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A Deep Learning Approach for Urban Block: Automated Extraction Tool for Urban Forms

Abstract Increasing access to geographic data and mapping technologies has pushed urban morphology research toward more quantitative and data-driven approaches. At the same time, the unprecedented rapid change in the urban form has prompted a growing number of research to capture, analyze, and understand the phenomenon in recent years. However, a thorough, systematic approach to evaluating and comparing urban forms in this setting is yet to be developed. The aim of this study is to build a comprehensive approach to defining urban form indicators by developing a simplified yet representative classification of the urban form. Notably, urban block as a constitutional feature of urban form is evaluated in relation to numerical indices. The applied methodology comprises the detection and classification of urban form using a deep convolutional neural network. The study attempts to use automated methods to address the gap in urban form classification and characterization. The methodological process encompasses a non-local classification of urban form, followed by an examination of the identified features of the urban block. The preliminary outcome of this study consists of an in-depth analysis of urban block indicators in the comparative literature. This will be one of the inputs of the deep learning model to classify urban blocks.

Keywords Urban Block, Automatic Tools, Deep Learning, Urban From.

Introduction

The contemporary treatment of urban form has shifted with the emergence of new technological tools and their implications. The conventional methods of analyzing, describing, characterizing, classifying and comparing urban forms are limited to using maps, drawings or images. The research is constructed to provide a new alternative way for the analysis of urban form and shaped based on the interest and need for new technological developments such as software, tool and their implementation in the field of urban morphology.

The role of machines and tools are reconsidered in studies of urban morphology to understand the complex form of cities. Accordingly, the research elaborates on the implementation of new technologies and tools in the field of urban morphology. Although conventional methods can be used to understand the complex system of cites, this process is limited compared to the computer recognition of form. Recently, the burgeoning development of automatic tools enables machines to get a human-like understanding of urban form hinged on images. The motivation is structured around the concern of whether a computer or machine can recognize urban form through learning rules to explain complex phenomena. In this research, the machine is recognized as an analysis tool, such as GIS, AI or Deep Learning. Unlike the general approach to studies of urban form, the study aims to use urban block and its indicators in relation to streets, plots and buildings to understand the complex urban forms.

The research questions whether a computer/machine can be trained to ‘read’ forms in complex urban textures. The aim is to identify learning rules for automated recognition of urban blocks.

> Using the learned urban vectors, one is able to easily find and compare similar urban forms all over the world, considering their overall spatial structure and other factors such as orientation, graphical structure, density, and partial deformations’ (Moosavi, 2017: 2–3).

In this regard, the research is structured twofold; first to identify learning rules for automated recognition of urban blocks. Second, by using learned urban vectors, identifying and comparing similar urban forms all over the world. The research preliminarily investigates urban form components based on theories of urban morphology. It aims to build the relationship between measurable urban form components and machine language in connection to identifying an automatic model for analyzing urban form. To do so, it is essential to define a systematic algorithm. This algorithm is constructed based on the definition of input, machine, and at the end to get the output. Each step in the construction of input, tool, and output requires systematic structure and systematic reading. Defining the input constituted based on theory will make it easier to train the machine to read the urban form. The second step is to identify and read the theory based on machine language.

The research context is shaped based on; literature analysis of urban block indicators, comparative analysis and evaluation of new technologies in the field of urban morphology and application of new technological tools in the field, such as GIS and deep learning. The implementation of new technologies is in progress and this research contributes to this progress by developing a unique perspective based on a comparative analysis of urban block.

The paper is structured based on; the introduction, background, presentation of the shift in the studies of urban form, representation of urban block and its indicators, methodological steps and conceptual framework of the implementation of the deep learning applications. However, the results of deep learning implementation are not presented due to ongoing progress. Nevertheless, a guideline for the implementation of the deep learning approach and the process of building language between machine and literature aimed to be presented.

Studies of Urban Form

Scholars in the recent era of urban morphology approached the study of urban form from various angles, including historical, statical, architectural and spatial (Larkham 2006). The discipline of urban morphology examines urban forms' definition, characterization and classification (Dibble et al. 2019). Recent scholars, thereby undertaking urban form studies, analyze the specific characteristics of the place by using plans, maps, drawings or pictures. As Larkham defines, urban form studies have developed in various directions, mainly historical. However,

> much of the recent work by geographers and others with professional interests in 'contextual' architecture and the planning, or management, of urban landscapes attaches considerable importance to the survival, and contemporary treatment, of urban and architectural forms created by previous generations (Larkham 2006:2–3).

This leads urban morphologists not to limit their studies to narrow conceptions but on various components constituting urban form, searching for new methodologies and approaches. Works done by M.R.G Conzen and Saverio Muratori opened a new area of research in the field of urban morphology. International Seminar of Urban Form (ISUF), held every year in different countries, became a platform for sharing and discussing research conducted in this field. Publications in the journal of urban morphology show rigorous evolution of urban morphology studies.

Although there are distinct approaches to studies based on the aforementioned schools of urban form, some studies evolved in parallel directions in terms of historical evolution. Distinct differences occurred in terms of context, case studies and methodologies developed on analysis of urban form. These differences and similarities in studies on urban form provide a rich library and perspective on new approaches and, eventually, future applications. This research aims to contribute to the existing literature by implementing a new perspective on existing literature.

Studies on cities' visual diversity of urban tissue, which constructed distinct dynamics lead researchers to examine the similarities and differences (Dibble et al. 2019; Falishmen 2021). As an emerging field in urban studies, the field of urban morphology consists of analyzing the evolution of cities from their formative years to consecutive transformations by identifying their various components (Moudon 1997). Additively urban morphology distinguishes urban form into components (street, building, block, etc.) and strives to understand each component's running pattern and their interactions (Chen et al. 2021; Olivera 2016; Kropf 2009).

Studies conducted in the literature can be summarized within four main perspectives; spatial, economic, social and planning in a geographical context. It is inevitable to add a technological perspective to the list thanks to the technological developments, availability of big data and different tools. Studies conducted in this line are differentiated with contextual approaches. The combination of different approaches in the field shows substantial results (Bertaud 2014, Eizenberg, Sasson, Shilon 2019; Kristjánsdóttir 2019; Moroni, Rauws, Cozzolino 2020). Furthermore, Kropf (2009) critically examines contexts of 'spatial analytical, configurational, process typological, and historico-geographical methods'. The aim is to conduct critical analysis approaches.

Studies shifted to another level based on critical approaches. Especially with technologic potentiality, recent studies in urban morphology have accelerated. As a representative example, combination of the different approaches within an integrated GIS environment is conducted. Diversification in studies extended within and between fields (D'Acci, 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.

Evaluating studies in urban form cannot be oppressed from a historical perspective. Interlink between studies allows for studying phenomena without historical and geographical boundaries. Studies developed with new methodologies open new opportunities for the new field of work. Eventually, this research recognizes a need for rigorous analysis of urban form. Within the framework for the analysis, it is essential to investigate concepts related to work to draw a comprehensive framework for this research. In defining the classification of urban form and providing a base for a methodological approach, it is necessary to investigate basic concepts.

In addition to the qualitative perspective developed over history, the accessibility to various forms of spatial data, the opportunity for computing power and the high eligibility of urban data accelerate quantitatively driven analysis of urban form (Chen et al. 2021). Therefore new approaches to examining shared formal characteristics on the data gathered from adequate sampling are constituted (Carneiro 2010; Potapenko 2020, Ye, Yu 2014). Diversity in applied methodologies for morphological computation is shaped by the different contexts as well as the accessibility of data.

Shift in methodological applications

The methodologies and tools used for quantifying urban form and automatic analysis are diverse depending on the study's context. Relatively, there is a need for rigorous analysis to construct comprehensive and practical methods in line with the aim of this study. Therefore, it is aimed to provide a detailed overview of explored methodologies and tools in the literature. The most common method of quantitative morphological research is to convert urban elements into numerical indexes. In the literature, a wide range of studies are devoted to quantifying urban form and its characters.

Quantitative relationship among space, distribution of urban area of open space, the definition of indicators of urban form, and characterization of urban form are very few hot topics in studies of quantification of urban form (Alexiou, Singleton, Longley 2016; Dibble et al. 2015; Fleischmann, Romice, Porta 2020; Marshall 2005). The development in these shifts also takes into consideration the role of machines in architectural studies. Most importantly, as a contemporary approach in the field of urban morphology, AI and its implications in the field are elaborated. This will guide the building of the language between architectural components and the machine and tool itself.

Methodologies applied for the analysis of urban form are mainly carried out through tools of analysis. With the technological development and access to big data, these tools provide an effective and comprehensive analysis of urban form. Scholars developed a new application of tools depending on specific concepts: momephy, grid calculation, deep learning applications, etc. (Carneiro et al. 2010; Chen, Wu, Biljecki 2021; Fleischmann 2019; Potapenko, Moor 2020; Ye, Van Nes 2014). As a platform for spatial analysis, GIS constructs a base for the examination of urban form (Nor, Noor 2014). With the application of tools in the GIS platform, using neural networks provides a comprehensive analysis of urban form (Chen, Wu, Biljecki 2021; Ye, Van Nes 2013).

Methodological formation in terms of analysis tools is diverse in different levels of analysis (D'Acci, Batty 2019). As observed in the literature, the first step is to defining tool of analysis on the classification of urban form (Lehner, Blaschke 2019). The second step is the automatic extraction of morphological properties, building footprints and analysis of urban form such as Lidar or neural networks (Carneiro et al. 2010; Ye, Van Nes 2014). The third step is to be the definition of tools to evaluate the results. The further definition and reasoning in the designation of methodologies and tools of analysis will be specified for each step within the context of this research.

In order to develop an automatic analysis of urban form within each specific context, studies show that there is a comprehensive need for a definition of urban form classification more detailed taxonomic classification. This will help to understand and analyze urban form quantitatively and qualitatively (Dibble et al. 2019; Leo et al. 2018; Marshall 2005; Pinho, Oliveira 2009; Venerandi et al. 2017; Ye, Van Nes 2014). Different concepts construct the classifications of urban form, for example, forming numerical taxonomy based on the analogy of a biological system (Fleischmann 2019; Fleischmann et al. 2021; Fleischmann, Romice, Porta 2020) and these are duly convened around certain concepts.

Urban block

As the most essential constitutional element of urban form, which is developed based on the relationship with streets, plots, and buildings, urban blocks constitute the core of the study. The first part presents a brief historical evaluation of the phenomena. With the aim of defining a systematic approach, relative literature is carefully filtered to identify; methodological perspectives, quantitative and qualitative methods, numerical indices and categorization of the indicators.

Scholars have defined the urban block differently, such as building blocks, street blocks and 'insulae.' Rowe (2019) briefly defines an urban block as the 'smallest area surrounded by street' and as the 'basic unit of urban fabric within a city.' In another context, it has been defined as a cluster of houses surrounded by streets. However, here it is aimed to develop a simple perspective on the definition of the pure urban block.

Specific historical processes have affected the formation of the urban block. Although the perimeter block represents the most common type of urban block, which 'block is built upon all sides, portraying a private and or semi-private internal space', the form of the urban block has changed thought history due to the amalgamation of plots or change in street structure. It is essential to state that to understand the urban block. It is crucial to understand its relation to streets and plots. Tarbatt (2020) states that the traditional urban block could not be understood as a discrete entity. Instead, 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).

Once the relationship between plot, block, and street is defined, the historical evolution of urban block can be better understood. Therefore, a better framework can be defined for the taxonomy of urban block which constitutes an important part of this research. Being the dominant type of urban block, the 'perimeter block' 'has a long but chequered history' (Tarbatt 2020). Its' pure form is mainly founded in cities, but also, it has been adapted to suburban areas with mixed results. The perimeter block can take myriad forms, which will be defined in more detail in the upcoming part.

The urban block's technical features are defined to identify different block types. The street structure can change in the same block type, and due to this change, we can see different block typologies in terms of shape and size. The same block shape can differ based on the street structure defining it. As well as shape, the block's size also has importance in different variations of the urban block. There is no 'one size fits all' formula for determining the appropriate size of an urban block. The size of the urban block is the most critical component in analyzing permeability and connectivity in further studies. But most importantly, shape and size are keys to understanding how the urban block has changed/evolved. This leads the research to also take into consideration the impact of change in the division/amalgamation of constitutional elements of the urban block to understand contemporary urban block types.

The urban block has changed and disrupted over time; today, the pure form of perimeter block is rarely found. Siksna (1997) highlights that certain factors and processes enable the modification of lots, blocks, and streets' layouts over time. Understanding the evolution of the urban block plays a key role in order to identify contemporary block types.

Methodology

The applied methodology is developed with a twofold approach. First, it is aimed to detect and classify urban form components based on comparative literature. Steps are defined as: a literature review on related studies, the definition of classification criteria, identification of indicators and identification of classification tree. The detection and classification of urban form by using a deep convolutional neural network are aimed. It is aimed to use Deep Learning applications to address the gap in urban form classification and characterization. The second step of the methodical process encompasses the identification of an algorithm for the deep learning model by examining the identified urban block's identified urban features; second, develop a guideline to prepare for the supervised deep learning model to detect urban block types automatically. This need not emerged only by curiosity and change but also based on a necessity.

The fundamental definition would be to develop a new approach to growing the number of data. In changing society, data produced every day is diverse. Although these data are accessible, it is not easy to analyze and understand an immense variety of data with conventional/manual methods. Machines became significant tools in this sense. Therefore, when they are trained systematically, machines give good quality of information and have humans like reading and understanding urban forms. It is also important to highlight that there is a need to compile machine language; therefore, urban form is read with its numerical indices in this study. Eventually, one of the outputs would be to provide systematic analytical analysis and a base to pave the way for further studies.

A supervised learning model is identified to be used to automatically extract urban form features using a convolutional neural network. Supervised machine learning is chosen because, as indicated earlier, machines can learn, and using learned vectors, detection of similar urban forms and comparison of detected urban forms become more easy and efficient. It is aimed to draw a framework from a manually trained model to automatic analysis. Due to its applicability in the GIS platform and flexibility of the model, the Mask-R CNN model aims to be used to train the model by labeling the urban block hinged in images. A Convolutional Neural Network (CNN), a type of artificial neural network, can be used in image recognition and processing. As a deep learning model, Mask R-CNN is:

a Convolutional Neural Network (CNN) and state-of-the-art in terms of image segmentation. This variant of a deep neural network detects objects in an image and generates a high-quality segmentation mask for each instance' (Odemakinde)[1].

Due to the ongoing process of the research, the results of the implication of the model will not take place in this paper. However, an algorithm will be presented. The steps are defined as the definition of urban block indicators, annotation of the objects-urban block, importing the annotated object to the model, identifying the data and testing the model based on the provided data.

This research aims to provide an algorithm that can be applied to different research contexts. Therefore the model is selected in a way that the required data structure can be easily accessible. It is aimed to use high-resolution satellite images to train the model. The primary aim is to access the open-access data to comply with the practicability of the methodological approach. Due to this study's ongoing process and context, data will not be presented. Instead, the data type structure is summarized as follows.

Data type and structure are chosen based on the accessibility and accuracy of the project. Since the research is mainly focused on the urban block and its structural components, selected case studies only play the role of training and testing the model. Case studies will be chosen according to the different compositions of urban block types. And as mentioned earlier, high-resolution images will be chosen to train and test the model. It is assumed that once the model is trained based on the data structure defined above, it can be tested in the different forms of block typology. It is expected to have high accuracy of the results also in historical centers.

Conceptual framework

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. Considering the systematic construction of computers/machines, and especially with the recent technological shift in the analysis of urban form, the concept of a more systematic perspective is defined.

It is essential to highlight that for systematic tools to work efficiently and to give 'qualitative' output; there is a need to construct qualitative input and systematic description of tools. For machines also for the systems to work well, there is a need to provide a relation between *input, the tool itself and output*. The algorithmic relation between input and tool is presented as an outcome of this research today. Input is dedicated to a thorough theoretical definition and its consecutive relation to the tool.

Conceptual Framework – Construction of input

Defining the input which is constituted from theory will make it easier to train the machine to read the urban form. Considering the field of urban morphology, it is essential first to understand how scholars read the urban form. Conzen and Muratori present a different perspective on reading the urban form and present the base for methodologies. Manifold studies conducted a systematic reading approach based on theories developed by Conzen and Muratori. The way they read the urban form became the basis for developing the shift from conventional methods to automatic analysis and still developed within different methodological perspectives and concepts.

For the studies of urban form to be studied as a system, it is necessary to change them into logical categories and infer the parameters that will guide the reading. Based on these theories of urban form, a systematic approach to developing a base for machines needs to be defined. Within the context of urban form, defining taxonomy and classification is one of the basic steps in this research. The following steps are analysis (twofold) and clustering. To give detailed information highlighted here, it is essential to define each step in details that will provide clear, systematized reading in urban form.

To have an efficient and comprehensive analysis, as an essential constituent element of urban form, a detailed analysis of urban block is conducted. Within this line, the urban block is read according to every single element that constitutes the urban block and their relation with numerical indices.

Urban block as an Input

This part of the study composes a comprehensive study to identify urban block indicators, including indicators based on the relationship with street, plot and building. Quantitative elements of the urban block, therefore, aimed to be summarized with a systematic approach. The systematic approach composes the categories and indicators listed in each category to draw a basis for further detailed analysis.

The following part is structured to define taxonomy and classification for the urban block. The aim is first to understand, define the urban block and manually identify urban block types to prepare input for the machine and

[1] For more details visit: https://viso.ai/deep-learning/mask-r-cnn/

eventually finalize the preliminary classification tree. Therefore, theories based on urban morphology are filtered to define the taxonomy and the classification of urban block. This will lead to further analyzing the urban block through tools. And to define the taxonomy and classification of the urban block, each element of the urban block are analyzed and categorized based on numerical representation, shape and size to guide the machine. The first step was understanding the urban block to define constitutive elements and identify the urban block (see Table 1). This will lead us to build the relationship between form and its numerical indices.

Table 1. Table showing urban block, its constitutive elements

Elements	**Indicators**
Block	Dimension Shape Size Position Connection to street Orientation
Plot	Dimension Shape Size Position Distance to the street Area
Building	Dimension Shape Size Position Relation to Plot Area Density
Street	Dimension Connectivity Relation to block

Source: author's own work.

The last part contains the definition of the urban block based on comparative literature. This will lead the study to identifying a classification tree of urban block types. Defining each block type based on its constitutional elements creates rich input for the ml model. The diagrammatic drawings are inserted to demonstrate combination of the street, plot, and building and their relation to the urban block.

To understand the urban block it is essential to understand its constitutive elements and the relation that it develops with these elements, thus street, plot, and building. Because the **combination** between and within each component and block leads to the creation of **variations** of urban block types. These variations provide us a concrete understanding of urban block which can be input for the ML model. The combination of these elements, especially plot structure, will guide the study to define urban block types as well as the building formation.

Street structure; the street structure can change in the same block type. Due to this change, we can see different block typologies in terms of shape and size. And additionally based on a numerical description such as street width, length, proportion with block structure and distance. The same block shape can differ based on the street structure that defines it. Diagrammatic drawings show some ways of the street and its relation to urban block (see Figure 1).

Plot structure; same as street structure, plot structure greatly impacts the definition of urban types. The detailed structure plot and relation of the plot and block structure are analyzed by Siksna (1997), representing how the same structure of the block can change due to plot structure (see Figure 1). The examples can be given as back-to-back plots or through plots.

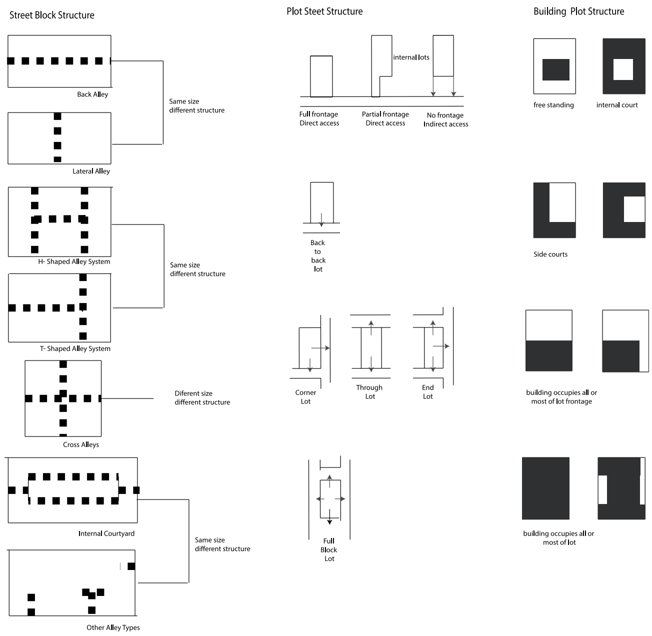

Figure 1. From left to right; street and block structure, plot street structure, building lot structure
Source: Siksna 1997.

Building structure; the formation of the building structure is shaped by plot structure and its relation to the plot and eventually the block. Therefore building structure can be taken as another element that defines different block types. Position of the building on the plot, the density and the connection with the street gain importance.

Size and shape; in addition to structural elements, urban block in literature are mainly defined by shape and size (square and rectangular or small, or big). Also, shape and size impact variation and combinations of urban block types. Square blocks are generally considered the most flexible for many uses but are not the most efficient ones. Block shapes can be distorted in various ways and generally contribute interest to the streetscape. The block can completely lose its fourth side in the skewing or dissecting process. They can become triangular or other shapes. As well as shape, the size of the block also has importance in different variations of the urban block. Urban block cannot be defined in one size. The size of the urban block is the most crucial component in analyzing permeability and connectivity in further studies. But most importantly, shape and size are keys to understanding how the urban block has changed/ evolved.

Toward definition of urban block

Similar to the definition of the urban block, different terminologies have been used to define urban block types. These terminologies developed mainly based on shape and size. Block types vary according to shape and size based on the configuration of streets, orientation and topography. Although they have a similar rectilinear layout, the forms, dimensions and geometric arrangement of their lots and street vary. With defining main block types, it is aimed to draw a framework for the 'taxonomy' of the urban block. It is aimed to define basic block types and their variations. Additionally, it is aimed to demonstrate variations between their surrounding street network and hybrid forms that have emerged or might emerge.

Urban block, in a very brief way defined as the smallest area surrounded by streets but as Rowe states, ‘it has been defined more precisely in different ways’. Although there is a broad literature on the urban block, detailed definition of types that constitute urban block is somewhat limited. A critical study by Siksna (1997) defines the urban block mainly according to shape and size. Based on shape, Siksna defines block types as rectangular blocks, square blocks, irregular blocks, etc. In terms of size, it has been defined by Siksna as small (under 10000 m^2), medium (10000 m^2 – 20000 m^2), and large (above 20000 m^2) according to context.

In another context, the most common block type that is defined in the literature is the perimeter block. The study conducted by Tarbatt (2020) gives a most comprehensive definition of the urban block and its types. In the study, Tarbatt aims to define not only perimeter block but also the way perimeter block has been changed to adopt different conditions. The taxonomy of fundamental forms that an urban block layout could take is outlined in the list of possible physical configurations. While defining block types, public-private space relation has been taken into account. Tarbatts' approach plays a vital role in determining the urban block to draw a better framework for taxonomy. Therefore, the limited description based on shape (rectangular, square, etc.) can be evolved to define terminology.

Urban block types are defined as ‘The perimeter block, The row block, The ribbon block, The ribbon block, The courtyard block and Other variants of urban form’ (Tarbatt states that they could be defined as blocks based on their understanding, thus, court, the close and the cul-de-sac). It can be said that the study is rather limited to defining all configurations of urban block types (mainly the perimeter block). Therefore, in further steps within this study's scope, it is aimed to analyze and define a comprehensive overview of the taxonomy of the urban block.

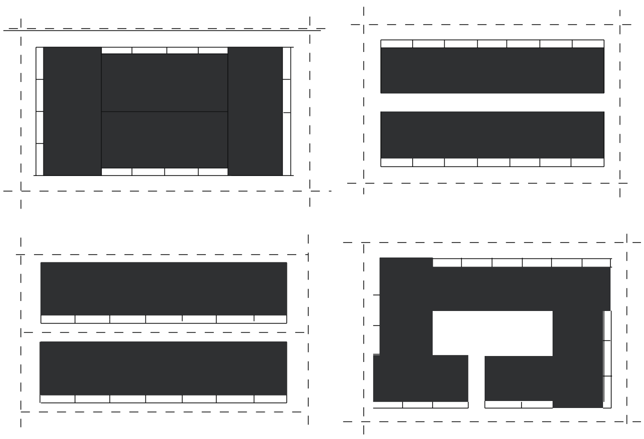

Figure 2. Most common block types – From to right top; perimeter block, row block, bottom; ribbon block, courtyard block
Source: Tarbatt 2020.

Conceptual Framework – From theory to machine language

How can we construct the relation between form and computer reading? A systematic reading for theory and tools needed to be promoted with the same language. Therefore, there must be a binary relationship between the way the machine is reading and the architect is reading. In order to convert this data for machines, a strong relationship between urban form elements and data must be constructed. Considering the second step, the machine itself processes the converted data after training and building the model. Consequently, it gives details about what has been read.

The analysis conducted to build the relationship between theory and ml (in this case deep learning model) is defined twofold. As the first step of the research, it is aimed to train the machine learning model based on identified **shapes and sizes** of the urban block highlighted here. For the machine to get a human-like understanding of the urban block it is aimed to summarize the most common block types identified from the comparative literature. One single change in the component of the urban block creates another type based on shape and size and its structural configurations. Once the machine is trained with these configurations, it is expected to have automatic detection of similar compositions.

Numerical indices extracted by every single element of urban form bear great importance. Urban elements can be defined by geometrical components. Urban form is constructed by aggregation through time and built by combinations and variations of each element. The examples and mechanisms provided before seemed like if we train the machine only with one single variation would be enough, but for a machine to read all these variations and forms constructed by these variations and combinations, it is essential to provide an algorithm. Machines became advantages in this sense. Once it can understand the algorithm, it can read urban form for different contexts when efficiently trained.

Without demonstrating how the machine is working, it prevents us from understanding what type of information we can get from it. Basically, machines themselves work in systematic ways and networks. The detecting is based on recirculation of over and over evaluation until it gets effective output. It automatically uses the input, provides feature extraction and classification and gives us an output.

Based on the data structure presented above, this research aims to train the model using high-resolution raster imagery data in the city context. The first step is to train the model based on the size and shape of urban block types hinged on images. Following the accuracy of the results obtained in the first step, it is aimed to train the model with descriptive elements of the urban block. Based on the shape and size of the urban block types, a classification tree is summarized in order to train the model with different block types. Due to the program's limitation, instead of structural components and their combinations, variations based on shape and size became the first input for the model.

The steps are annotating the block types, training the model based on these annotations, and testing the model. As aforementioned, each block type is taken from real-life examples; annotations are defined based on these examples, such as cases of Barcelona, Paris, Berlin, etc. Annotations are structured straightforwardly so that model can go through the instance segmentation, and the ongoing process is presented as follows (see Figure 3).

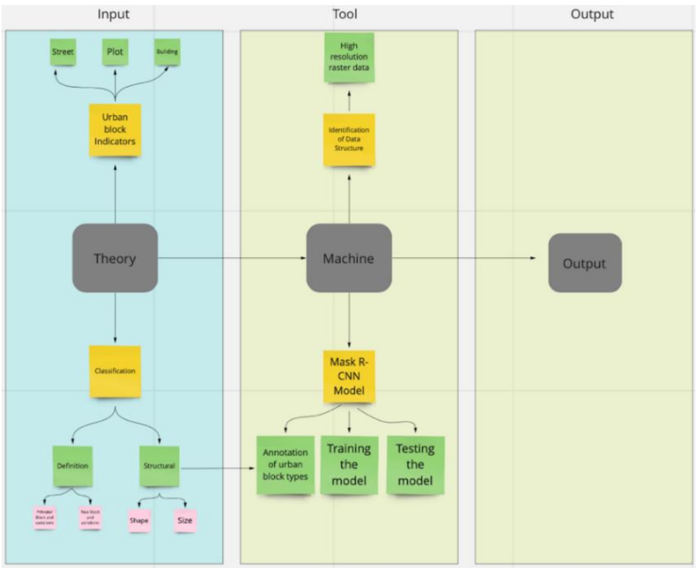

Figure 3. Workflow of the input-tool-output
Source: author's own work.

Discussion

Based on the framework presented here, a classification tree of urban block types is summarized. The most common block types and their relationships are identified considering the diagrammatical representations presented here. The analysis conducted to build the relationship between theory and machine is defined twofold. As 1st step of the research, it is aimed to train the machine learning model based on identified shapes and sizes of the urban block that is highlighted here. For the machine to get a human-like understanding of the urban block, the most common block types are identified from the relative literature. These types are used to train the model; however, results are not presented in this paper due to the ongoing process. As highlighted earlier one single change in the component of the urban block creates another type based on shape and size and eventually its structural configurations. It is expected to have an automatic detection of similar configurations once the machine is trained with different configurations (see Figure 3).

The detailed structural elements will be used to conduct the analysis based on testing the model. Here the relationship between these indicators and the tool is presented. In addition to the classification tree, an algorithm between the theory and tool was conducted. It is assumed that this algorithm can be adapted to other study contexts. It was not aimed to show details of the model but rather to present a guideline for the new application of the tool in urban morphology studies.

The ongoing process shows that although new technological tools play a critical role in the analysis of urban form, the application of these tools is still limited. The literature presented above shows that machines cannot be used for all means of analysis. Therefore, the process will be carried on based on the limitation of shape and size. In the future studies it is aimed to have a model also to test the constitutional elements of urban form.

Conclusions

New approaches in the urban morphology field show a need for further development of the process. Here is an algorithm between theory and machine presented to compile with the latest technological development. Although, in general, the street is at the core of the analysis, in this research, urban block and its relation with its constitutional elements are examined. Using a deep learning model to analyze the urban form is a new practice. Therefore building the bridge between theory and machine became vital. The systematization started from the analysis of theory on urban form and in more details of urban block. The following steps were to build the relationship. A thorough analysis of urban block is conducted from relative literature.

The steps followed, first to identify urban block indicators, second to define taxonomy and classification of the urban block and third to define guidelines for the deep learning model. The preliminary output is promising, but it is aimed to provide information on how to build an algorithm or a model to pave the way for further studies. The data structure and the selection of the indicators are defined so that they can easily be accessible and replicated. In further studies, it is aimed to present further details of the model and data structure that have been used for this research.

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