A Systematic Approach to Urban Block: Defining Automatic Tool for Urban Form

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Abstract. *The unprecedented rapid change in the urban form has prompted a growing number of research to analyze and understand the phenomenon in recent years. In a never-ending cycle of change and re-elaboration, the broad diversity of urban forms that we see today serves as the baseline for future and new forms. At the same time, the growing accessibility of geographic data and mapping tools have boosted urban morphology studies. The burgeoning development of automatic tools enables machines to get a human-like understanding of urban form hinged on images. In this new context, a comprehensive, systematic method of evaluation and comparison of forms needed to be defined. This study aims to present the manual definition of urban form features to create systematic input for automatic tools. Particularly, as a constitutional element of urban form, urban block is analyzed within the scope of classification approaches. The preliminary step is to present organized knowledge of urban block to understand how it is constructed. The methodological process is encompassed detection and classification of urban block by in-depth analysis of relative literature. The second step of the study is defined by using this structural classification to detect the urban block with automatic tools such as a deep convolutional neural network. The preliminary outcome of this study is the representation of urban block by providing a classification tree of the urban block based on comparative literature.*

Introduction

Diversity in the urban area has emerged based on the never-ending cycle of change in cities. Variations that emerged based on this change led the researchers to analyze the similarities and differences. As an emerging field, urban morphology analyzes these similarities and differences in investigating the consecutive transformation by identifying the main urban components; thus, streets, building, plot, block and their contextual relationship.

The methodological approach bears great importance in this rich physical and contextual context. Protagonists of urban form studies thus M.R.G. Conzen and Saverio Muratori, defined main concepts to analyze urban form. Their approach has been discussed and evolved by scholars in time, by developing manual approaches to automatic ones (Kropf, 2009; Oliveira,2016; Chen, 2021).

In contemporary studies, it can be seen that the impact of data used in urban form studies is game-changing. In changing society, there is diversification in the data produced every day. Width the emergence of mapping tools, the accessibility of geographic data accelerated in recent years. Accessibility of data draws controversial graphs with the conventional/manual methods. Therefore, the impact of machines and tools is reconsidered in urban morphology studies. The significance of machines in this role, changes the understanding and reading of the complex system of cities. When trained systematically, machines or tools give a good quality of information and have human-like reading of urban form. Rhee (2019)) states that, the recognition of a diagram by a computer means that the computer and the architect share the architectural design language and, ultimately, the new interaction with the machine. This ideology leads urban morphologists to inquire about new methodologies rather than restrain their studies to narrow conceptions.

The research aims to provide an alternative to reading the complex form of cities. The research questions how a computer can be trained to recognize urban form through learning rules. In the case of this study, ml models, particularly a deep learning model, are considered as computers. However, the operation of the model and results are not presented. The aim is to build the relationship between machine reading and architect reading by exemplifying the case of the urban block. Considering the systematic logic behind the tools and machines, a systematic reading of the urban block is presented.

Taking block as the core, comparative literature on the urban block is evaluated. Urban block is the most important fundamental unit of urban form, shaped by the contextual relationship of plot, street and building. In order to understand the urban block, it is essential to have comparative information based on its types, shapes, size and arrangements that resulted in different periods and places. The article is structured based on a literature review of related studies, the definition of classification criteria, the identification of indicators, and the identification of a classification tree.

Applied Methodology

Converting the urban elements into numerical indices is the most common method of quantitative morphological approach; therefore, manifold studies are devoted to quantifying urban form and its characters. Some approaches developed in this regard are analyzing the space's quantitative relationship, identifying urban form indicators, characterization of urban form, etc. (Fleischmann, 2020; Marshall, 2005; Yu, 2014).

Moreover, based on the tools of analysis, morphological formations are distinguished in different levels of analysis (D'Acci and Batty, 2019). The comparative literature shows that the first step is to define the practical analysis tool for the classification of urban form (Lehner and Blaschke,

2019). The second step is to automatically extract the morphological properties, building footprints, and analysis of urban form, for example, lidar or neural networks (Carneiro et al., 2010; Ye and Van Nes, 2014).

The methodological approach of the research is defined twofold. Firstly, it is aimed to investigate urban block components by providing a classification tree of urban blocks. Secondly, it is aimed to use the identified urban blocks to train the model. Based on this approach, the basic systematic logic behind the machine is used, thus input-tool-output. There is a systematic structure and reading in constructing the input, tool and output. Theories based on the urban block constitute the input for the machine, and it is believed that this will make it easier to train the machine to read the urban form. In this article, the first methodological approach with the results will be presented.

In order to identify learning rules for automated recognition of urban blocks, it is essential to create a relationship between machine language and theory. Therefore, the approach is to develop a systematic analysis of urban form elements (particularly urban block as the core of the study) and machine recognition. The optimized framework drawn for the question raised for this research requires a detailed analysis of the theoretical framework, which will be the article's focus. The detail about the model is not presented but mainly the preparation for input to train the model is presented. It is aimed to combine an in-depth analysis of the theoretical framework to identify constitutive components of the urban block from comparative literature to identify a classification tree to be input. Once the constitutive components are identified, the following step will be exploiting the supervised machine learning model to automatically detect the urban block to shed light for further analysis of the phenomena.

Urban form and the role of urban block

The literature presents a broad diversity in urban form studies within manifold perspectives, thus economic, social, spatial, planning and geographical context. Due to recent changes in methodological applications, it is inevitable to add a technological perspective to this list because of the accessibility of big data and the application of different tools. This resulted in conducting many studies in specific contexts, and different approaches based on these contexts show substantial results. (Eizenberg and Sasson, Shilon, 2019; Kristjánsdóttir, 2019; Moroni and Rauws, Cozzolino, 2020).

Technology-based urban morphology studies have accelerated in recent years. As a representative example, integrating the different approaches within an integrated GIS environment is conducted based on various problem definitions. Diversification in studies extended between fields (D'Acci and Batty, 2019; Qin et al., 2015; Stojanovski et al., 2020, etc.). Integration of different approaches and fields of research gives a vast opportunity to develop the studies further.

Moreover, studies developed with new methodologies open new opportunities for the new field of work. From an overview of the literature and based on reviews of previous works, morphological indices are generally constructed from three main components; building, street, and block (Chen and Wu, Biljecki, 2021; Kropf, 2009; Oliveira, 2016). Comprehensive frameworks are defined to provide common ground. One approach is to define classification criteria for the urban form (Fleischmann, 2020; Dibble, 2019; Gil et al., 2012).

Due to its constitutional and contextual relationship with the urban form elements, the urban block has been chosen as the core of the study. These relationships are constructed with street, plot, and building elements. Tarbatt (2020) defines that the urban block cannot be understood as a discrete entity. Its relationship with its constitutional elements must define it.

In the literature, there is not only a single definition for the urban block. It is defined as the; 'smallest area surrounded by streets' (Rowe, 2019) and as the 'basic unit of urban fabric within a city' (Ghisleni, 2021) or cluster of houses surrounded by streets. To understand urban block, there is a need for an in-depth analysis of the literature. Comparative literature shows that different perspectives developed in order understand and define urban blocks. In this paper, theories are systematized in order to filter the approaches developed for the urban block (Metrasys, 2012; Oikonomou, 2014, Panerai et al. 2004). In order to provide the base for comprehensive understanding, urban form studies developed based on approaches of two important scholars and their schools are evaluated. Studies conducted by Saverio Muratori and M.R.G. Conzen create the base for urban form studies. Therefore the role of the urban block in these approaches is carefully studied.

The in-depth literature analysis shows the path to define the taxonomy and classification of urban blocks, which will create a base for the tool of analysis. The pathway to defining a classification tree of the urban block goes through understanding and defining the urban block. Each element of the urban block is analyzed and categorized systematically based on numerical representation to define the taxonomy and classification of the urban block. In order to define the constitutive elements and identify urban blocks, the first step is to understand the urban block. This will lead the research to understand the relationship between form and its numerical indices.

Urban form elements and classification

Studies show that the systematic approach to classifying urban form components is required to conduct rigorous analysis regardless of the methodological approach. Fleishman (2021) defines that to understand the complex entity of the cities, there is to divide them into simplified and manageable pieces of information. Joining more minor things into higher-ordered groups constitutes the essence of classification (Fleishman, 2021). Therefore, each element of the urban block will be defined to classify urban blocks based on understanding and defining them as groups.

Taxonomy and classification of the urban block are discussed to comprehend, define, and manually classify different urban block types to prepare data for and complete the initial classification tree. This will create the base for analyzing blocks through tools. Each indicator of the urban block is analyzed and categorized concerning its numerical representation, shape and size to define the classification tree of the urban block (Siksna, 1997; Tartbatt, 2020).

Through its development, urban blocks changed and took different forms over time, starting from antiquity, where the significant term 'insula' was used to define the urban block at the outset of the roman empire. The term is used the way that street surrounding form the urban block (Tarbatt, 2020). Disruption in the form of urban blocks can be seen in the medieval period. In later periods the impact of certain urban forms can be seen in urban block formation. For example, in time, grid formation created another form of an urban block. The plans were developed based on a repeating grid of rectangular blocks (Tarbatt, 2020). A similar example can be seen in Barcelona, where squared block took part in the Cerda plan. Contrary to square form, mega blocks can be seen in Copenhagen, where the plan resulted in a trapezoid-shaped block. It can be seen that literature devoted to the urban block defines mainly based on the shape and size of the urban block (Siksna,1997). However, to understand the urban block completely, there is a need to understand each component of the urban block.

Urban block indicators

The way of understanding urban block goes through understanding its constitutive elements

and the contextual relationship it develops with these elements. These elements can be summarized as street, plot, and building. Because the variations and diversity in urban block types are defined based on the combination between and within each of these elements. These variations provide a comprehensive understanding of urban blocks that will define the classification tree aimed to be summarized in this article. Eventually, they will be input for the machine learning model. The configuration of the streets, orientation and topography, have an impact on urban block types. The forms, shape, size and geometric arrangement of the plots and streets can vary, although some have similar rectilinear layouts (Siksna, 1997)

The same block size can be defined by the street's different formations, which will affect the block shape (see figure 1). Similarly, it can also affect the block shape based on the division in the width and length of the street structure. As well as street structure plot structure had a big impact on the formation of urban block types. The different configuration of plot structure in the same block is detailly studied by Siksna (1997), showing how the plot structure can affect the building configuration, etc. The examples are also highlighted by Tarbatt (2020) as back-to-back plots or through plots. As well as its relation to plot structure, building structure significantly impacts understanding urban blocks.

In addition to the above-mentioned structural elements, the urban block is defined based on its shape and size, for example as seen in figure 1, as square, rectangular and small or large (Siksna, 1997; Moule, 2005). This creates diversity in different block types. According to Siksna (1997), square blocks are generally considered the most flexible for various uses, but they cannot be described as the most efficient. Based on the street, the shape of the urban block can be distorted in many ways. Siksna defines that block can be completely lose their forth side in the skewing or dissecting process and become triangular and other take other shapes (Siksna, 1997). At the same time, Tarbatt defines that 'there is no one size fits to all formula for determining the appropriate size of the urban block'(Tarbatt, 2020, p.77). The size of the urban block can be taken as an essential component to analyze the permeability and connectivity. In terms of size, the urban blocks are defined by Siksna as small, medium, and large according to context. Similarly, Tarbbat state that 'It can vary considerably in shape and size according to the configuration of streets, preferred orientation and topography, for instance, as well as the nature of plot subdivisions and building types that are to be accommodated" and adds that it is "a component of a system that is dependent on both its symbiotic relationship with the street and the substrate of subdivisions that split it into smaller, more or less self-contained pieces of land ownership known as plots or lots" (Tarbatt, 2020, p.6).

In addition to the above-mentioned structural elements, the urban block the evolution of urban block from antiquity represents the basis for defining the urban block. The perimeter block, traditional block, and superblock are some terminologies used to define the urban block. Additionally, it is defined as rectangular or square block depending on its shape and size. However, there is a need for clarification of these terminologies. Basic geometry, shape, and within the context of usage, the connection of street and plot create the basis to define urban block.

The pure form of urban block can hardly be found due to changes and disruptions in time. According to Siksna (1997), the modification of lots, blocks and street layouts is impacted by certain factors. In order to identify contemporary urban block types, it is essential to understand the evolution of the urban block. Shape and size became vital keys to understanding how the urban block has changed/evolved. That is why this article also considers the impact of change in division and amalgamation of constitutional elements of the urban block to understand how contemporary urban block types took shape. In detail, the evolutionary aspects and

components that affect urban block formation are highlighted by Siksna as; the addition or deletion of the street and public spaces; creation of sub-blocks and amalgamated blocks: insertion and deletion of features such as alleys, arcades, and public spaces with block; subdivision, and amalgamation of lots and their effect on block structure, and compatibility of lot sizes and shapes within changing building for and process of their mutual adjustment, last but not least locational and topographical conations (Siskna, 1997)

Terminologies used to define the urban block vary in the relative literature. Tarbatt (2020) draws a clear and comprehensive definition of the urban block and its types. This study is conducted to identify not only perimeter block, which can be defined as the most common urban block type, but also other forms that urban blocks can take. It shows a clear classification of how urban block is adapted to different conditions. Types are highlighted as The perimeter block, The row block, The ribbon block, The courtyard block, and other variants of urban forms (see figure 2). Additionally, the transition between these types is identified based on the street structure, plot structure and etc. A list of possible configurations and the taxonomy of urban block layout is defined. Public-private relations are taken as the basis while defining the block types. The framework defined by Tarbatt improve the limited description of the urban block based on shape and size.

Nevertheless, block shape and size also become essential inputs for the definition of the block because the square and rectangular shapes of the block types are mainly used to define the perimeter block type. Of course, in terms of size, these variations differ, giving examples of the distinction between small and large and transitional forms of other sizes between these two. Although the literature presents a clear definition of the urban block, it is rather limited in defining all configurations of the urban block types. Based on the variations, urban block types are summarized based on the comparative literature. This leads the study to understand the notion and physical and contextual relationship behind the urban block. A classification tree is summarized to define the urban block types (see Figure 3). The classification tree represents the diagrammatical relationships to identify the most common urban block types.

The analysis conducted to build a relationship between theory and machine is twofold. Due to the machine's limitations, the research's first step aims to train the machine learning model based on identified shapes, sizes and predefined definitions of urban block types. The classification tree presented above will create input for the machine-learning model and will be used to train the model. It is observed that based on the structural configurations of the urban block, any change in its element creates another with the shape and size. The study state that once the ml model is trained with these configurations, it is expected to have automatic detection of similar configurations. The model and application process details are not presented due to the ongoing process. However, a systematic classification of the urban block and systematic input for automatic tools are presented to create the base to train the model.

Conclusion

The initial development requirements and land parceling determined mainly the choice of different block sizes and shapes. Throughout history, each period shows the consistency in size and form of urban blocks and their types (Siksna, 1997). Based on the framework presented above, a classification tree of urban block types is summarized. The relation between the theoretical framework on the urban block and machine language can be built to automatically analyze the urban block. This article systematically elaborates on this relation and presents a systematic approach to urban block based on relative literature.

Urban block presents a rich input for the study in terms of its contextual relationship with its constitutional elements. Based on these relations, the summarized classification tree contains the basic formation of urban block types defined based on understanding and defining the urban block. It is believed that the literature results can pave the way for many studies, starting from applying conventional methods to automatic tools.

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Illustrations and tables

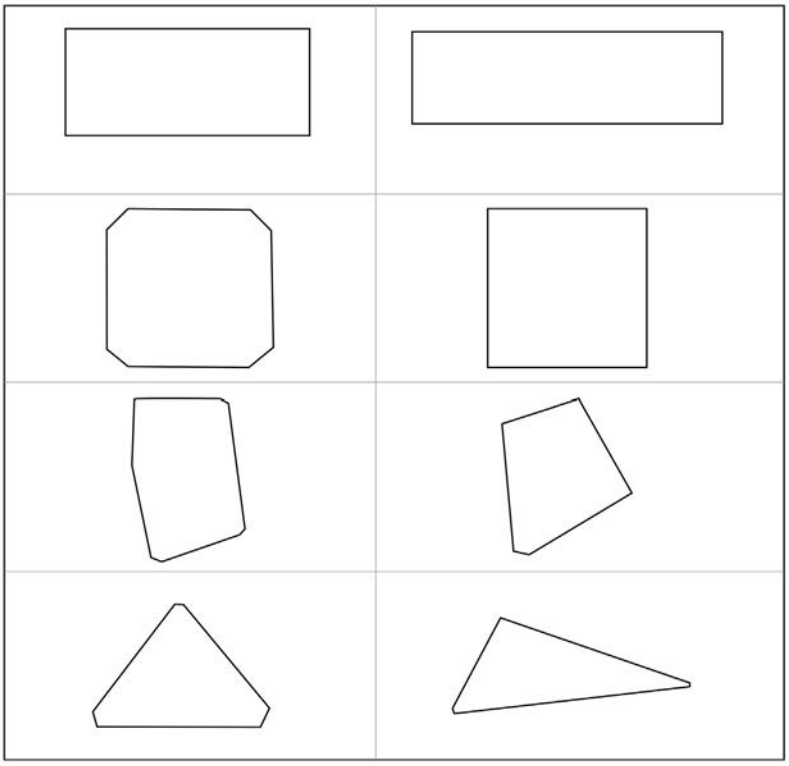

Figure 1. Urban block types based on shape and size

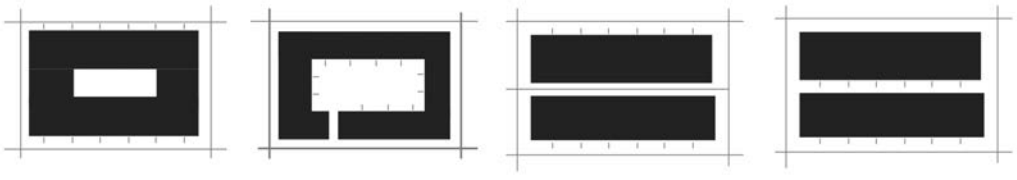

Figure 2. Main urban block types – Left to right: Perimeter block, courtyard block, row block, ribbon block- Redrawn from Tarbatt, 2020

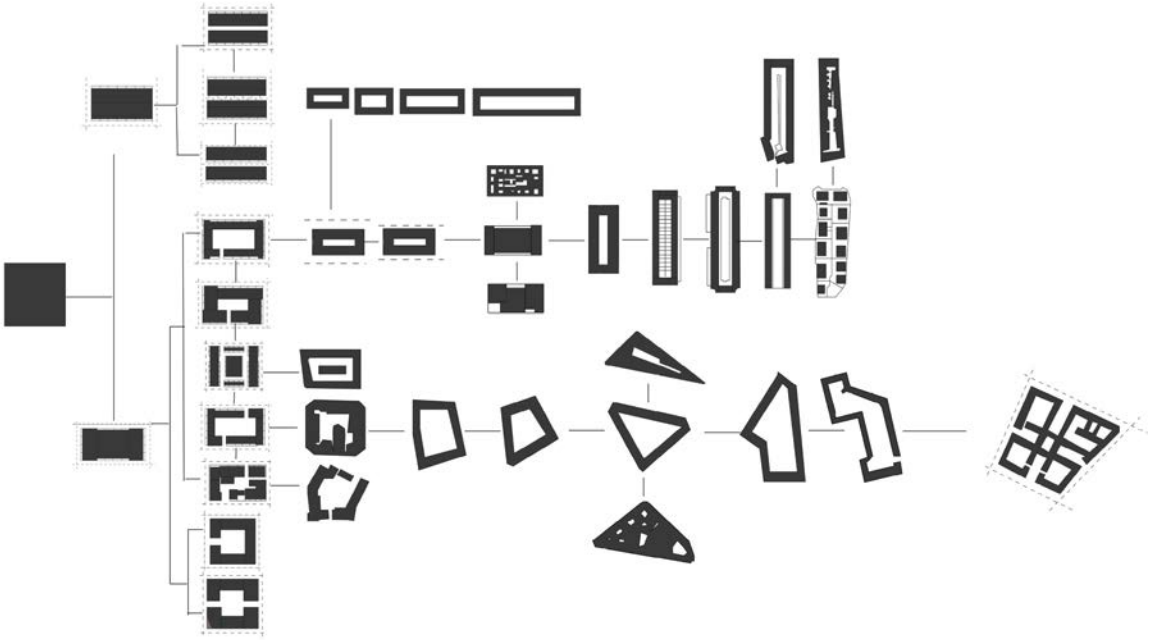

Figure 3. Classification tree of urban block