods from inland and the highlands to Hoian (i.e., east-west axis). The De Vong channel entered the estuary from the north, creating a major route from Turon to the town. Nevertheless, at the end of the 17th century, the channel became shallow. In the south of the lagoon, the Truong Giang River connected large coastal areas up to Ha Than, embracing a significant part of Quang Nam. Water navigation therefore linked Hoian with strategic coastal, inland, and highland areas and formed the basis of a littoral society, as Charles Wheleer (2006) indicates.

Pattern #9

T-Junction Town

According to the diagram that Shichirobe sent to his relatives in Japan (Chinho 1973), Tung Ban Pagoda was located somewhere between the Chinese and Japanese towns. The diagram also shows the relationship of the Pagoda to the Vietnamese village

(i.e., Hoian village). This evidence supports the argument that the Chinese and Japanese towns were divided by Tung Ban Pagoda and the nearby Tung Ban Hall.



Remarks: The Pagoda is facing the south with its back to the north. There is a river in front of the Pagoda.

Figure 4.5: Location of Tung Ban Pagoda. *Source*: Shichirobei in Chingho 1973.

The T-junction was formed by the intersection of *Main Street* and the street from Hoian village. Dang Truong (2013) mentions a path that led from Hoian village past the Shrine of the Tiger to the riverbank. Currently located at this former junction is an alley that proceeds northward from what is now Hoang Van Thu Street. It is argued that Tung Ban Palace was located at the corner of this junction. With the Market across from *Tung Ban Palace and Tung Ban Pagoda* on the other corner of the junction, this group of civic buildings formed the centre of the Japanese town. A tentative map of the Japanese town is provided in Figure 4.6.

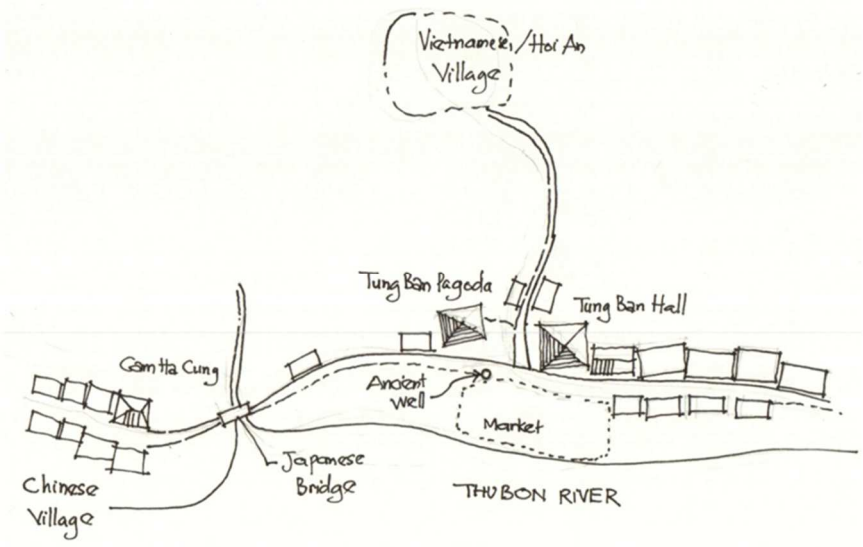


Figure 4.6: A Tentative Schema of the Japanese Settlement as a T-Junctioned Town. Pattern #10

Tung Ban Pagoda and Tung Ban Palace

I hypothesise that the first structure built after the market was Tung Ban Palace, which was constructed in a prime location. Because the market was on the riverbank close to the T-junction, the most favourable location for Tung Ban Palace was on the other side of the street. Therefore, the palace may have been built on the northeast corner of the junction. The Chinese sometimes purchased Vietnamese buildings and turned them into cultural and religious structures (Dang Truong 2013). Therefore, the Chinese possibly did the same with the structures left by the Japanese. Duong Thuong Hoi Quan, or the Chinese Assembly Hall, was the only major building near the T-intersection. Tung Ban Palace's foundation may have lain beneath the Chinese Assembly Hall. After building Tung Ban Palace, the Japanese built their pagoda, most likely near the Palace. Shichirobe's diagram of Tung Ban Pagoda shows the pagoda facing south. Therefore, the pagoda may have been located at the northwest corner of the junction.

Pattern #11

The Vietnamese Villages

As mentioned in the T-Junction pattern, the villages of Cam Pho and Hoai Pho (established since 1533) were situated along the path that ran past the Shrine of the Tiger to form a junction with *Main Street*. Ly Ngoc Son[1] (2014) reports that the area near the Shrine of the Tiger became a settlement only during the 1930s and 1940s. Therefore, the location of the Vietnamese villages must have been located between The Shrine of the Tiger and Tran Phu Street.

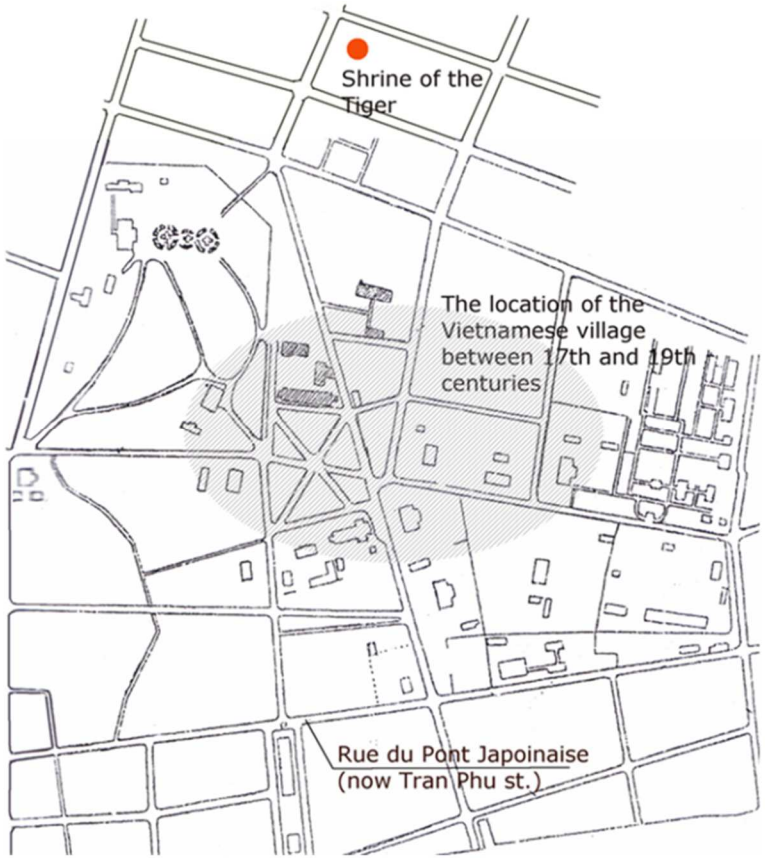


Figure 4.7: The Hypothetical Location of the Vietnamese Village. The village's location is suggested between Shrine of the Tiger and Tran Phu street. Source: Adapted from Kỷ-yếu trường Nam tiểu-học và nữ tiểu-học Hội An 2011.

[1] Personal communication May 4th, 2014

Pattern #12

Main Street

Main Street was the centre of the town's commercial and cultural life. Christophoro Borri, Shi Dashian, and William Bowyear (in Chinho 1973) all mentioned a lively town with boisterous activities that happened on Main Street. The street ran along the Thu Bon River and was flanked on the north side by cultural and administrative buildings. One- and two-story storefronts faced and rhythmically lined the street on both sides. The junction served as a square and a gathering place for the activities conducted on Main Street. Being crooked based on incremental house construction the street provided constant changes in perspective for onlookers. Lastly, the name of Main Street changed from Great Tang Street (Đại Đường Nhai) to Rue du Pont Japonaise at the end of the 19th century would express the ethnic diversity of the town.

Pattern #13

Row houses

Row houses were one of the main structures of Hoian urban form. A row house often has one or two stories used for both living and commercial purposes. The width of its façade ranges from 2 to 4 metres. The row houses typically comprised three to five parts with separate roofs and were primarily developed with a length of 20 to 40 metres (Viện Nghiên Cứu, 2006). This type of configuration gave the houses one or two inner courtyards. The first courtyard often served as a place for cooking and other service purposes. The second courtyard, if it existed, served as a place to rest and enjoy tranquillity. A fish tank and plants contribute to the characteristics of this space, becoming a truly zen space where the owners build and enjoy their own universe.

Some large houses could accommodate other commercial purposes. They served as inns and storage places. According to Dang Truong (2013), the Portuguese commenced commercial activities in the Hoian area in 1613. The Nguyen Lord, Nguyen Phuc Nguyen, even allowed them to build their own town as the Japanese did. Nevertheless, the Portuguese viewed Hoian as an intermediate spot to trade with Japan and other countries in the region. The Portuguese did not develop permanent establishments as they did in Macao or India. Furthermore, the Portuguese did not operate through a united company as the Dutch VOC did (Chinho 1973; Dang Truong 2013)—they rented inns and warehouses for their business. The logical location for these hotels was near the market, perhaps not far from Tung Ban Hall because of the convenience of the area for conducting business. After the Portuguese, the Dutch (VOC), the British from the British East India Company, and the French came to Hoian to develop commercial establishments. For various reasons, only the Dutch started their VOC establishment in 1633 (Chinho 1973). Nevertheless, the establishment was short-lived, as it closed in 1654.

In conclusion, houses were operated with various functions: shops in front, in the middle or the upper parts could be a room or two served as a "hotel room" and the back of houses served as stores.

4.6 Hoian's Form Language

A generative system includes a pattern language and a form language. In the previous section, a pattern language was developed for Hoian, with twelve patterns working as organic planning principles. These principles directed the spatial patterns of

Hoian between the 17th and 19th centuries. Then, a form language, which combines urban elements (paths, nodes, edges, landmarks, and districts) and their properties, was considered. This section assesses Hoian's form language by analysing how the properties of the urban form operate in each pattern (see Table 4.2 and Figure 4.10).

4.6.1 Thanh Chiem Palace

According to Chaya's Map, the Palace occupied a large area and was a prominent architectural complex. Analysis is based on both the District and Landmark categories considering the qualities of the *Centre, Dominance, Singularity*, and *Good Shape* . At times, the palace was called Dinh Ciam, implying the whole Quang Nam region, which is associated with the *Name and Meaning* quality. The *Level of Scale* of the complex includes several structures of distinctive size and recognised thresholds present in the palace. Its *Thick Boundary* was created by a bamboo fence, as illustrated in Chaya's map (Sadao in Kuniye 2011). Inside the complex were several courtyards that exemplified *Positive Space.*

Figure 4.8: Thanh Chiem Palace as Dinh Ciam. *Source:* Le Royaume de Siam.

4.6.2 The Japanese Town

The town had *Centre, Dominance,* and *Singularity and Contrast* qualities because it emerged as a unified and organised space from among the surrounding villages. The *Echoes* quality is reflected in the shapes of the Japanese facades and roofs. *Roughness* emerged through the irregularity of the houses and streets and a focus on the town's most important architecture (e.g., the *Tung Ban Palace*). *Simplicity* was expressed through the T-shape and the uniformity of Japanese building style. *Clarity of Joint* expresses the clear relation of the town with the surrounding villages and the clarity of each element in the town (e.g., the T-Junction, Tung Ban Pagoda and Tung Ban Palace) The town had *Directional Differentiation and Gradient* when onlookers walked along Main Street and recognized the intensity of activity towards the town center. *Visual Scope* was facilitated by the T-Junction, enabling people to enhance their vision throughout the town. Main Street gave the town a *Continuity* quality. *Local Symmetry* was developed by houses symmetrically located along the streets. Finally, onlookers perceived 'form in motion', or *Motion Awareness*, as they moved along the streets.

4.6.3 The Origin and Expansion of the Chinese Town

The Chinese town inherited the qualities of the Japanese town: *Centre, Singularity, Dominance, Motion Awareness, Continuity, Echoes, Clarity of Joint, Visual Scope, Local Symmetry,* and *Directional Differentiation.* Nevertheless, the town lost its *Simplicity* when buildings and activities were built rapidly.

Figure 4.9: Buildings of Similar Types Lining Main Street. *Source:* Vinh Tan, in Nguyen Chi Trung 2009.

4.6.4 The 19th Century Expansion

With the addition of two streets south of *Main Street*, the town lost its two properties *Local Symmetry* and *Clarity of Joint* as buildings, shops, and activities became so developed that they complicated the perception of these properties. Eight properties were inherited from the Chinese Town.

4.6.5 The Japanese Bridge

The bridge's development occurred in two phases. Its initial purpose was to facilitate transportation. *Similar* to *Thanh Chiem Palace*, the bridge had *Singularity and Contrast* quality. It was named Lai Vien Kieu, or 'the bridge that welcomes friends from faraway', by Lord Nguyen Phuc Chu in 1719. This narrative profoundly enhanced and reinforced it as a landmark, associating with the *Name and Meaning* quality. Its *Simplicity* was created by its location, its relationship with the surrounding area, and its

functional simplicity. The qualities of *Centre, Good Shape, Level of Scale,* and *Dominance* emerged in the second phase. Nevertheless, in the second phase, the *Simplicity* was lost because of the sophisticated built structure.

4.6.6 Central Market

The qualities associated with this landmark were *Strong Centre, Dominance,* and *Singularity and Contrast*. A new quality, *Directional Differentiation*, emerged as the flow of goods and people and the building density intensified in the direction of the market.

4.6.7 Assembly Halls

Each assembly hall became a *Strong Centre* with its own *Good Shape, Singularity and Contrast, Clarity of Joint,* and *Dominance*. *Name and Meaning* was also important because a hall was a gathering place where each Chinese clan shared its myths and narratives. *Deep Interlocking* was reflected in the thorough integration of these halls into the townscape. Each hall often had its own front and inner courts, which served as resting places — *The Void* — in the middle of intensified centres.

4.6.8 The Lagoon-Type Estuary and Water Elements

Water is a special feature in Hoian — not only building a network on regional scale[1], water connects the whole landscape through ponds, mangrove swamps, and rivulets into a complex of a water-based community. This water nexus represents the *Echoes* (i.e., the presence of water is everywhere in the region), *Visual Scope* (the capacity to develop new perspectives and visual penetration while navigating), and *Continuity* (the interconnection of water elements throughout the landscape) qualities. *Center, Singularity and Contrast,* and *Dominance* also operated in the estuary. Water

[1] Charles Wheeler (2006) asserts that water features serve as the connecting elements of the Quang Nam area.

acted as physical and visual resting places — *The Void*. The integration of water into the cityscape produced the *Deep Interlocking* quality.

4.6.9 The T-Junction

The junction created a sense of directional and spatial relational clarity (*Clarity of Joint*). As one moved towards the intersection, commercial activities intensified (*Directional Differentiation and Gradients*). With a strong sense of centeredness, the *T-Junction* had *Centre* and *Singularity and Contrast* qualities. It also included *Visual Scope* because of the visual penetration offered by the *T-junction* and *Positive Space*. *The T-junction* also had *Motion Awareness* (people perceived the T-shape through movement). Finally, *Simplicity* was created by the perception of the town's simple T-shape form.

4.6.10 Tung Ban Pagoda and Tung Ban Palace

As focal points in the social and economic life of the town, this pattern had the major qualities of a landmark: *Strong Centre, Singularity and Contrast, Dominance, Good Shape, Level of Scale,* and *Positive Space.* The inner courts served as a place of rest—*The Void. Thanh Chiem Palace* was sometimes called Dinh Chiem, which implied the whole region of Quang Nam prefecture (Dang Truong, 2013). Likewise, *Tung Ban Palace* was equated with the Japanese town. Hence, the *Name and Meaning* of *Tung Ban Palace* surpassed its functionality.

4.6.11 The Vietnamese Village

The whole village expressed *Simplicity.* It also served as a *Centre* because of its interconnected paths, the spatial organisation of its houses, and its gardens. The paths were usually crooked, creating favourable conditions for *Visual Scope.* Similarities in form and repetitiveness gave the village *Echoes*. *Deep Interlocking* embodied the

integration of houses with gardens and the whole village. *Roughness* was seen in a focus on the most essential elements of the village, such as the communal houses or shrines. *The Void* was reflected in ponds or abutting gardens.

4.6.12 Main Street

Main Street operated as a *Centre*. It was the soul of the town as it created *Continuity* and *Local Symmetries* through *Echoes* of roofs, façades, and commercial activities. Travellers could perceive the town's form while walking along the street (*Motion Awareness*). *Positive Space* was introduced at the intersection of the path towards the Vietnamese villages and swell-off sections. *Directional Differentiation and Gradient* was expressed in several focal points along *Main Street*: *Assembly Halls*, the *Japanese Bridge*, and the *Central Market.* Finally, *Name and Meaning* amplified *Main Street's* functionality when it took on multiple identities as Great Tang Street or the Rue du Pont Japonaise**.**

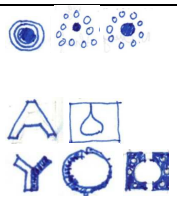
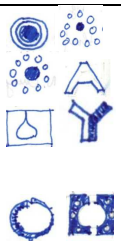
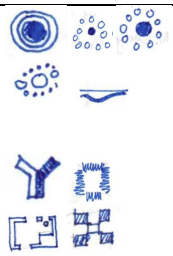
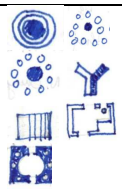
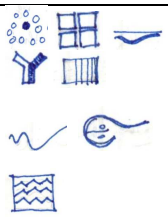
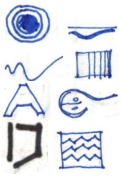
4.6.13 Row Houses

Each house serves as a *Center* for the urban form of Hoian. Althought *Simplicity*, every house has *Local Symmetries, Deep Interlocking,* and *Roughness.* The *Echoes* are reflected in the repetition of roofs of the houses. *The Void* was embodied in inner courtyards. The quality *Continuity* was created by the continuation of row houses on streets.

Finally, a sequence of Hoian's patterns and properties is suggested**.** The city of Hoian originated from topography of the region (i.e., *Lagoon Type-Estuary*) and political calculation (i.e., *Thanh Chiem Palace*). From the market as a center of trade, the Japanese town was established. Successful in commerce helped the Japanese built essential

structures to meet their needs: the *Tung Ban Pagoda* and *Tung Ban Hall* located by the *T-junction*. After the Japanese, the Chinese took over the business of the town and develop a prosperous city. In the next page is an excerpt of the sequence of the development in Hoian. The full sequence is listed in the Appendix D.

Table 4.2: The Relationship between the Urban Elements and Patterns. A Complete Table of the Relationship between Urban Elements, Properties, and Patterns is Listed in the Appendix E.

No	**Pattern language**	**Urban elements**				
		Paths	Edges	Nodes	Districts	Landmarks
1	Thanh Chiem Palace					
8	The Lagoon-Type Estuary & Water Elements					
9	The T-Junction Town					
12	Main Street					

Sequence of Hoian's pattern

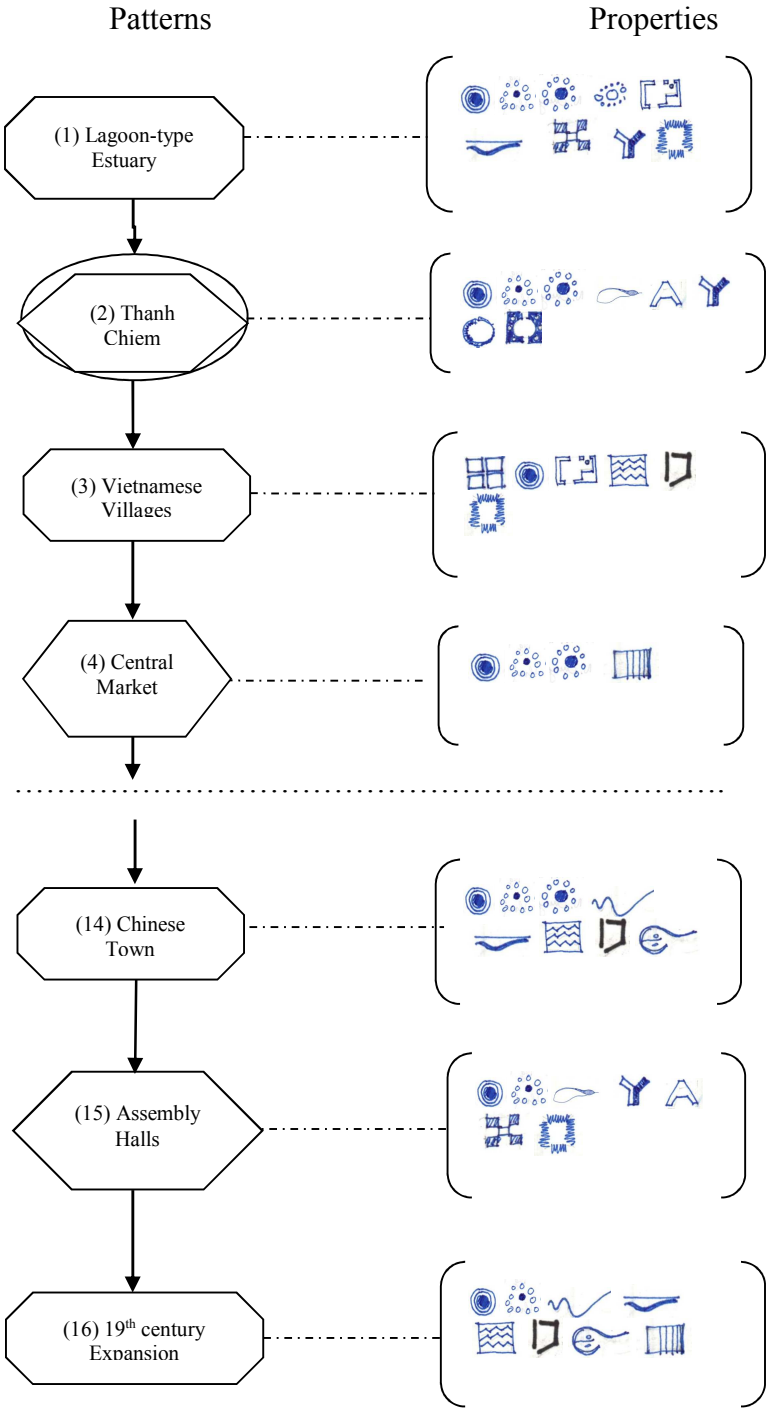


Figure 4.10: The Sequence of Patterns and Properties for Hoian. A Complete Sequence is Listed in the Appendix D.

4.7 Discussion

By investigating the frequencies of the properties in each pattern, the generative forces shaping the form of Hoian can be revealed. Even if a pattern operated in two different categories, such as region and district (e.g., *Thanh Chiem Palace*), the property was counted only once. For example, *Strong Centre*'s association with *Thanh Chiem Palace* is counted once even though it appears in both the District and Landmark categories. Those patterns in which properties are presented twice are signified by multiple representations of images and meanings.

Properties in each pattern:

Japanese Town	11
Chinese Town	10
Thanh Chiem Palace	9
Row Houses	8
Lagoon-type Estuary	8
Tung Ban Pagoda and Palace	8
Main Street	8
T- Junction	8
The 19th Century Expansion	8
Vietnamese Village	7
Assembly Halls	7
Japanese Bridge	6
Central Market	4

Employing the Coherent Index developed in chapter 6 and exploring the distribution of properties in Hoian pattern language in table 4.3, I observe that at the threshold of 7, there are 11 patterns that the mathematical product of their average number of patterns and properties' threshold is the highest (5.92). I call this threshold is

the first rank threshold. Because this index represents both properties and the average number of patterns at each threshold, it is the representation of urban form. When this index is highest, the patterns in this group (i.e., patterns at threshold 7) contribute the most to the form of the city.

Table 4.3: The Distribution of Properties in the Pattern Language of Hoian.

	Patterns	Properties																				Sum
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	Lagoon-type Estuary																					8
2	Thanh Chiem Palace																					9
3	Vietnamese Villages																					7
4	Central Market																					4
5	Japanese Bridge																					6
6	Row Houses																					8
7	TungBan Pl & Pagoda																					8
8	Main Streets																					8
9	T-junction																					8
10	Japanese Town																					11
11	Chinese Town																					10
12	Assembly Halls																					7
13	19th century Expansion																					8
Sum		13	10	8	4	6	3	6	6	5	5	3	1	0	5	5	4	4	2	8	5	7.85

There are patterns that have fewer than 7 properties, specifically, *The Japanese Bridge* (6 properties) and *The Central Market* (4 properties). These patterns still contribute to the urban form because, as Alexander and colleagues (1977, 2002) mentioned, a pattern language is complete only when it includes all patterns to form a full image of the city or urban settlement for the pattern language readers. Therefore, we cannot ignore patterns whose number of properties below the first rank threshold (i.e., bellow 7). We need all patterns even some of those with thresholds lower than 7, because these patterns make the aforementioned product reach the highest value. *In fact, evaluation of the impacts that a group of patterns has on urban form is meaningful only in the presence of patterns at lower threshold.*

Therefore, the question such as what pattern has the greatest impact on the urban form of Hoian seems meaningless because all patterns are in an interconnected relationship with other patterns. Figure 4.11 illustrates the hierarchical relationship of patterns. Instead, the question regarding what groups of patterns have the largest impact on the form of Hoian is the valuable. The analysis in this section provides the answer: the group of patterns with 7 or more properties (i.e., threshold 7).

I propose to call this group the ***core group*** of patterns for Hoian form. Although this group cannot be separated from the 'lower level' group (i.e., groups with lower thresholds), this group contributes the most to the form of Hoian. From this finding, we can explore other issues, such as the forces that have the largest impacts on the form of Hoian. The impacts of the patterns with threshold 7 can be interpreted as follows:

Japanese, Chinese Towns, and Vietnamese Village embodied the multiethnic origin of Hoian and the international commercial activities of the town.

Thanh Chiem Palace embodied the *autocratic power* of the Nguyen Lords, especially their ability to promote foreign trade in the town and to establish firm control of the country.

Row houses and Main Street traded along the Main Street and combined living and working space.

The Lagoon-type Estuary expressed the strong association of water elements with the economic and cultural life of Hoian.

Tung Ban Pagoda and Palace and the Chinese Assembly Halls embodied spiritual and cultural activities intertwined with administrative work.

T- Junction reflected the integration of the Japanese town into the landscape of the Vietnamese village and the interdependence between the two communities.

The 19th Century Expansion reflected the *continuing expansion and enhancement of the form of the town across multiethnic generations of Hoian residents.*

The Japanese Bridge gradually became an important symbol for Hoian by representing a peaceful amalgamation of different cultures.

I summarise these patterns as follow:

The group of patterns *Japanese, Chinese Towns, Vietnamese Village, T- Junction, The Japanese Bridge, Tung Ban Pagoda and Palace,* and *the Chinese Assembly Halls* represent the ethnic interdependence and integration of multiethnic communities.

The group of patterns *Row houses and Main Street, Japanese Town, Chinese Towns, Vietnamese Village,* and *Lagoon-type Estuary* embodied the power of water and trade.

The patterns *Thanh Chiem Palace* embodied monarchical power.

The group of patterns *Tung Ban Pagoda and Palace, the Chinese Assembly Halls,* and *The 19th Century Expansion* embodied the continuous expansion and enhancement of the town's form across generations of Hoian settlers.

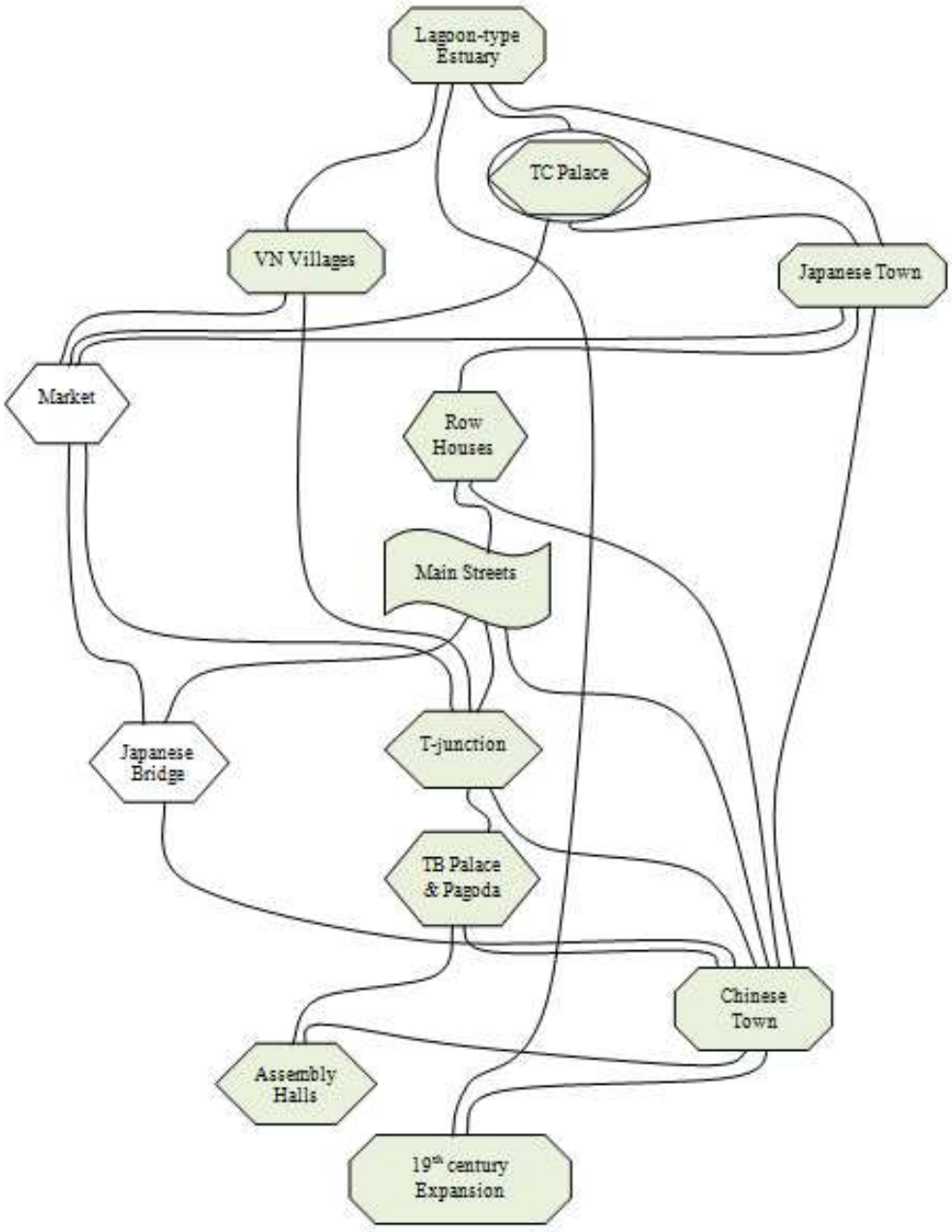


Figure 4.11: Hierarchical Patterns in the Pattern Language of Hoian.

Certain implications regarding the issue of resilience can be inferred from the case of Hoian. By definition, resilience is the capacity of a system to absorb shocks and stresses while maintaining its functions, structure, and identity (Pijawka and Gromulat 2012). This chapter therefore relates to the basic issue of urban design and planning: the

relationship between form and social functions. Research (for example, Jacobs 1961, Kostoff 1995, Talen 2005) has directly or indirectly demonstrated that urban form does not determine function but that form can facilitate or impede social activities. The case of Hoian is no exception to this principle. After the Tay Son rebellion, the town was rebuilt in almost exactly the same location where it had existed before being destroyed. The persistent use of ancient Cham wells is additional evidence. Even after one hundred years, people continued to use the same wells in their daily lives. The rebuilding of old houses in Tran Phu Street confirmed this persistence of form. Although the urban form of Hoian did not solely determine the town's resilience, its form during the 17th to 19th centuries indicated the resistant and elastic capacities of form (i.e., lots, streets, public spaces, and other physical elements were returned to their former states and facilitated urban activities). These urban elements remained and were rebuilt because of the useful features of urban spaces, such as being close to the river or having a convenient junction for commercial activities, among other characteristics. Form may bend under external impacts but will then return to its former shape, despite various opposing forces. Thus, this chapter partly contributed to the issue of resilience: a town with a good urban form should possess resilient capabilities.

4.8 Conclusion

This chapter examines the GP using an operational approach. Three Alexandrian elements (i.e., patterns, properties, and sequence) are employed to uncover the creation of traditional urban form. Fifteen of Alexander's properties and ten of Lynch's qualities were aggregated into a set of twenty properties of urban elements. Using the ancient

quarter of Hoian as a case study, the research investigated the pattern and form languages of the town between the 17th and 19th centuries. Thirteen patterns for Hoian were developed, and their relationships with the urban elements (Paths, Nodes, Edges, Districts, and Landmarks) were analysed. By putting the pattern language of Hoian in relationship with its urban elements and gauging its properties, the research uncovers the underlying shaping forces of Hoian form. These forces are found in the core group of patterns with the highest coherent index; they are patterns with the threshold 7 (in chapter 6 I will discuss further the concept of Coherent Indices). Eleven patterns in this group represent the *ethnic interdependence and integration of multiethnic communities, the power of water and trade, monarchical power, and the continuous expansion and enhancement of the town's form across generations of Hoian settlers* were the most important forces that determined the form of Hoian between the 17th and 19th centuries.

CHAPTER 5

Simulating the Generative Process of Urban Form: An Application Using Opensim

About this Chapter

This chapter is the last of three articles about the generative process in traditional cities. This article aims to understand and evaluate the generative process of urban development using simulation methods. The open-source platform OpenSim was used to allow participants to build three-dimensional virtual environments representing the ancient town of Hoian, Vietnam. The study substantiates the proposition that the same generative rules can build diverse and unified urban structures. Generative systems including patterns and urban properties can serve as rules guiding urban growth. In addition, through the enriching and immersive environment of OpenSim, communities can establish effective public participation in urban design. This study also reveals a new opportunity for using OpenSim simulation in testing and building codes. This article will be submitted to the *Journal of Urban Design.*

5.1 Introduction

Urban designers recognize the importance of legal tools in shaping the urban environment. Although planners and researchers exert considerable effort researching form-based codes (FBCs), their counterpart—generative codes and the generative process (GP)—do not receive sufficient attention. Nevertheless, Besim Hakim (2008, 2014), Christopher Alexander (1987, 2002), and other researchers have argued in support of the

GP, based on the virtues of coherence, human scale, flexibility, and adaptability of the environment.

A GP is an underlying mechanism that creates traditional urban forms with qualities such as compactness, mixed use, and human scales (Alexander 2002; Hakim 2008). Nevertheless, with the exception of research conducted by scholars such as Hakim (1994, 2008, and 2014), knowledge of the GP remains inadequate for the purposes of understanding the coherence of the traditional built environment. The original study of the GP could be traced as far back as to Patrick Geddes (1915) and Lewis Mumford (1961). The latter coined the term 'organic city' to describe the type of urban settlement that incrementally evolved into a coherent configuration.

The GP is primarily defined in the contexts of traditional settlements. Researchers describe what has already occurred in urban environments; they can observe discrete events in the timeline of urban development based on historical records, but they can scarcely observe the actual unfolding of the process in time and space. In other words, archival research lacks a dynamic view of urban transformation, and urban observers cannot capture a continuous evolution of the built environment over time.

The use of a simulation method can remedy this weakness by enabling researchers to observe the unfolding of the GP. Through observation, scholars gain insights about generative growth. Employing a simulation tool, this study investigates how the GP actually unfolds. This work also verifies the proposition by Christopher Alexander (2002) that the same set of generative protocols would build diversity in an urban settlement—one set of protocols producing many different outcomes.

To test this possibility, this study employed OpenSim, an open-source platform operating as an immersive environment. Through their representation in OpenSim — avatars — the participants engaged in a three-dimensional computer environment to simulate the virtual town of Hoian, Vietnam, based on its history and geographical accounts. In chapter 4, I developed twenty urban properties based on the work of Alexander and Kevin Lynch. Twelve patterns of Hoian were also analyzed and developed.

Using the case of Hoian to understand generative development in traditional cities, this research aims to answer the following questions: 1) How did the generative process unfold, as revealed by understanding the properties and patterns operating in the immersive environment of OpenSim? 2) Can the same generative rules create diverse and unified urban patterns? 3) How do cultural norms serve as patterns in the generative process?

5.2 Background

5.2.1 The 'Cardboard and Wooden' Simulation by Alexander and Colleagues

Alexander, Neis, Anninous, and King (1987) simulated a GP involving the redevelopment of the northern segment of the Bay Bridge of San Francisco. The general guidance for their simulation was the continuing improvement of the wholeness of the urban structure. Seven generative rules guided the simulation: i) the urban structure must follow incremental growth, ii) the process must enhance the growth of large wholes, iii) the process must engage participants with their vision at each step, iv) participants must create positive urban spaces, v) participants must provide detailed layouts of large

buildings, vi) detailed construction processes must be followed, and vii) participants should ensure the formation of centres at each step.

Hakim's and Alexander's ideas share the following assumptions: (a) the GP is a step-wise process; (b) it is the product of many hands; (c) it must be recorded in the form of written codes; (d) the same set of generative regulations can create diverse and unique built environments, and sometimes the structures were novel even to the builders. For Arabic-Islamic countries, the codes were religion-based regulations (Hakim 2014). Nevertheless, the actual unfolding of a physical urban environment, a common problem with research on the GP, was largely unknown. For Alexander and colleagues, the simulation was based on their proposed rules. Their simulation allowed designers to observe the dynamics of the GP, but it was not based on the historical facts that actually occurred 'on the ground'. By contrast, in Hakim's study, the GP is observed through historical materials and discrete events in the past. Nevertheless, the study is static. The present study aims to address these limitations by providing a simulation based on historical facts—i.e., a transformation of the patterns that actually occurred in a traditional city.

5.2.2 The Computer Simulation for the Generative Process

Simulation in urban planning and design has been in use for years. UrbanSim, one of the most well-known simulation tools, is defined as 'models that support land use and transportation planning and growth management' (Waddell 2002). UrbanSim is a successful tool for predicting land use evolution (2002). As an open-source land use modelling system, UrbanSim integrates with a transportation module to simulate urban land use, transportation, and environmental impacts (Borning, Waddell and Förster

2008). In the field of urban design, the other well-known tool is CommunityViz™ (Placeways 2015), which allows communities and laypeople to be involved in the planning and design process (Ben-Joseph 2005). One of the primary features of CommunityViz™ is that it assesses the impact of development projects on communities. The tool offers 'more visual, collaborative, and effective by providing capabilities for comparing land-use alternatives' (Ben-Joseph 2005, 163). Ben-Joseph thus argued that CommunityViz™ can help the planning process to become more democratic through informed debates. Recently, Synthicity (Synthicity 2015), a company founded by Waddell, introduced UrbanCanvas™, a new tool that enables communities to participate in urban design. It is a visualizing tool for early-stage design.

In this chapter, I proposes deployment of the GP in an immersive environment—i.e., an interactive and computer-created world in which users can immerse themselves through avatars (Johnson 2010)—to observe how the GP unfolds and to determine the potential implications of its unfolding.

The OpenSimulator (or OpenSim) platform used in this simulation was the open-source multi-user 3D application server OpenSim 0.6.7.1 developed by Overte Foundation (Overte Foundation 2011). OpenSim was a sibling of the virtual commercial platform SecondLife™ (Linden Lab 2015). With the exception of some capacities that were not adequately developed because of licensing issues (such as voice chat), OpenSim has all of the same functions as SecondLife. OpenSim has been used in education, archaeology, and exhibitions (for example, Morgado et al. 2010; Sequeira and Morgado 2013). Nevertheless, in the field of planning and design, the use of OpenSim has not been examined.

I employed OpenSim based on its numerous advantages. First, OpenSim is a user-generated content platform. In this study context, it means that participants were able to improve the urban structure based on their vision and interpretation of the patterns and properties that I provided. The overall 'content' is the enhancement of the coherence of an urban structure. The goal/content is generally defined but implemented in flexible ways. This feature reflects the nature of the traditional building process in which human idiosyncrasies (and visions) involved and guided the evolution rather than random variables. The underlying idea of this simulation in OpenSim is pursuing values in urban design— thereby reflecting the normative nature of urban design endeavor that scholars such as Jane Jacobs (1961), Lynch (1961), and Talen and Cliff (2002) emphasized; this simulation avoids Lynch's critique of value-free modelling. Second, OpenSim provides an immersive and interactive virtual environment that other simulation tools cannot provide. The unique qualities of OpenSim (and SecondLife™), such as the sound, vision, realistic landscape, and awareness of each avatar's walking movements provides users with experiences in enriching and immersive ways that are similar to the real world (OpenSim's term for being logged in is 'in-world'). Third, simulating a historical town is similar to an archaeological dig to some degree. The GP operating in OpenSim allows me to combine obscure historical facts within the virtual environment and to do so 'interactively, piece by piece, like assembling a giant puzzle' (Sequeira and Morgado 2013, 8). This task is similar to how Morgan (2009) re-created archaeological works at the virtual site of Çatalhöyük (Turkey). Similarly, the simulation serves as a 'history laboratory'—a phrase borrowed from Sequeira and Morgado (2013, 9)—for reexamining the historical events in the case study and placing them in the most reliable *sequences*.

Finally, a characteristic that is unique to OpenSim compared with other simulation and visualization tools is the feature of 'gamification'. Researchers such as Sequeira and Morgado have argued that this feature helps participants engage more actively in virtual worlds compared with the alternatives. In summary, the experiment in this study is closer to Alexander's simulation than to UrbanSim or CommunityViz™. To some degree, it is a human-based simulation.

5.3 Simulation in OpenSim

The GP in this study includes pattern and form languages. A set of patterns and its sequences directed the town's spatial arrangement, while properties built on urban elements (paths, nodes, districts, landmarks, and edges) gave the town a specific form. The simulation occurred from August 25 to October 11, 2014. Twenty-two participants who were architecture students from Danang University in Vietnam generated the virtual development of Hoian in OpenSim. I organized in-person meetings with the participants twice a week to receive feedback or provide additional information. Beyond the in-person meetings, the participants worked in-world (i.e., they worked online in OpenSim).
In this simulation project, OpenSim was deployed on a desktop computer (Core i7 processor, 8GB RAM) used as a host server. The participants had to download the viewer software called Singularity developed by Sianna Gearz, the name of a SecondLife resident avatar (Gearz 2014). The participants used this viewer to connect to Hoian's OpenSim server.

5.3.1Terrain Building

Each region in OpenSim has a fixed dimension of 256×256 pixels. In this simulation, I established three groups of islands (or OpenSim regions). Each group comprised fifteen regions representing the landform of Hoian.

To build the terrain for Hoian, I used Global Data Explorer from the U.S. Geological Survey's website (U.S. Geological Survey 2014). Specifically, I used the Seamless Shuttle Radar Topography Mission (SRTM) 3-arc-second data from the National Geospatial-Intelligence Agency (NGA), which provides high-resolution heightmaps for terrains outside the United States. The SRTM data were used to create digital terrain maps of the Earth's surface with data points spaced every 3-arc-seconds (approximately 90 metres) (Lloyd Reeds Map Collection 2015). However, because the landform of Hoian between the 17th and 19th centuries differs from its current landform, I used multiple historical maps to adjust and generate the terrain that best represented Hoian's topography during the researched time period.

Figure 5.1: The Heightmap of the Researched Area at 5120×2560 Pixels. This GeoTIFF format's heightmap was generated from NGA's SRTM. The black represents height level 0, and a lighter colour represents a higher the elevation. Source: U.S. Geological Survey 2015.

Figure 5.2: The Hoian Region in 1745. Source: Le Floch De La Carrière 1745.

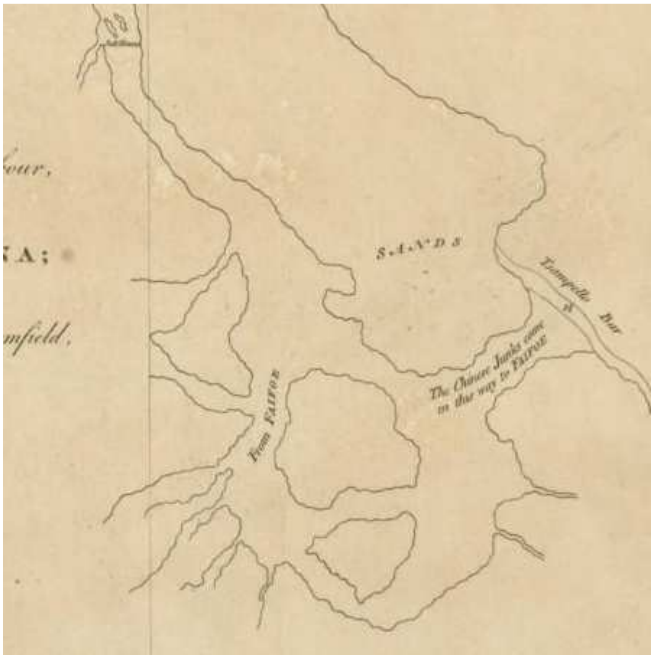


Figure 5.3: The Hoian Region in 1764. Source: Gore and Bromfield 1764.

Because OpenSim uses only a square map of 256×256 pixels as its basic region, I divided the 5120×2560 pixel heightmaps into smaller square maps of 256×256 pixels. Fifteen maps of this size were arranged in three rows and five columns. This organization

represents the landform of Hoian while imposing few constraints on the computer's capacity.

Notably, the simulated town is small relative to the entire Hoian's area (approximately 1 km^2 compared with 20 km^2). Therefore, as long as the main features of the regional landscape are respected including a delta region, a lagoon-type estuary, and low and relatively flat terrain, the detailed topographical features on a large scale do not affect the town structure.

5.3.2 The Participants

Twenty-two undergraduate architecture students from Danang University participated in the simulation. These students were familiar with Hoian's history and geography. The participants included twelve females and ten males with different design experience levels (from second-year students to newly graduated students).

The participants were divided into three groups. Each group collectively built the virtual town of Hoian based on rules and guidelines that I provided in a simulation manual. Group 2 comprised participants with few design skills (the second-year students). Through this arrangement, I sought to observe how design skills would affect the simulation results.

Role-playing simulation was also implemented. Each week, a participant was assigned to be the mayor of the Japanese town. The mayor's responsibility included providing guidance and coordination to the other participants (who were assigned as the residents) in building the town. The holder of the mayor's position changed each week.

5.3.3 The Participants' Manual

I provided a working manual that guided each step of development. The manual format followed the spirit of building codes. Each step in the manual could be considered a pattern associated with the necessary properties. During the simulation, I constantly provided feedback to the participants on their work and suggested refinements based on discrepancies between the qualities that were stipulated in the manual and the results in the OpenSim environment.

The following provides a brief description of the steps in the manual:

Step zero. Site selection*:*

Select a site to build the town based on the advantages of location and ancient Cham wells[1]. The site must be close to the river but not on land prone to flooding. The site must also be close to the ancient Cham wells and Vietnamese villages. Do not build the town near the river mouth, given the unstable conditions of this area.

Step 1: the Central Market

The market was initially an open space in which people brought goods to trade (in Do Bang 1996). The market should occupy a prime location close to a wharf and could possibly close to a Cham ancient well.

Associated properties: *Strong Centre, Dominance, Singularity and Contrast*, and *Directional Differentiation.*

Step 2: The Japanese Bridge

Initially built to serve transportation needs, the bridge also acted as a western gate of the town. At the beginning, the bridge was a simple uncovered wooden or a stone structure and did not have symbolic significance as it did now.

Associated properties: *Singularity and Contrast*, *Deep Interlocking, Name and Meaning,* and *Simplicity.*

[1] The Cham wells were built by ethnic Chams, the people who built the Champa Kingdom, which was at war with Dai Viet for centuries. The Hoian area and Dien Ban Prefecture (now Danang City and Quang Nam Province) became Dai Viet lands after 1470, but the land changed hands many times until Nguyen Hoang accepted a position as a count and reigned over the south of Vietnam (from today's Quang Tri to Quang Nam provinces), including Hoian, beginning in 1598 (Li Tana 1998).

Step 3: The Tung Ban Hall and Tung Ban Pagoda

At the beginning, the buildings were simple structures; later (in *Step 8* and *9*) they were enhanced to reach a higher symbolic and architectural status. These structures served as the administrative and religious centre of the town.

Associated properties: *Strong Centre, Singularity and Contrast, Dominance, Good Shape, Positive Space,* and *Name and Meaning.*

Step 4: the T-shape town

The T-junction was formed by the intersection of Main Street and the street from Hoian village. Tung Ban Palace was located at the corner of the junction. With the market across from the Tung Ban Palace and Tung Ban Pagoda on the other corner of the junction, this group of civic buildings formed the centre of the Japanese town.

Associated properties in *Nodes* and *District* categories.

As a node*: Clarity of Joint, Directional Differentiation and Gradients, Strong Centre, Singularity and Contrast, Dominance, Visual Scope,* and *Positive Space.*

As a district: *Local Symmetry, Motion Awareness, Echoes,* and *Simplicity.*

Step 5: Inns and Warehouse

The Portuguese and other foreign merchants rented inns and warehouses to do business. The location for these hotels must be close to the market. It should not houses were operated with many functions: shops in front, in the middle or the upper parts can have a room or two served as a "hotel room" and the back of the houses served as storage areas.

Associated properties: *Good Shape, Deep Interlocking, Roughness,* and *Echoes.*

Step 6: Main Street

Main Street was the centre of the town's commercial and cultural life. The street ran along the Thu Bon River and was flanked on the north side by cultural and administrative buildings. One- and two-storey storefronts faced and rhythmically lined the street on both sides. The junction served as a square and a gathering place for the activities conducted on Main Street.

Associated properties: *Center, Continuity, Local Symmetries, Echoes, Motion Awareness*, *Roughness, Directional Differentiation and Gradient,* and *Name and Meaning.*

Step 7: The Vietnamese Villages

The villages of Cam Pho and Hoai Pho (sometimes called the Hoian village) were once located in the place that became known as Hoian town in 1533 (Do Bang 1996). The Vietnamese villages were situated along the path passing the Shrine of the Tiger to form a junction with Main Street. The location of the Vietnamese villages of Cam Pho and Hoai Pho must have been located between The Shrine of the Tiger and Tran Phu Street (See Figures 4.6 and 4.7).

Associated properties: *Simplicity, Centre*, *Visual Scope, Echoes*, *Roughness*, and *the Void.*

Step 8: Enhancing Tung Ban Palace

Tung Ban Palace would be enhanced after the Japanese community in Hoian prospered. It was the main administrative building in town and would be likely embellished with lavish decoration. The size and architecture of the Palace should match the importance of this edifice.
Associated properties: *Strong Centre, Singularity and Contrast, Dominance, Good Shape, Positive Space, a*nd *Name and Meaning.*

Step 9: The enhancement of Tung Ban Pagoda

After building Tung Ban Palace, the Japanese built their pagoda, most likely near the Palace. The Shichirobe's diagram of Tung Ban Pagoda shows the pagoda facing south. The pagoda was the most important religious building in the town, therefore, it was built with spectacles and elaborated decoration.
Associated properties: *Strong Centre, Singularity and Contrast, Dominance, Good Shape, Positive Space,* and *Name and Meaning.*

Step 10: The enhancement of the Japanese Bridge

After the Japanese settled and built important administrative and religious structures they embellished the bridge with a tiled roof. Subsequently, the Chinese attached a small temple to its northern side. Over time, the bridge became a prominent landmark because of its unique shape and religious meaning.

Associated properties: *Singularity and Contrast* and *Deep Interlocking, Name and Meaning, Simplicity, Centre, Good Shape,* and *Dominance.*

Table 5.1 describes evolutionary steps in Hoian. Figure 4.10 in chapter 4 and Appendix D detail this sequence.

The following excerpts from the specification manual describe how to build the *Strong Center* property:

> Instruction: To obtain the quality of a *Strong Centre,* you need to combine one or more of Alexander's and Lynch's properties. They include but are not limited to properties such as *Thick Boundaries* or *Local Symmetries*. Therefore, you should organize the urban environment following one of the properties discussed in the manual to build a strong centre. The following recommendations are offered:
>
> - Build *Thick and Porous Boundaries* by planting tree lines or rows of houses (with gaps between houses).
> - Build the *Dominance* property by using the volumes of buildings such as Tung Ban Palace and Tung Ban Pagoda.
> - Build *Singularity and Contrast* through the contrast between the Japanese town with the Vietnamese villages, the rice fields, and the surrounding woodlands.
> - Build *Alternating Repetition* by repeating alternating elements.
> - Build *Positive Space* through easily intelligible structures, typically convex or near-geometric spaces (e.g., closely shaped, such as squares or circles). You can use Nolli's map of Rome for a reference on how to establish a positive space.
> - Build *Good Shapes* through easily comprehensible shapes (i.e., typically symmetrical or nearly symmetrical).
>
> Verification: You should verify the structure that you created at every step. You should walk through the streets to get a feel for the town and the *Center* quality. You must also fly[1] and look down from an aerial view using the Camera Control function (Menu → Camera Control) to verify and maintain the quality of the *Centres*.

[1] An avatar in OpenSim can fly.

Table 5.1: List of Properties for Each Pattern.

Step 1 Central Market	**Step 2 Japanese Bridge**	**Step 3 Tung Ban Palace & Pagoda**	**Step 4 T-junction town**	**Step 5 Inns and Warehouse**	**Step 6 Main Street**	**Step 7 Vietnamese Villages**
Center	Center	Center (later period)	Center	Good shape	Center	
Dominance	Dominance (later period)	Dominance	Dominance			
Singularity & Contrast	Singularity& Contrast	Singularity & Contrast (later period)	Singularity & Contrast			
Directional Differentiation			Directional Differentiation	Directional Differentiation	Directional Differentiation	
	Interlocking			Interlocking		
	Name & Meaning (later period)	Name & Meaning			Name & Meaning	
	Simplicity		Simplicity			Simplicity
	Good Shape (late period)	Good Shape				
		Positive Space	Positive Space			
			Clarity of Joint			
			Visual Scope			Visual Scope
			Local Symmetry		Local Symmetry	
			Motion Awareness		Motion Awareness	
			Echoes		Echoes	Echoes
				Roughness	Roughness	Roughness
					Continuity	
						The Void

5.4 Results

On the whole, the simulation results showed that Group 1 closely followed the manual instructions. The group's participants understood patterns and their sequence and the form properties. To some degree, the Japanese town simulated by Group 2 showed

less coherence in its urban form. Nevertheless, their town had the qualities of clarity and clear orientation. Group 3 presented an interesting case: their town possessed a diversity of urban space that was reminiscent of Nolli's 1748 map of Rome. From an aerial perspective, their urban structure could be perceived as the smooth flow of alternating closed and opened spaces. Nevertheless, when an avatar closely investigated the urban setting, she or he found that it showed a level of disorder, and the town structure lacked coherence.

Some common characteristics of the Japanese town that the three groups shared were the following:

- Site selection: all three groups successfully selected the site for the town. However, the participants in Group 1 showed great attention to the factors determining the location of the Japanese town: close to the river, avoiding floods and instable areas, and close to the ancient Cham wells. This group achieved the best site selection.
- A T-shaped town: all groups successfully built this pattern constructed by Main Street and the street leading to the Vietnamese villages.
- The Central Market: All groups not only successfully chose the site for the Central Market but also built the market with vivid feeling and details.
- Tung Ban Pagoda and Tung Ban Palace: all three groups built these two structures in diverse ways to represent the Japanese town's civic centre.

Furthermore, some properties, such as *Strong Center, Good Shape*, and *Positive Space*, were well perceived and implemented by the participants, whereas other properties, such as *Motion Awareness, Singular and Contrast*, and *Clarity of Joint*, were

difficult to discern and implement. Overall, with different levels of understanding and adherence to patterns, pattern sequences, and form properties, the three groups built distinctive urban structures that characterized the potentiality of Hoian's forms during the research period.

The following scenes illustrate the sequences of the town's growth by the three groups.

5.4.1 Group1

Figure 5.4: Group1 – the 24th Day of the Simulation. The Central Market was built as the first *Center*. The participants in Group1 imagined it as an open space with stands. The market was covered with parasols as depicted on Giao Chi's map.

Figure 5.5: The Market with Parasols as Depicted in the Chayashin Roku Family. Source: Nguyen Chi Trung 2009.

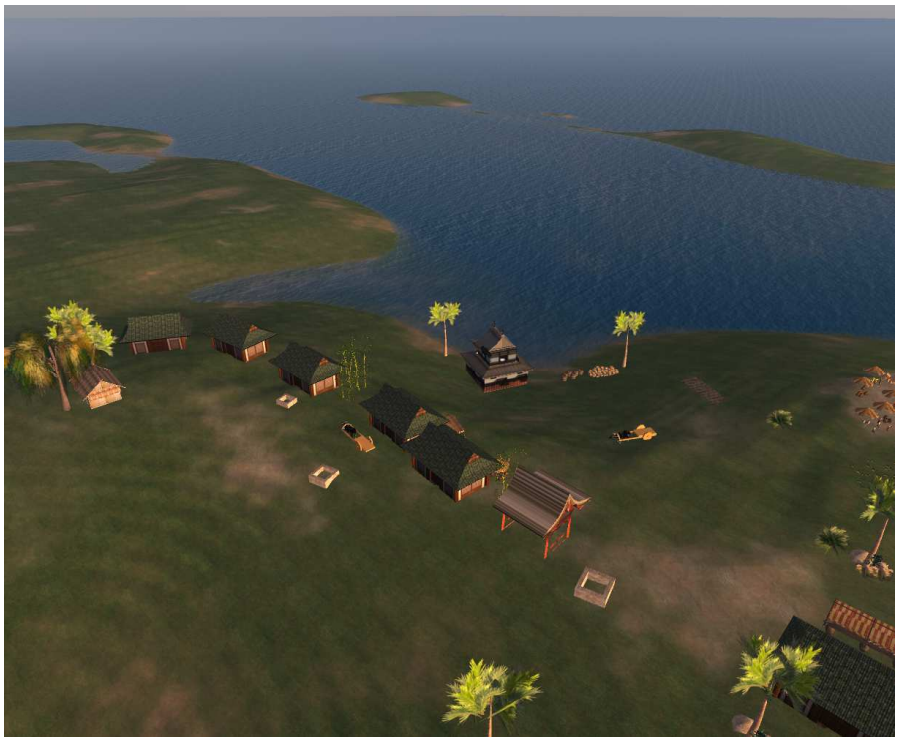


Figure 5.6: Group 1 – The 29th Day of the Simulation. The town began to form with the Central Market and the first row of houses along the river. This figure shows a view towards the riverbank. Note the location of ancient wells near houses.

Figure 5.7: Group 1 – the 37th Day of the Simulation. The dormant T-junction began to emerge as the road along the river and the path to the Vietnamese villages were being shaped. The junction was enhanced by smaller centers: Tung Ban Pagoda (on the left with reddish rooftile), Tung Ban Palace (on the right with white-blueish tiles), and the Central Market.

Figure 5.8: Group 1 – the 41st Day of the Simulation. The T-junction was enhanced further by Tung Ban Pagoda, Tung Ban Palace, and the Central Market. The path to the Vietnamese villages was narrow, creating a sense of enclosure. Main Street was also emphasized by both row houses and rows of trees.

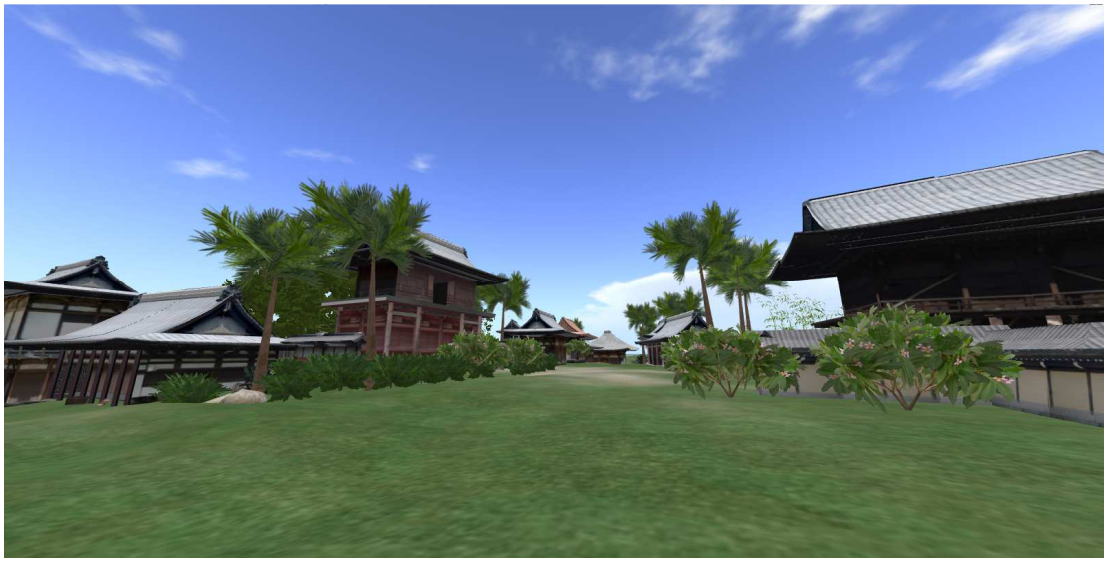


Figure 5.9: Group 1 – the 44th Day of the Simulation. The Junction.

Figure 5.10: Group 1 – the 47th Day of the Simulation: A Street View. An urban sense could be perceived when walking along Main Street from the town outskirts to the junction. This riverfront Main Street reflects the qualities *Strong Center, Continuity, Motion Awareness*, and *Differentiate Direction.*

Figure 5.11: Group 1 – the 47th Day of the Simulation: An Aerial View. The Japanese town in its finished shape. The town's properties were fully developed: *Strong Center* (e.g., in the T-junction, Tung Ban Palace, the Market, and Main Street), *Dominance* (e.g., in the T-Junction, Main Street), *Singularity and Contrast* (e.g., in Tung Ban Palace and the Central Market), *Directional Differentiation* (e.g., in the T-junction), *Simplicity, Positive Space* (in the T-junction and the Central Market), *Clarity of Joint* (in the T-junction), *Visual Scope* (in the T-junction), *Local Symmetry* (on Main Street), *Motion Awareness* (on Main Street), and *Echoes* (on Main Street).

5.4.2 Group 2

Figure 5.12: Group 2 – the 29th Day of the Simulation. The Central Market was built as the first center.

Figure 5.13: Group 2 –the 33rd Day of the Simulation. Tung Ban Pagoda (the bluish and white building on the left) and Tung Ban Palace (a white building on the right) emerged as the *Strong Center* and *Dominant* structures.

Figure 5.14: Group 2 –the 36th Day of the Simulation. Tung Ban Pagoda as a center and the nearby buildings were enhanced by L-shaped row houses.

Figure 5.15: Group 2–the 39th Day of the Simulation. Tung Ban Pagoda and its surrounding houses were weakened by the removal of L-shaped row houses. However, the T-junction was enhanced significantly by paving Main Street and completely clearing groups of houses that once blocked the path from the Vietnamese villages to the river.

Figure 5.16: Group 2–the 47th Day of the Simulation. The town had a clear sense of direction based on major patterns: the T-junction, Main Street, Tung Ban Pagoda, and Tung Ban Palace. These patterns are supported by the properties *Strong Center, Dominance, Thick Boundary* (in Tung Ban Palace), *Positive Space* (in Tung Ban Pagoda and Tung Ban Palace), and *Good Shape* (in all four patterns).

Figure 5.17: Group 2 –the 47th Day of the Simulation: a Street View. The town's T-junction has not been built as a *Strong Center*, as the view along Main Street revealed—the street lacks an urban sense.

5.4.3 Group 3

Figure 5.18: Group 3 –the 32nd Day of the Simulation. The T-junction was created with nearby *Strong Centers* and the Central Market. Each center supports one another and the T-junction. The evolving structure began to generate diversity in the city form.

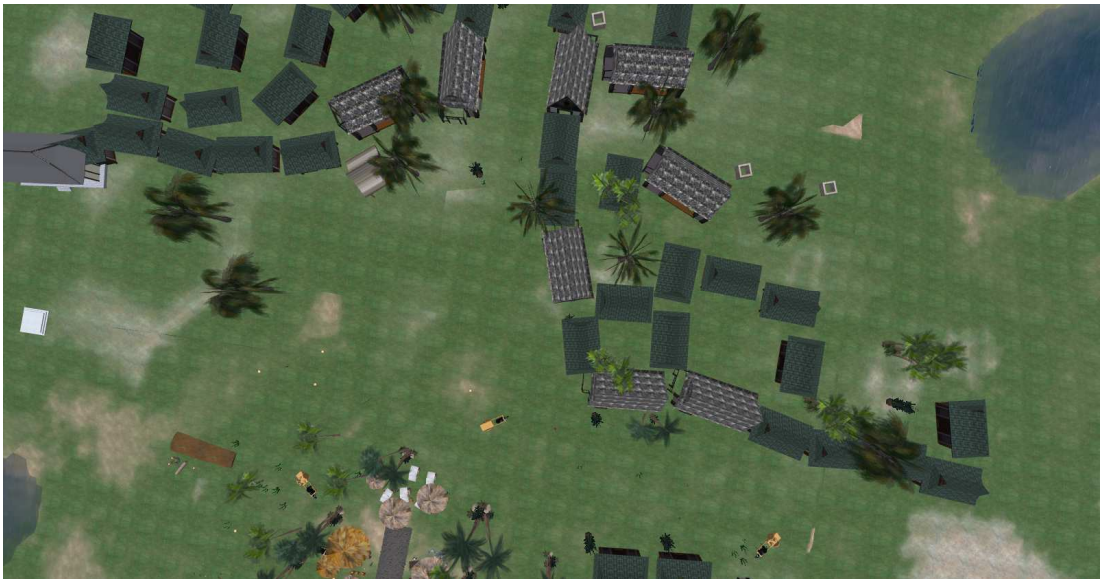


Figure 5.19: Group 3 –the 36th Day of the Simulation. The participants established the T-junction as a large square adjoining the Central Market.

Figure 5.20: Group 3 –the 39th Day of the Simulation. Tung Ban Pagoda (including the Bell Tower, the Front Hall and the Rear Hall) was created as a *Strong Center*. The pagoda's components support one another and are in turn strengthened by a row of houses behind them. On a larger scale, the Pagoda was also enhanced by the T-junction pattern and several nearby centers of different sizes and shapes. This spatial relationship created mutually supporting *Centers*.

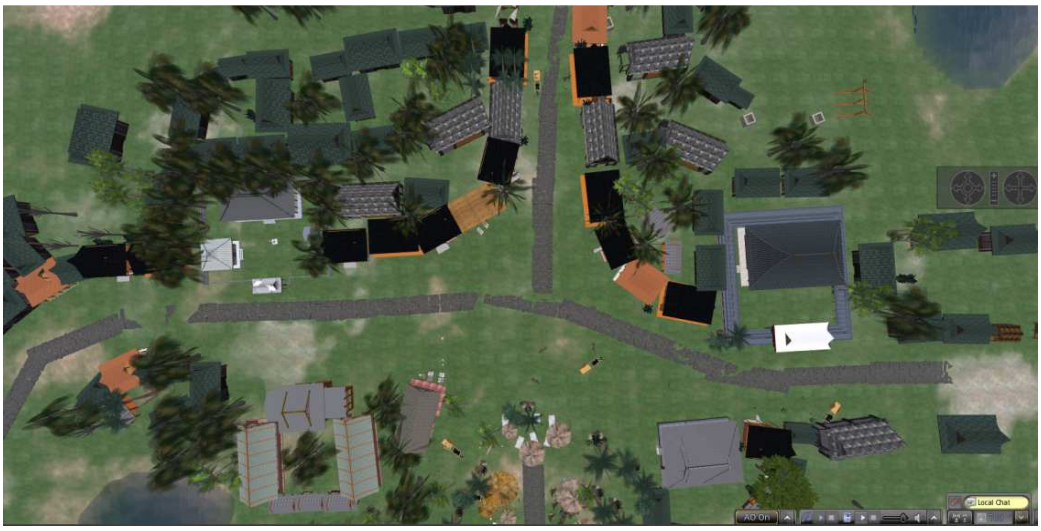


Figure 5.21: Group 3 – the 47th Day of the Simulation: an Aerial View. The T-junction and surrounding patterns: Tung Ban Pagoda, Tung Ban Palace, inns and warehouses, and the entrance to the Central Market. There was strength in these centres, including the *Strong Center* (in all mentioned patterns), *Thick Boundary* (the inns and warehouses), *Good Shape* (the palace and pagoda), *Positive Space* (Main Street, pagoda, and palace), and *Continuity* (Main Street).

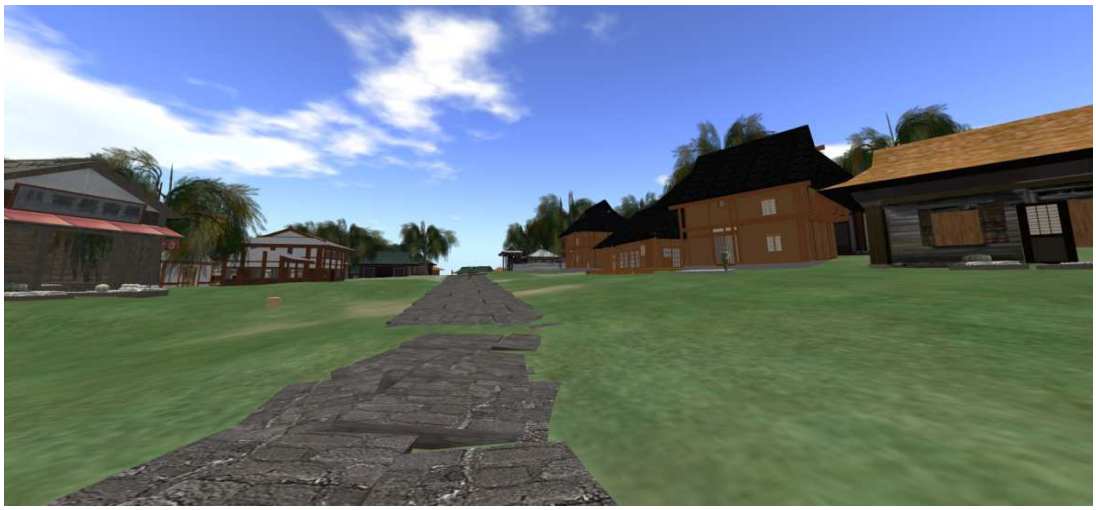


Figure 5.22: Group 3 –the 47th Day of the Simulation: a Street View. The quality that an avatar perceived on the ground was the most important criterion for assessing the urban space. This scene of Main Street showed the lack of spatial enclosure and the feeling of street wall.

Overall, Group 3 generated a town with diverse spaces and good shapes that partially echoed the quality of famous traditional cities. Nevertheless, this town configuration had several drawbacks; for instance, Main Street was overly broad, reducing the effect of the spatial enclosure. Furthermore, because the quality that an avatar perceived on the ground was the most important criterion for judging the urban form, among the three groups, Group 1 created a Japanese town with the highest level of coherence and wholeness of urban form.

5.5 Discussion

The GP in urban design and planning has been addressed and investigated in various urban contexts (i.e., traditional and modern cities) and under different names (i.e., organic or traditional planning). Beyond Hakim's research on traditional cities in Mediterranean and Arabic-Islamic regions, no existing study examines the GP of other traditions of urbanism. Based on Alexander's work on pattern and form languages, the

open-source platform OpenSim was used in this study to simulate the unfolding of pattern and form languages in the ancient town of Hoian, Vietnam. Several findings emerge from this study. First, the study substantiates the propositions that similar patterns and their sequences can generate diverse built environments. Second, the patterns, pattern sequences, and properties of urban elements served as generative rules in creating a virtual urban structure. The study participants were able to perceive and create properties such as *Strong Center, Good Shape*, and *Positive Space*; however, *Motion Awareness, Singular and Contrast*, and *Clarity of Joint* posed difficulties.

The results reveal the diversity in the urban form of the three virtual towns. Although I expected differences in the forms of the three towns, the simulated towns' levels of uniqueness, coherence, and completeness exceeded expectations. Another valuable lesson was in understanding how the process of generative development unfolded. The three groups showed different levels of competence, as each group's perceptions of the form's properties affected their results. The group that showed the most coherence in the virtual town was the group that demonstrated greater understanding of its properties. The results for Group 1 were impressive, with a virtual structure that not only adhered to the patterns and the sequences but also achieved nearly all of the properties stipulated in the manual. During Group 1's town growth process, I observed the emergence of a coherent urban settlement that exceeded the builders' and my expectations.

Regarding the results of Groups 2 and 3, although they were not as successful as Group 1, their virtual towns are poised to a higher levels of wholeness. For example, Group 3 generated a town with a more diverse spatial structure than that presented by the

other groups. If the group had replaced their unremarkable houses with buildings that were more appropriate to Hoian's context or if they had narrowed the streets to build the sense of enclosure that Hoian had, the quality of the town would have been enhanced considerably. Group 2 could have built a more remarkable town if the participants had used appropriate frontage and appropriate properties, such as *Roughness* and *Positive Space*. *This finding implies that planners can adjust structures by giving appropriate instructions*; thus, a structure can be enhanced even if it possesses minor flaws[1]. The simulation of repairing a given structure through the GP and codes in what-if analysis can provide important lessons.

The study substantiates a number of propositions. First, pattern language has typically been regarded as a design solution. However, as shown in this study and chapter 3 and chapter 4, *a pattern language can be used as a systematic tool to unearth past urban structures, i.e., as a tool to generate knowledge*. Second, unlike other computer simulations that use computer codes, this research involved humans, with their idiosyncrasies, which have a major role in building human settlements. Furthermore, because the simulation was conducted by architecture students, the results could be expected to differ with participants without or with limited design skill. To address this issue, I assigned students with limited experience and skills in architecture and design to Group 2. The simulation reflects invariable qualities in the three Japanese towns: *novel, diverse*, and *coherence at different levels*. That is, the GP creates qualified environments even when the participants have limited design skills. Third*, the study reveals a new opportunity for using computer simulation to test urban codes.* Planners can use

[1] This is similar to Alexander's (2002) observation that in the GP, there is a sequence that birfucates into two branches: one with essential flaws and the other with the potential for continuing enhancement.

OpenSim to build and test different urban form development scenarios based on different sets of rules. Researchers can also verify the strength and reliability of each property of a form language, thereby improving its properties. Finally, with proper preparation and minimal cost, *laypeople can participate effectively in public design sessions such as charrettes*—similar to the type of real-time design and visualization that Ben-Joseph (2005) advocates. If such participation can occur, planners can fulfil the requirement of 'engaging the public in the "code-making process"' (Talen, 2009, 157). Furthermore, the detailed manual instructions were important for the participants to be able to implement the needed patterns and properties, thereby improving the wholeness of the town.

5.6 Conclusion

This simulation corroborates the conclusion from chapter 3 and chapter 4 that *the GP can give form to a city without generative codes* (as in the case of Hoian). Specifically, place-based norms as patterns are the drivers of a city's form.

The simulation results for the growth of Hoian between the 17th and 19th centuries suggest that the same generative rules created diverse and unified built environments. Second, generative systems including patterns and urban properties can serve as rules to direct building processes. Third, the OpenSim application (with its enriching and immersive virtual environment) allows for public participation in design processes such as charrettes in which communities engage in the code-making process. Finally, this study also allows for verifying the applicability of each property of a form language. The results indicated that individual properties have different levels of

applicability and that the participants' understanding of these properties greatly affect the coherence of the simulated town.

This research reveals a new opportunity for the task of code building. I suggest that an OpenSim simulation using the generative method can be applied to districts in today's cities in which the districts' sizes and their social and spatial complexities are comprehensible. Specifically, this type of simulation can be applied to designing and testing generative modules for the SmartCode —a zoning code that helps to categorize each type of development in its proper place (Smartcodecentral.com n.d.). There have been calls for greater flexibility in building codes. Generative modules for SmartCode can respond to this call (Talen 2012). Thus, I expect that generative modules can be built and tested in OpenSim in a manner similar to the process used in this study. Code-builders can use what-if analysis to observe how generative modules actually operate in the SmartCode. Code-builders can use OpenSim to test and adjust the generative rules, to find ways to improve them, and to discard those that do not work.

CHAPTER 6

The Coherent Indices and Qualitative Formulas for Urban Forms

About this chapter

This chapter is a further development from the research in chapters 3, 4, and 5. It proposes a quantitative method to evaluate urban form through the Coherent Index (CI). The second part of this chapter addresses the qualitative formulas for urban form. It also proposes for combination between FBCs and generative components.

6.1 The Coherent Indices

6.1.1 The Coherent Indices

In chapter 3 and 4, I have provided the distribution of properties for each urban pattern (tables 3.1, 3.3, and 4. 3). For each pattern language, there are thresholds that specify number of properties per pattern. For example, for medieval European cities (table 3.1), there is only one pattern with 12 properties. Then, there are two patterns with 11 properties, and four patterns with 10 properties, etc. The number of properties that corresponding patterns possess is the thresholds of properties. Therefore, threshold 7 is the number of patterns that have 7 properties.

Tables 3.1, 3.3, and 4.3 also demonstrate that each pattern language has different number of patterns: the medieval European pattern language has 15 patterns, the Arabic-Islamic pattern language has 16 patterns, and the Hoian pattern language has 14 patterns. To arrive at the average number of patterns per threshold case for every pattern language, the number of patterns in each threshold case is divided by the total number of patterns.

The average number of patterns and the threshold number represent the characteristics of an individual urban form. Upon first observation, a higher threshold number corresponds to a lower average number of patterns. Nevertheless, the mathematical product of the threshold number and the average number of patterns does not result in a linear relationship. The product is highest with the thresholds of 6 to 8; then it declines at smaller or higher thresholds. Because the product is composed of both patterns and properties, it represents the characteristics of an urban form. In addition, it embodies both the level of wholeness and the idiosyncrasy of each type of urban form. I call this product the Coherent Index.

For example, to calculate the Coherent Index for Hoian, I ranked the number of patterns per threshold as in the column **Hoian pt**. Then the column **Hoian pt** is divided by total number of patterns in Hoian, which is 13. The result is **Hoian Avrg**. Then the column **Hoian Avrg** and **Thresholds** are multiplied. The result is the Coherent Index for Hoian. The highest index (5.92) is called the first rank of CI for Hoian. The second highest index is the second rank of CI, etc. Table 6.1 represents the calculation of the Coherent Index.

Table 6.1: The Calculation of the Coherent Index for the Three Types of Urban Form.

Thresholds	Medieval pt	Med. Avrg.	Med. CI	Islamic pt	Islam. Avrg.	Islam. CI	Hoian pt	Hoian Avrg	Hoi. CI
12	1	0.07	0.80	1	0.06	**0.75**			
11	2	0.13	1.47	2	0.13	**1.38**	1	0.08	**0.85**
10	4	0.27	**2.67**	3	0.19	**1.88**	2	0.15	**1.54**
9	7	0.47	**4.20**	4	0.25	**2.25**	3	0.23	**2.08**
8	12	0.80	**6.40**	9	0.56	**4.50**	9	0.69	**5.54**
7	13	0.87	**6.07**	11	0.69	**4.81**	11	0.85	**5.92**
6	15	1.00	**6.00**	14	0.88	**5.25**	12	0.92	**5.54**
4	na	na		16	1	**4.00**	13	1	**4.00**
Total patterns	**15**			**16**			**13**		

The scatter plot in Figure 6.1 demonstrates a family of urban forms similar to the illustrations in Figure 2.1 in the chapter 2. Despite the differences in specific forms, styles, and typologies of each urban tradition, traditional cities share a common trait. This common trait is the family of urban forms with quantifiable features. Using this method, planners can quantify an urban form, which also allows for the use of statistical techniques for assessing the urban form.

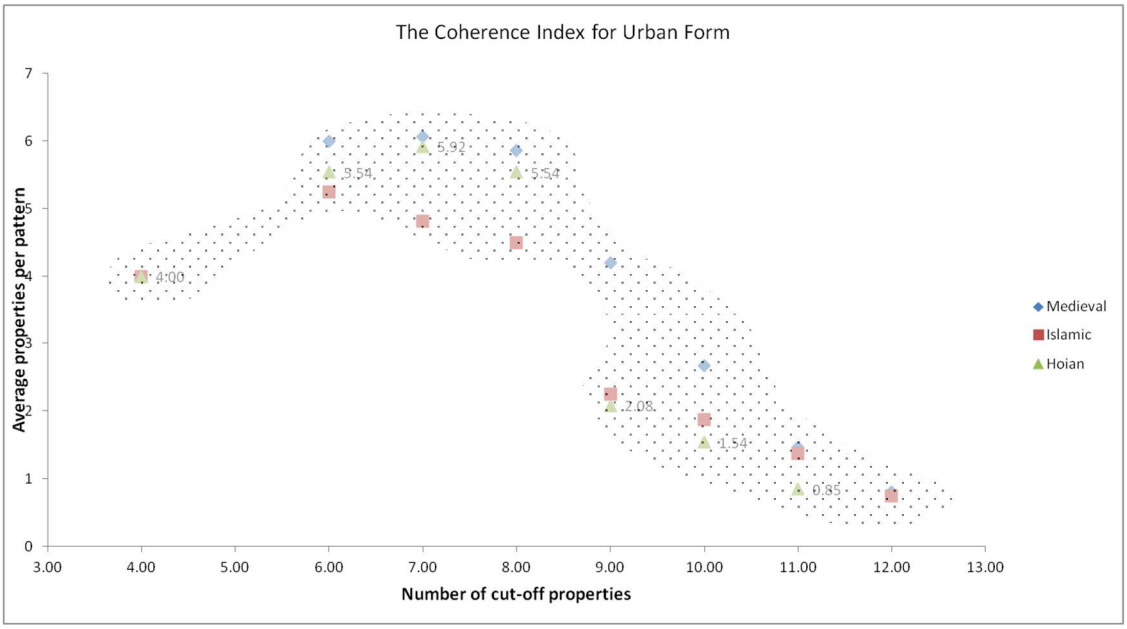


Figure 6. 1: The Coherent Indices for Different Pattern Languages. This CIs introduce a family of urban form.

6.1.2 The Map and the Isolines of Coherent Indices

Based on the results of the CIs from the above section and the table 4.3 for the patterns and properties of Hoian, I draw lines that cover groups of patterns that have the same thresholds. Each line represents the ranking of the level of coherence that groups of patterns carried out. For example, for the group that have the highest CI (i.e., 1st rank), the line will wrap eleven patterns *The Japanese Town, The Chinese Town, Thanh Chiem Palace, Lagoon-type Estuary, Row Houses, Tung Ban Palace and Pagoda, Main Street,*

T-junction, The 19th century Expansion, Vietnamese Villages, and *Assembly Halls* into one group (See Figure 6.2). The group of eight patterns that has the second highest CI is wrapped by the second rank line, etc. I call these lines isolines of CIs and the schema that illustrate these isolines as the Map of CIs.

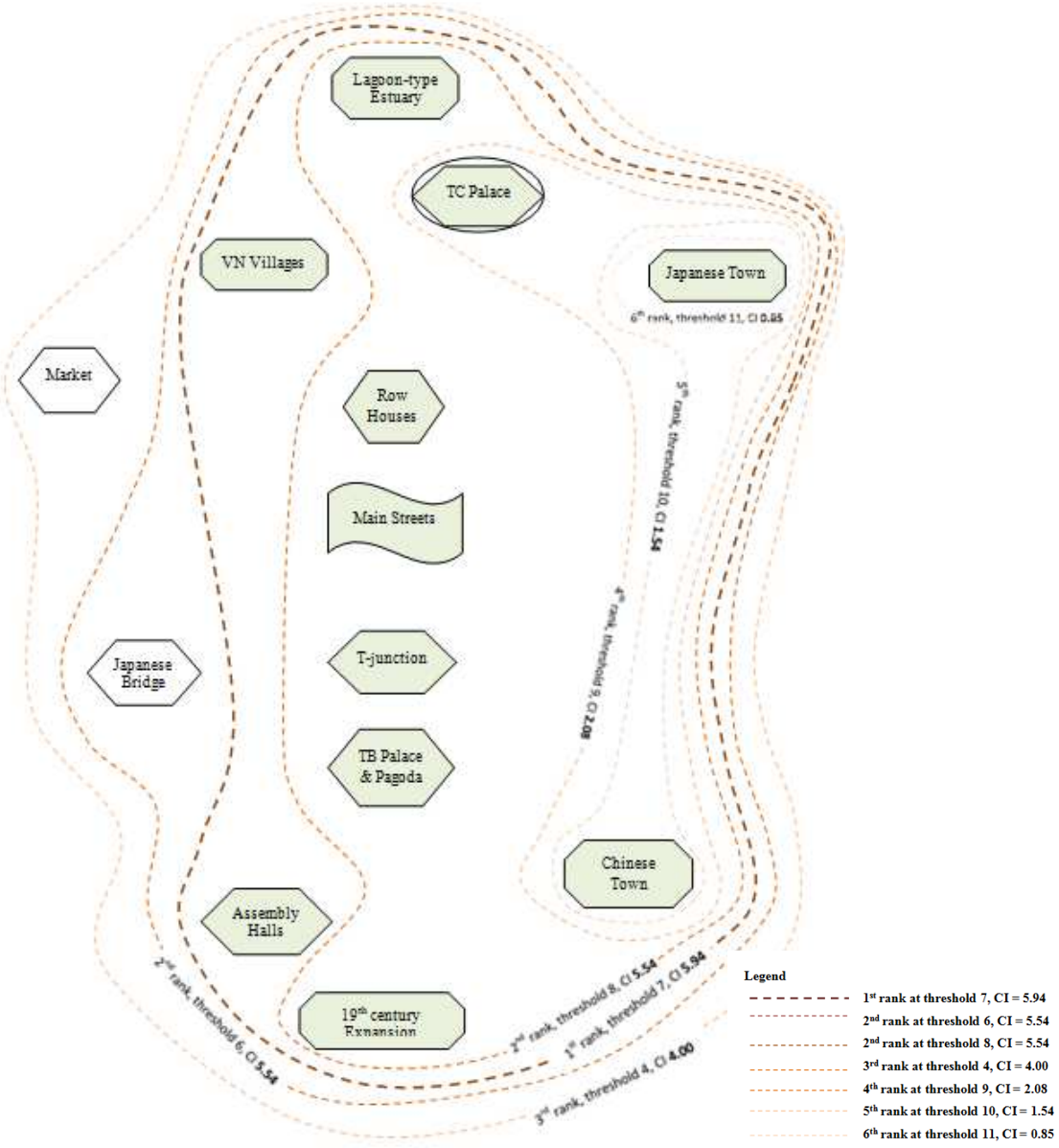


Figure 6. 2: The Coherent Index Map for the Urban Form of Hoian. This map shows the isolines with different CI ranks. The isoline with the first rank of CI is drawn in the dash and bold line.

These CIs and the corresponding map can be used for studying different issues of urban form such as assessing forces that shape the form of Hoian as Chapter 4.

6.2 Qualitative Formulas for Urban Forms

6.2.1 General formulas

Based on knowledge about the roles of norms and rules in the generative process (see chapters 3 and 4), a qualitative formula for the fundamental characteristics—the DNA— of the urban form of traditional cities is presented. The formula for the DNA of traditional cities is qualitative because it reflects the relationships between operands (i.e., inputs) rather than mathematical quantities. The formula is written as follows:

$$\text{TradDNA} :: (\text{norms} + \text{codes}*\beta)*S \qquad (6.1)$$

Where: TradDNA is the DNA for the traditional urban form.

:: means established by or based on.

norms are place-based norms.

codes are written regulations that affect urban form.

β is a coefficient that represents the involvement of written codes in the built environment. β is close to zero in some traditions in which very few rules control the form of a city (e.g., Hoian).

β can be close to 1 when rules are strong and dictate the development process. Islamic cities illustrate this situation.

S is a constant and represents a building sequence. In traditional cities, S is equal to 1, reflecting the one-off nature of the GP.

From these, a formula for the form of contemporary cities is provided:

$$\text{ContDNA} :: (\text{mkt} + \text{codes}^* \beta)^* S \qquad (6.2)$$

β is equal to 1 in the case of a strong legal tradition, such as that found in contemporary American cities.

mkt is market forces.

The primary mechanism of contemporary urban form is the operationality of the market and regulations. Norms are under the control of the market. In modern society, S is a large number (hundreds or thousands) where large-scale construction occurs.

In addition, I propose a formula for sustainable urban forms in today's context:

$$\text{SustDNA} :: [\text{codes}^* \beta + (\text{patterns} - \text{mkt})]^* S \qquad (6.3)$$

In this formula, β is between 0 and 1, reflecting the argument that planners only stipulate key elements of the urban form (Jacobs 2002,) i.e., a less controlled and more flexible process.

I propose that the operands (i.e., patterns and market) should reflect the principle that there is a need to implement patterns that prevail over market forces. For example, in favelas, where market power does not operate strongly, people use affordable materials to build patterns. Despite sanitation and safety issues, this type of development generates a form that is more sustainable than that in conventional American suburbs (Salingaros et al. 2006)

A conclusion stemming from formula (3) is that to guarantee that the sustainable urban form operates successfully both urban codes and patterns must control over market forces. Formula (3) disentangles the issue of codes, development, and sustainability.

(3) can be rewritten as follows:

$$\text{SustDNA} ::[(\text{codes}^* \beta - \text{mkt}) + \text{patterns}]^* S \qquad (6.4)$$

In (4), the relationship between the market and codes is expressed under a negative sign. This expression indicates that codes* β, representing building regulations (transect-based FBCs, for example), must have the power to *control the market.* Under this condition, patterns generate diversity in urban form. From this formula, a sustainable urban form can be viewed as a balance between patterns, codes, and market forces.

A commercial establishment such as a restaurant can be used to illustrate the application of this formula. Under this proposed conceptual framework, we have formulas (3) and (4) suggest that regulations must control over the market forces so that sustainable urban form operate successfully. Therefore, planners must assign some strict rules, such as build-to lines, percentage of windows and doors on a façade, parking in the rear or sides or other sign regulations. These rules are non-compromised and reign over business demands. Planners and communities subsequently build new patterns (or reuse patterns from a pattern book) to operate adaptively to the location. Patterns such as *Front Porches*, *Main Entrance* or *Positive Space* are similar to some of Alexander's 253 patterns or can be collectively developed by communities under the form of a pattern book.

6.2.2 A Formula for the Combination between FBCs and the Generative Components

The SmartCode is an advanced type of transect-based FBCs. It defines the six transect zones from the most rural (T1) to the most urbanized areas (T6). Furthermore, Duany (2013) provides a conceptual framework for defining zones based on their combination of social-economic and natural diversity. Theoretically, the higher the social-economical diversity in a T-zone, the less natural diversity that zone has and vise versa. For example, T6 and T5, the theory postulates, have higher social-economical

diversity but their natural diversity is low, whereas T1 and T2 have higher natural diversity but their social-economic diversity is lowest.

Duany (120) proposes an equation for Sustainable Urbanism where the tradeoffs of the natural and socioeconomic diversity in one place after urbanization must be higher than the natural diversity of that place before the start of construction. His equation for Sustainable Urbanism formula is as follows:

$$N: \sum [Ds + Dn]post \approx > N: [DN]pre$$

Where: N is a constant

Ds is the socioeconomic diversity per unit of land, after urbanization

Dn is the natural diversity per unit of land, after urbanization

DN is the natural diversity per unit of land before urbanization

Drawing from Duany's equation for Sustainable Urbanism, I extend his presentation of natural and social-economic diversity using a new format:

$$[(\lambda_i Ds|\ Dn - mkt) + (\lambda Pa^i_{i'}|\lambda\ Pr^i_{i'})]S :: sustDNA \qquad (6.5)$$

λ_i means combination or association of different transect zones

| means two elements co-exist in a category such as natural diversity and socioeconomic diversity co-existing in a transect zone. This could also be patterns and properties co-existing in a specific public or private space. It is noted that there are several patterns in a zone and each pattern can and should have multiple properties.

Ds represents the socioeconomic diversity of a transect zone

Dn represents the natural diversity of a transect zone

Pa^i_j represents the pattern j in the transect zone i (i is from 1 to 6)

Pr^{j}_{k} represents the property k of the pattern j

S is a constant and represents a building sequence.

SustDNA is the DNA for a sustainable urban form

Therefore:

$\rceil_{i}Ds|\ Dn$ means socioeconomic diversity combined with natural diversity for all six transect zones.

$\rceil Pa^{i}_{j}|\rceil\ Pr^{j}_{k}$ means patterns combined with properties of urban elements, representing the generative components. It provides diversity and flexibility for the SmartCode.

Nevertheless, we can rewrite (5) as:

$$[\rceil_{i}Ds|\ Dn + \rceil Pa^{i}_{j}|\rceil\ Pr^{j}_{k} - mkt]S :: sustDNA \qquad (6.6)$$

As mentioned above the first operand is the SmartCode, the second operand is the generative components. For six transect zones, we have:

$$(Ds_{1}|\ Dn_{1} + \rceil Pa^{1}_{j}|\rceil\ Pr^{j}_{k} + Ds_{2}|\ Dn_{2} + \rceil Pa^{2}_{j}|\rceil\ Pr^{j}_{k} + \ldots + Ds_{6}|\ Dn_{6} + \rceil Pa^{6}_{j}|\rceil\ Pr^{j}_{k} - mkt)*S :: sustDNA \quad (7)$$

In T6, for example, we have:

Ds_{6} means the socioeconomic diversity in T6

Dn_{6} means the natural diversity in T6

Pa^{6}_{j} means j patterns of T6

$\rceil Pr^{j}_{k}$ means k properties of the pattern j in T6. Each pattern has different number of properties.

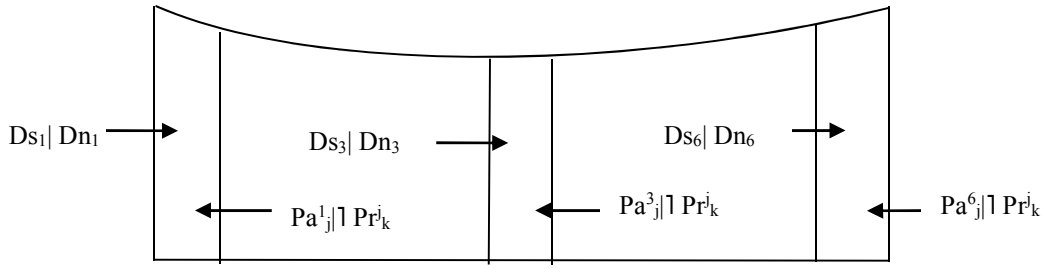


Figure 6.3: The Combination of Socioeconomic and Natural Diversity for Transect Zones. This combination based on Duany's proposal for Sustainable Urbanism (2013). Besides these two elements, patterns and properties are incorporated to bring diversity and flexibility to the transect zones.

In Figure 6.1, k are properties that the pattern j possesses; therefore the number of properties must less than 20 and larger than 1: $1 \leq k \leq 20$

Example of T3 where pattern in T3 can be represented as Pa^3_j. Some of the patterns in T3 can be:

Pa^3_1 : *Houses with Front Porches*

Pa^3_2 : *Cascade Roofs*

Pa^3_3 : *Gardens in Front*

Pa^3_4 : *Parking in the Rear*

These patterns are adapted from *Pattern Language* by Alexander et al. (1977).

Then we have some properties for Pa^3_1 (*Houses with Front Porches*).

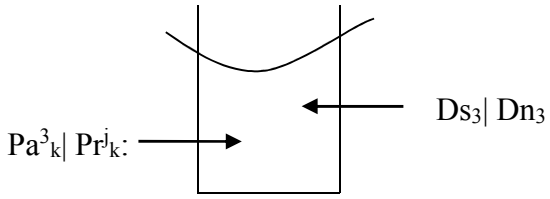
Pr^1_1 : *Strong Center*

Pr^1_2 : *Echoes*

Pr^1_3 : *Thick boundary*

Pr^1_4 : *Level of Scale*

Pr^1_5 : *Continuity*



T3

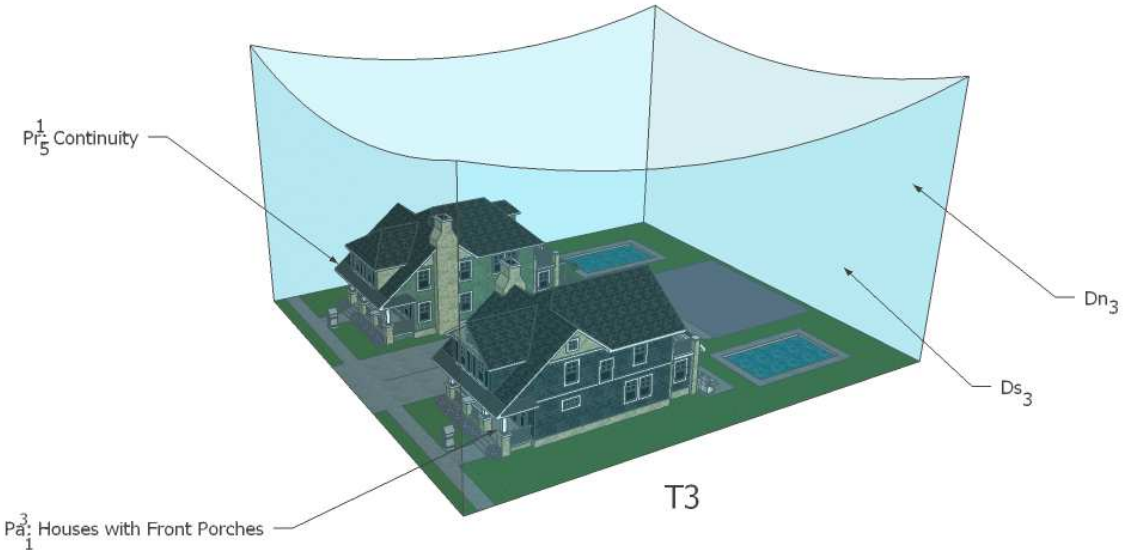


Figure 6.4: The T3 Zone with Socioeconomic (Ds_3) and Natural (Dn_3) Diversity. The generative components include patterns (e.g., Pa^3_1 *Houses with Front Porches*[1]) and properties (e.g., Pr^1_5 *Continuity*) are integrated providing flexibility and adaptability to the T zones.

Similarly, general patterns for T6 is Pa^6_k, some patterns can be:

Pa^6_1: *High-rise Buildings* (e.g., Chrysler-typed buildings)

Pa^6_2: *Small Square*

Pa^6_3: *Civic Buildings*

[1] All models of buildings are imported from Google 3D Warehouse (3D Warehouse, 2015).

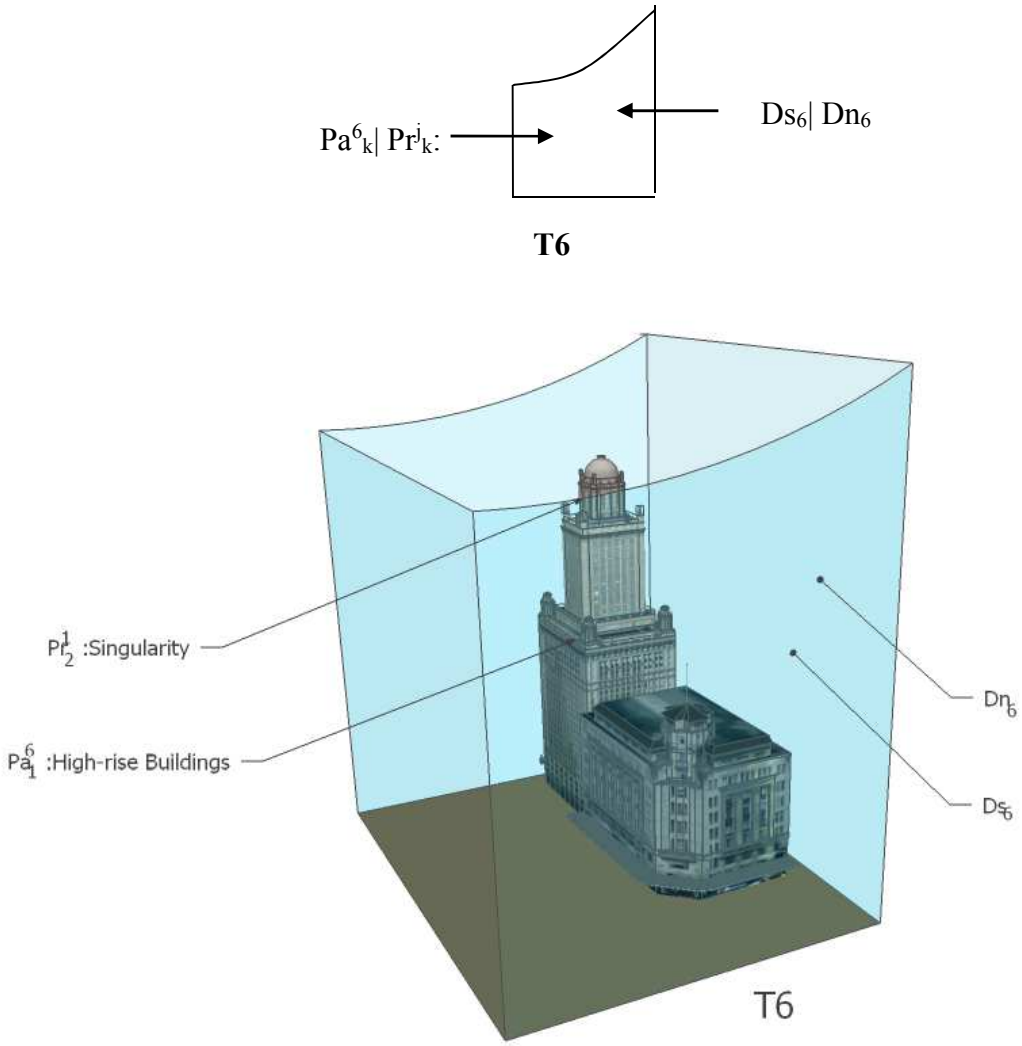


Figure 6.5: The T6 Zone with Socioeconomic (Ds_6) and Natural (Dn_6) Diversity. The generative components include patterns (e.g., Pa^6_1 *High-rise Buildings*) and properties (e.g., Pr^1_2 *Singularity*) are integrated.

Likewise, every Pa^6_i has its own collection of properties. For example, Pa^6_1, *High-rise Buildings* pattern has properties:

Pr^1_1 : *Strong Center*

Pr^1_2 : *Singularity*

Pr^1_3 ; *Dominance*

Pr^1_4 : *Name and Meaning*

Pr^1_5 : *Level of Scale*

Pr^1_6 : *Positive Space*

Pr^1_7 *: Good Shape*

Pr^1_8 : *Contrast*

In T6, S as the developmental sequence equals to or near 1. S is a small number due to the importance of each project in T6. Each project in T6 should be implemented at one time incrementally.

6.3 Discussion

This chapter is the further discussion about the GP. It provides two approaches to the GP and urban form. The first one is the quantitative approach, in which I propose to use the Coherence Indices to assess the urban form of the traditional cities. On the other hand, the second approach employs qualitative formulas to give insights about different types of urban form.

In the first part of this chapter, I propose to use CIs to quantify the coherence of urban form. Based on the CIs' result, I draw the isolines that represent different levels of coherence by groups of patterns. I argue that the highest CI—the first rank of the thresholds—can be used as the best proxy for an urban form. Together, the CIs and CIs' map can be implemented to study issues related to urban form. One of the applications is the use of CIs to understand generative forces that shape the form of Hoian (chapter 4).

The second part of this chapter discusses about qualitative formulas for different types of urban forms; these formulas not only help to clarify relationship of elements in the GP but also allow for obtaining insights about the GP and the generative method.

Furthermore, using qualitative formulas can suggest the possible combination of generative components and FBCs, particularly the SmartCode.

Drawing from the analysis in chapter 3 and 4, a qualitative formula for traditional urban form is developed. Elements (i.e., operands in the qualitative formula) of the traditional urban form are norms, urban codes, and a sequence, in which the sequence acts as a generator —applying norms and codes perpetually. Using the same method, I develop a formula for contemporary cities. Operands of the today's urban form are market, urban codes (e.g., zoning), and a sequence. The market is often conflict with goals that urban code upholds (e.g., a tendency to build whenever it is convenient for selling products can conflict with issues of sanitation and safety that the urban code wants to protect). From there, I develop a formula for the sustainable urban form that includes urban codes, market forces, and urban patterns, in which the later bring values such as adaptability and diversity to urban form.

In the last part of the chapter, based on Duany's proposal for Sustainable Urbanism, I investigate the integration of the generative components into the SmartCode. The combination is illustrated under the form of a qualitative formula. This formula, in turn, suggests the way to bring generative components including patterns and properties into the SmartCode.

6.4 Conclusion

Drawing from analysis in chapters 3 and 4, this chapter first proposes the coherent indices and map for urban form. In the second part, the chapter explores qualitative formulas for different types of urban form: traditional, contemporary, and sustainable

urbanism. After that, I argue for the way to incorporate generative components into the FBCs, specifically the SmartCode.

This is the first step towards understanding urban form through the coherent indices and applying qualitative formulas to the issues of coding the generative components into the SmartCode. Further work should investigate a collection of patterns and potential properties for each T zone. These generative components will serve as modules for the SmartCode.

CHAPTER 7

Conclusions

7.1 General Conclusion

The overarching goal of this dissertation is to find the fundamental characteristics or DNA of successful traditional urbanism (i.e., city form with human scales, mixed land uses, compact and walkable). Chapters 3, 4 and 5 reveal that the secret of traditional urbanism's DNA includes patterns, their properties, and a growth sequence in which the sequence acts as an engine for the operationality of patterns and properties. In the GP, the sequence expresses a one-off nature. That is, small production is based on customary design and is often carried out by highly skilled labor. I combined these elements of the generative process in an applicable package that has the potential to recreate urban forms with qualities such as coherence and human scale without the need to emulate particular architectural motifs or urban typologies. Using simulation, the dissertation approaches the GP from another angle, looking at the GP's elements (patterns and properties) as they unfold in time and space. Another purpose of chapter 5 is the provision of a framework for verifying the statements regarding the GP in chapter 3 and chapter 4. The study also suggests applying an immersive environment, e.g., OpenSim, to the task of code building and code testing.

Chapter 3 reveals the important role of place-based norms in the generative process of traditional cities. The norms are the foundation of any generative process in traditional cities. The study finds that a generative process is the product of place-based norms as well as written codes. Whenever written codes do not control urban space, cultural and social norms emerge to operationalize the building process. Social and

cultural norms are the core of any generative process. That is, a generative process must always accompany norms. The norms shared by medieval European and Arabic-Islamic urbanism are based on religion and are driven by the economy. The norms in medieval cities are largely based on solidarity between different professional groups, whereas the norms in Islamic cities manifest the segregation of residential precincts from other precincts.

In chapter 4, taking an operational approach, the generative method of Alexander was revisited. Three functional elements of the generative process, i.e., patterns, properties, and a sequence, were reexamined and revamped. This renewed tool can be used for different purposes in the assessment of a traditional urban form. Finally, to test its applicability, this improved method was applied to uncover the forces that shaped the form of the traditional town of Hoian. The recurrence of each property and the pattern of its repetition in urban elements were investigated to assess the impact of generative forces on the urban form of the ancient quarter of Hoian, Vietnam. The article reveals that the ethnic interdependence and integration of the international community, the power of water and trade, and monarchical power were the most important forces that determined the form of Hoian between the 17th and 19th centuries.

In chapter 4, I rebuilt the properties of the urban elements. Fifteen of Alexander's properties and ten of Lynch's qualities were combined into a set of twenty properties of urban elements. Alexander proposes to use these properties to express the built environment's forms. They are *Level of scale, Strong center, Thick boundary, Alternating repetition, Positive space, Good shape, Local symmetries, Deep interlocking and ambiguity, Contrast, Gradient, Roughness, Echoes, The void, Simplicity and inner calm,*

and *Not separateness* (Appendix A provides the full details of these properties). Nevertheless, these properties are appropriate for the assessment of the built environment at an architectural scale. These properties seem inadequate for capturing the qualities of urban form at urban scales —neighborhoods or cities. Therefore, I have included Lynch's qualities to assess urban form on both small and large scales. Lynch's ten qualities are as follows: *Singularity, Form Simplicity, Continuity, Dominance, Clarity of Joint, Directional Differentiation, Visual Scope, Motion Awareness, Time Series,* and *Name and Meaning*. Some of Alexander's properties and Lynch's qualities overlap; therefore, I further revised my set for a total of twenty properties. Chapter 4 detailed these properties and the process I used to filter out unnecessary properties. Appendix B provides a full description of these properties. By relating the pattern language of Hoian to its properties, this research uncovers the generative forces that underlie the form of Hoian.

Chapter 5 employs a simulation approach to confirm the unfolding of the GP and to verify the role of the norms identified in chapter 3 and the performance of the operational elements (patterns, properties, and a sequence) identified in chapter 4. The simulation shows that these elements can be combined to create a coherent form for traditional cities. The study in chapter 5 also substantiates the proposition that the generative system includes patterns and that urban properties can serve as rules for directing urban growth. These rules build diverse and unified urban structures. Finally, the application of OpenSim implies that communities can participate in design elements such as the charrette, where they engage in a code-making process.

7.2 Theoretical Contribution

This dissertation contributes to the literature of urban form in general and of the generative process in particular. The structural and operational views offer different angles on the GP. The structural view—a perspective on structural components of the generative process—investigates place-based norms and written codes and notes that these norms *play a decisive role in the generative process of traditional cities.* Traditional urban forms can be established by norms (under the form of patterns) without the need for written codes. The generative process is constrained by technology and materials in traditional building methods. The constraints force growth, following the mode of one-off transformation. However, the operational view introduces the operation of three operational elements in the GP: patterns, properties, and the sequence. The greater the number of properties associated with a pattern, the more coherent the structure is.

Chapter 6 contributes to the literature of urban form and urban design by proposing the coherent index and qualitative formulas for the foundational characteristics of different types of cities. Through these index and formulas, researchers and policy makers can assess the roles of different elements that affect urban form, such as norms, patterns, codes or market forces. Chapter 6 also proposes a method to quantify the urban form. Each property is a feature of an urban element—similar to the meaning of a sentence in a poem. The more properties a pattern has, the deeper the meaning is of its urban representation (i.e., its urban form). This is, again, similar to poetry; the more meanings a sentence has, the deeper the connotation of that sentence is, and the sentence thereby conveys poetic power. Therefore, the quantity of properties per pattern in a generative process characterizes the level of coherence of that generative process. This

chapter represents the process of calculating a coherent index: the mathematical product of the thresholds of properties and the average number of patterns. This method lays out the initial path for quantifying urban form.

7.3 Policy Implications

Understanding the generative process will encourage planners and designers to use tools for building coherent urban forms. The results presented here can point planners and designer toward financial and non-financial incentives to build coherent urban settlements (i.e., qualities in the built environment such as human scales, walkability, etc.) The financial side would include loan or grants, tax incremental financing (TIF), tax abatements for communities that aim to use the generative process in revitalization or new development. The non-financial side would include grass-root groups conducting research and building patterns. For example, communities, with the help of planners and designers, can create pattern books based on the method outlined in this dissertation. They can also establish a crowd-sourcing environment where planners and laypeople collaborate on building patterns and brainstorming the generative rules for producing an urban form. A virtual online platform such as OpenSim can be an effective and low-cost tool for sharing and experimenting with planning ideas everywhere.

The government can act as a top-down player that creates favorable conditions for the emergence of sustainable communities (including sustainable urban form). A current trend is that local governments in the U.S. have started to adopt different types of form-based codes (Talen 2012). While this is just a first step toward sustainable codes, the next

step for these governments should be incorporating generative components or modules into form-based codes.

This study also demonstrates that the *healthier the patterns are in term of human scales, adaptability, compactness, and mixed uses in the generative process, the less control is needed from written regulations and vice versa.* For example, because the fina (the space approximately 1 m-1.5 m abutting a frontage wall of a house) benefits urban activities (selling, relaxing, socializing and the intermediate realms between private and public domains), it requires only a few stipulated rules about its usage. A sabat—a room bridging the street or the cul-de-sac—requires more sophisticated rules stipulating its construction and interdependence between neighbors. I argue that code developers for contemporary cities must recognize this issue. *They should uphold healthy patterns by allowing them to operate with minimal legal interference and should provide stricter regulations when the patterns are prone to negating public and private realms.*

Chapter 5 reveals new opportunities for using *simulation in testing and building* codes. The chapter also proposes that communities can establish effective public participation in urban design through an enriching and immersive OpenSim environment.

7.4 Future Research

There are three lines of inquiry that must be explored in future research.

7.4.1 Building the metrics of sustainable urban form

Drawing on Chapter 4, I will develop metrics for the contemporary urban form. For example, I will select districts in contemporary cities based on qualities such as human scale, walkability, adaptability, and mixed land use. Next, I will build patterns for

the districts, establish the developmental sequence, and assess the properties attached to each pattern. I will employ the method delineated in Chapter 6 to create a coherent index for the district. Using this index as a template for the assessment of comparable districts from other cities (based on population, geography, etc.), I can gain further insight into why the urban form of these other districts are not coherent or whole. Based on this analysis, planners can brainstorm solutions for attaining a coherent form for contemporary cities (e.g., through building patterns, establishing needed properties and the needed sequence). Using these dynamic parameters (patterns, sequences, needed properties), planners can design *real* generative codes. Finally, they can establish legal protocols based on the parameters emerged from the comparison.

7.4.2 Simulating strategies to envision opportunities

This future research path is inspired by Massive Small Organization (Massive Small Compendium 2015), which states that communities and planning professionals can and should experiment with different scenarios to gain an understanding of potential outcomes and poise themselves for new opportunities. The core philosophy is to learn by experimenting. Based on my dissertation, OpenSim, with its user-defined content, can take part in this process. Players can actively engage in an immersive environment to experiment with different development scenarios. I will focus on making OpenSim applicable for this purpose. To achieve this goal, I will do the following: a) develop a land subdivision tool in OpenSim (e.g., tools for land demarcation); b) streamline the process from OpenSim to other computer-aided programs; c) develop a testing space in OpenSim to test generative codes or development scenarios in popular OpenSim grids such as OSgrid (Osgrid Inc 2015) or Metropolis (Metropolis Project 2015).

7.4.3 The fusion between form-based codes and generative components

Future research will focus on the interface between GCs and FBCs. Because creating a balance between the top-down and the bottom-up approaches in regulation is an issue for the planning profession from the beginning of this field (Talen 2012), the appropriate fusion of these two types of codes can provide a practical solution to the problem. I will explore which type of fusion between generative codes and FBCs will benefit contemporary cities. Although the FBCs match the reality of the real estate market with its virtues of predictability and its capacity to work within an existing system, employing the GCs will bring flexibility, local-based, and democracy to the planning process. Future research will look for a way to combine these codes to produce an urbanism with qualities such as equitability, mixed uses, walkability, vibrancy, and soul-nourishment. Talen proposes a possible solution by integrating generative codes into modules for FBCs such as the SmartCode. This is similar to the organic growth of plants on a "trellis" (Mehaffy 2008). The theoretical contribution from identifying the proper relationship between FBCs and generative codes is that it addresses one of the serious problems of modernity: the problem of large numbers, i.e., the relationship between large-scale production and one-off painstaking manufacture. This reminisces Alexander's words to Duany: "we both know what the appliance is. What we need to do now is to design the plugs to connect to the current power grid" (in Mehaffy 2004).

REFERENCES

3D Warehouse, 2015. *3D Warehouse Sketchup*. [online] Available at: https://3dwarehouse.sketchup.com/ [Accessed 1 Mar. 2015].

Anchorages on the Coast of Anam [map]. Washington, D. C.: Hydrographic Office, Secretary of the Navy. 1913.

Alexander, C. 1978. *Timeless way of building.* London: Oxford University Press.

Alexander, C. 2002a. *The nature of order: The phenomenon of life, Book 1.* Berkeley, CA: Center for Environmental Structure.

Alexander, C. 2002b. *The nature of order: The process of creating life*. Berkeley, CA: Center for Environmental Structure.

Alexander, C. 2005. Unfolding of A Community from a Generative Code: The Riverside Community of Strood. [online] *Living Neighborhood*. Available at: http://www.livingneighborhoods.org/library/stroodunfolding-v19.pdf [Accessed 10 Feb. 2015].

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., and Angel, S. 1977. *A pattern language: towns, buildings, construction*. London: Oxford University Press.

Alexander, C., Neis, H., Anninou, A. and King, I., 1987. *A New Theory of Urban Design*. New York, NY: Oxford University Press.

Alexander, C., Neis, H. and Alexander, M. 2012. *The battle for the life and beauty of the earth*. New York: Oxford University Press.

Banai, R. and A. Rapino, M. 2009. 'Urban theory since *A Theory of Good City Form* (1981)–a progress review.' *Journal of Urbanism*, 2 (3): 259–276.

Bardill, A, M Karamanoglu, and K Herd. 2005. 'Pleasure-Based Design Approaches To The Built Environment'. In *The Municipal Engineer*. Institution of Civil Engineers.

Barrow, J. 1806. *A voyage to Cochinchina, in the years 1792 and 1793.* London: London, T. Cadell and W. Davies.

Batty, M. 2013a. *The New Sciences of Cities.* Boston, MA: MIT Press.

Batty, M. 2013b. 'Big Data, Smart City and City Planning.' *Dialogue in Human Geography* 3(3): 274-279.

Ben-Joseph, E. 2005. *The Code of the City: Standards and the Hidden Language of Place Making.* Boston, MA: The MIT Press.

Bergson, Henry. 1998. *Creative Evolution*. London: Dover Publications.

Bettencourt, L. 2013. 'The Kind of Problem a City Is.' *Santa Fe Institute working paper series no 13-03-008.* Santa Fe: SFIWP. Available at: http://www.santafe.edu/media/workingpapers/13-03-008.pdf [Accessed: 3 Dec 2014].

Bohm, D. 2002. *Wholeness and the Implicate Order.* London: Routledge.

Borning, A., Waddell, P. and Förster, R. 2008. 'Urbansim: Using Simulation to Inform Public Deliberation and Decision-Making'. In: H. Chen, L. Brandt, V. Gregg, R. Traunmuller, S. Dawes, E. Hovy, A. Macintosh and C. Larson, ed., *Digital Government*, 1st ed., 439–64. London: Springer.

Bortoft, Henri. 1996. *The Wholeness of Nature*. Lindisfarne Press.

Braunfels, W. 1988. *Urban design in Western Europe*. Chicago: University of Chicago Press.

Center for Environmental Structure, 2006. *Generative Code Welcome*. [online] Livingneighborhoods.org. Available at: http://www.livingneighborhoods.org/ht-0/gcwelcome.htm [Accessed 12 Feb. 2015].

Chew, Geoffrey F. 1970. *Lectures On Modelling The Bootstrap*. Bombay: Tata Institute of Fundamental Research.

Chinho, Chen. 1973. *Historical notes on Hoi-an.* Carbondale, IL: Center for Vietnamese Studies, Southern Illinois University at Carbondale.

Dang, Truong. 2013. *Đô thị thương cảng Hội An*. Hanoi, Vietnam: Cultural and Information Publishers.

Do Bang. 1996. *Phố cảng vùng Thuận Quảng Hội An - Thanh Hà - Nước mặn thế kỷ XVII-XVIII*. Hue, Vietnam: Thuan Hoa Publishers.

Do Bang. 2011. 'The relations and pattern of trade between Hoian and the inland.' In *Ancient town of Hoian-International Conference in Danang,* 4th edn. Hanoi, Vietnam: The Gioi Publishers.

Duany, A. 2013a. '20 Years of New Urbanism.' In: E. Talen, ed., *Charter of the New Urbanism*, 2nd ed. 9-13. New York: McGraw-Hill.

Duany, A. 2013b. ‘A General Theory of Ecological Urbanism.’ In: A. Duany and E. Talen, ed., *Landscape Urbanism and its Discontents: Dissimulating the Sustainable City*, 1st ed., 115-123. Gabriola Island, BC (Canada): New Society.

Ewing, Reid H, and Otto Clemente. 2013. *Measuring Urban Design*. Washington, D.C.: Island Press.

Ewing, Reid, and Susan Handy. 2009. 'Measuring The Unmeasurable: Urban Design Qualities Related To Walkability'. *Journal of Urban Design* 14 (1): 65-84. doi:10.1080/13574800802451155.

Form-Based Codes Institute, n.d. *Form-Based Codes Institute - Fostering Time-tested Urban Form*. [online] Available at: http://formbasedcodes.org/ [Accessed 25 Jan. 2015].

Gabriel, R. 1996. *Patterns of software*. New York: Oxford University Press.

Gamma, Erich, Richard Helm, Ralph Johnson, and John Vlissides. 1998. *Design Patterns*. Reading, MA: Addison-Wesley.

Gehl, Jan. 2010. *Cities For People*. Washington, DC: Island Press.

Gearz, S. 2014. *Singularity Viewer*. [online] Available at: http://www.singularityviewer.org/ [Accessed 25 Jan. 2015].

Geddes, P. 1915. *Cities in Evolution*. London: Williams and Norgate.

Gore, A. and Bromfield, P. 1764. *Plan of Turon harbour, on the coast of Cochin China.* National Library of France [online] Available from http://gallica.bnf.fr/ark:/12148/btv1b5963010m/f1.zoom [Accessed 08 December 2014].

Grabow, Stephen. 1993. *Christopher Alexander: The Search For A New Paradigm In Architecture*. Stockfields, UK: Oriel Press.

Hakim, Besim. 1994. 'The "Urf" And Its Role In Diversifying The Architecture Of Traditional Islamic Cities'. *Journal Of Architecture And Planning Research* 11 (2): 108-127.

Hakim, Besim. 2001. 'Julian of Ascalon’s Treatise of Construction and Design Rules from Sixth-Century Palestine'. *Journal of the Society Of Architectural Historian* 60 (1): 4-25.

Hakim, Besim. 2007. 'Generative Processes for Revitalizing Historic Towns or Heritage Districts'. *Journal of Urban Design International* 12: 87-99.

Hakim, B. 2008a. *Arabic-Islamic cities: Building and Planning Principles.* London: Kegan Paul.

Hakim, B. 2008b. 'Law and the Cities'. In: S. Khadra Jayyusi, R. Holod, A. Petruccioli and A. Raymond, ed., *The City in the Islamic World*, 1st ed., 71-92. Boston, MA: Brill Academic Pub.

Hakim, Besim. 2014. *Mediterranean Urbanism: Historic Urban/ Building Rules and Processes*. New York: *Springer.*

Hakim, Besim, and Zubair Ahmed. 2006. 'Rule For The Built Environment In 19Th Century Northern Nigeria'. *Journal of Architecture and Planning Research* 23 (1): 1-26.

Ioachim Ottens, n.d. 'Le Royaume de Siam Auec les Royaumes qui luy font Tributaires et les Isles de Summatra Andemaone.' Image delivery Service- Harvard University Library. http://ids.lib.harvard.edu/ids/view/25867757?buttons=y [Accessed 21 January 2015].

Jacobs, J. 1961. *The death and life of great American cities.* New York: Vintage Books.

Jacobs, Alan. 2002. 'General Commentary'. In *The Seaside Debates; A Critique Of The New Urbanism*, 1st ed. New York: Rizzoli International.

Jessop, A. 2004. 'Pattern Language: A Framework for Learning'. *European Journal of Operational Research* 153 (2): 457-65.

Johnson, M. 2010. 'Virtual and Immensive Environments.' In: *Encyclopedia of Geography*, 1st ed. [online] Literati.credoreference.com.ezproxy1.lib.asu.edu. Available at: http://literati.credoreference.com.ezproxy1.lib.asu.edu/content/entry/sagegeography/virtual_and_immersive_environments/0 [Accessed 6 December. 2014].

Kostoff, S. 1991. *The City Shaped.* New York, Bullfinch.

Kubala, T. 2011. 'The Fifteen Fundamental Properties Of Wholeness'. *The Kubala Washatko Architects, Inc.* Available from: http://www.tkwa.com/fifteen-properties/ [Accessed 1 June 2014].

Kuniye, Kawamoto. 2011. 'The international outlook of the Quang Nam regime as revealed in Gaiban Tsuusho'. In: *Ancient town of Hoian-international conference in Danang,* 4th edn, Hanoi, Vietnam: The Gioi Publishers.

Kỷ-yếu trường Nam tiểu-học và nữ tiểu-học Hội An [Yearbook of the Hoian Boys and Girls School]. 2011. Hoian.

Le Floch de la Carrière. 1745. *Carte d'une partie de la côte de Cochinchine, depuis l'Isle Cham- Collao.* National Library of France [online] Available from http://gallica.bnf.fr/ark:/12148/btv1b5963009z/f1.zoom [Accessed 8 December 2014].

Library of Congress, ca. 1899. *Prints & Photographs Online Catalog*. [online] Available at: http://www.loc.gov/pictures/item/2001699385/ [Accessed 25 Jan. 2015].

Linden Lab 2015. *Second Life Official Site - Virtual Worlds, Avatars, Free 3D Chat*. [online] Available at: http://secondlife.com/ [Accessed 25 Jan. 2015].

Lloyd Reeds Map Collection 2015. McMaster University. [online] Available at: https://library.mcmaster.ca/maps/SRTMreadme.pdf [Accessed 25 Jan. 2015].

Lynch, K. 1960. *The image of the city*. Cambridge, MA: MIT Press.

Lynch, K. 1981. *Good city form*. Cambridge, MA: MIT Press.

Massive Small Compendium,. 2015. 'Massive Small'. http://www.massivesmall.com/wp-content/uploads/2015/01/DRAFT-COMPENDIUM-STRUCTURE.pdf. [Accessed 18 Mar. 2015].

Mehaffy, Michael. 2008. 'Generative Method In Urban Design: A Progress Assessment'. *Journal of Urbanism* 1 (1): 57-75.

Mehaffy, M., 2004. 'An interview with Andres Duany'. *Katarxis 3*. [online] Available at: http://www.katarxis3.com [Accessed 5 Feb. 2015].

Mesle, R. 2008. *Process-relational Philosophy: an Introduction to Alfred North Whitehead*. West Conshohocken, PA.: Templeton Foundation Press.

Metropolis Project,. 2015. 'Metropolis - Demokratische Republik Freier Virtueller Welten'. http://metropolis.hypergrid.org/ [Accessed 18 Mar. 2015].

Mattern, S. 2013. 'Methodolatry and the Art of Measure'. *Place*[Online]. Available at: https://placesjournal.org/article/methodolatry-and-the-art-of-measure/ [Accessed 3rd December 2014].

Morgan, Colleen L. 2009. '(Re)Building Çatalhöyük: Changing Virtual Reality In Archaeology'. *Archaeologies- Journal of the World Archaeological Congress* 5 (3): 468-487. doi:10.1007/s11759-009-9113-0.

Morgado, L., Varajão, J., Coelho, D., Rodrigues, C., Sancin, C., & Castello, V. 2010. 'The attributes and advantages of virtual worlds for real world training'. *The Journal of Virtual Worlds and Education*, 1(1), 15–36. Retrieved from http://home.utad.pt/~leonelm/papers/jvwe-volume-onenumber-one.pdf.

Mumford, L. 1961. *The city in history: its origins, its transformations, and its prospects*. New York: Houghton Mifflin Harcourt.

Nguyen, Boi Lien. 2008. 'Đi tìm nguồn gốc phổ cổ Hội An'. In: *Proceeding of Conference about ancient town of Hoian 1985*. Danang: Nxb Danang. [Danang, Vietnam: Danang Publisher].

Nguyen, Ngoc Chung. 2008. 'Góp phần tìm hiểu nguồn gốc của một số địa danh và vai trò của phố cảng Hội An'. In: *Proceeding of Conference about ancient town of Hoian 1985*. Danang, Vietnam: Danang Publisher.

Diep, Nguyen Ngoc. 2008. 'Phố Có Vui Không.' *Diepdanangblog.* Translated by Nguyễn Tuấn An. Available at: http://diepdanang.blogspot.com/2008/05/ph-c-vui-khng.html [Accessed 10 Mar. 2015]

Nguyen, Chi Trung. 2009a. Vietnam-Japanese Cultural Exchange. Hoian: Center for Heritage Management and Preservation.

Nguyen, Chi Trung 2009b. 'The Sea Trading Map to the State of Jaiaozhi'. *Images on the cultural exchange between Japan and Vietnam in Hoian.* Hoian, Vietnam: Hoian Center for Monuments Management and Preservation.

Nguyen, Dinh Dau. 2011. 'The birth and the historic evolution of Hoian'. In: *Ancient town of Hoian-International Conference in Danang,* 4th edn, Hanoi, Vietnam: The Gioi Publishers.

Osgrid Inc,. 2015. 'Osgrid - Opensimulator Metaverse'. http://www.osgrid.org/ [Accessed 18 Mar. 2015].

Overte Foundation, 2011. *Opensim Project*. [online] Available at: http://www.overte.org/ [Accessed 25 Jan. 2015].

Phan, Dai Doan. 2011, 'Hoian and Dang Trong'. In: *Ancient town of Hoian-International Conference in Danang,* 4th edn, Hanoi, Vietnam: The Gioi Publishers.

Pijawka, David, and Martin A Gromulat. 2012. *Understanding Sustainable Cities: Concepts, Cases, and Solutions*. Dubuque: IA: Kendall Hunt Publishing.

Placeways, 2015. *CommunityViz | Placeways*. [online] Placeways.com. Available at: http://placeways.com/communityviz/index.html [Accessed 28 Jan. 2015].

Pound, N. 2005. *The Medieval City*. Westport, CT: Greenwood Press.

Profburp.com, n.d. *Cartes postales et photos de Tunisie*. [online] Available at: http://www.profburp.com/galerie/ [Accessed 25 Jan. 2015].

Quang, Van Cay. 2008. Trungphuong and related heritages to Hoian. In: *Proceeding of Conference about ancient town of Hoian 1985*. Danang, Vietnam: Danang Publisher.

Salingaros, N A. 2008. *A theory of architecture*. Solingen, Germany: Umbau-Verlag.

Salingaros, N., Brain, D., Duany, A., Mehaffy, M. and Philibert-Petit, E. 2006. *Favellas and Social Housing: The Urbanism of Self-Organization*. [online] Presented at the Brazilian and Ibero-American Congress on Social Housing. Available at: http://zeta.math.utsa.edu/~yxk833/socialhousing.pdf [Accessed 11 Feb. 2015].
Saalman, H. 1968. *Medieval Cities (Planning and Cities)*. New York: Braziller.

Seamon, David. 2007. 'Christopher Alexander and a Phenomenology of Wholeness'. Presentation, Sacramento, CA.

Seiichi, K. 2010. *Nghiên cứu đô thị cổ Hội An từ quan điểm khảo cổ học lịch sử.* Hà Nội: Nxb Thế giới [Study ancient town of Hoian from history-archaeological view. Hanoi, Vietnam: The gioi Publishing].

Sequeira, L. and Morgado, L. 2013. 'Virtual Archaeology in Second Life and OpenSimulator'. *Journal of Virtual Words Research*, 6(1), pp.1-16.

Sequeira, Luis Miguel, and Leonel Caseiro Morgado. 2013. 'Virtual Archaeology In Second Life And Opensimulator'. *Journal Of Virtual Words Research* 6 (1): 1-16.

Sitte, Camillo. 1889. Der Sta dtebau nach seinem ku nstlerischen Grundsa tzen, Vienna: Carl Graeser (trans. *City planning according to artistic principles.* 1965. New York: Random House).

Slater, T. 1981. 'The Analysis of Burgage Patterns in Medieval Towns'. *Royal Geographical Society* 13 (3): 211-16.

Smartcodecentral, n.d. 'SmartCode Central'. Available at: http://www.smartcodecentral.com/ [Accessed 29 Jan. 2015].

Synthicity, 2015. 'Synthicity'. Available at: http://www.synthicity.com/ [Accessed 28 Jan. 2015].

Tabak, I. 2006. 'Prospects for Change at The Nexus of Policy And Design'. *Educational Researcher* 35 (2): 24-30.

Taleb, N. 2013. 'Beware the Big Errors of "Big Data"'. *Wired*. Available at: http://www.wired.com/2013/02/big-data-means-big-errors-people/[Accessed: 3rd December 014].

Talen, Emily. 2005. *New Urbanism And American Planning*. New York: Routledge.

Talen, E. 2008. *Home | The Codes Project*. [online] Codesproject.asu.edu. Available at: http://codesproject.asu.edu/sites/default/files/code_pdfs/RebuildingAct1666.pdf [Accessed 19 Jan. 2015].

Talen, Emily. 2009. 'Design By The Rules: The Historical Underpinnings Of Form-Based Codes'. *Journal Of The American Planning Association* 75 (2): 144-60.

Talen, Emily. 2012. *City rules: How regulations affect urban form*. Washington, DC: Island Press.

Talen, Emily, and Cliff Ellis. 2002. 'Beyond Relativism: Reclaiming the Search for Good City Form'. *Journal of Planning Education and Research* 22: 36-49.

Tana, Li. 1998. *Nguyen Cochinchina: southern Vietnam in the seventeenth and eighteenth centuries*. Ithaca, NY: Cornell University Southeast Asia Program Publications.

Tran, Ky Phuong and Vu, Huu Minh. 2011. 'Cua Dai Chiem (Port of Great Champa) in the 4th-5th centuries'. In: *Ancient town of Hoian-International Conference in Danang,4th edn*. Hanoi, Vietnam: The Gioi Publishers.

Ulrich, Werner. 2006. 'The Art Of Observation: Understanding Pattern Languages'. *Journal of Research Practice* 2 (1).

U.S. Geological Survey, 2014. *Global Data Explorer*. [online] Available at: http://gdex.cr.usgs.gov [Accessed 25 Jan. 2015].

Viện Nghiên cứu Văn Hóa Quốc Tế- ĐH Nữ Chiêu Hòa, 2006. *Kiến trúc phố cổ Hội An-Việt Nam.* H à N ội: Nxb Thế giới [International Institute of Cultural Research- Showa WomanUniversity., 2006. *Architecture of the ancient town of Hoian, Vietnam.* Hanoi: The Gioi Publishing].

Vu Van Phai, and Dang Van Bao. 2011. 'Geomorphological features of Hoian and its neighborhood (Thu Bon Estuary)'. In: *Ancient town of Hoian-International Conference in Danang,4th edn*. Hanoi, Vietnam: The Gioi Publishers.

Waddell, Paul. 2002. 'UrbanSim: Modeling Urban Development for Land Use, Transportation, and Environmental Planning.' *Journal of the American Planning Association* 68 (3): 297–314. doi:10.1080/01944360208976274.

Wheeler, C. 2006. 'Re-thinking the sea in Vietnamese history: littoral society in the integration of Thuan Quang seventeenth-eighteenth centuries'. *Journal of South East Asian Studies* 7 (1): 123–153.

Whitehead, A. N. 1979. *Process and Reality*. 2nd ed. Boston, MA: Free Press.

Yinger, R. 1987. 'Learning The Language Of Practice'. *Curriculum Inquiry* 17 (3): 293-318.

APPENDIX A

FIFTEEN PROPERTIES BY ALEXANDER

Alexander's properties

1 *Level of scale*: A coherent structure usually comprises a range of scales—the relative relationship between an element and others around it—within which a series of clearly defined sizes exist and have recognisable thresholds (Kubala 2011). To have a good level of scale, the differences among the scales should not be too large or small (Alexander 2002).

2 *Strong centre*: A centre is an object that has a prominent shape or position within a structure—a dominant and organised spatial zone. Centre is also a concept used to describe a structure's interrelationships with other structures outside itself. It must support the centres that are around it, are inside it and contain it.

3 *Thick boundary*: A thick boundary focuses attention on the centre. It also unites other surrounding centres (Salingaros 2008).

4 *Alternating repetition*: Structures should include complex repetitions (Salingaros 2008). The repeated elements need not be exactly the same; however, they must have common geometrical characteristics (e.g., size, shape, details, etc.)

5 *Positive space*: A structure itself should create a definite and beautiful shape in conjunction with the surrounding area without creating amorphous, extraneous spaces.

6 *Good shape*: Shape is the primary trait of form. It results from the specific configuration of a form's surfaces and edges. A good shape often has internal symmetry, overall bilateral symmetry, and a well-defined centre.

7 *Local symmetries*: A structure should have overlapping symmetry on many local scales. This symmetry creates a balanced distribution of forms without leading to rigidity in the overall organisation.

8 *Deep interlock and ambiguity*: Forms interpenetrate and are linked together (Salingaros 2008). Through interlocking forms and spaces, a zone belonging to both the form and its surroundings emerges.

9 *Contrast*: A coherent and balanced structure usually has a high degree of

contrast (i.e., texture, mass, noise, etc.).

10 *Gradient*: In coherent structures, slow and incremental changes pervade the overall structure.

11 *Roughness*: Roughness, often defined as irregularity, describes the focus and attention given to important elements, whereas less important components remain loosely defined.

12 *Echoes*: Similarities tie all the elements together to form a unified structure (Salingaros, 2008).

13 *The void*: An object is complete if it has at its core a rested, calm, and empty space. The void alleviates the noise of surrounding centres.

14 *Simplicity and inner calm*: Removing unnecessary or distracting and confusing parts creates simplicity.

15 *Not separateness*: Creating overall coherence in which nothing appears separate. This concept describes the level of connectedness between a centre and that which surrounds it.

APPENDIX B

TWENTY REVISED URBAN PROPERTIES

The revised set of urban properties

No	Form qualities	Description
1	Singularity and Contrast	A coherent and balanced structure usually has a high degree of contrast that creates a sense of differentiation and emphasizes contrasting elements.
2	Simplicity	The intelligibility and simplicity of form. Unnecessary and distracting parts are removed.
3	Continuity	Continuity through repetition.
4	Dominance	A dominant feature in the urban context, accompanied by sub-elements.
5	Clarity of Joint	The 'high visibility of joints and seams', i.e., clear relation and interconnection.
6	Directional Differentiation and Gradient	Directional ′asymmetries' and 'gradients'—slow and incremental changes throughout the overall structure.
7	Visual Scope	The capacity to increase the 'range and penetration' of vision.
8	Motion Awareness	The ability to perceive 'form in motion' as it relates to spatial concepts such as distance or direction.
9	Name and Meaning	The quality attached to urban elements through meaning, stories, and history.
10	Level of Scale	Structures comprise components of different sizes: a few large, several medium-sized, and many small components.
11	Strong Centre	A center is an object with a prominent shape or position within a structure. It must support the centers around it, inside it and that contain it.

12	Boundary	A thick boundary focuses attention on the center.
13	Alternating Repetition	Once the alternating rhythm of the centers emerges, the repetitive centers amplify one another.
14	Positive Space	A structure itself, in conjunction with the surrounding area, should create a beautiful shape without creating amorphous extraneous spaces.
15	Good Shape	A good shape is easy to comprehend and is usually symmetric.
16	Local Symmetry	A structure should have symmetry at many local scales to create a balanced distribution of forms without global rigidity.
17	Deep Interlocking	By interlocking forms and spaces, a zone belonging to both the form and its surroundings emerges.
18	Roughness	Roughness as irregularity and non-geometrical rigidness describes a focus on the most important elements while ignoring unimportant elements.
19	Echoes	Similar forms exist at different scales and within a single scale but at a distance.
20	The Void	The stillness, calm, and empty space in the center that alleviates the noise of surrounding centers.

APPENDIX C

SYMBOLS OF TWENTY PROPERTIES

Symbols of properties. Symbols of properties

1. Centre 
2. Singularity and Contrast 
3. Dominance 
4. Simplicity 
5. Continuity 
6. Clarity of Joint 
7. Directional Differentiation and Gradient 
8. Visual Scope 
9. Motion Awareness 
10. Name and Meaning 
11. Level of Scale 
12. Boundary 
13. Alternating Repetition 
14. Positive Space 

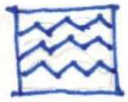
15. Good Shape

16. Local Symmetry

17. Interlocking

18. Roughness

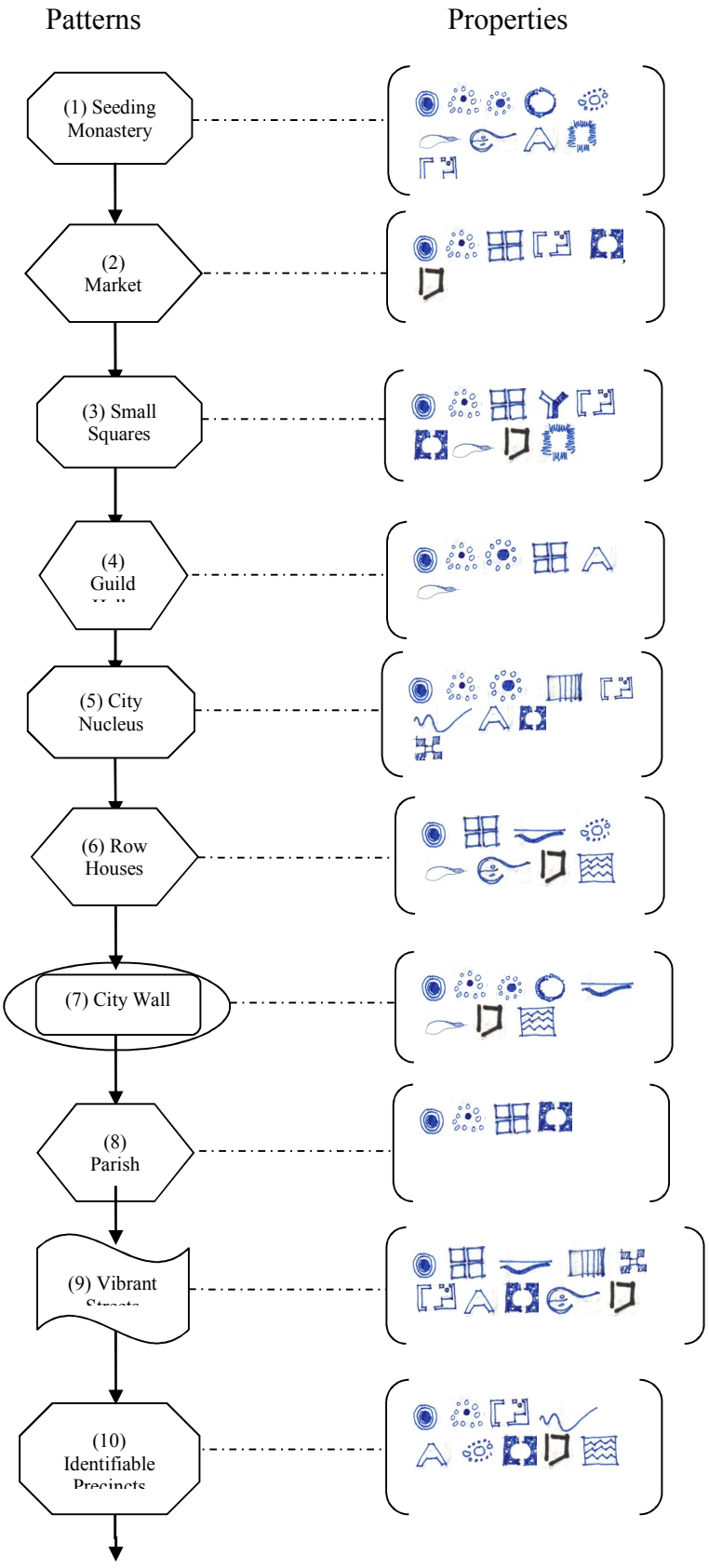
19. Echoes

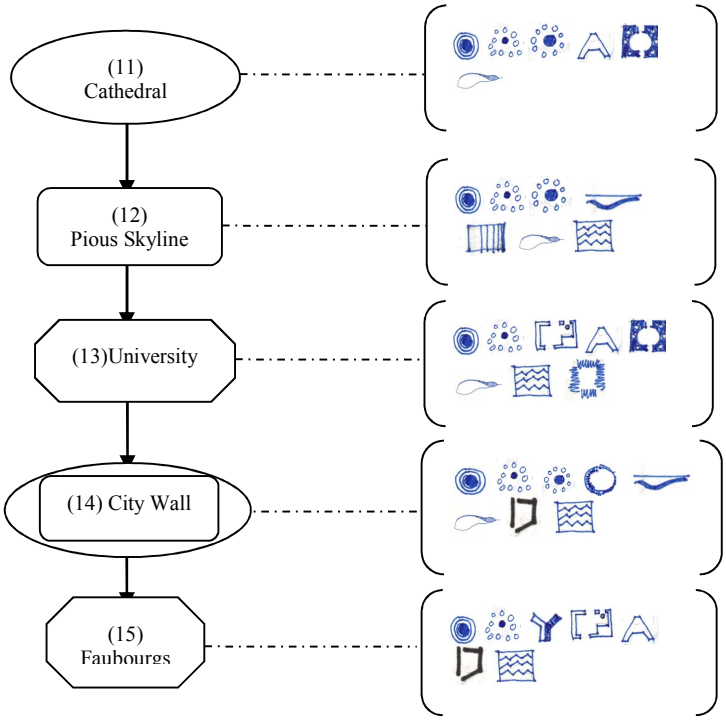


20. The Void

APPENDIX D

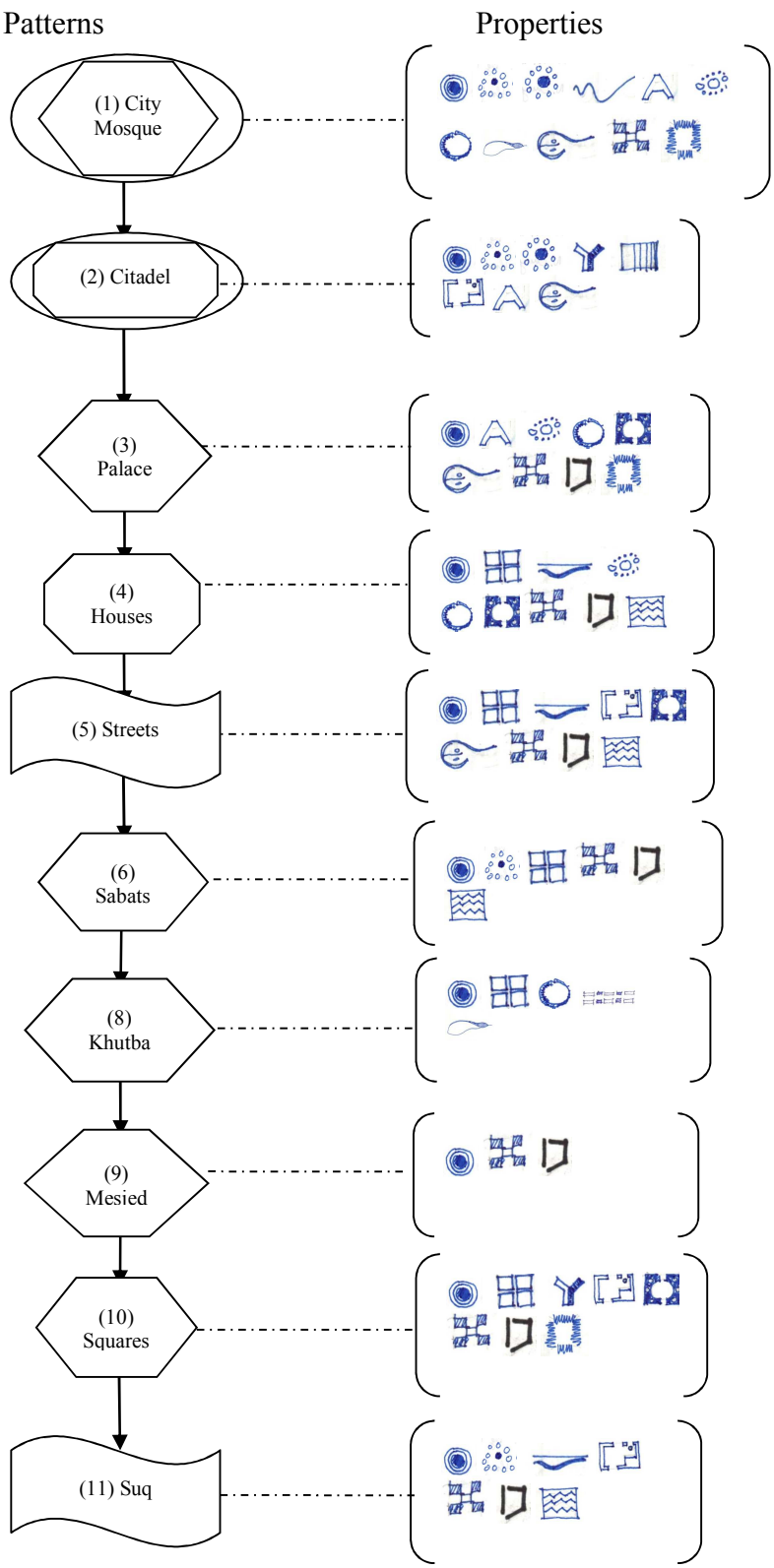
SEQUENCES OF PATTERNS IN MEDIVAL EUROPEAN AND ARABIC-ISLAMIC CITIES, AND HOIAN


Patterns
Properties
(1) Seeding Monastery
(2) Market
(3) Small Squares
(4) Guild
(5) City Nucleus
(6) Row Houses
(7) City Wall
(8) Parish
(9) Vibrant
(10) Identifiable



Symbols of Lynch's urban elements

Figure D.1: Sequential Patterns of Medieval European Cities and Their Properties.


Patterns
Properties
(1) City Mosque
(2) Citadel
(3) Palace
(4) Houses
(5) Streets
(6) Sabats
(8) Khutba
(9) Mesied
(10) Squares
(11) Suq

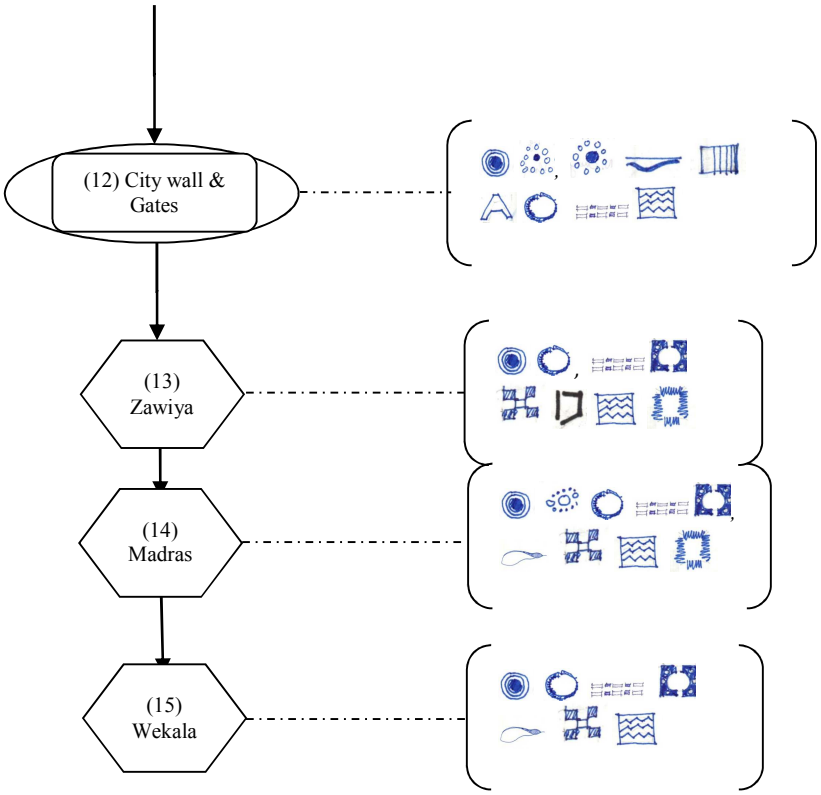
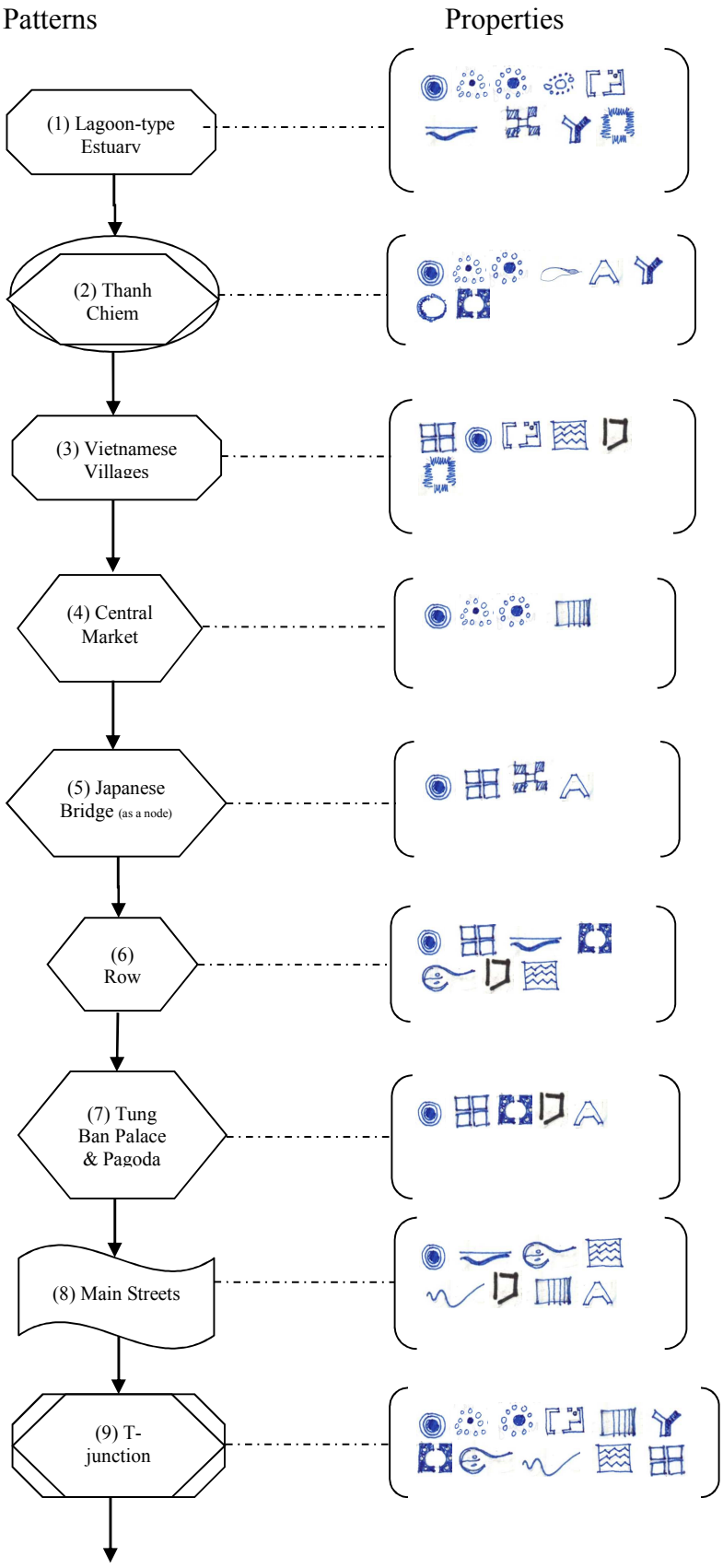


Figure D.2: The Sequence of Arabic-Islamic Urban Patterns.


Patterns
Properties
(1) Lagoon-type Estuary
(2) Thanh Chiem
(3) Vietnamese Villages
(4) Central Market
(5) Japanese Bridge (as a node)
(6) Row
(7) Tung Ban Palace & Pagoda
(8) Main Streets
(9) T-junction

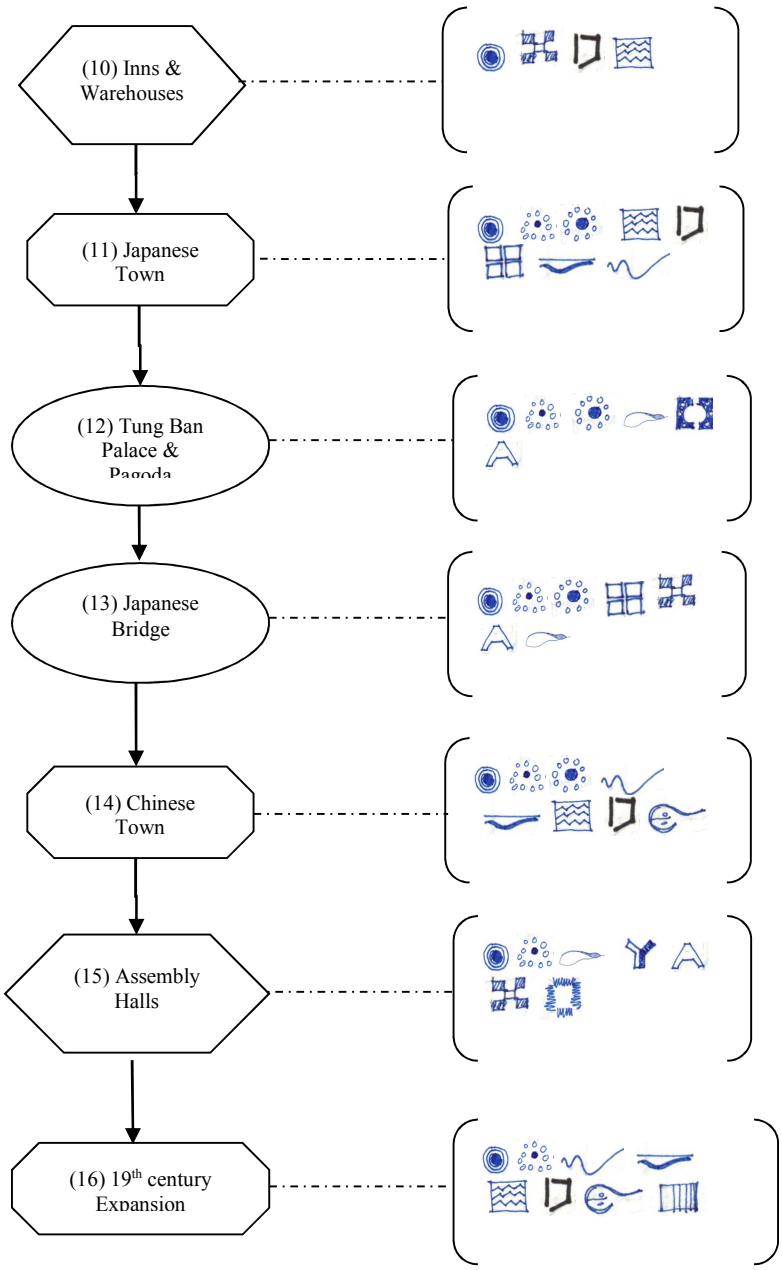
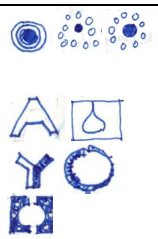
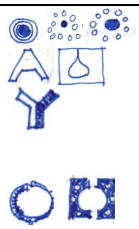
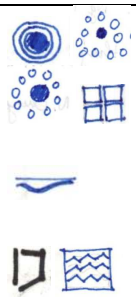
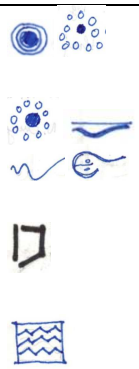
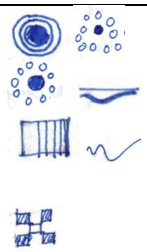


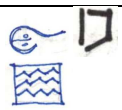
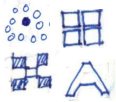
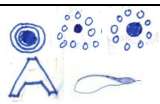
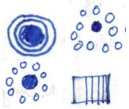
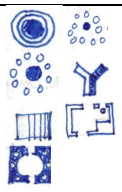
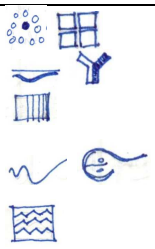
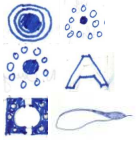
Figure D.3: The Sequence of Hoian's Patterns Accompanied with Properties.

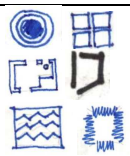
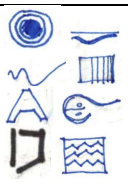
APPENDIX E

THE RELATIONSHIP BETWEEN PATTERNS, URBAN ELEMENTS, AND PROPERTIES IN HOIAN

Table E.1: The Relationship between the Urban Elements and Patterns.

No	**Pattern language**	**Urban elements**				
		Paths	Edges	Nodes	Districts	Landmarks
1	Thanh Chiem Palace					
2	The Japanese Town					
3	The Origin and Expansion of the Chinese Town					
4	The 19th Century Expansion					

						
5	The Japanese Bridge					
6	Central Market					
7	Assembly Halls					
8	The Lagoon-Type Estuary & Water Elements					
9	The T-Junction Town					
10	Tung Ban Pagoda & Tung Ban Palace					

11	The Vietnamese Village					
12	Main Street					

APPENDIX F

THE HIEARCHIAL PATTERNS AND MAP OF COHERENT IDICES FOR MEDIEVAL EUROPEAN CITIES

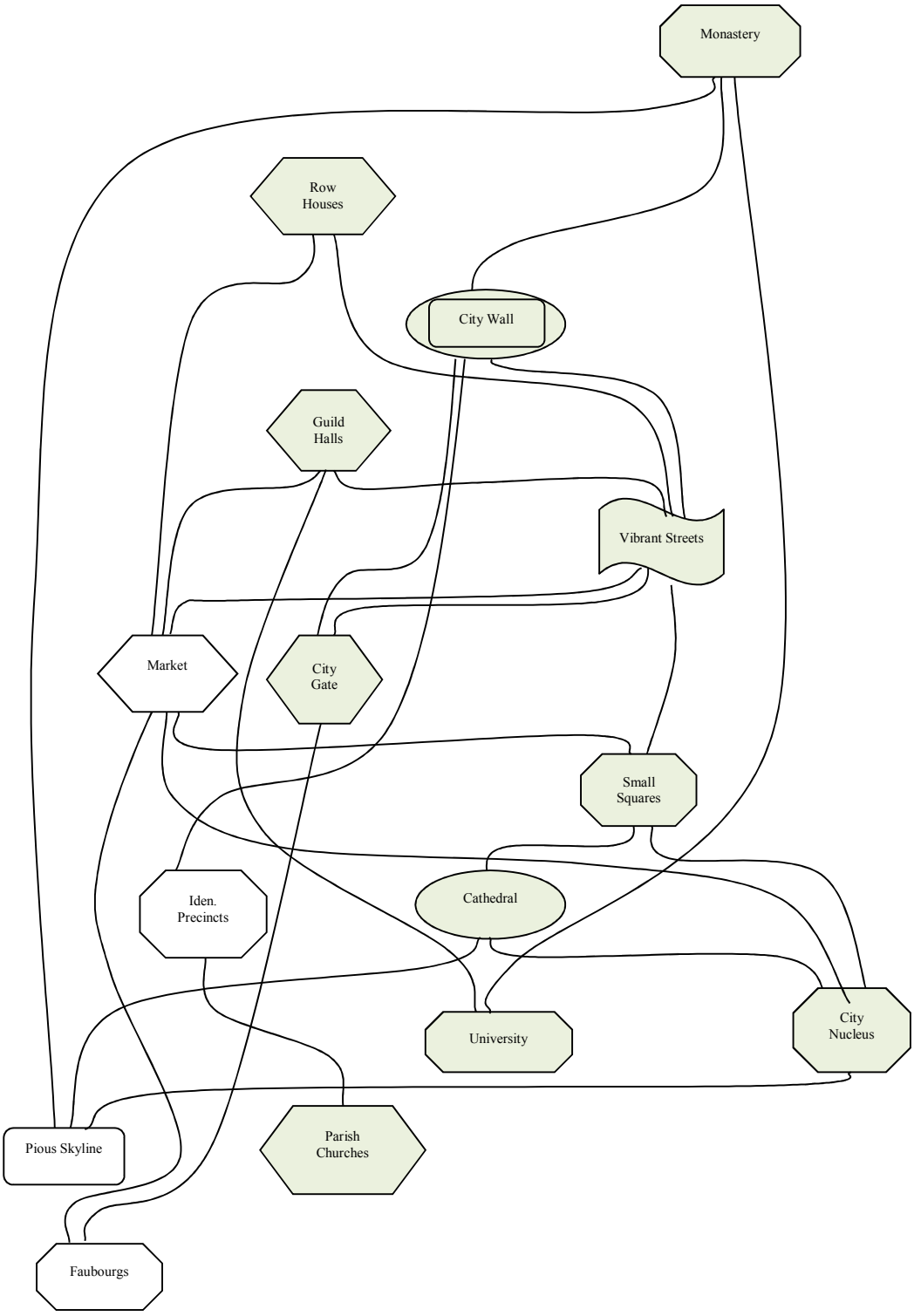


Figure F.1: Hierarchical Patterns in the Pattern Language of Medieval European Cities.

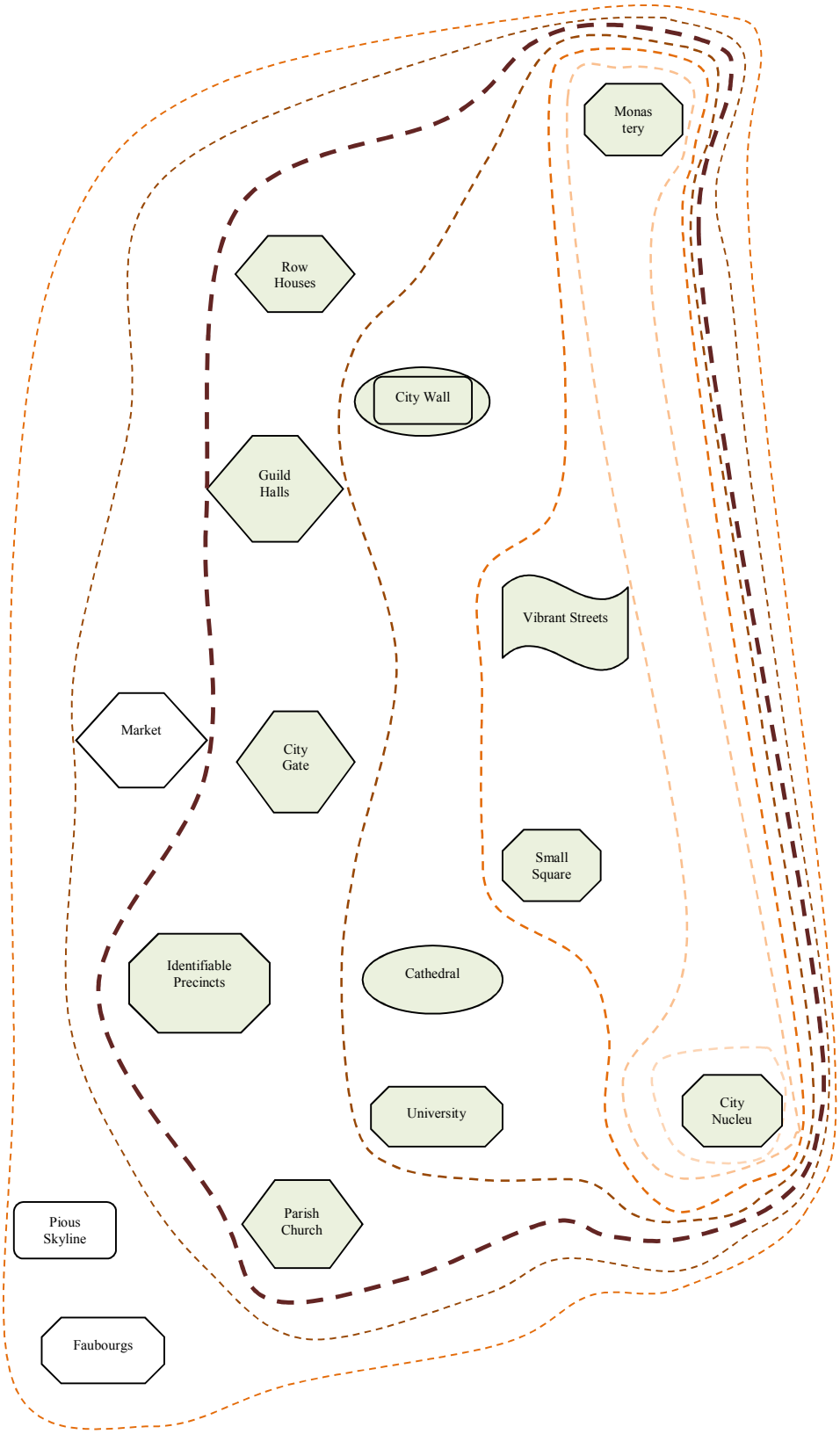


Figure F.2: The Map of CIs for the Medieval European Urban Form.

Seeding Monastery, *Cathedral, Parish Churches*: religion

Row Houses, *Guild Halls*, *Identifiable Precincts,* and *Vibrant Streets*: craft and commercial activities

City Wall, *City Gates*: protection

City Nucleus, *Small Squares,* and *University:*: civic life

APPENDIX G

THE HIEARCHIAL PATTERNS AND MAP OF COHERENT IDICES FOR ARABIC-ISLAMIC CITIES

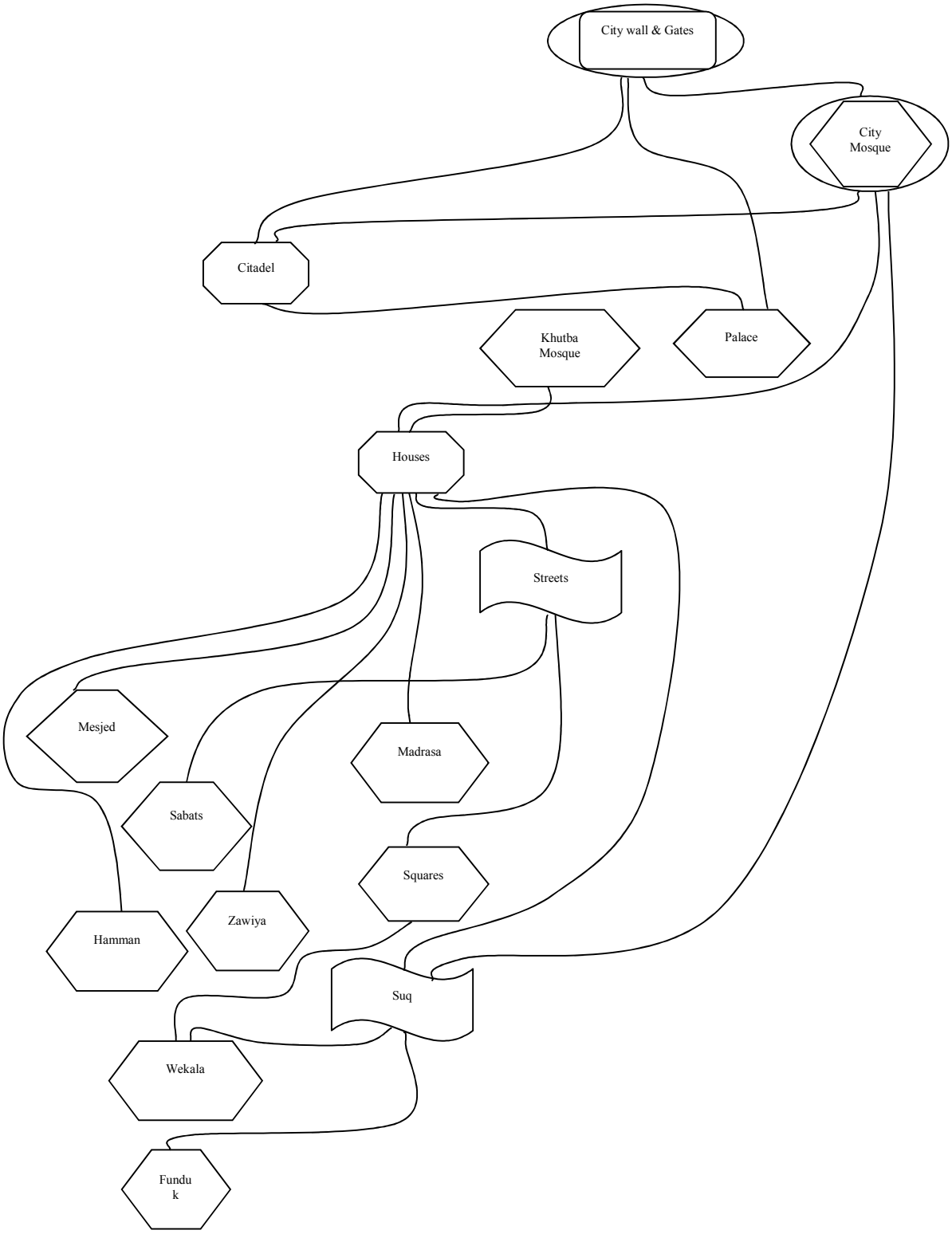


Figure G.1: Hierarchical Patterns in the Pattern Language of Arabic-Islamic Cities.

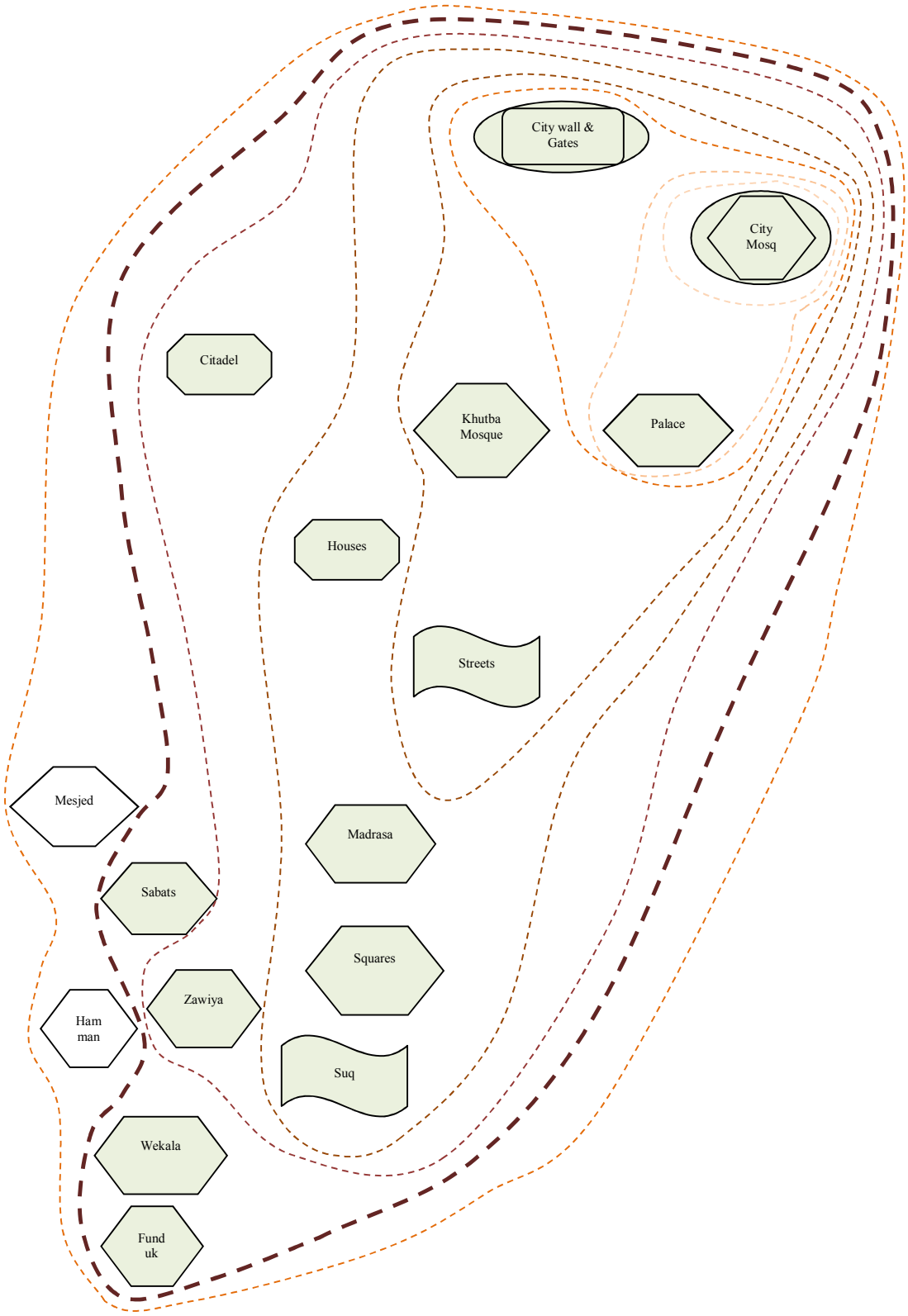


Figure G.2: The Map of CIs for Arabic-Islamic Urban Form.

City Mosque, *Khutba Mosque*, *Madrasa,* and *Zawiya:* religion and education

City Wall and Gates, *Citadel*, *Palace*: Monarchical power

Street, *Sabat & Vault*, *Squa*re, *House*: reparation of residential from other areas

Suq, *Wekala*, *Funduk*: commercial activities.