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Evaluation of Analysis Techniques for Decoding the Design Principles of Historic Environments

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Abstract

There is a complex relationship between many factors that shape the buildings in the historic environment, which is formed according to cultural lifestyles. Analyzing this complex relationship is important in revealing and documenting the design language of historic environments and creating a basis for new designs to be made in the environment. There are many specialized analysis methods for analyzing the design principles of the environment. The question of which attributes are to be extracted from the environment, what the scale of analysis is, and how the collected data will be processed are important in terms of which analysis technique to choose. In this study, ten analysis techniques, which are the most commonly used methods for historic environmental analysis, including visual analysis, image analysis, morphological, typological and typomorphological analysis, space syntax, shape grammar, fractal analysis, geographic information system (GIS) and data mining, are examined. Analysis techniques have been compared regarding their quality, scale, and opportunities, and their similarities and differences have been revealed. While some analysis techniques focus more on the building scale, others have shown more effective use at the urban scale. It has been observed that analysis techniques frequently used at both urban and building scales are often used together and form a bridge between them. At the end of the study, a comprehensive assessment of the existing body of knowledge in the literature has been made, providing a helpful background for researchers whose field of study is analysis in the historic environment.

1. Introduction

Historic environments present the cultural, social, economic, and architectural data of the society in which they exist in all spatial dimensions, including objects, buildings, building groups, and urban scale [1], by transferring them from the past to the present [2]. Preserving all the values contained in historic environments, transferring them to future generations, and integrating them with contemporary life ensures cultural continuity [3].

In forming the historic environment and the emergence of architectural formation, several cultural and social factors and religious needs or taboos are influential [4]. The identity and design principle of traditional environments is revealed through the question of which element is used in the historic environment, why and how, and the studies to find answers to this question. It is important to use specialized analysis methods to identify and document this design principle and create data for new designs in the environment.

Although there are many techniques to be used in analyzing the historical environment, the choice of analysis method is essential according to the purpose and scope of the analysis. Studies' most commonly used analysis techniques to reveal the historic environment's design principles are 'visual analysis, image analysis, morphological, typological, typomorphological, space syntax, shape grammar, fractal geometry, geographical information system, and data mining.'

The analysis techniques are available from the urban scale to the minor building scale (city, street, alley, open spaces, building communities, interior organizations, façade setup, etc.) and include different objectives to be achieved as a result of the analysis. There is no study in which these analysis techniques are collected, and their similarities and differences are revealed in the literature.

For this reason, this study aims to provide a base to help designers determine which qualities must be determined before starting the historical environmental analysis.

2. Method

The methodology of the study has five stages. First, a literature review on historic environmental analysis was conducted, and the analysis techniques used in the studies examined were evaluated. The analysis techniques were compared according to whether they worked at the city scale or building scale, and it was determined which design elements were revealed at the specified scales. These findings from the literature review were collected in a graph. At the end of the study, summary findings regarding the gains obtained from the graph and the literature review were presented. The graphical representation of the Method is given in Fig. 1.

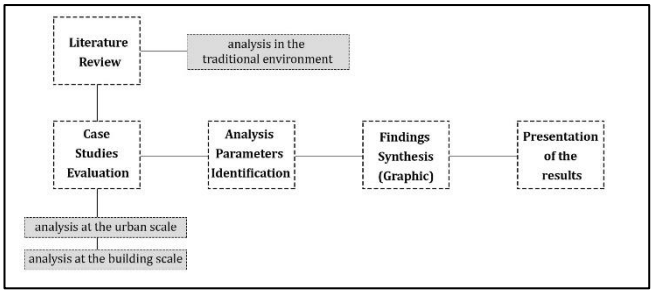

Figure 1. Research Framework

3. Analysis Techniques Used in Decoding The Historical Environment

The analysis techniques used in the historic environment make it possible to understand historic environments' physical characteristics and formal formations and analyze their social, cultural, and economic contexts. The main features and application examples of the techniques used in analyzing historic environments are discussed as separate summaries for each of the ten analysis techniques, supported by the visuals in the studies to serve as examples.

3.1. Visual Analysis

Visual analysis is used in many fields, such as art history, urban planning, and landscape design. In architecture, it is used at both urban and building scales. At the urban scale, it helps to analyze the unique geometric construction of building communities that come together in different ways and the spaces, streets, squares, etc., bounded by these building communities. At the building scale, it is possible to analyze mass movement and façade patterns such as proportion, scale, rhythm, and fullness-voidness with visual analysis [5]. Visual analysis can be done on basic design elements, design principles, and theories of visual perception. Fig. 2 shows an example of façade analysis related to the gestalt principles of similarity and proximity.

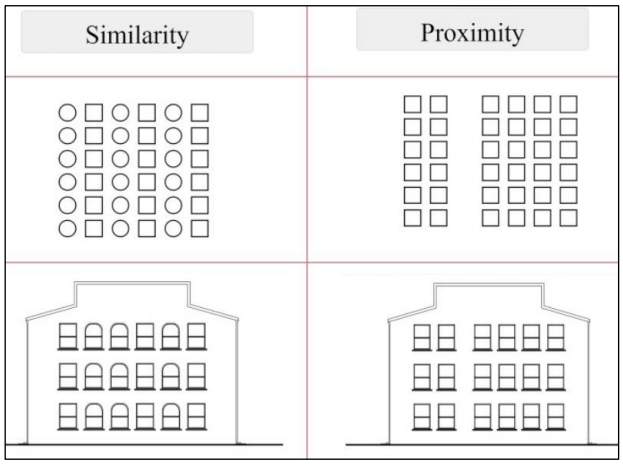

Figure 2. Facade analysis based on the Gestalt principles of similarity and proximity [6].

In visual analysis at the urban scale, situations such as the location of the building, the height of other buildings around it, and its harmony with the city silhouette can be analyzed. Visual analysis at the building scale can be divided into evaluating the building as a mass and analyzing the façade pattern.

In the mass analysis, the form of the floors that make up the building, the ratio-proportion of the building within itself and with the neighboring buildings, the symmetrical order formed by elements such as windows, etc., the dominance of elements that are more dominant than other elements in the building, the presence of elements that create mobility on the facade and elements that contrast with other building elements in the building, and whether the building can be handled as a whole can be analyzed [7].

In the analysis of the facade pattern, the rhythm created by the elements such as windows, moldings, struts, shutters, etc., on the facade, the continuity of the elements such as floor moldings, windows, doors, etc., the grouping of the elements on the facade according to whether they are similar or not, the separation of the material types used on the facade according to their color and texture, and the superiority of the materials used over other materials can be analyzed.

3.2. Image Analysis

Image analysis is a method that examines the perceptual effects of the physical environment on individuals and societies. The images that form the basis of environmental perception and spatial experience, as well as the mental maps that individuals create in their minds, are directly related to the organization of spatial elements. Kevin Lynch laid the foundation for the studies on the perception of the city. He evaluated the elements he called 'The City Image and Its Elements' under five headings as the elements used to define the urban texture [8]. These are districts that differ from others, edges that delimit these zones [8], paths between zones, nodes that are gathering, dispersal, and transfer points, and easily identifiable landmarks that residents cannot enter (Fig. 3). Whether a city is readable or not is revealed when these visual qualities are analyzed

according to their presence in the minds of the city's inhabitants [9]. Since image analysis is an analysis method designed to examine relationships at the urban scale, no studies analyze images at the building scale in the historic environment.

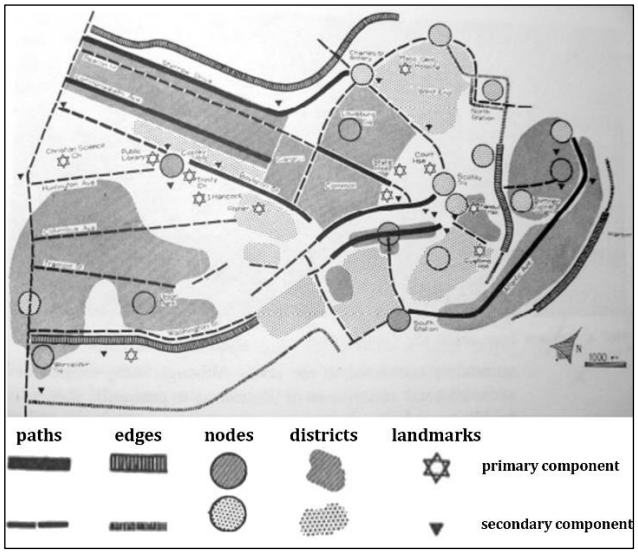

Figure 3. An examination of the Boston Peninsula in the context of Lynch's five headings [10].

3.3. Morphological Analysis

Morphological analysis is a methodology that focuses on examining the physical characteristics of space and their changes over time. Used in disciplines as diverse as urban planning, architecture, and geography, it provides a detailed framework for understanding the built environment's form, layout, and organization. The morphological analysis enables the analysis of the physical elements that define the urban form, such as streets, alleys, islands, parcels, open and green spaces, buildings, and building communities, and their changes over time based on factors such as history, culture, geography, etc. [11]. Fig. 4 shows an example of a study that analyzes the morphology of road networks in a given city.

Different methods can be used in morphological analyses, such as the 'Conzenian Approach' to urban morphology, the 'Moudon approach' based on building typologies, and the 'space syntax' that mathematically expresses the formation of the city. In the Conzen approach, a systematic layout that helps to analyze land and parcel use and streets and street systems is used to read the physical changes of urban elements. After mapping the regions at the urban scale, the typomorphological analysis phase begins, which involves a smaller scale and more detailed analysis. In typomorphological analysis, parcels, buildings, building-parcel relationships, land use, and building story heights can be analyzed [12]. Therefore, it can work simultaneously with typological-typomorphological analysis or space syntax.

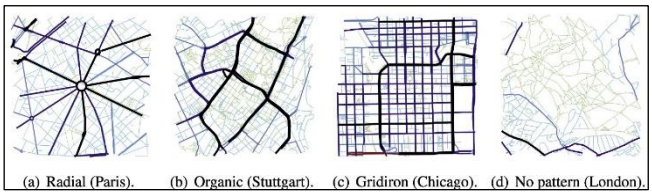

Figure 4. Morphological analysis of road networks [13].

3.3.1. Typological analysis

Building typology is the basis of urban research to understand the historic environment's structure [11]. Type and typology enable the development of a systematic view to understand urban structures at the city and building scale [14]. Typologies are an abstraction that defines the same elements in a neighborhood, street, or building [15].

The trends seen in specific periods and changing over time can be explained by typological analysis of facades and spaces. The researcher considers and analyzes all the buildings to be limited for the desired purpose as a concrete element [16] and creates typology tables in which the most common architectural elements are grouped. Typological analysis can be examined under three main headings [17]: environmental position, mass movement, and façade composition.

3.3.2. Typo-morphological analysis

The combination of typology and morphological analysis in the analysis of urban space is called typomorphological analysis [14]. Typomorphology, an approach that classifies and analyzes urban elements to understand the city's complex structure and historical evolution [15], is a field of morphology and reveals typologies of specific structures in the historic environment [18].

3.2.1. Space syntax

Space syntax, used to analyze spatial organization in the context of physical and social relationships, is a method developed for the morphological analysis of architectural structures [12]. It defines the spatial organization of regions, cities, built environments, and building groups at different scales and examines their interaction with social structure [9].

Space syntax involves four stages of thinking: representation, analysis, genotype, and finally, theory [19]. Representation is the stage of identifying spatial elements; analysis is the stage of determining the relationship between the elements that comprise the whole. The spatial elements in question are graphically represented, and their relationship is analyzed. Genotype is the stage of revealing common patterns in urban models, and theory is the stage of revealing general trends between different genotypes [20, 19]. The Space Syntax approach is based on four basic steps used to perform a structural analysis of a space [21]. These steps are called spatial units, axial maps, connectivity graphs, and color/coded representations. An example is shown in Fig. 5.

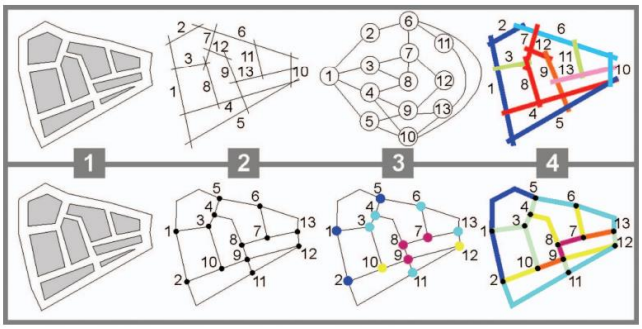

Figure 5. The four steps of the Space Syntax approach [21].

3.4. Shape Grammar

A shape grammar is an analysis technique that expresses how spatial organization occurs using tools such as points, lines, and surfaces [22] or a system of rules to create a design [23]. It can be approached in three ways: analysis, creation of new grammar, and synthesis studies that combine the two [23].

Analytical studies are carried out to examine the existing language of spatial organization to reveal the rules of design composition in abstraction [24]. Studies to create a new grammar are based on introducing and producing a new design rule (Fig. 6). Synthesis studies, on the other hand, reveal the rules of the existing architectural language and enable new productions from these rules [23]. Shape grammar studies in the historic environment can be carried out to create rule sets related to the composition rules of the plans and facades of traditional houses [25] and to produce design alternatives compatible with the environment by using these rule sets for new building design [26].

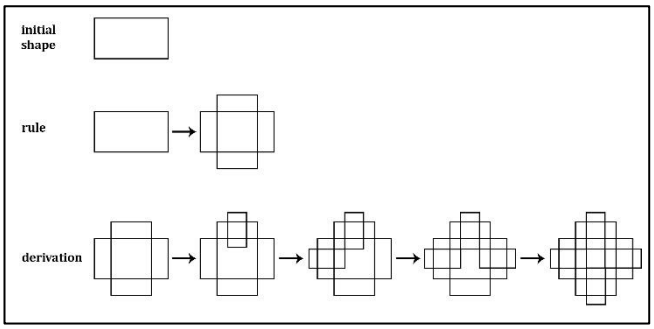

Figure 6. Shape grammar rule derivation model example

3.5. Fractal Analysis

Fractals are used to describe forms and shapes that are different from the forms of Euclidean geometry, such as circles, squares, and spheres, and cannot be defined by this geometry. Concepts related to fractal fiction are self-similarity, fractal geometry, generative algorithms and form grammar, and fractal dimension [27]. Fractal geometry is a mathematical form formed by combining complex and continuous details, and fractal geometry can mathematically define all kinds of objects [28]. In the field of architecture, it is frequently used to examine the change of design approach in housing [28], to investigate the effect of user change on the change of spatial fiction [29], and to reveal the differences and similarities of communities with different cultures and social lives through building façade constructions [27]. Fig. 7 shows an example of how a complex building façade is analyzed with the fractal method [30].

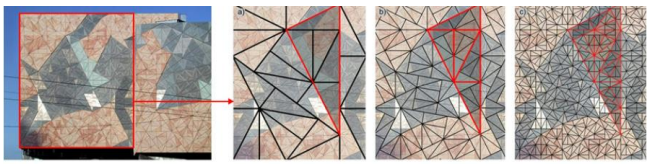

Figure 7. Fractal analysis of a building facade [30].

3.6. Geographic Information System

Geographic Information Systems (GIS), the first definition of which was made by Burrough (1998), is a system that enables processes such as storing, controlling, updating, analyzing, and visualizing geographical and spatial information of the earth to be used for a specific purpose in a computer environment [31]. Since the information stored in the system uses geographic coordinates, GISs can also be called map systems. However, depending on the scope of the field of study, not all information is geographical; it includes spatial information.

GISs can be used both as tools and systems. If the data obtained is analyzed and contributes to problem-solving, this defines it as a tool, and if all its features, including the design phase, are utilized, this defines it as a system [31]. The fact that it can analyze spatial data sets it apart from other computer-aided design tools [32]. Spatial data can be collected from maps, satellite photos, and tabular studies. Spatial analysis can include calculating the distance between specified points and area measurement. GIS systems map the information in the stored spatial data, reveal dominant repetitions, and predict how these data may change after a specific time. It is frequently used to analyze the city's complex structure and determine urban attributes [32].

3.7. Data Mining

In urban fabric analysis, the data mining method is very effective for analyzing and interpreting the data collected by methods such as GIS and finding the attributes and structure clusters that frequently occur together in the urban fabric. Urban plots with urban components (buildings, streets, neighborhoods) can be analyzed with a data mining method. They can be used to determine the possible uses of land in the urban renewal process [35].

4. Results

The analysis techniques used to analyze the historic environment involve a detailed study of spatial, visual, and typological elements. Each analysis method addresses different environmental dimensions, helping us understand how urban and built elements have shaped, evolved, and interacted. A graphic is presented to visually support the scope of the analyses and help

understand how these elements relate to each other (fig. 8), showing which elements and at what scale (urban or building) these analyses examine. The graph relates the analysis techniques to 'urban scale' and 'building scale' and shows the design parameters that each analysis method focuses on.

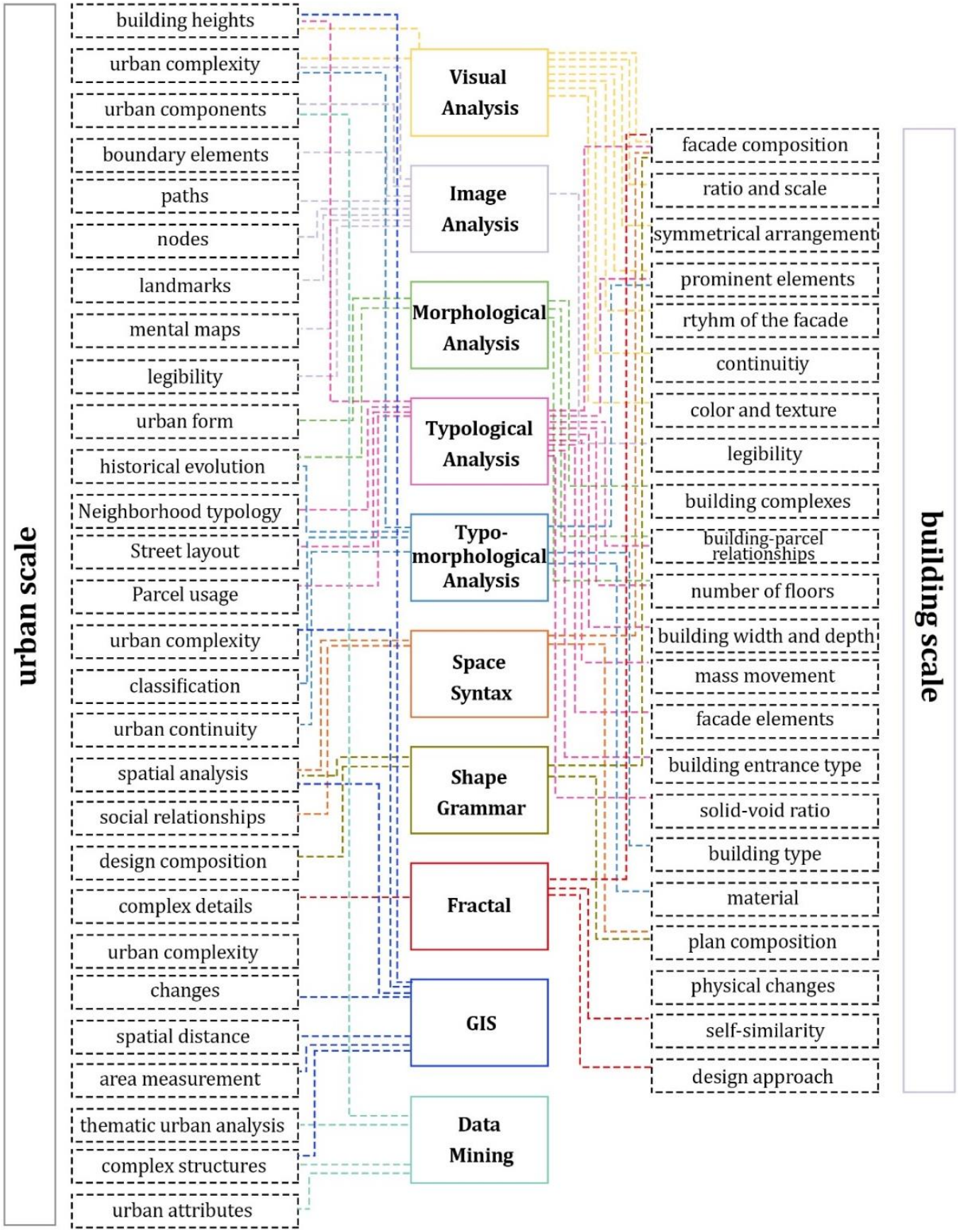

Figure 8. Analysis techniques relationship graph

When the analysis techniques are generally examined, it is possible to analyze at two different scales: urban and building scale. In the methods examined, more design elements can be analyzed at the building scale than at the urban scale. The reason for this is that when revealing the design language in a historical environment, the uniqueness of each building requires analysis at the building scale.

When we look at the studies analyzing the design principles of traditional environments, visual analysis and fractal analysis focus more on the building scale, while image analysis, GIS, and Data mining focus more on the urban scale. Morphological, Typological, and Typo-morphological space syntax and shape grammar analyses are frequently used at urban and building scales. In this respect, these analysis methods are not limited to the urban or building scale but form a bridge between both scales.

In line with the reviewed studies, a summary table has been created to explain which aspect of the different analysis techniques is more substantial (Table 1).

Table 1. Comparison of Analysis Techniques

Analysis technique	Advantages and strengths
Visual Analysis	Aesthetic and proportional evaluation of design elements at building and urban scale
Image Analysis	Determination of experience-oriented perceptibility of space at the urban scale
Morphological Analysis	Monitoring spatial changes over time at building and urban scale
Typological and Typo-morphological Analysis	Classification of architectural trends and formal relationships at building and urban scale
Space Syntax	Determination of the internal organization of traditional spaces
Shape Grammar	Understanding traditional design principles and creating new design rules
Fractals	Identification of similarities and differences between historic structures
GIS Data Mining	Large-scale data analysis

5. Conclusion

It is possible to document the historic environment for its preservation and build new structures that can provide cultural sustainability by analyzing the attributes of the environment. Many techniques have been used to analyze the historical environment. Analyzing the historic environment provides in-depth insights into environmental design and spatial relationships. This type of analysis allows us to reveal the relationships between buildings and individual buildings' form and functional characteristics. The analysis techniques used to analyze the historic environment involve a detailed examination of spatial, visual, and typological elements. By addressing different dimensions of the environment, each method of analysis helps us to understand how urban and structural elements have shaped, evolved, and interacted with each other.

In this study, ten methods of historic environmental analysis were extracted from the literature review. In order to summarize the extent to which the methods are used in urban and building scales, which design parameters can be analyzed, and which purpose of analysis they can serve, the studies in the literature were examined in depth. At the end of the study, researchers are provided with a summary of which analyses can be used for which purposes.

Although the reviewed studies generally use a single analysis method, in most cases, the analysis techniques mentioned above should be used together to analyze a complex system such as a historical environment. Using various analysis methods in a complementary manner enables historical environments to be handled with a holistic understanding. For example, after the original architectural elements used in the historic environment are identified through visual analysis, typology studies can be conducted to group the architectural elements found. Alternatively, after the formation rules of traditional façades are abstracted using the shape grammar method, the dimensions of the façade elements can be examined with morphological analysis.

This study is the result of examining thirty studies in the literature review. It will be helpful for future studies to update the study by adding new studies due to the increase in the number of studies examined and the development of new analysis methods due to increasing technological developments.

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Author contributions

Saliha Erdurmuş: Conceptualization, Methodology, Field study **Arzu Özen Yavuz:** Data curation, Writing-Original draft preparation.

Conflicts of interest

There is no conflict of interest between the authors.

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