



REPUBLIC OF TÜRKİYE

ALTINBAŞ UNIVERSITY

Institute of Graduate Studies

Architecture

**ANALYSIS OF THE CIRCULATION
STRUCTURE OF GRAND BAZAAR THROUGH
SPACE SYNTAX AND SEMANTIC
SEGMENTATION**

Nour ALSAYED

Master's Thesis

Supervisor

Asst. Prof. Dr. Can UZUN

Istanbul, 2023

**ANALYSIS OF THE CIRCULATION INTEGRATION
THROUGH PEDESTRIAN ANALYSIS IN THE GRAND BAZAAR IN
ISTANBUL**

Nour ALSAYED



Architecture

Master's Thesis

ALTINBAŞ UNIVERSITY

2023

The thesis titled ANALYSIS OF THE CIRCULATION STRUCTURE OF GRAND BAZAAR THROUGH SPACE SYNTAX AND SEMANTIC SEGMENTATION prepared by NOUR ALSAYED and submitted on 17/04/2023 has been **accepted unanimously** for the degree of Master of Science in Architecture.

Asst. Prof. Dr. Can UZUN

Supervisor

Thesis Defense Committee Members:

Asst. Prof. Dr. Can UZUN

Department of Architecture,

Altınbaş University

Asst. Prof. Dr. Çağda ÖZBAKİ

Department of Architecture,

Altınbaş University

Asst. Prof. Dr. Orkan Zeynel GÜZELCİ

Department of Interior
Architecture,

Istanbul Technical University

I hereby declare that this thesis meets all format and submission requirements for a Master's thesis.

Submission date of the thesis to Institute of Graduate Studies: ____/____/____

I hereby declare that all information/data presented in this graduation project has been obtained in full accordance with academic rules and ethical conduct. I also declare all unoriginal materials and conclusions have been cited in the text and all references mentioned in the Reference List have been cited in the text, and vice versa as required by the abovementioned rules and conduct.

Nour ALSAYED

Signature

DEDICATION

To my dear professor who did not hesitate to guide me with all of his experience and knowledge since the starting of my thesis and was always doing his best to make this journey easier and more fun my thesis advisor Asst. Prof. Dr. Can Uzun.

To the ones that always believed in me and no matter what they encouraged me to pursue my dreams and be the person I am now to my biggest supporters through my educational life to my family my father Tarek Alsayed, my mother Lina Shehade to my sister Tamara Alsayed and my brother Eyad Alsayed.

To the one that supports me unconditionally the one that believed and made me believe we can achieve everything together the one that has been always by my side especially through my hard times my husband Fatih Şureyyif.

To all the professors that taught and advised me through my academic life.

Thank you all, without you I wouldn't be able to complete this work.

ABSTRACT

ANALYSIS OF THE CIRCULATION STRUCTURE OF GRAND BAZAAR THROUGH SPACE SYNTAX AND SEMANTIC SEGMENTATION

ALSAYED, Nour

M.Sc., Architecture, Altınbaş University,

Supervisor: Asst. Prof. Dr. Can UZUN

Date: 04/2023

Pages: 88

Shopping is a social activity in which people build bonds with each other in exchange for the fulfilment of some of their needs. The turns that occurred to the human's lifestyles as they moved from living individually to living in groups have arisen many new demands that needed to be met.

The act of shopping has been propelled by changing and expanding necessities and desires, resulting in the development of more structured and organized spaces and infrastructures.

Within the scope of this study, first of all, the Grand Bazaar in Istanbul, the development of this bazaar in the process of integration with the space and the active criteria in the design of the bazaar were examined. Then, the spatial analysis were applied, in which the spatial organization of the bazaar can be explained and classified with numerical data, those analysis were done using space syntax and semantic segmentation, The aim of the study is to examine the circulation organization that have been going on since the past of the Grand Bazaar through the pedestrian analysis, and then comparing the analysis results in order to have a better understanding of it.

Keywords: Istanbul Grand Bazaar, Spatial Analysis, Semantic Segmentation, Space Syntax, Correlation.

TABLE OF CONTENTS

	<u>Pages</u>
ABSTRACT	vi
LIST OF TABLES.....	ix
LIST OF FIGURES.....	x
LIST OF CHARTS.....	xii
ABBREVIATIONS.....	xiii
1. INTRODUCTION	1
1.1 CASE STUDY: GRAND BAZAAR IN ISTANBUL (KAPALIÇARŞI)	2
1.2 MORPHOLOGICAL DEVELOPMENT OF GRAND BAZAAR	5
1.3 PROBLEM STATEMENT	8
1.4 AIM OF THE STUDY	8
2. METHODOLOGY	11
2.1 SPACE SYNTAX.....	12
2.2 SEMANTIC SEGMENTATION.....	15
2.3 CORRELATION	19
3. CIRCULATION ORGANIZATION OF THE GRAND BAZAAR.....	21
3.1 HISTORICAL DEVELOPMENT OF THE GRAND BAZAAR.....	21
3.2 GRAND BAZAAR STREET ORGANIZATION.....	26
3.2.1 Gates of The Grand Bazaar	26
3.2.2 Street Planning	33
4. SPACE SYNTAX OF THE GRAND BAZAAR	38

4.1	CONNECTIVITY ANALYSIS OF THE GRAND BAZAAR	39
4.2	VISIBILITY ANALYSIS OF THE GRAND BAZAAR	40
5.	SEMANTIC SEGMENTATION OF THE GRAND BAZAAR.....	43
5.1	SEMANTIC SEGMENTATION OF GRAND BAZAAR INTERSECTION POINTS	43
6.	CORRELATION OF THE ANALYSIS.....	47
7.	RESULTS.....	53
	REFERENCES	60
	APPENDIX A.....	65
	APPENDIX B.....	75

LIST OF TABLES

	<u>Pages</u>
Table 6.1: Resulted Normalized Values of The Analysis	49
Table 6.2: Heat Map	52



LIST OF FIGURES

	<u>Pages</u>
Figure 1.1: The Grand Bazaar of Istanbul Location.....	4
Figure 1.2: Landmarks Near The Grand Bazaar.....	5
Figure 1.3: Depiction of Grand Bazaar From Miniature By Matrakçı Nasuh (1533-1537)..	6
Figure 1.4: Mercan Gate	7
Figure 1.5: Timeline of The Fires and Earthquakes Damaging The Grand Bazaar (Hamza, 2022).....	8
Figure 2.1: Flow Chart of The Methodology	11
Figure 2.2: Depthmap Application, Museum for Decorative Arts, Frankfurt (Maria Doxa, 2000)	14
Figure 2.3: Map Analysis Diagram of Traditional Antakya Houses and TOKI Houses (Ergün Et Al., 2022).	15
Figure 2.4: Example of Self-Driving Car (Semantic Segmentation, 2021).....	16
Figure 2.5: Segmentation of Medical Images (Raj, 2019)	17
Figure 2.6: Segmentation Through Satellites (Raj, 2019).....	17
Figure 2.7: Convolutional Encoder-Decoder (Beginner’s Guide to Semantic Segmentation, 2023).....	18
Figure 2.8: Correlation Analysis (Gogtay & Thatte,2017).....	20
Figure 3.1: Grand Bazaar’s Bedestans	21
Figure 3.2: Grand Bazaar’s Morphological Changes	22
Figure 3.3: Grand Bazaar 1886-1887 Plan (Dilaveroğlu & Pilehvarian, 2022).	23
Figure 3.4: The Main Axes of The Grand Bazaar	25

Figure 3.5: Grand Bazaar Gates	27
Figure 3.6: Grand Bazaar Street Organization at 2000s (Köroğlu, 2010).....	34
Figure 4.1: Connectivity Analysis of The Grand Bazaar Using DepthmapX	40
Figure 4.2: Visual Integration Analysis of The Grand Bazaar Using DepthmapX.....	41
Figure 4.3: Scatter Plot Analysis of The Grand Bazaar Using Depthmapx	42
Figure 5.1: Intersection Points of The Grand Bazaar	44
Figure 5.2: The Results of Semantic Segmentation in Excel	45
Figure 5.3: Citycapes Classifications	46
Figure 6.1: The First Developed Excel Sheet of The Analysis Values	48
Figure 7.1: Human Score Plan.....	53
Figure 7.2: Connectivity Value Plan	54
Figure 7.3: Visibility Value Plan.....	55
Figure 7.4: Comparison of Plans	56
Figure 7.5: 3D Presentation of The Plans and Values	57

LIST OF CHARTS

	<u>Pages</u>
Chart 7.1: Values Comparison	58



ABBREVIATIONS

CNN : Convolutional Neural Network

2D : Two Dimensional

VGA : Visibility Graph Analysis

AI : Artificial Intelligence

DXF : Drawing Format



1. INTRODUCTION

Istanbul Grand Bazaar, is a renowned cultural landmark on Istanbul's historic coastline along with its distinctive environment, historical importance, and exhaustive cultural features (Yalinay et al., 2018), The Grand Bazaar, which is located in a region of the city that has maintained its importance since ancient times, is a covered grand bazaar located between Nuri osmaniye and Beyazıt, with two bedesten in the main core. The great bazaar with its old name "Çarsuy-i Kebir" is an important complex of buildings that have survived from the date of "Fatih Sultan Mehmet ".

The Grand Bazaar, which is standing as a building complex after it was transformed to masonry, expanded as a result of the articulation of the shops around the bedesten and the hans over time after the process that started with the first nucleus (the bedesten), and spread along the streets and took its current form. The grand bazaar has been an urban reformer economically and maintained its dynamism for decades. In terms of designs or remodels for redevelopment, The Grand Bazaar has always served as a model and will continue to do so for future shopping centres (Kocaili,2010).

In this thesis the main subject will be to discuss the circulation of the grand bazaar along with the integration of the inner-outer circulation with the pedestrian movement of the visitors of the grand bazaar.

In the first chapter the research area will be discussed which is the Grand Bazaar in Istanbul along with the morphological change of it, then the problem statement will be explained and the aim of this study, In the second chapter the methodology used for this research will be discussed, in addition to a general description about the analysing programmes used in the research, then at the third chapter the circulation organization of the grand bazaar in Istanbul will be discussed from the aspects of its historical developments, its gates arrangement and its street organization, after that at the fourth chapter the space syntax method will be explained, how it was utilised to analyse the circulation of the grand bazaar, In the fifth chapter the implementation of semantic segmentation to the photos of the grand bazaar will be described with the output data of it, and In the sixth chapter the results of the done analysis will be shown and explained in addition to the methods used to compare it, finally at the seventh chapter the outcomes of the comparison of the analysed results will be discussed.

1.1 CASE STUDY: GRAND BAZAAR IN ISTANBUL (KAPALIÇARŞI)

The word *Çarşı* is the combination of two words that forms the word Cihar-Suk which literally means “four” which is *cihar* in Persian and the word *souk* In Arabic, which means “bazaar”, as it was expressed in the sources (Hasol,1995). Today, it is also used in Persian in this way. However, In Persian, direction means *cihet*, and the word *sû* and *cihar* It comes from the word *cihar-sû*, which means four sides, which is formed from the unification that is also etymologically correct. Because of the similarity of the word *sûk* to the word *sû*, the word *çarşı* it can be thought that its origin has arisen (Hasol,1995). The reason the Ottomans favored the term "*Çar'su*", or "*Çarşı* " in Modern Turkish, is that the Cevahir bedestan, which serves as the Grand Bazaar's focal point, has four gates that face four streets (Aygen, 2015). So, it is indicated that the name of the bazaar was directly related to the circulation system of the bazaar (the gates of the bedestan).

Apart from the derived origin and terminological meaning of the word *Çarşı*, what needs to be stated when examining the word in terms of its use in the Ottoman Empire is the history of the word due to the fact that it is used to express different meanings When there is a need to define the area or structure specified as the *Çarşı* by referencing documents and sources, it is the definition confusion that arises. Likewise, according to (Aygen, 2015) in historical sources, there are other areas or structures that we define as *Çarşı* today. it is understood that the words *Çarşı* is used for the small businesses in the vicinity, for the region consisting of shops or for the movable areas consisting of most worktops, and for the more comprehensive trade areas. However, it is seen that these definitions, which did not have very sharp boundaries even for that period, were later used intertwined with each other both in the folk language and in official documents and in the sources obtained.

Some descriptions of the *Çarşı* as the whole group of buildings with a bedesten in the centre and surrounded by shops, workshops, inns, baths, imarets, mosques and hospitals belonging to various groups of artisans, *Çarşı* is the most active shopping centre of the city all day long. A long main street and it consists of more narrow streets that lead to this street. The shoppers and business owners consider the ease of preserving their place, as much as the possibilities allow. All kinds of goods and services produced in the city are located here. Each of the side streets leading to the main street produces goods and services in a separate business line. usually devoted to artisan organizations (Küçükkömürcü, 2005).

Aygen (2015) mentions that while the origin of the word Bedesten comes from "*Bezistan*" and "*Bazzazistan*". In Arabic *bez* or *bezzaz* (cloth seller) and *bezistan* is the (land of cloth). The word *bezistan* was called on the places that sold fabrics and precious goods later transformed to *bedesten* in Turkish language. Bedesten is a guildhall, a meeting space for guilds and craftsmen; in the past, the word "guild" meant craftsmen (Aygen, 2015). Where according to (Ceylan,1989) these structures, due to their structural properties, are used to sell and store valuable items, and there have been structures in which documents have been archived in it. Bedesten used to be a bank, a stock market. The people used to keep their money, jewels and precious papers here.

As (Wohl, 2015) mentioned the bazaar began to function under the Ottomans' vakıf system (religious foundation), in which the vakıf enabled the establishment of the bazaar with funding drawn from charitable donations and then collected rents from merchants. The sultans, their mothers, and high-ranking state officials established these religious foundations in the Ottoman Empire's towns and cities in the early days. These institutions, which were financially and organizationally independent, were in charge of establishing commercial and cultural facilities in conquered towns.

Hamza (2022) states that the Grand Bazaar, which grew alongside the growth of the city, was, until the 19th century, an incomparable marketplace in terms of the quantity, diversity, and quality of its items (Hamza, 2022). It continues to be a vibrant, resilient location for retail and products trading, in addition to its structural design and connectivity with its surrounding, surviving numerous massive fires, earthquakes, and socioeconomic disturbances, these qualities made the Grand Bazaar an important station of the Silk Road in history. According to (Suver, 2019) in the past, there were professionals and merchants working in a certain discipline in every street. It was a place where the guild system was fully implemented. There was no competition in price and the manufacture of products was not shown to the customer. In the bazaar, the business and moral rules that passed from father to son were kept alive. The state determined the price of the product, and the goods were not sold above the specified price.

As (Wohl, 2015) mentioned the Bazaar which was founded in 1454 by Ottoman Sultan Mehmed II, has functioned as Istanbul's economic centre for centuries and is an important social centre today, also he mentions that the location of the bazaar was initially chosen in

accordance with Byzantine city settlement patterns in an area that had already established itself as a major commerce hub. The site of the Istanbul Bedesten, the earliest portion of the bazaar (next to the Imperial Road, now Divan Yolu) (Figure 1.1), preserved historic trading patterns.

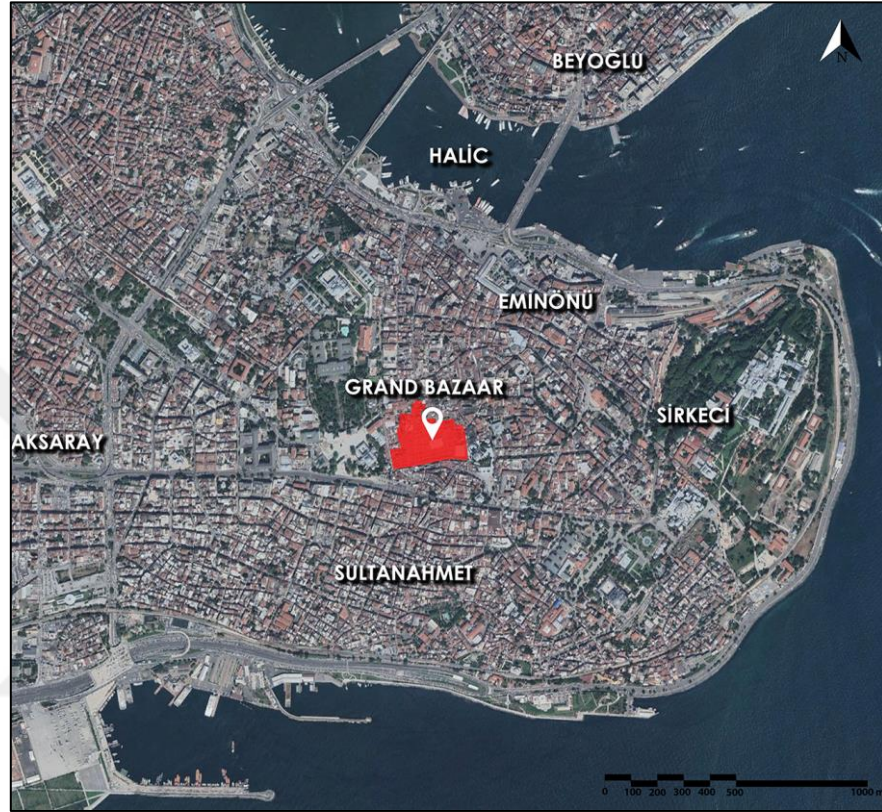


Figure 1.1: The Grand Bazaar of Istanbul Location.

As we can see a variety of landmarks and other important land uses, such as the old shore on the Golden Horn, have important connections to the Grand Bazaar. It is located in the middle of a geographical region that is bordered from three edges by adjacent bodies of water with additional border that includes a large portion of the old metropolitan area, is created by the link of a main artery bridge to the west.

While there are numerous factors that affect The Grand Bazaars' capacity to continue operating as it has for centuries, its integrity as an urban public space is what matters most to us. In addition to having a wide range of stores and public areas, The Grand Bazaar has complex pedestrian accessibility.

1.2 MORPHOLOGICAL DEVELOPMENT OF GRAND BAZAAR

The Grand Bazaar (Kapalıçarşı), has always held a special location in Istanbul and the world, The Grand Bazaar, which has been around for 600 years and is part of Istanbul's historical peninsula, being an exceptional representation a vital trade centre. The bazaar, which is located in the Fatih district and extends between the mosques of Beyazıt and Nuruosmaniye (Figure 1.2), reaches from west to east with two bedestens in its main core.

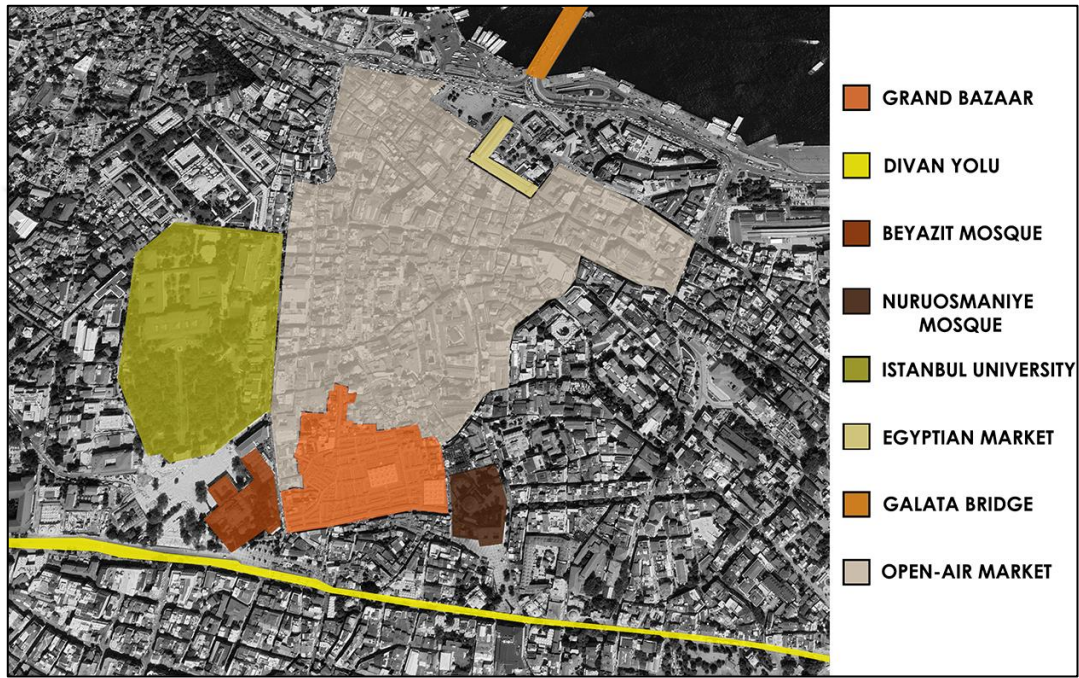


Figure 1.2: Landmarks Near the Grand Bazaar.

Küçükkömürcü (2005) indicates that Although a significant number of the current grand bazaar shops were built during the reign of Fatih Sultan Mehmet, no information about the cover of the streets in front of the shops is found in the old sources since the architectural examination of both existing bedestens and the surrounding streets in the Grand Bazaar makes it clear that the construction of them was not initially done in the form of veiled streets (Küçükkömürcü, 2005). (Figure 1.3) and the vaulted Grand Bazaar in the Era of Fatih became the largest trade centre with two bedestens, that were the main core.

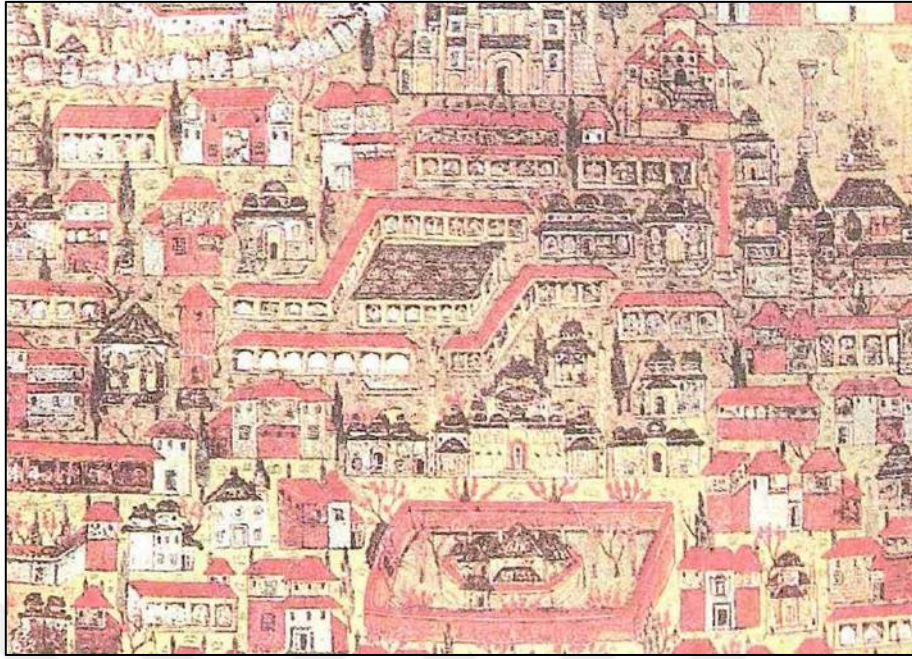


Figure 1.3: Depiction of Grand Bazaar From Miniature By Matrakçı Nasuh (1533-1537).

As (Küçükkömürcü, 2005) suggested that the first shops are made of wood However, the bazaar without covers of the streets was damaged by fire, which is the eternal problem of Istanbul, and burned many times, only the masonry structures survived these fires.

Streets around the bedesten were established by several guilds as places where traders may offer their goods. These commercial avenues grew throughout time in response to the needs of an increasing population. Hans were constructed to act as central storage facilities for shipments meant for a certain trade or organization. As a result, the bazaar was divided into guild streets (zoned by trade), Hans that surrounded the outside and acted as central warehouses, and bedestens that were utilized as vaults and storage facilities for valuable commodities (Wohl, 2015).

The Grand Bazaar has already had many fires and earthquakes that caused damage, and (Müller- Wiener, 1977) mentioned that the impacted areas have constantly been reconstructed. In order to protect traders and their products and to protect the bazaar from flames, the Law of 1696 was established and various areas of the bazaar between the borders of Cevahir and Sandal bedestens were vaulted.

There is an inscription from 1151 on the shape and fountain on the side of the “Mercan Gate” (Küçükkömürcü, 2005) (Figure 1.4). In addition, the inscription on the fountain opposite the door facing the street in the bazaar on “Kalpakcılar Street” indicates that these parts were developed 290 years after the first facility of the bazaar, in the “Fatih” era. While the whole bazaar used to be covered with lead, today there are no lead roofs anywhere but bedesten, and over time they all turn into bricks.



Figure 1.4: Mercan Gate.

Küçükkömürcü (2005) suggested that all the shops of the bazaar were made on different dates. And the wooden construction that started in the “Fatih” era continued for too many eras, she also mentions that its known that additional shops were built in the bazaar during the reign of Sultan Suleiman (Küçükkömürcü, 2005), so we can understand that the Grand Bazaar is a widespread bazaar that grows over time with a focus on bedestens

The development of the grand bazaar was affected by fires and earthquakes since many parts of it were demolished and built again, even though the main structure was kept according to (Wohl, 2015). The covered market first appeared in its current form around 1750’s, But the earthquake that happened in 1894 unfortunately diminished the size of the market; as a result, certain streets such as the (book market) that were originally included inside the bazaar were now outside of its borders.

The last big restoration took place following a fire in the 1950s, although notwithstanding severe damage, the rebuilt structure maintained its original constructed form (Wohl, 2015). As in (Figure 1.5) it illustrates the series of the fires and earthquakes that the Grand Bazaar has gone through over the history.

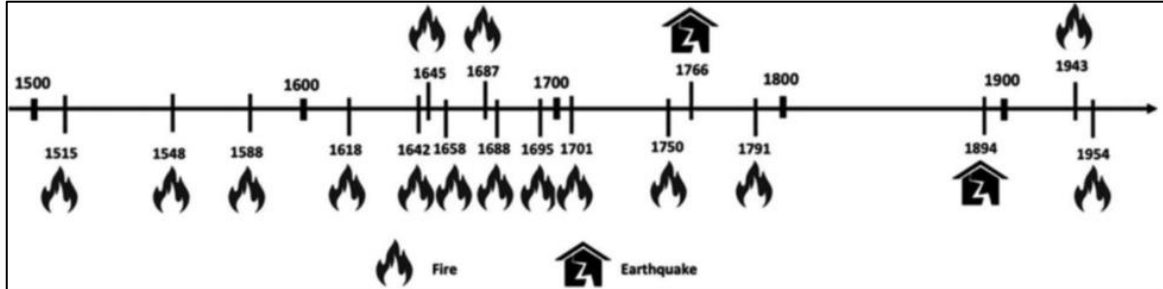


Figure 1.5: Timeline of The Fires and Earthquakes Damaging the Grand Bazaar (Hamza, 2022).

Today the bazaar has over 4,000 stores and 61 streets on about 75 acres. Numerous supporting facilities, including hans, restaurants, cafés and mosques, are located in this neighbourhood (Wohl, 2015). A continuous open-air market is created by the streets that surround the bazaar. The lines between these internal and external streets are occasionally distinct and other times ambiguous. (Wohl, 2015) also mentioned that for example some of the bazaar's streets are inside the original gates but are still unpaved, while in other instances, streets that are now covered are beyond the bazaar's walls.

1.3 PROBLEM STATEMENT

Being one of the oldest and largest historical trade centres in the world, as well as having a very distinctive location, were the focal points considered while choosing the grand bazaar as the area of the circulation analysis, along with the way the bazaar is integrated in the urban tissue of Istanbul city. Following these definitions, the problem statement of the thesis focuses on two questions as how these connections developed from the outside to the inside of the bazaar, and to understand how the circulation of the bazaar affected the pedestrian movement in it.

1.4 AIM OF THE STUDY

It is accepted that trade centres are the most important centre that forms the city core in history; The primary purpose of the study is to conduct research on the circulation and spatial organization of the Grand Bazaar, whose spatial history dates back to the Roman Period, the

core of today's spatial order, which was established in the 15th century and continued its architectural development until the 19th century, and its location in the city.

The Grand Bazaar, which has maintained its place in the walled settlement with all its vitality among many monumental works over the centuries, is looked at as a focal point for the bazaars of the city and the need for a comprehensive study that examines its circulation organization emerges at this point. As a result of the literature reviews carried out so far, it has not been determined that there is a comprehensive study in which the detailed analysis of the circulation of the bazaar is included, a general analysis is made in this context with the transfer of information about the urban positioning and basic features of the bazaars in the historical process, revealing the architectural development of the Grand Bazaar over the centuries and revealing its relationship with its surroundings, And at this point, this thesis focus is to analytically studying the circulation of the Grand Bazaar. The motivation of the study is to understand the structure of the Grand Bazaar circulation.

This study acknowledges how using the multidimensional comparative models of pedestrian movement for identifying diverse data and various factors of the urban environment might produce an outcome that would clarify the functionality of the urban dynamics and would be a useful tool to develop quite habitable and social urban environments in the future.

By comparing the data results of the analysis done using Space Syntax and Semantic Segmentation then evaluating the findings of this comparison will be as the starting point for more in-depth investigations that could be conducted on particular populations and types of buildings using case studies in order to evaluate the circulation of a space.

The aim of this study is to analyse the circulation organization of the grand bazaar by utilizing stimulations which are “space syntax” and “semantic segmentation” , analysis results are compared and combined in order to visualize and display the neglected and unrecognized aspects of the circulation system of the grand bazaar.

The models used in this analysis ability to depict pedestrians’ motion in a layout as an animation is one of its key features. In order to categorize and identify the essential elements that Should be taken into account when analysing the circulation structure of grand bazaar in general, and to show how closely which element relate to the circulation of the grand bazaar The literature review played a crucial role in establishing a higher level of consistency

in terms of generic space dimensions and categories, as well as in arranging the key spatial functional aspects.

After introducing the grand bazaar and its morphological history, and explaining why it was chosen to be the case study of this research and what the aim of this study is. In the next chapter the methodology used for this research will be discussed in terms of which methods are used and why those methods where used to conduct the circulation structure analysis.



2. METHODOLOGY

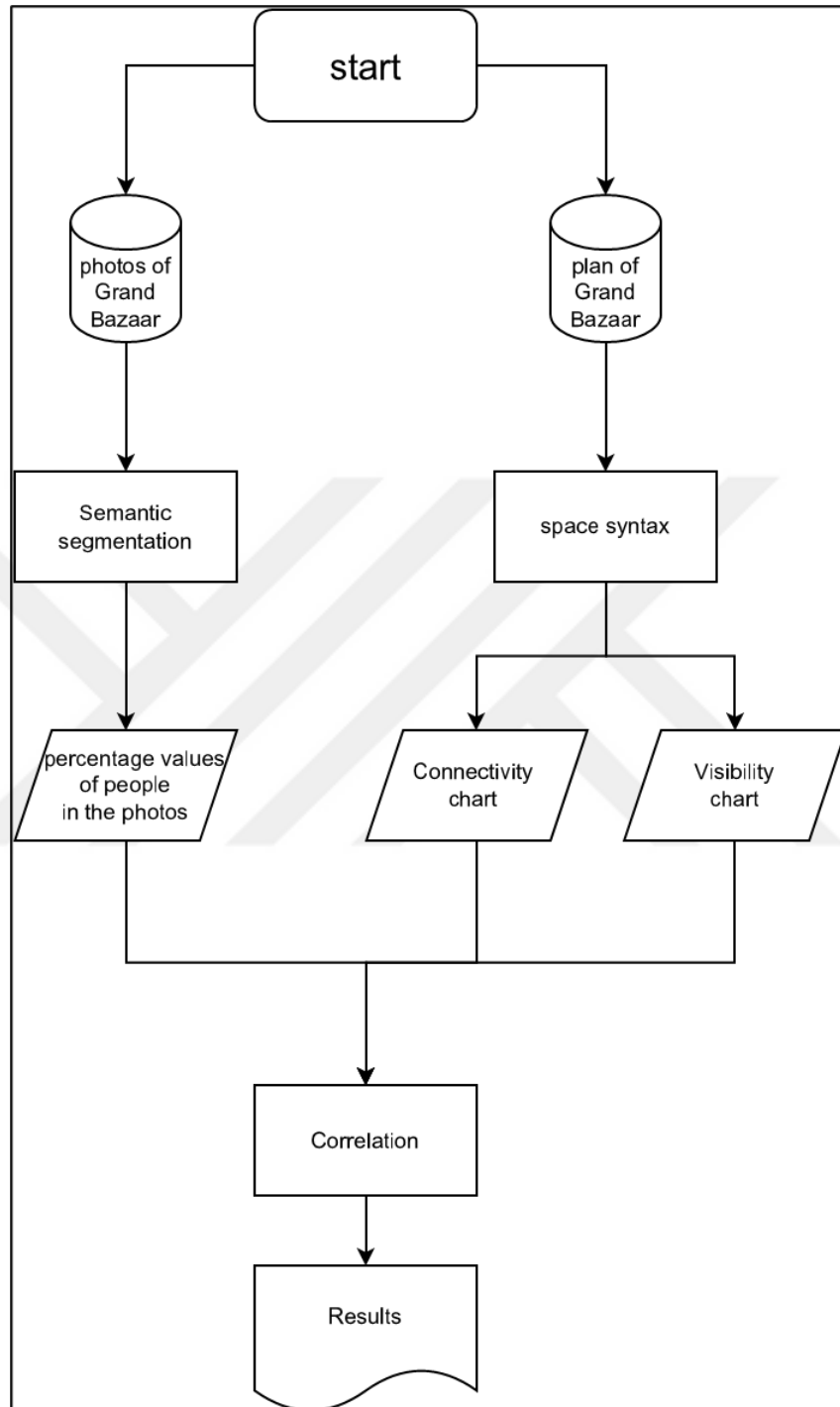


Figure 2.1: Flow Chart of The Methodology.

As shown in the flow chart (Figure 2.1), the starting point of this study is gathering the data needed to start the analysis, and that is by drawing the plan schema of the grand bazaar and taking photos of the intersection points in the Grand Bazaar.

The next step is starting the analysis, space syntax analysis is done using the 2D plan of the grand bazaar and the semantic segmentation is done using the photos of the grand bazaar. Those analysis results are represented as the connectivity chart and the visibility chart that is conducted from space syntax analysis, and segmented photos with the percentage values of the categorizes are the results of the semantic segmentation.

Then those results are analysed in a correlational way in order to find the relation between the conducted analyses and then present those correlation results at the end.

2.1 SPACE SYNTAX

Space syntax method according to (Hiller&Hanson,1984) is a theory about space as a combination of analytical, statistical, and interpretive methods for analysing how space is organized in cities and buildings. It is possible to obtain understanding in both the social origins and implications of spatial layout in the city or in buildings varying from houses to any major structure by learning to manage the spatial component at the level of the complex designs of space that make up the city.

By utilizing space syntax theory Hillier and Hanson were able to demonstrate how social connections and physical environments are linked. Spatial organizations are carried out with the use of space syntax in order for individuals to describe the similarities and contrasts in a building.

The structured space, often in the format of building plan layouts or urban tissue plans, is the major focus of evaluation in space syntax analysis (Bafna, 2003). Civilizations employ space as an essential and vital component in structuring themselves, which is the reference point for space syntax. Which is defined as the act of converting a flowing space into a linked network of separate units.

As (Bafna, 2003) mentioned various classifications can be assigned to different regions of the space, and these regions can subsequently be attributed to several groupings, individuals, or activities; multiple restrictions of behaviours and practices can be connected with various

regions of the space; and specific sections of space can be identified as containing a special symbolism or cultural significance. (Ruohonen, 2013) indicates that the analysis of spatial organization at various dimensions, including buildings, building complexes, communities, urban districts, and people's movement inside these places is done using the theory of space syntax, which is based on graph theory that treats each space as a point (corner) and depicts connections as lines.

As the main purpose of space syntax is to give an objective approach for representing a building's continuous spatial layout in relation to how we use it. Those was used to study the circulation structure of the Grand bazaar using the “depth map” software in order to understand the spatial organization of the grand bazaar. Also, those analysis were made to cover many aspects that may be affecting the pedestrian movements in the Grand bazaar.

According to (Turner et al., 2001) Depthmap is computer software developed at Space Syntax Lab to create visibility analyses of architectural and urban systems. Depthmap creates a map of visually integrated areas within itself. And it is capable of performing a series of regulatory analyses called the spatial syntax umbrella. Spatial constellation tests the relationships between parts of space, creates a graphical representation of each spatial part, and finally analyzes using this generated graph.

Depthmap arose from two lines of thinking. The first was isovist analysis (Benedikt, 1979), and the second was space syntax (Hillier & Hanson, 1984). Benedict created feature maps of visible areas from points within the plans of buildings. Benedict drew contours equal to the visible area in the plan and named the map result a visible area. then, Hillier and Hanson developed the concept of space syntax, creating different representations of the components of space, and then mapping these components and evaluating the relationships of the components with each other. Later Turner and his colleagues made the decision to combine space syntax and isovist analysis to provide an integrated visible measurement of an ambient plan. The method was later named visibility graph analysis, VGA. The graph is constructed with other points that are integrated with each point.

Depthmap is used to create visibility graph analysis of spatial environments. The software allows the user to enclose a 2D drawing in the graph and fill the open spaces of this layer with grid points. The user utilizes the software to create a visibility graph, to represent the

visible connections between these point locations. with each point connected to every other visible point. Every space inside the pattern would then be classified according to its inter-visibility. (Figure 2.2) shows a Depthmap application from the Museum for Decorative Arts.



Figure 2.2: Depthmap Application, Museum for Decorative Arts,
Frankfurt (Maria Doxa, 2000).

Also, we can see in this case study of (Ergün et al., 2022) which was made to compare between the traditional houses of Antakya and the TOKI houses (social housing complex) in Antakya, the space syntax methodology was applied as the primary analysis method in the study, specifically to evaluate the old Antakya dwellings. It was examined how Antakya homes with atria created substantial socio-cultural and inferences via spatial and structural configurations. Furthermore, the influence of socio-cultural features on the structural construction and long-term maintenance of Antakya historical courtyard legacy was studied. The space syntax was used in this study to illustrate the shared and diverse aspects of dwelling principles that have changed over time. When both cultural and social distinctions evolved, the spatial organization changed radically.

As (Ergün et al., 2022) indicated that the outcomes of the space syntax analysis of traditional houses and TOKI houses revealed that the concept of privacy was not observed in the flats. The traditional courtyard houses-maintained privacy, that relied on practical strategies to safeguard the family instead of just personal activities. On the other hand, the rooms in multi-story residences were transformed into places that their owners may lock or keep closed. As a result, rather than architectural features, privacy was provided by room doors (Figure 2.3).

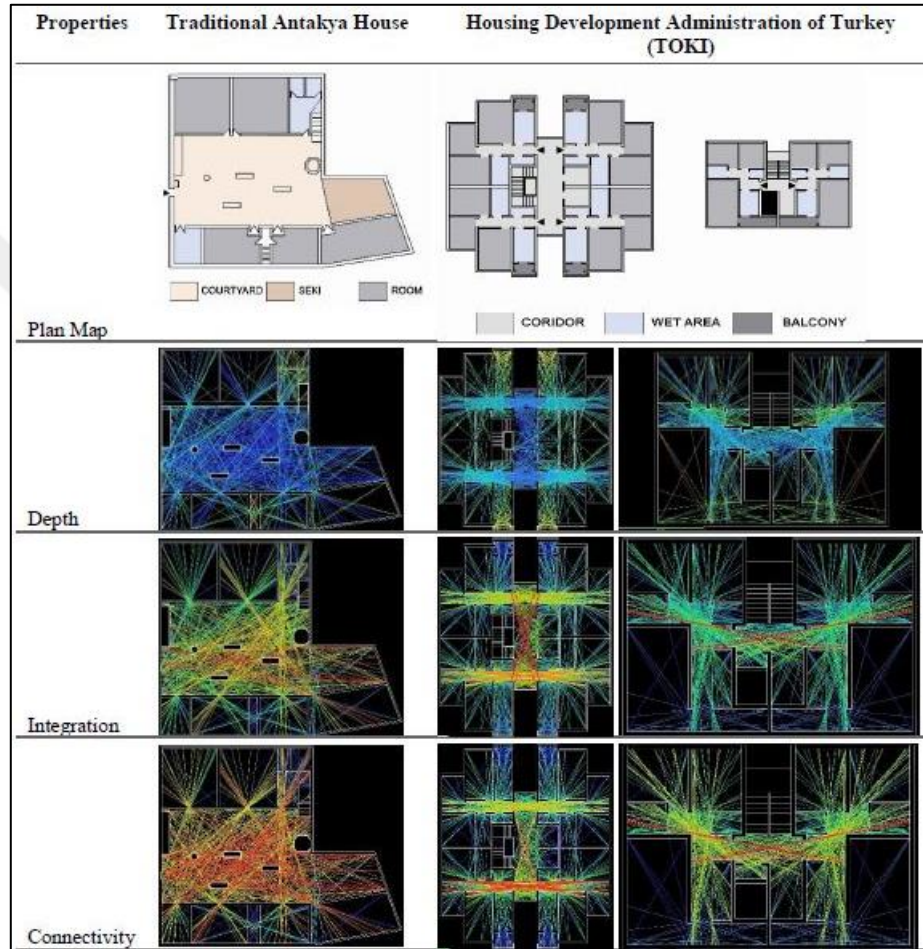


Figure 2.3: Map Analysis Diagram of Traditional Antakya Houses and TOKI Houses (Ergün Et Al., 2022).

2.2 SEMANTIC SEGMENTATION

As (Kaur & Kaur, 2014) describe semantic segmentation, is a deep learning system which assigns a tag or categorization to each pixel of an image. It is designed to identify groups of

pixels that represent various categories. An automated vehicle, for instance, needs to recognize other cars, pedestrians, traffic signs, sidewalk, and other elements of the road.

The classifications might be anything from animals to flowers to lions (Kaur & Kaur, 2014). Semantic segmentation is directly related to pixel-level picture categorization. The procedure starts by Categorizing a specific visual element. Then, locating that element and creating a boundary over it which is known as localizing. After that starts the process of producing a segmented masking to group the pixels in the localized picture.

As implied by (Asgari Taghanaki et al., 2021) Semantic segmentation is implemented in a range of real-world applications. One of the major uses of semantic segmentation is in self-driving cars. Since, routes, cars, pedestrians, and other small details of relevance can be detected using semantic segmentation. And the outcome is utilized to create smart judgements in order to correctly direct the car (Figure 2.4).



Figure 2.4: Example of Self-Driving Car (Semantic Segmentation, 2021).

Other application is Segmentation of medical images, Semantic segmentation has been used to find critical attributes in CT scans. It is very beneficial for detecting irregularity such as tumor. The reliability and of algorithms are critical for these situations (Figure 2.5) (Asgari Taghanaki et al., 2021).

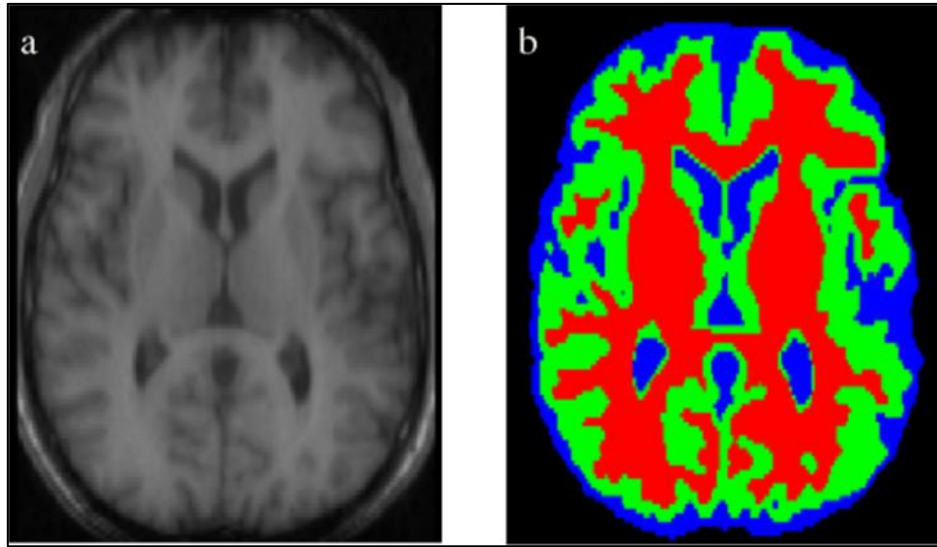


Figure 2.5: Segmentation of Medical Images (Raj, 2019).

Semantic segmentation is also used in Image processing through satellites, it is applied to determine land types from satellite data. Segmenting wetlands to produce precise geographic data is a common application case. Road mapping, crop classification, finding available parking spots, and other complex application scenarios (Figure 2.6) (Asgari Taghanaki et al., 2021).

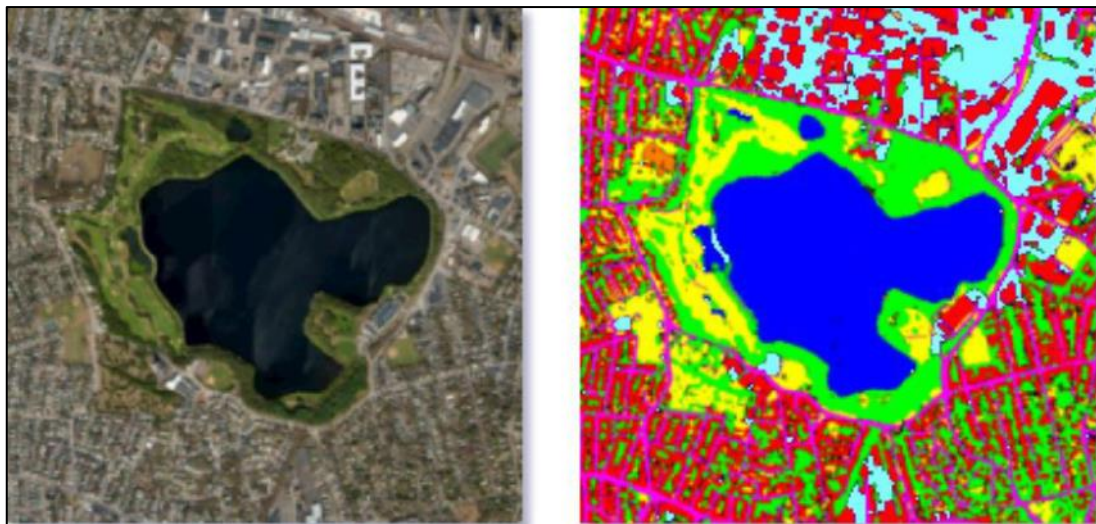


Figure 2.6: Segmentation Through Satellites (Raj, 2019).

As (Wu, 2017) mentioned the Separation of characteristics and interpretations is frequently necessary for semantic segmentation in order to obtain significant similarity of the given picture, effectively reducing the background noise, this action is carried out using the CNN

(convolutional neural network), which is often applied in the majority of the digital visual applications. The architecture may often be adjusted by the addition of new layers and elements or by completely modifying its architectural layout.

While (Wu, 2017) also indicated that in order to recognise category labels, CNN typically contains an entirely linked layer at its end. However, since the objective in semantic segmentation isn't to anticipate the category label of the picture, we often don't need a completely linked layer at the end.

As (Wu, 2017) mentions in the process of semantic segmentation, there is an attempt to extract characteristics prior to actually utilizing them to break the picture into several segments. to effectively split the picture into many segments, it is a must to up-sample it using an interpolation approach that employs deconvolutional layers. According to (Wu, 2017) The convolutional network that is applied to extract characteristics is referred to as an encoder in standard AI language. While the convolutional network that is used for up - sampling is referred to as a decoder, the encoder actually down-samples the picture (Figure 2.7).

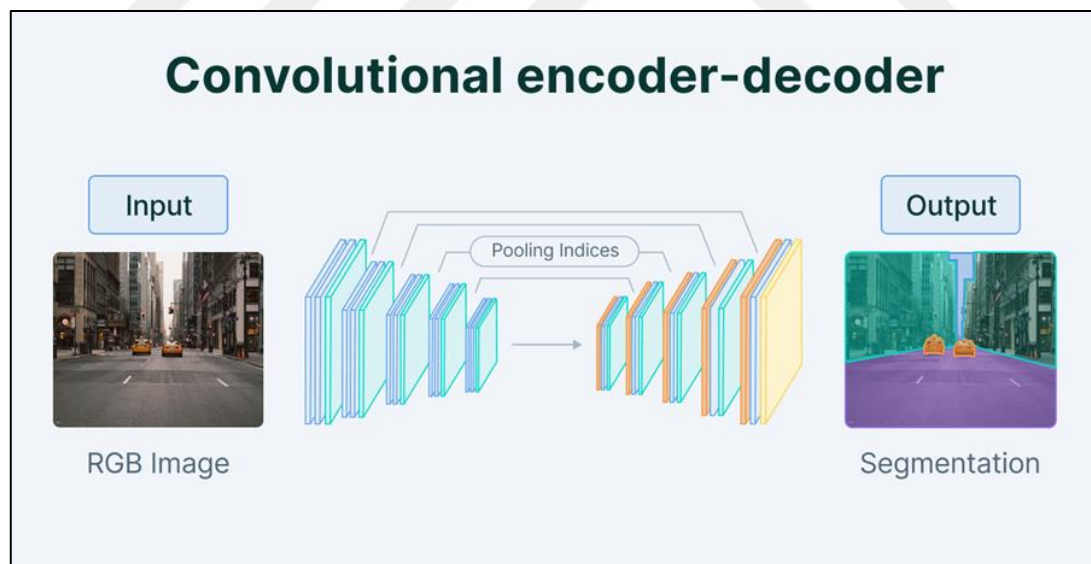


Figure 2.7: Convolutional Encoder-Decoder (Beginner's Guide to Semantic Segmentation, 2023).

So, in summarized words Semantic segmentation consists basically from inputs which are images and outputs which are the different region and structures off the images. For the

purpose of this study, a ready scripted Python code by “Lex Fridman” was used and executed on Google Colab (Colaboratory).

According to (The Theano Development Team et al., 2016) Python is an object-oriented, high-level, interpreter-based language of programming with flexible semantics. Rapid Application Production, as well as utilization as a programming or connector language to bring installed components together, find its wide developed data configurations, coupled with dynamic characteristic and flexible bonding, to be particularly appealing. Python's straightforward language promotes clarity, which lowers the expense of software maintenance. Moreover, the cycle of editing, testing, and debugging is exceptionally quick because there is no compilation phase. (The Theano Development Team et al., 2016) mentions that Python scripts are simple to debug since segmentation errors are not caused by mistakes or poor input. Instead, the interpreter raises an exception when it finds a mistake. The interpreter produces a stack trace when the program fails to catch the error. With the source-level debugger, you may go through the code line by line, evaluate arbitrary expressions, examine local and global variables, and more. The debugger was created in Python, demonstrating the language's capacity for introspection

The code by “Lex Fridman” (Fridman, 2017), is utilized for semantic segmentation task. Firstly to build the model (Fridman, 2017) uses the “Cityscapes” data set to train the model “checkpoint”, and the in order to Import the model from a previously stored graph he uses the “MobileNetV2” model which is among the other models has a faster reading to the applied images.

2.3 CORRELATION

According to (Albayrak, 2006) Correlation is a method used to reveal the relationships between variables between two data sets (X and Y) containing variables. Correlation analysis is a multivariate method that evaluates the relationship between two data sets through linear components. In correlation analysis, the linear components (variables) of the X and Y matrices are found to determine the magnitude, direction and significance of the relationship between the X data matrix containing p number of variables and the data matrix Y containing q number of factors, and the correlation between the two groups of variables is calculated through these variables. It reflects the "depth" or "severity" of a connection between the

variables, if it is theoretically possible to distinguish between two sets of dependent arguments, then the purpose of correlation analysis is to determine whether the independent variable set affects the dependent variable set.

As (Gogtay & Thatte, 2017) indicates, the Correlation finding gives a Correlation matrix with values varying from -1 to +1. A correlation value of +1 shows as the two variables is completely associated in a positive manner, a correlation value of -1 shows as the two variables are completely associated in a negative manner, and a correlation value of 0 shows as there absolutely no linear association connecting the two variables being analysed (Figure 2.8)

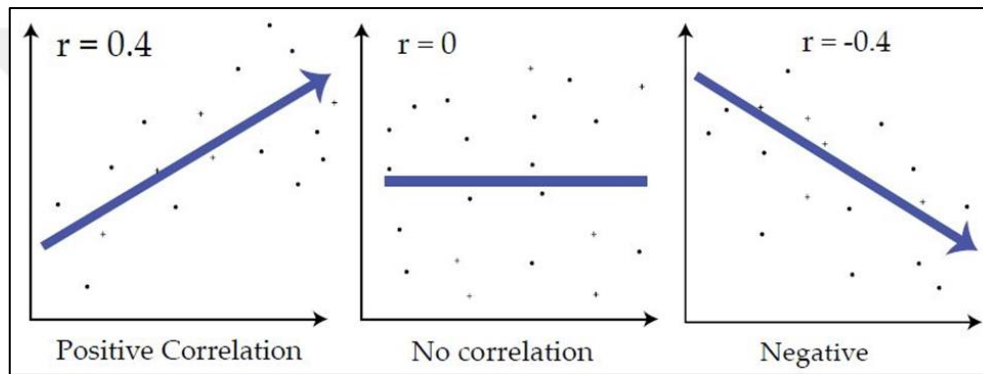


Figure 2.8: Correlation Analysis (Gogtay & Thatte,2017).

So, after conducting the data from space syntax and semantic segmentation analysis that will be done in this research the finalized results will be analysed correlatively in order to obtain the correlation results from the used analysing methods the findings of this analysis will be the key to understand the circulation organization of the grand bazaar.

In conclusion, the chosen methodology is utilizing stimulations which are “space syntax” and “semantic segmentation”, in order to visualize and display the neglected and unrecognized aspects of the circulation system of the grand bazaar. Then, after conducting the data from space syntax and semantic segmentation the finalized results will be analysed correlatively in order to obtain the correlation results from analysed data

then in the next chapter the historical development of the grand bazaar along with its street and gates organization will be explained, in order to understand how the integration between the grand bazaar the urban environment surrounding it formed over the years.

3. CIRCULATION ORGANIZATION OF THE GRAND BAZAAR

3.1 HISTORICAL DEVELOPMENT OF THE GRAND BAZAAR

The bazaar is constructed in a squared layout with a grid street system. The bedestens of Cevahir and Sandal served as the Grand Bazaar's main centrepieces in the past [Figure 3.1].

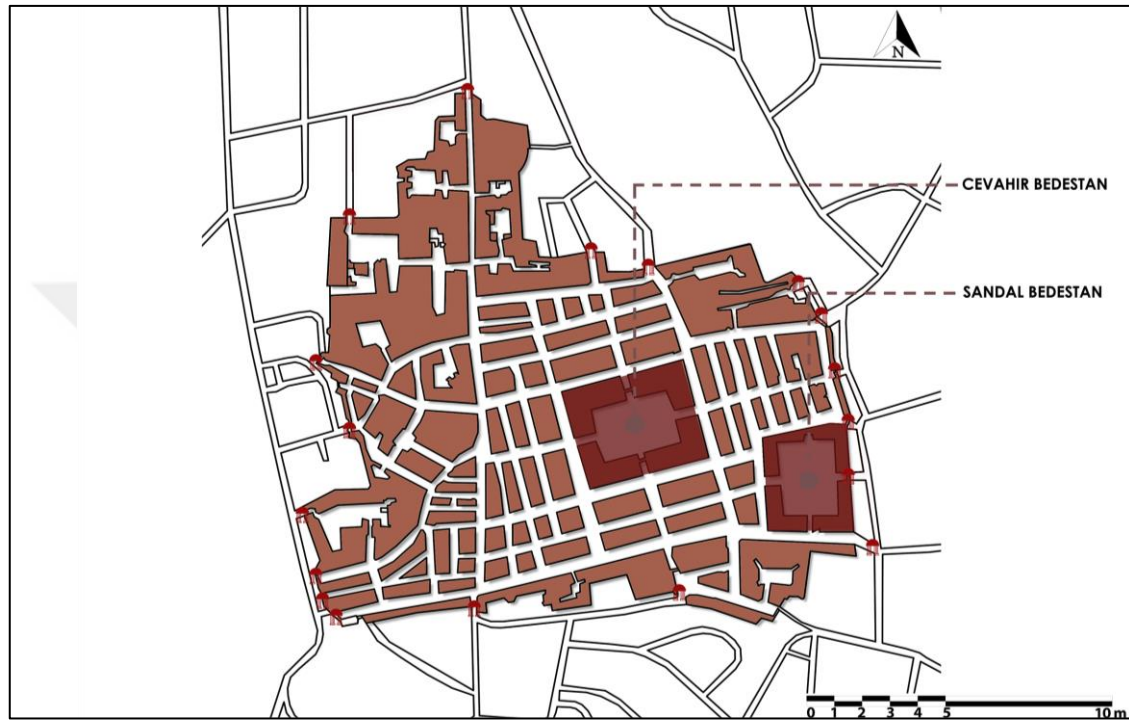


Figure 3.1: Grand Bazaar's Bedestens.

According to (Müller-Wiener, 1977) These bedestens were surrounded by stores and khans on all sides, transforming the entire area into a commercial centre. The bazaar steadily increased its commercial capacity three times to its initial size (Figure 3.2). (Müller-Wiener, 1977) also indicates that in the 17th century consisted of 67 streets, more than 3,000 stores in the bazaar, and 300 stores in the adjacent khans. The bazaar also had a number of prayer areas, 7 fountains, and 18 gates that were closed and opened every day in the mornings and evening.

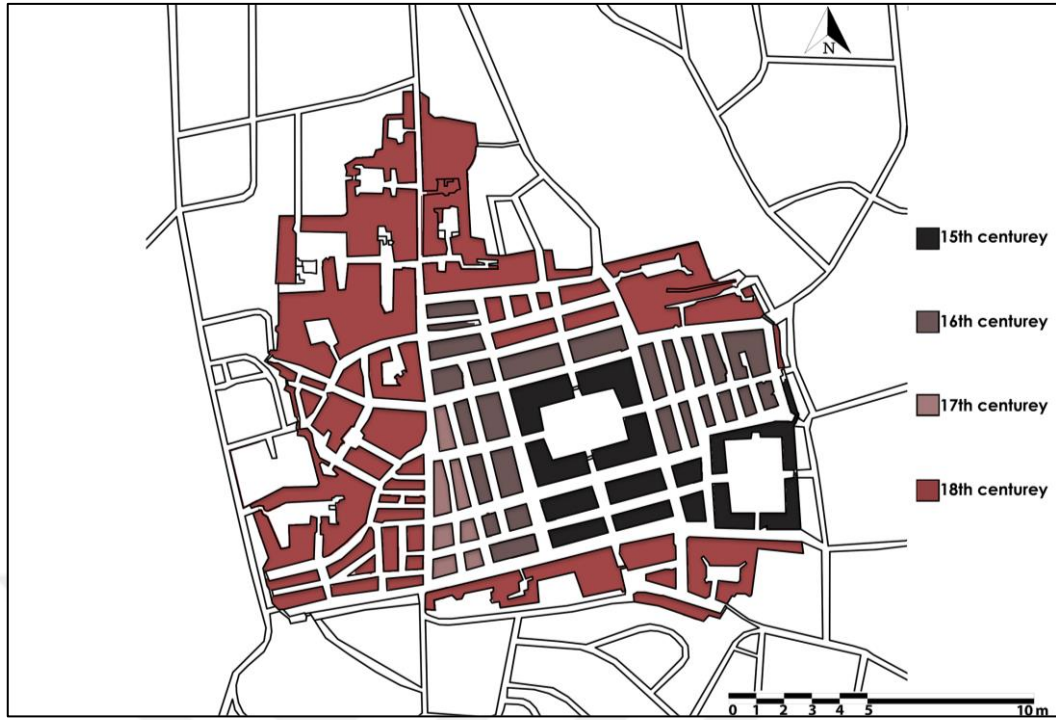


Figure 3.2: Grand Bazaar's Morphological Changes.

At the 19th century, over a tenth of Istanbul's stores were located in the Grand Bazaar. (Müller-Wiener, 1977). In 1887, the bazaar included 4,399 shops, 2,195 rooms, 1 hammam, 1 mosque, 1 madrasa, 16 fountains, 2 şadırvans and a sebil, a tomb, and 24 khans in addition to the 2 bedestens. as by the late nineteenth century, it had significantly enlarged. (Figure 3.3) (Müller-Wiener, 1977).

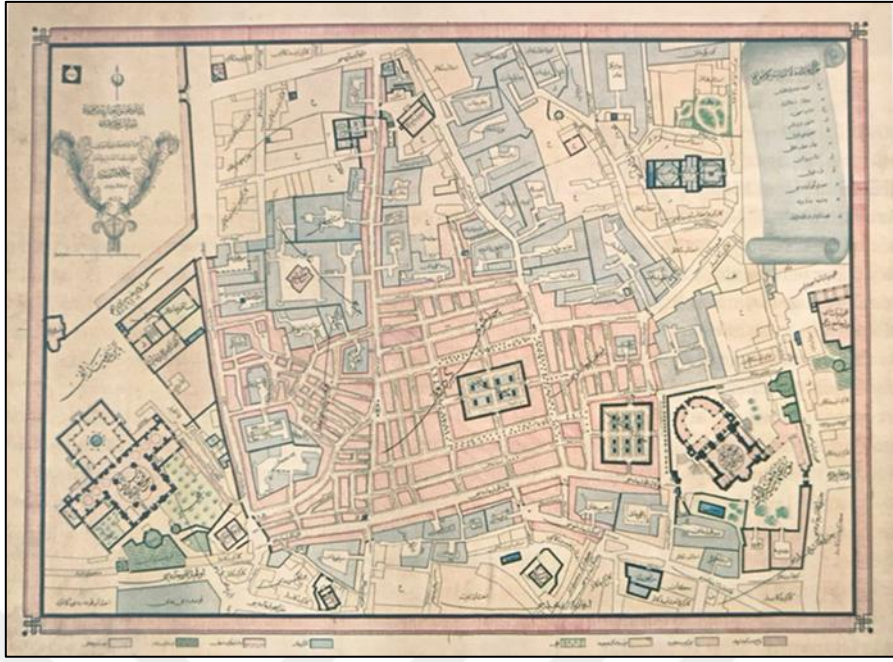


Figure 3.3: Grand Bazaar 1886-1887 Plan (Dilaveroğlu & Pilehvarian, 2022).

(Dilaveroğlu & Pilehvarian, 2022) mentions that after the 19th century, the old bazaar turned into the Grand Bazaar, that consisted mainly of two bedesten, which took on a new identity with its covered streets and was separated from the surrounding commercial areas with its doors. Currently the structure takes up an area of approximately 30,700 square meters on 64 streets, including between 3,000 to 4,000 stores (Dilaveroğlu & Pilehvarian, 2022).

(Hamza, 2022) states that the bedestens of *Cevahir* and *Sandal* have been initially topped with brick domes. Which are rectangular-shaped masonry structures supported by masonry columns. 44 cellars of vaulted chambers with no external openings were chiselled into the internal and external walls of *Cevahir Bedesten*, whereas only the outer walls of *Sandal Bedesten* included stores according to (Hamza, 2022). Meanwhile a lot of the bazaar's other structures were initially made of wood, but following the fires of the 17th century, they were reconstructed with stone and brick and vaulted.

(Gülersoy, 1997) mentioned, that it is predictable that there are differences between the fact that a structure formed by the subsequent closure of an area that expands and grows with articulations is built as a closed space from the beginning. During the closure of a large area with different topographic features with a top cover, the internal heights of some streets were different, while the roof elevations and slopes of some street covers differed. This natural texture, which has not changed despite the interventions for centuries, is one of the most

prominent features of the Grand Bazaar. It has also been stated by (Gülersoy,1997) the fact that the Grand Bazaar is not symmetrical and geometric due to its formation over time and its closure by converting it into a masonry structure later has saved the structure from monotony

Apart from these height differences between the closed streets of the bazaar, although they are generally similar, some structural differences are also remarkable according to (Dilaveroğlu & Pilehvarian, 2022). In Turkish cities, the main bazaar is assembled around the bedestens, which we can accept as the centre of the bazaar as mentioned above.

The Grand Bazaar of Istanbul was also developed next to the wall of the Old Palace around the Old Bedesten *Cevahir Bedesten* and New Bedesten *Sandal Bedesten*, which were built by Mehmet II to provide income for the Hagia Sophia, which was converted into a mosque (Dilaveroğlu & Pilehvarian, 2022). For this reason, it would be correct to accept the bazaar structures between the two bedesten as the first period structures of the bazaar known for its shops and streets.

As expressed in the previous section, the structure of the Grand Bazaar has been transformed to a masonry structure, the process started with the first core, the bedesten, then the shops around the bedesten and the inns in time enlarged as a result of articulation, the complex that is present today has formed by the spreading of the bazaar along the streets.

Cezar (1983) mentioned that *Cevahir bedestan*, which forms the core of the grand bazaar, was the first of the two bedestens to be existed, the present bazaar structure with a texture consisting of covered closed streets and masonry structure was not existed yet in that time (Cezar,1983).

When we look at the first period streets around the Cevahir Bedesten and Sandal Bedesten, which are dated to the 15th century, it is seen that the streets are located at approximately right angles with each other and reveal a grid structure. This situation shows that the bazaar is within the framework of a plan intended to extend to the east, that is, to the Sandal Bedesten after the first construction point. it is clearly read from the plans and engravings of the ancient periods that the regions such as residential or free trade areas are formed in organic form. For this reason, as mentioned above, it can be easily said that the construction of the shops there was planned in the first years of construction, considering that the market texture between Cevahir and Sandal Bedesten was in grid system. In contrast to the grid

construction between the two bedesten, a more organic street texture stands out as you go to the west of Cevahir Bedesten.

Within this texture, the presence of two main axes extending in the east-west and north-south directions stands out. As seen in the aerial photographs that provide the opportunity to look at the bazaar from above in the space, these two axes are easily determined thanks to the variability in the dimensions of the streets, which is the biggest feature that attracts attention in the plans of the streets inside the bazaar. (Dilaveroğlu & Pilehvarian, 2022) states that *Kalpakkılar* Street, which stretches on the east-west axis in the south of the bazaar and is about 280 meters long, is the most important passage axis that can be called the primary axis of the bazaar with its width of 6.50 meters and a height of 7 to 8 meters. The street ends with *Nuruosmaniye* Gate at the eastern end and *Beyazıt* Gate at the western end (Figure 3.4).

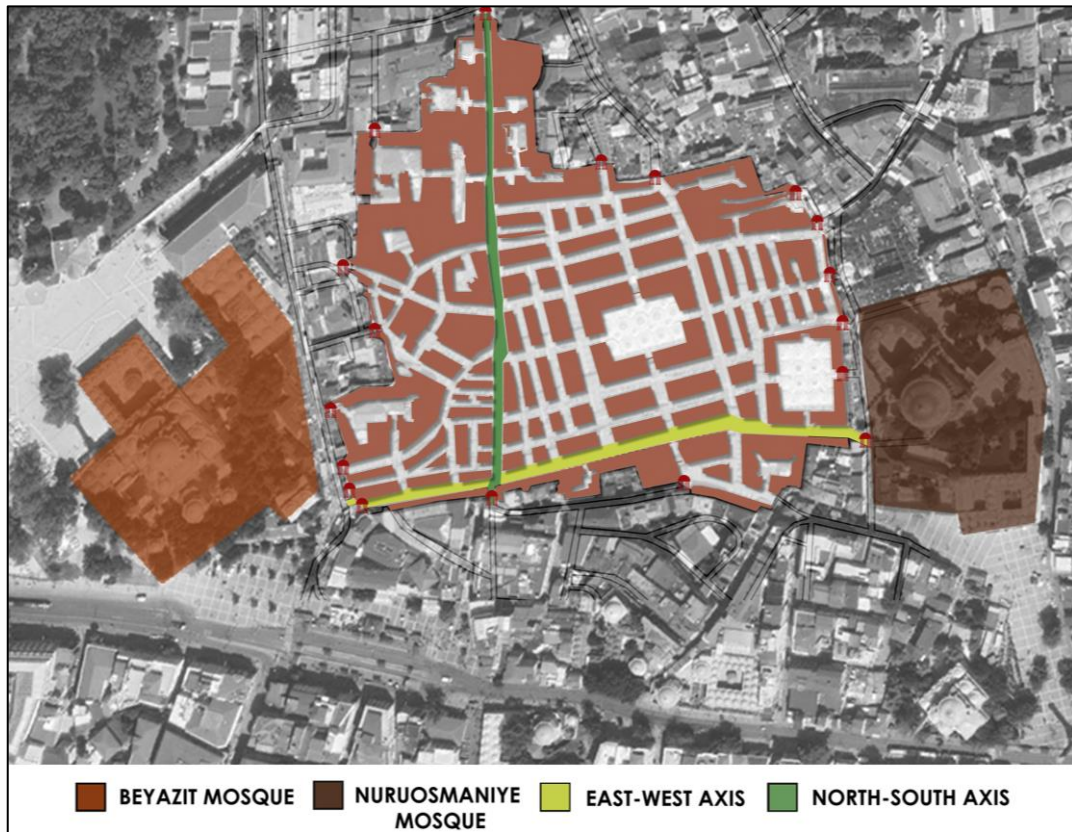


Figure 3.4: The Main Axes of The Grand Bazaar.

The secondary axis of the Bazaar extends from the Çarşı Gate to the Örucüler Gate. consists of a combination of successive streets named with different names.

This place starts with Yağıkçılar Street in the north and progresses towards the south. It is the axis that continues with Feraceciler, Sipahi and Çarşı gate street. This axle is also Starting from Örucüler Gate outside the Grand Bazaar, towards Eminönü Continuing with the advancing long Çarşı Street, forming the Long Bazaar from which it takes its name. is the axle.

(Dilaveroğlu & Pilehvarian, 2022) mentioned that this line is known as Makros Embolos, the backbone of the Byzantine-Era bazaar. stated in the sources. There is also the view that the line connects the Golden Horn and Marmara ports. At the intersection of these two lines, When the statues of the covered bazaars located in the area is examined, (Dilaveroğlu & Pilehvarian, 2022) indicates that this place was determined as the core of the trade area and the trade area was combined with the palace area. In order to prevent the spread of the city towards the built-up area, the old settlement of the city can be considered to be limited by its routes.

3.2 GRAND BAZAAR STREET ORGANIZATION

3.2.1 Gates of the Grand Bazaar

The doors, which are among the façade elements belonging to the Kağılıçarşı, have the right to achieve the closed identity of the Çarşı as much as the covered streets. While some of them are not even known to most tradesmen with their structure resembling a corridor, some of them a total of 21 units that stand out with their intensive use due to their functionality door. (Figure 3.5)

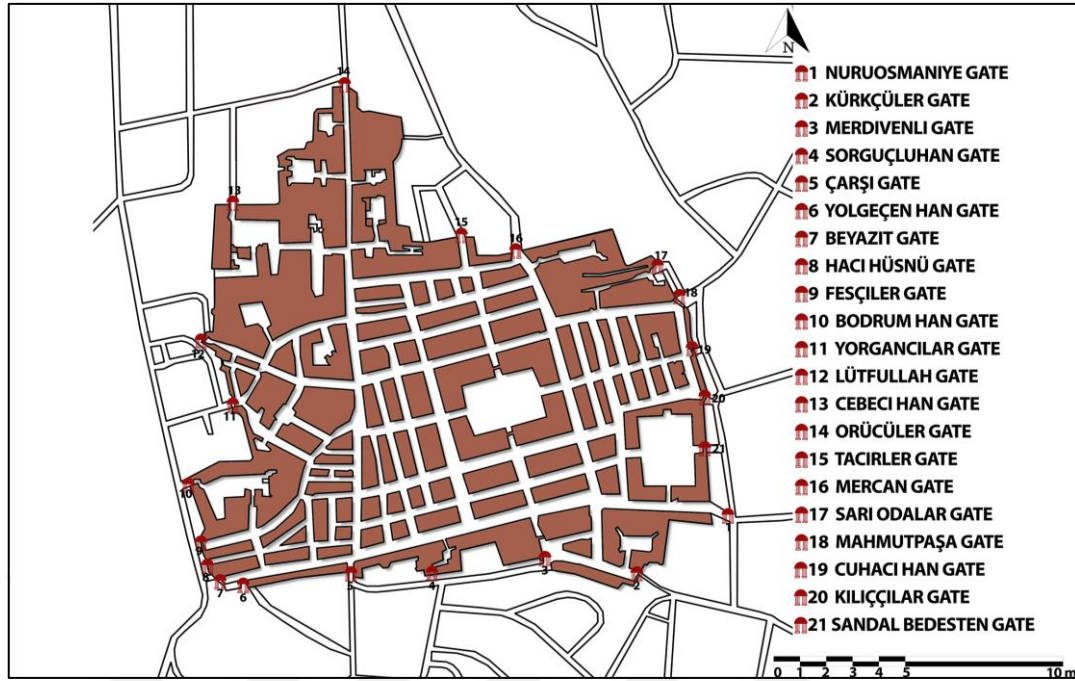


Figure 3.5: Grand Bazaar Gates.

Also (Dilaveroğlu & Pilehvarian, 2022) indicates that the doors which were placed for security purposes have turned into monumental structures over time. Especially *Nur-u Osmaniye* Gate and *Beyazıt* Gate which are the gates representing the Grand Bazaar and at the same time at the two ends of the most important “east-west” axis. Also, the *Çarşı* Gate at the southern end of the “north-south” axis is another monumental gate (Figure 3.5).

(Yücel & Arun, 2010) mentioned that the Grand Bazaar has a direct connection to the street through 12 gates. Other gates are reached by passing through the inn. The intensity of use order is *Çarşıkapı*, *Beyazıt*, *Nur-U Osmaniye*, *Mahmutpaşa*, *Mercan* and *Örücüler* gates respectively.

Same as the Grand Bazaar, that has been repaired many times throughout history, it is understood from the archived documents that the doors of the bazaar have been renovated and restored over time.

Nur-U Osmaniye Gate

The Nur-u Osmaniye Gate is located on the east side of the bazaar and is named after the nearby Nur-u Osmaniye Mosque. The gate is located on the east-south side of the bazaar and is the main entrance to the bazaar.

The Nur-U Osmaniye Gate (also known as the *Osmaniye Kapi*) is considered a historical gate that was built in the late 15th century.

As (Yücel & Arun, 2010) states that the Gate which has a three-meter width and 3.70-meter height, is located in a flattened arched doorway. The door is located in the wall with cut stone braids that also has a height of 10 meter, a large, arched structure made of stone and brick. It has a triangular shape and is adorned with decorative elements such as horizontal stretching from the door to the right and left at the level of the stirrup of the pointed arch, niches with plastered edges with a half-hexagonal plan under the erasers and motif at the top end. The bottom of the base of the niches protruding from the wall surface is embossed with motifs, one badge on each side of the pointed arch and above the arch is a row of tulips after the muqarnas line. embossed motif. The bun caps in the two corners at the top and the wall ends with the deletion between them. A cradle behind the height of the wall hides the roof.

Kürkçüler Gate

The Kürkçüler Gate, located at the eastern exit of the Kürkçüler Çarşı, and as (Yücel & Arun, 2010) mentioned it has a 2.15-meters width with 4.16-meters height, this gate connects the *tavuk pazarı* Street with the *Kürkçüler Çarşı* , It differs from the other doors with three arched doorways, one small on the sides and a wider and higher entrance in the middle, located on a cut stone braided wall. The doors are closed by folding iron doors that reach stirrup levels and there is a wrought-iron cage in the arched parts. Since the elevation of Kürkçüler Çarşı Street is lower than the outside, it can be entered after a few steps.

Merdivenli Gate

Merdivenli Gate is located in the Kürkçüler Çarşı also, at the exit in the west according to the Kürkçüler Gate. It has a 1.6-meters width with 2.6-meters height (Yücel & Arun, 2010). In this doorway opening to the south, this gate is the connecting point between the Iskender pass Street and Kürkçüler Çarşı, there are two iron wings and it is understood that this name was given because due to the elevation difference stairs were used in entering and exiting through this gate.

Çarşı Gate

It is located at the southern exit of the north-south axis of the Grand Bazaar, Çarşı Kapı street leads to Çarşı gate which is an important factor in the circulation structure of the grand bazaar since it opens to the two main axis of the grand bazaar, entering this gate gives access to the *Kalpakkılar* street and the *Sipahi* Street as well, according to (Yücel & Arun, 2010) the door gap with flattened arches is 3-meters in height and 2.4-meters in width It is seen that the wall where the door is located has a cut stone mesh up to one height, while the door arch continues

as brick mesh. In the part that is directly above the door, it is seen that there is a rectangular window with a cut stone jamb. When viewed from the outside, it is noticeable that the window is covered with a portico with diamond slices. From Inside, unlike the one outside, the window is covered with a floral pattern and colored stained glass. From where the brick arch ends, a plastered forehead in a curvilinear form rises. The wall, which ends with two rows of hedgehog eaves at the top, is covered with alaturka tile. The doorway is covered with iron, rectangular wings that open inwards, folded on two sides in two parts. The lower sections of each of the wings have two bellies, one large and the other small, and the upper sections have glass with internal railings. There is a threshold when entering the road at the lower level. It is seen that the inner surface of the wall has an irregular mesh consisting of brick and cut stone. A flat scarf at the starting level of the barrel vault on the inner street leads to the plastered and pencil-worked-adorned surface above (Dilaveroğlu & Pilehvarian, 2022).

Yolgeçen Han Gate

It is located to the east of the Beyazıt Gate and connects the Yolgeçen Han to the bazaar.

Beyazıt Gate

It's one of the monumental gates of the Grand Bazaar, this gate gives access to the east-west axel of the grand bazaar since it is located at the intersection of Çadircılar Street and Kalpakcılar Street. It is seen that the wall with the flattened arched door gap on the exterior façade is cut stone braided, there is a pointed arched gradation in the façade that is further ahead of the surface where the passage is located and larger than the door gap, and the corners in this surface difference are profiled. On both sides of the doorway there are shallow recesses with embossed frames, niche-looking. The surface that ends above the pointed arch ends with a erasing and motif finish. Again, circular reliefs appear on the surface on both sides of the pointed arch, suggesting that the surfaces were left empty in this way as a result of insufficient restitution in previous restorations. The wall on which the door is located is raised to provide the appearance of a crown door, so the gable behind it hides the roof (Dilaveroğlu & Pilehvarian, 2022). According to (Yücel & Arun, 2010) it was measured that the height of the door cavity from the arch peak was 3.7 meters and the width was three-meters and the wall was 9 meters high.

When you enter through the door, it is seen that a step is descended from the door threshold because the level of Kalpakcılar Street is about 0.15 meters below as (Dilaveroğlu &

Pilehvarian, 2022) mentioned. In the doorway there is a folding iron door with two wings that can be opened to both sides, and the rectangular shaped wings are higher than the door gap, which prevents the flattened arched weft from being seen when viewed from the inside when the door is closed.

Hacı Hüsnü Gate

It is located at the western end of Hacı Hüsnü Street at the northern side of Beyazıt Gate, this gate connects the Çadırcılar Street with Hacı Hüsnü Street. According to (Yücel & Arun, 2010) it has a 1.5-meters width and 2.8-meters height, it has a narrow door gap with flattened arches. It is seen that the door gap, whose exterior surface is plastered, is passed to the windowed façade of the floor above the door with a deletion. The door, which is entered into the bazaar from the same elevation as the street, has iron wings that open to both sides. the upper part of the door wings gap is covered with glass with railings (Dilaveroğlu & Pilehvarian, 2022).

Fesçiler Gate

It is located on the right side, when we pass the Hacı Hüsnü Gate while passing the Çadırcılar Street from the Beyazıt Gate, at the end of Fescılar Street to the west of the Grand Bazaar, it connects the Çadırcılar Street with Bitpazarı street. With a width of 2.8-meters and a height of 3.2-meters as (Yücel & Arun, 2010) mentions. The flattened arched door gap on the façade of Çadırcılar Street is located on the wall with artificial stone surface and there is another arch formed by a profiled gradation at the top. The mirror of this arch has a profiled ornament, and on the right and left is an empty medallion-shaped ornament protruding from the surface. There are horizontal moldings extending to the right and left from the level of the stirrup of the arch and an inscription of the door in a frame just below. The façade where the door is located ends with wiping, and the four wings of the door open by folding inwards. The doorway, which is arched on the outside, is the flat scarf on the inside (Dilaveroğlu & Pilehvarian, 2022).

Yorgancılar Gate

It is located in the west at the exit of the Grand Bazaar's Yorgancılar Street, it connects the Yorgancılar Street from the outside of the bazaar to two streets of the inside of the grand bazaar which is the Yorgancılar Street and the yarım taş han Street. According to (Yücel & Arun, 2010) the gate has a 2-meters width with 2.9-meters Hight. The doorway, which is closing with the iron wing, is flattened arched. Horizontal moldings are noticeable, extending

from the level of the stirrup of the door to both sides and above the arch. There is a pointed arched window on the upper side of the doorway and a pediment rising above the brick hedgehog eaves on the window (Dilaveroğlu & Pilehvarian, 2022).

Lütfullah Gate

It is located to the west of the Grand Bazaar, at the end of Lütfullah Street. which is reached by descending five steps from the road elevation, is closed by a three-leaf iron door. Above this door there is a narrow window with pointed arches (Dilaveroğlu & Pilehvarian, 2022). The door width is 2-meters and height is 2.7-meters as (Yücel & Arun, 2010) mentioned.

Orücüler Gate

It is located at the northern exit of the secondary important axis of the Grand Bazaar at the end of Yağlıkcılar Street and through this door the Grand Bazaar leads to Mercan Street. According to (Yücel & Arun, 2010) the gate has a 3-meters width with 3.7-meters height. The stirrup stones of the flattened but wide arched door protrude out in profile, there is a flattened arched window just above the door with three iron sashes in both directions, and a profiled molding is seen on the window. Despite the importance of its location, the fact that it is very simple compared to other monumental gates leads to the idea that the passage of this axis has been changed over time (Dilaveroğlu & Pilehvarian, 2022).

Tacirler Gate

It is located at the exit of Tacirler Street that is connected to the Perdahçılar Street, its width is 1.8-meters and height is 2.5-meters according to (Yücel & Arun, 2010). The flattened arched door gap on the cut stone façade ends with a flat weft over two stones where the shafts sit from the inside. The door has stirrup stones protruding outwards and a profiled eraser on the keystone. It can be seen that the wall, on which there is an arched window space above the door elements, also ends with a profiled wipe (Dilaveroğlu & Pilehvarian, 2022).

Mercan Gate

It is the gate that opens to Tığcılar Street through the bazaar and is connected to the Perdahçılar Street from the inside of the bazaar, Zincirli han can also be accessed from this gate, as (Yücel & Arun, 2010) mentioned the gate has a width of 2.5-meters and a height of 2.9-meters. As is familiar from other doors, there is a flattened arched door gap on the façade, which is passed to the upper floor window with a wipe. Stirrup stones protrude with the profile. The upper floor window has a stone jamb (Dilaveroğlu & Pilehvarian, 2022).

Sarı Odalar Gate

It is a passage that opens to the Grand Bazaar from the area called Sarı Odalar, which consists of small rooms on the left and right of a narrow street. And has a width of 0.74 meters and a height of about 12 meters so its considered as a passage according to (Yücel & Arun, 2010).

Mahmutpaşa Gate

It is stated that it is the most used door after Çarşı Gate, Beyazıt Gate and Nur-u Osmaniye Gate as (Dilaveroğlu & Pilehvarian, 2022) mentioned. It is located on the northwest corner of Çuhacı Han on Aynacılar Street. (Yücel & Arun, 2010) stated that it has a 2.7-meters width and 2.8-meters height. Unlike most other doors, it is on a wall separating two open streets. The cut stone wall has three doorways with flattened arches. Just above the arch of the large opening in the middle, which is closed by a two-piece folding iron wing, there is an unadorned badge and iron bars in the arch mirror. The narrow door gaps on the other two sides are also closed by iron wings, and the wall finish on the middle door is seen to be higher, while the metal railing added to the door probably for security reasons is noticeable (Dilaveroğlu & Pilehvarian, 2022).

Çuhacı Han Gate

It is located at the east of the grand bazaar at the eastern end of the Ağa street. It consists of a 2.7-meters width by 4.1-meters height door gap at the transition from Çuhacı Han to the Grand Bazaar as (Yücel & Arun, 2010) mentioned.

Kılıççılar Gate

It is on the wall at the intersection of the southwest corner of Çuhacı han and the northeast corner of Sandal Bedesteni. This door is located on the wall in an open-top street like Mahmutpaşa Gate. According to (Yücel & Arun, 2010) its width is 2.7-meters and height is 3.4-meters It is seen that the door cavity with a flat weft standing on the iron profile is closed with three folding iron wings (Dilaveroğlu & Pilehvarian, 2022).

Sandal Bedesten Gate

It is the eastern gate of Sandal Bedesten and opens to Nur-u Osmaniye Mosque, the gate is located at the west side of the east-west axis of the grand bazaar at the eastern end of Kalpakçılar Street. With a width of 2.8-meters and a height of 5.3-meters, it has the highest doorway among all the bazaar gates as (Yücel & Arun, 2010) mentioned. The two wings of the door in the arched passage open inwards and the other two wings consist of iron joinery with fixed four-pane glass. This glazed joinery is also protected by iron bite bars outside.

Since the road elevation is lower, there are steps at the entrance. Also, inside is the recessed arched inner door of the Sandal Bedesten (Dilaveroğlu & Pilehvarian, 2022).

Sorguçlu Han, Bodrum Han, Cebeci Han Gates

Those gates can be considered more of a passage than a gate, their average width doesn't exceed 1-meter as (Yücel & Arun, 2010) stated. And according to (Dilaveroğlu & Pilehvarian, 2022) the mediocrity of these passages suggests that they were opened in the 19th or 20th centuries due to the ease of access to the Bazaar.

3.2.2 Street Planning

(Hamza, 2022) mentioned that within the Grand Bazaar, the streets are divided according to their functions. Each street is named according to the product produced and sold by the tradesmen in it. for instance, jewelers, goldsmiths, armorers, creators of knives, caps, footwear, or rugs, and textile traders have all been located in their particular regions. The fact that the shops where similar products were sold were gathered on the same street ensured that the people could easily access the product they wanted. This structural organization evolved over time, Although the majority of these shops do not exist today, street names still exist. Including those who made oil cans, footwear, sandals, silk or cotton threads, iron or tin pot polishers, headscarves, caps, and other items. However, the street and khan titles, such as Skullcap makers' Street (Takkeciler Sokak) and Calpacmakers' Street (Kalpakçılar Sokak), still reflect the historical geographical structure (Figure 3.6).

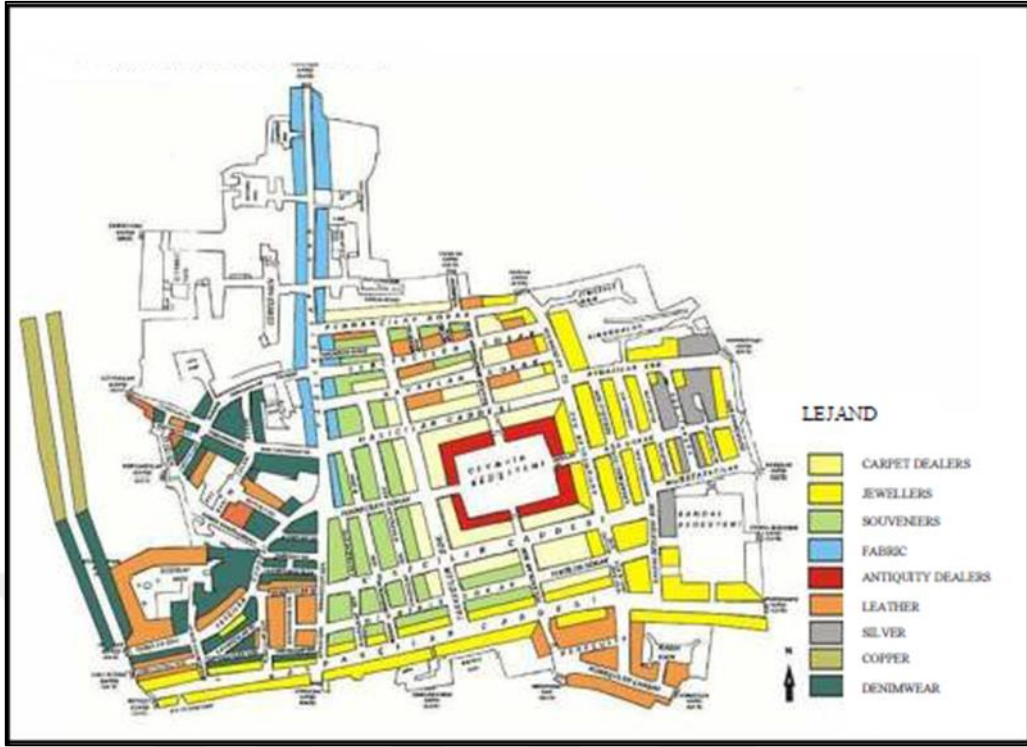


Figure 3.6: Grand Bazaar Street Organization at 2000s (Köroğlu, 2010).

The *Hans* Region, which is located in the middle of Eminönü-Sirkeci-Beyazıt Squares, is the area where intensive commercial activities take place. In this region, which is completely devoted to commercial functions, the imbalance between day and night population is very obvious. (Bildik, 1998) mentioned that the ground floor of the buildings in the region is used for trade and the upper floors are generally used for warehouse purposes.

One of the planning principles of the Grand Bazaar is that each street is devoted to a certain product. Street names for pedestrian circulation and ease of circulation are also mentioned by the names of the products sold on that street. This situation provides benefits for the consumer in terms of ease of circulation, easy access to the desired product. At the same time, the fact that people move the bazaar only in line with the product they demand both prevents unnecessary circulation of the person and relieves the human circulation in the bazaar.

Hamza (2022) mentioned that Sandal Bedesten was primarily the core of the silk market, while other textile goods were also sold there. Cevahir Bedesten was home to the most expensive goods, including jewelers, armorers, and specialists in gemstones. Later, the spices and herb trade were transferred to the Egyptian Bazaar in Eminönü, which was close

to the jewelers, the market for armor and weapons, the ancient market, and the flea market (Hamza, 2022).

When we look at the plan of the Grand Bazaar as a whole, the most striking feature is that the street structures of the east and west of the Uzunçarşı axis are different from each other. It is a line that we define as the Uzunçarşı (Long Bazaar) axis, which we define from north-south of the bazaar, continuing with Örücüler Kapısı Street, Yağlıkcılar Street, Feraceciler Street and Sipahi Street and passing through the bazaar.

Assuming that this line divides the Bazaar into two sections, it is seen that the uniform and gridal structure of the building islands around Bedesten has been replaced by a more natural texture on the west side of the line. This suggests that this side, which shows an organic distribution, is formed as a result of a more unplanned progress.

However, where the formation of Bedesten and the surrounding building islands can be traced, it is understood that it is a structure consisting of shops lined up in a side by side order.

According to (Küçükerman & Mortan, 2007) Considering that the Bazaar was masonry at the beginning of the 18th century, this irregular expansion, which can be considered more uncontrolled than the center towards the west of the Long Bazaar axis, is likely to have occurred in the 17th century.

The Grand Bazaar has a plan determined by the building islands and streets. (Küçükerman & Mortan, 2007) also stated that there is a total of 61 streets named according to artisan groups such as Kalpakçılar, Kuyumcılar, Aynacılar, Fescılar. The most noticeable features of the streets, some of which are open-top, are that they are different in length and width.

Especially between the streets, the presence of two main axes extending in the east-west and north-south directions is noticeable. Kalpakçılar Street, which stretches on the east-west axis in the south of the bazaar and is about 280m long, is the most important transportation axis that can be called the primary transportation axis of the bazaar with its 6.50m width and 7m to 8m height according to (Yücel & Arun, 2010). The secondary transportation axis of the Çarşı consists of a combination of successive streets named with different names extending from Çarşı Kapı to Örücüler Gate..

The other element that makes up the Grand Bazaar is the building islands. (Yücel, 2015) stated that there are 2439 separate places located on a total of 2466 parcels on these islands. Although they have different functions, these places are referred to as shops both in

documents and in the reports prepared within the scope of the preliminary project. It was observed that the shops generally had a quadrangular plan type, but they sat on a triangular plan at the corners of the islands. It can be said that this applies to islands in the form of smooth quadrilaterals. It has been determined that the types and sizes of shop plans vary on the islands with different forms located to the west of the axis formed by Yağlıkcılar, Sipahi and Feraceciler Streets.

Apart from these, when talking about the plan features of the Grand Bazaar, it will be necessary to mention the two special Bedesten structures of the Bazaar.

In conclusion, we can summarize the chapter by these findings:

- a. The circulation organization of the Grand Bazaar is based on a grid system, with a number of smaller alleys and passages that connect the main streets, where the main streets are wider and more spacious.
- b. The bedestens of Cevahir and Sandal served as the Grand Bazaar's main centerpieces in the past. These bedestens were surrounded by stores and khans on all sides,
- c. To further facilitate movement within the bazaar, It has a direct connection to the street through 12 gates while other gates are reached by passing through the inns, the total of the gates is 21 gates.
- d. Knowing the fact that the bazaar steadily increased its commercial capacity three times to its initial size, the market texture between Cevahir and Sandal Bedesten was in grid system, But In contrast to that more organic street texture stands out as we go to the west of Cevahir Bedesten. which shows that the bazaar where it was within the framework of a plan intended to extend to the east to the Sandal Bedesten after the first construction point.
- e. Overall, the circulation organization of the Grand Bazaar is designed to balance and ensure efficient movement within it.
- f. The analysis of the urban integration of the bazaar shows that the presence of two main axes extending in the east-west and north-south directions stands out.
- g. the Kalpakcılar Street which stretches on the east-west axis in the south of the bazaar and is about 280 meters long, it is the most important passage axis that can be called the primary axis of the bazaar with its width of 6.5 meters and a height of 7 to 8 meters. The street ends with Nuruosmaniye Gate at the eastern end and Beyazit Gate at the western end, while the secondary axis of the Bazaar extends from the south

where its connected to Sultanahmet and Sirkeci region by carsi gate toward the north to continue towards Eminönü by Örucüler gate.

After analyzing the circulation organization of the grand bazaar and relationship between it the urban tissue surrounding it, in the next chapter Space Syntax analyzing method will be discussed, in terms of how it is used, why it is used it to analyze the circulation of the grand bazaar, how it is utilized to analyze the circulation structure of the grand bazaar and what is the conducted data from it.



4. SPACE SYNTAX OF THE GRAND BAZAAR

Space syntax in research; in particular, is used in buildings that contain complex functions of social life, consisting of many functional units that work with a wide range of time. Examples of these are hospitals and university structures consisting of many units, blocks and functions; the space, time and space it occupies. Transport complexes, such as airports, because of the functional complex; shopping centers that contain holistic functions of daily life can be shown. There are many studies carried out on an urban scale, hospitals, university buildings, airports, housing organizations and shopping centers in the architectural sense are the examples where spatial constellation technique is used the most in environmental and behavioral studies.

Within the scope of this study, the Grand Bazaar and the Great Bedestens in it will be examined.

Its objective is to make the relationships between spatial configurations clear. To demonstrate the connections between the physical layout and user behavior, the amount of density in the corridors, and the links between patterns of activity and space, the Grand bazaar's visitor's Movement has been incorporated by determining the consequences of the design data. Findings that may be analyzed are the connections between their relationship and space. has been presented. The behavior of the design force in Grand Bazaar served as the basis for the analysis' findings. This must be accomplished, in order to do this, it is necessary to investigate how the structure of the building affects how people Move, and it is also necessary to find how spatial and design differentiation affects how people circulate in their spaces.

As the main purpose of space syntax is to give an objective approach for representing a building's continuous spatial layout in relation to how we use it. Those was used to study the pedestrian movements at the Grand bazaar using the “depth map” program in order to understand the preferences made by the pedestrian at the bazaar according to many factors that contributes to the decisions made by the pedestrian.

In depth map buildings are represented by a grid of points that create a visibility graph, with each point connected to every other visible point. Every space inside the pattern would then be classified according to its inter-visibility.

Those analysis were made to cover many aspects that may be affecting the pedestrian movements in the Grand bazaar.

4.1 CONNECTIVITY ANALYSIS OF THE GRAND BAZAAR

To start the pedestrian analysis of the grand bazaar on the depthmapX program, the first step was to have a 2D plan of the grand bazaar in dxf format, so firstly I had to draw the grand bazaar plan using AutoCAD and then saved the file in dxf format.

Then I imported that dxf file into depthmap, After the drawing file is imported, in depthmap the toolbar can be accessible, to find more information about the file size and location of the Depthmap chart, "properties" from the "file" menu can be selected.

After incorporating the 2D plan into Depthmap, a grid layout should be prepared for the visibility chart point positions. To make a grid of point positions in the analysis, "set grid" is selected from the toolbar. This allows the analysis to establish a grid layout. The grid spacing is set to "2", The part that is considered to be analyzed takes place by using the "Fill" tool to fill the space created within the streets of the grand bazaar in the grid layout.

The aim of the integration analysis is to create a hierarchy of the streets in the settlement from the most frequently passed open spaces to the least used space.

To start Visibility Graph Analysis, "Make visibility graph" is selected from the "tool"- "visibility" menu. This connects each point location to the other point locations on the map which will result to our first analytical map the "Connectivity" map, where the map is color coded from the high connectivity value points to the low connectivity value points on the map as shown in (Figure 4.1), where the orange color refers to the highest connectivity value points, the yellow color refers to lower connectivity value points and the blue refers to the lowest connectivity values points.



Figure 4.1: Connectivity Analysis of The Grand Bazaar Using depthmapX.

4.2 VISIBILITY ANALYSIS OF THE GRAND BAZAAR

The next step is to create the "visual integration analysis", so we select "Run Visibility Graph analysis" from the "tool" – "visibility menu". The analysis results in a new color-coded map from the most integrated axes of vision to the most isolated one. Axle maps are the locomotive of urban analysis. In the integration analysis indicated in (Figure 4.2), the axes intersections shown in red are where according to the integration values can be described as high integrated areas, the axes intersections shown in orange can be described as medium integrated areas and the axes intersections shown in yellow-green can be described as low integrated areas. These integrated areas are formed by reference to the number of connections of the streets with each other.



Figure 4.2: Visual Integration Analysis of The Grand Bazaar Using depthmapX.

After that the scatter plot of the connectivity values with the visual integration values is conducted and the direct relationship between the connectivity and the visual integration factors can be clearly observed by the exponential growth of the scatter plot (Figure 4.3). where the X axes represents the visual integration values and the Y axes represents the values connectivity, we can observe the same ratio changing between the values through the plot.

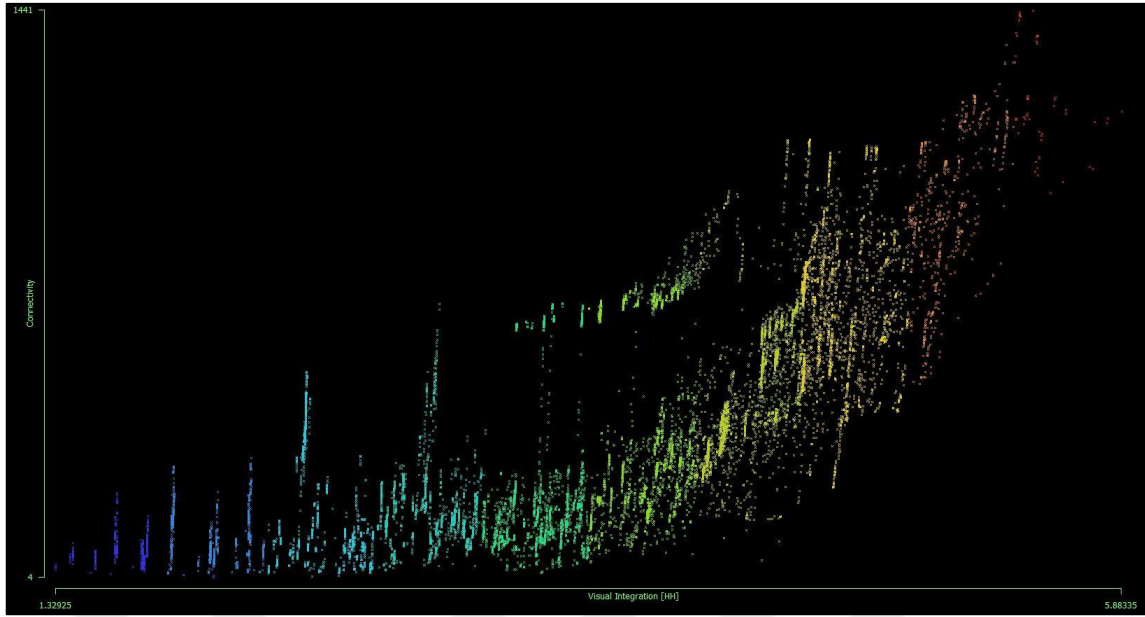


Figure 4.3: Scatter Plot Analysis of The Grand Bazaar Using Depthmapx.

After explaining the space syntax method and how it used to analyze the grand bazaar and the conducted data from it, in the next chapter the semantic segmentation analyzing method will be discussed how it works, why it was chosen to be one of the analyzing methods in this research, how it was applied on the grand bazaar and what data is produced from this analysis.

5. SEMANTIC SEGMENTATION OF THE GRAND BAZAAR

5.1 SEMANTIC SEGMENTATION OF GRAND BAZAAR INTERSECTION POINTS

The amount of people crossing through imaginary points placed strategically at intersections of the street network is one of the classic methods for measuring pedestrian movement as a measure of circulation flow. Typically, the recording is done throughout the day at a number of small ranges. The Bazaar's spatial distributions of pedestrian circulation density represent the strategic element of circulation motion.

That's why a specific points were determined at the joints of the main streets of the grand bazaar, at this process, relations between an individual's activities, spatial perception, and engagement with the urban context become more apparent. The joints selected were as follows:

(A) Point is at the intersection of Kalpakçılar street with Sipahi street, at the Çarşı gate, (B) Point is at the intersection of Püskülcüler street with Sipahi street, (C) Point is at the intersection of Fesçiler street with Sipahi street, (D) Point is at the intersection of Hacıhasan street with Yağlıkçılar street, (E) Point is at the intersection of Yorgancılar street with Yağlıkçılar street, (F) Point is at the intersection of Perdahçılar street with Yağlıkçılar street, (G) Point is at the intersection of Kalpakçılar street with Takkeçiler street, (H) Point is at the intersection of Keseciler street with Takkeçiler street, (I) Point is at the intersection of Zenneciler street with Takkeçiler street, (J) Point is at the intersection of Halıcılar street with Takkeçiler street, (K) Point is at the intersection of Terlikçiler street with Takkeçiler street, (L) Point is at the intersection of Perdahçılar street with Takkeçiler street, (M) Point is at the intersection of Kalpakçılar street with Kolancılar street, (N) Point is at the intersection of Keseciler street with Kolancılar street, (O) Point is at the centre of Cevahir Bedesteni, (P) Point is at the intersection of Halıcılar street with Sahaflar bedesten street, (Q) Point is at the intersection of Terlikçiler street with Sahaflar bedesten street, (R) Point is at the intersection of Perdahçılar street with Sahaflar bedesten street, (S) Point is at the intersection of Kalpakçılar street with Terzibaşı street, (T) Point is at the intersection of Keseciler street with Terzibaş street, (U) Point is at the intersection of Ağa street with Kuyumcular street, (V) Point is at the intersection of Halıcılar street with Kuyumcular street, (W) Point is at the

intersection of Terlikçiler street with Acıçeşme street, (X) Point is at the intersection of Perdahçılar street with Acıçeşme street.

Each of those points is a vital point in the bazaar and was chosen depending on the values of space syntax analysis which suggests that these points have the highest connectivity and integration values.

For the sake of collecting the data that will be implemented in the segmentation analysis, I visited the grand bazaar to take photos at the selected points, the photos were taken in each direction of the selected intersection points. Typically, the west direction of the point was referred to as 1, the north direction as 2, the east direction as 3 and the south direction as 4 (Figure 5.1).

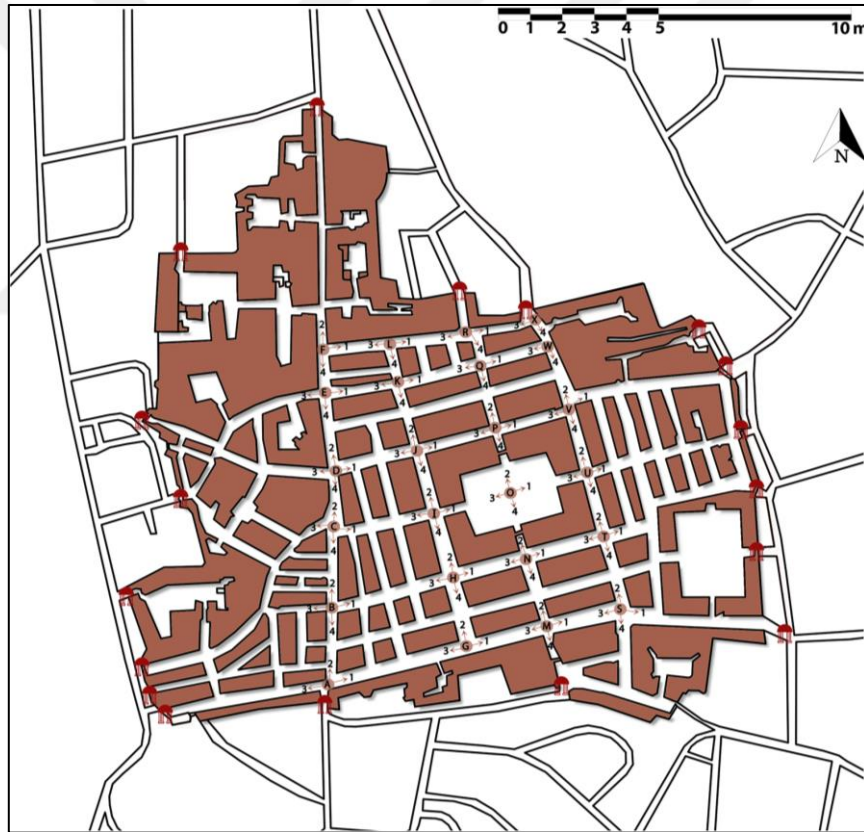


Figure 5.1: Intersection Points of The Grand Bazaar.

After collecting all the needed data, I proceeded to do the semantic segmentation of this images, and as mentioned in the Methodology chapter the code used to apply the segmentation was a ready code scripted by “Lex Fridman” that is available at GitHub website

(Fridman, 2017). after getting the code it was applied by using Python in Google Colaboratory.

At the beginning I had to add all the taken photos in the same file as the code in a google drive file then I had to run the code and select the photos from the file in order to apply the code to the selected photos, after running the code all the photos that has been selected will be segmented.

And the results of this process are a file that has a segmented photo of each of the original taken photos, in addition to an excel chart that contains percentage values of the elements that has been analysed in the photos as shown in (Figure 5.2) see (Appendix A.1) for the full results.

	image_id	built_score	paved_score	auto_score	sky_score	nature_score	human_score	road_score	sidewalk_score	building_score	fence_score	pole_score	traffic_light_score	sign_score	vegetation_score	terrain_score	sky_score	person_score	scuder_score	car_score	truck_score	bus_score	train_score	motorcycle_score	bicycle_score	vold_score		
A1.jpg	37.03538	13.88782	24.12724	0.384119	2.146022	19.20824	12.86699	1.018133	40.18797	0	0	0	0	0	2.146022	0.007763	0.384119	18.32047	0.687763	24.12724	0	0	0	0.001185	0.010459	0		
A2.jpg	41.73559	14.68196	4.438459	0.375289	8.836859	29.67135	9.699793	4.982163	41.73559	0	0	0.226844	0	0	0	8.698489	0.13837	0.375289	29.57961	0.091733	4.432119	0	0.006163	0	0.000178	0.013659	0	
A3.jpg	37.03538	26.85239	6.467378	3.212148	3.994133	22.02027	16.60207	10.25031	37.03538	0	0	0.300741	0	0.000711	3.994133	0	3.212148	21.9693	0.050963	6.46741	0	0.000237	0	0	0	0.116859	0	
B1.jpg	43.13695	29.63401	3.139852	4.102696	3.934578	15.3181	4.003733	25.63028	42.79099	0.343956	0.017067	0.421274	0.000237	0.002726	3.931378	0.0032	4.102696	14.19307	1.325037	3.124207	0.0096	0	0.003496	0.006044	0.089007	0		
B2.jpg	54.75338	18.28415	2.993185	0	3.568889	20.05647	17.22341	1.060741	54.75338	0	0.000119	0.257067	0.004267	0.010607	3.568889	0	0	19.28539	0.771081	2.840578	0.027793	0	0	0	0.118815	0.009867	0	
B3.jpg	39.36196	14.93444	10.92213	0.629096	4.590578	28.82329	6.41843	6.506015	39.36196	0	0	0.466133	0	0	4.590578	0	0.629096	28.81144	0.811852	10.92178	0	0	0	0	0.000356	0.27437	0	
B4.jpg	31.75994	16.93564	24.94346	0.176	3.603556	22.34607	6.5648	10.17084	31.75994	0	0	0.187378	0	0.000119	3.394904	0.208852	0.176	20.82003	1.326044	24.85932	0.033793	0	0	0	0.04883	0.047348	0	
C1.jpg	29.36942	23.29861	5.662519	10.35301	5.602904	24.95804	12.73914	10.55947	29.36942	0	0.00403	0.639526	0	0	5.602904	0	10.35301	23.17203	1.788015	5.439704	0	0	0	0	0.222815	0.111941	0	
C2.jpg	36.93973	38.8736	4.313067	3.064	3.252504	13.03662	17.18228	21.69132	36.93973	0	0.000119	0.489244	0	0.001126	2.721304	0.5312	3.064	12.54904	0.487585	3.564089	0.005156	0	0	0	0.743822	0.029985	0	
C3.jpg	39.02201	26.18436	2.513185	0.6	18.93665	12.46886	22.86839	3.31597	39.02201	0	0.080415	0.075852	0	0.004385	18.71253	0.224119	0.6	12.41813	0.050726	2.448393	0	0	0	0	0.064593	0.111289	0	
C4.jpg	39.09079	15.96809	7.976178	0	0.506311	17.03031	11.75479	3.313304	39.09079	0	0	0.300622	0	0.003837	0.506311	0	0	16.02216	0.968148	7.94178	0.151763	0	0	0	0.000237	0.044267	0	
D1.jpg	11.22744	34.85043	5.289778	5.315911	7.402542	15.28892	30.63247	4.217956	11.22744	0.009007	0.167052	0.015052	0.014933	0.058311	7.396978	0.00557	5.315911	14.26596	1.002963	5.223881	0.001837	0	0	0	0.064059	0.38963	0	
D2.jpg	42.10856	20.63076	7.015111	3.650193	6.42003	19.97612	10.95828	9.672474	42.10856	0	0	0.142519	0	0.016652	6.42003	0	3.650193	15.52593	0.450193	6.9616	0	0	0	0	0.053511	0.040559	0	
D3.jpg	45.12047	2.226193	12.14669	2.722963	5.361896	31.9696	2.181385	0.044207	45.12047	0	0.000474	0.1792	0	0	5.352652	0.009244	2.722963	27.05239	4.917215	12.09944	0.000119	0.000356	0	0	0.049778	0.269511	0	
D4.jpg	35.59633	16.11881	7.094815	0.067378	2.741985	35.0765	11.10619	5.012622	35.59633	0	0.078578	2.107911	0	0.029511	2.733985	0.008	0.067378	18.42133	16.65517	6.837215	0.007644	0	0	0	0.249956	1.088178	0	
E1.jpg	22.09861	10.86388	19.82029	2.271644	12.85511	31.25618	9.030104	1.833778	22.09861	0	0	0.070044	0	0.000237	12.84136	0.013748	2.271644	25.16812	0.088059	14.41724	0.124385	0.000178	0	0	0.278281	0.764207	0	
E2.jpg	36.26655	23.5517	3.212523	2.859522	9.892326	23.99799	11.67384	11.8777	36.26655	0.008889	0.135704	0.001778	0	8.891236	0	2.859522	22.8834	1.159644	2.788104	0	0	0	0	0	0.420148	0.069693	0	
E3.jpg	44.29138	12.4989	14.57446	3.122193	3.779556	21.17641	11.71111	0.787793	44.29138	0	0.006756	0.432533	0	0	3.779556	0	3.122193	20.87384	0.302578	14.54483	0.024237	0	0	0	0.005393	0.117807	0	
F4.jpg	38.86904	21.02501	3.435437	7.099081	12.28486	17.1293	15.80492	5.220089	38.86904	0.002074	0	0.116163	0.000948	0.0144	12.28486	0	7.099081	16.82844	0.300859	3.43123	0	0	0	0	0.004207	0.025896	0	
F1.jpg	32.99342	13.25167	4.736474	0.571615	6.636741	41.29742	5.437985	7.813689	32.99342	0	0	0.023467	0.002074	0	6.601659	0.035081	0.571615	39.6211	1.678326	4.442133	0.003437	0	0	0	0.290904	0.487111	0	
F2.jpg	33.24201	18.48776	11.87988	2.8048	8.185274	24.87123	17.2144	1.73393	33.24201	0	0.000237	0.083674	0	0.054993	8.185274	0	2.8048	24.56966	0.30157	10.9117	0.043378	0	0	0	0.9248	0.409541	0	
F3.jpg	20.58931	14.76865	37.72326	1.790519	8.466193	20.42662	7.507437	7.253215	20.58931	0	0.023052	0.07917	0	0.048563	8.466193	0	1.790519	18.91093	3.517809	32.05766	0.912356	0	0	0	0.73244	0.096059	0	
F4.jpg	35.09612	13.46074	15.57096	0.987437	10.08213	24.08539	10.87324	2.587496	35.09612	0	0.000119	0.100444	0	0.010785	10.05553	0.026607	0.987437	18.25831	5.827081	13.54056	0	0	0.593505	0.0304	2.605807	0		
G1.jpg	44.19283	23.43159	2.718281	2.079585	3.01037	24.43164	9.305778	14.12581	44.19283	0	0	0.115022	0	0.000237	3.01037	0	2.079585	23.4979	0.933748	2.696474	0	0	0	0	0.021807	0.020444	0	
G2.jpg	42.36664	23.75111	5.225719	6.133748	1.421096	20.95585	9.233363	14.51775	42.36664	0	0.002074	0.08557	0.001244	0.056296	1.421096	0	6.133748	20.94886	0.006993	5.224237	0	0	0	0	0.001481	0.000652	0	
G3.jpg	39.536	41.2896	1.123911	4.765274	1.009639	12.1837	12.61369	28.67991	39.536	0	0	0.007793	0	0.014409	1.009639	0	4.765274	12.14246	0.041244	1.005197	0	0.010726	0	0	0.061215	0.0096	0	
H1.jpg	40.77541	23.64788	3.568889	2.950281	7.938059	20.73754	15.95407	7.693867	40.77541	0	0	0.001304	0	0.013096	7.937926	0.020133	2.950281	18.12172	2.618222	3.549607	0	0	0	0	0.019081	0.377541	0	
H2.jpg	54.20954	23.58649	7.965215	1.653193	1.531733	10.61849	11.18204	12.40444	54.20954	0	0	0.189896	0	0.179911	1.531022	0.000711	1.653193	10.41908	0.194007	7.907081	0	0.058133	0	0	0	0.085333	0	0
H3.jpg	27.24901	25.90933	8.270563	3.248889	14.75686	19.93683	9.307081	16.60225	27.24901	0	0	0.0992	0.0432	0	0	14.74222	0.014637	3.248889	17.74252	2.194311	5.95615	0.079881	0	0.255407	2.241067	0.224711	0	
H4.jpg	42.36664	10.99514	6.701452	3.363556	6.737896	30.36367	7.204207	3.790933	42.36664	0	0	0.015585	0	0	0.263585	0.010311	3.363556	27.03597	3.327704	6.587615	0	0	0	0	0.113837	0.050667	0	
I1.jpg	39.27058	23.61476	16.0365	0.465244	1.944237	8.133363	4.229867	19.38489	39.27058	0.025896	0.119704	0.061096	0.000474	0.039704	1.944237	0	0.465244	7.608948	0.584415	25.0305	0	0	0	0	0.054341	0	0	
I2.jpg	86.71307	5.734993	1.027852	2.693274	1.795615	1.742459	3.017817	2.171756	86.71307	0	0.099963	0.200333	0	0.000356	1.797753	0.055881	2.693274	1.689393	0.070067	1.027881	0.000593	0	0	0	0.000178	0.000889	0	
I3.jpg	34.31259	37.76693	0.999259	4.097422	2.366281	12.23609	21.8253	15.94163	34.31259	0	0	0.097067	0	0	2.366281	0	4.097422	11.79941	0.436681	8.572096	0.477985	0	0	0	0.048178	0.024356	0	

Figure 5.2: The Results of Semantic Segmentation in Excel.

The segmentation of the images represents each category of the analysed pixels in the image in a different colour. the colour is determined by the data set used in the semantic segmentation process which for this research is “Cityscapes” dataset, i.e. for the humans it assigns the Red colour for built structures it assigns Gray colour, for the sidewalks it assigns violet colour (Figure 5.3) (Cordts et al., 2016).

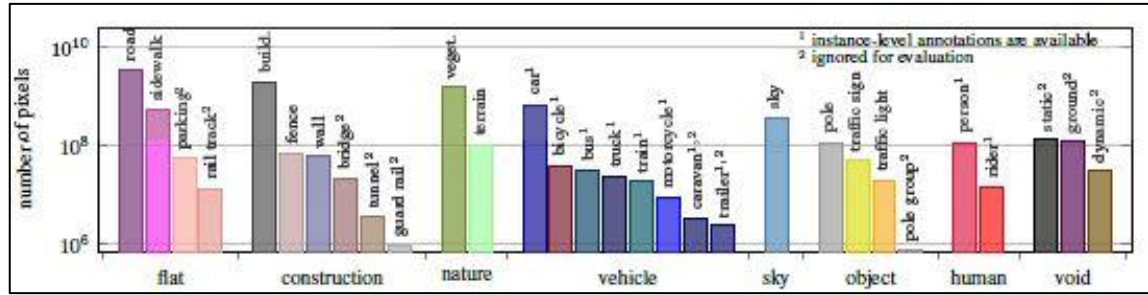


Figure 5.3: Cityscapes Classifications.

The resulted photos of the semantic segmentation can be seen in (Appendix A.2), as it's seen I arranged each segmented photo with the original photo that was used in the semantic segmentation.

As the red color in the segmented photos represents the Human factor, the purple color tones represent the Surfaces such as the paved and the sidewalk factors and the gray color represents the Built factor.

After explaining the space syntax and sematic segmentation analyzing methods and the conducted results in the previous chapters. In the next chapter the correlation method will be examined, how its utilized in this research and what findings is conducted from it.

6. CORRELATION OF THE ANALYSIS

In this chapter, we will try to find the answer to the main question of this research which is that, what kind of correlation elicited from the analysis results of space syntax and semantic segmentation?

To find the answer many methods are utilized for this purpose first method is comparison, where the output of the analysing methods is compared on the visual scale, as seen in (Appendix B.1) it shows the selected intersection points of the grand bazaar that has been conducted from Space Syntax analysis combined with the segmented images related to that point.

The next step was to compare the statistical results of the analysis, the statistical results of semantic segmentation analysis were constructed from the excel sheet that resulted after performing semantic segmentation on the taken photos of the grand bazaar.

However, the resulted excel sheet had many classifications, so it was necessary to select some of the classifications that are directly related to the scope of the analytical goal of this research. And the remaining of these classifications have been neglected due to their insignificance.

The selected classifications ranges were built score, human score, and the average values of sidewalk with paved score under the label of paved score since it has the same affect in our analysis.

After gathering the values of this classification in the excel sheet, the next step was to conduct the corresponding values from space syntax analysis so the values of connectivity and visual integration analysis that have been done using DepthmapX program, were conducted according to each point of the intersection points and then added to the excel sheet that has the arranged semantic segmentation values.

The developed excel sheet had variable values to each label of the classifications (Figure 6.1) see (Appendix B.2) for full chart.

	A	B	C	D	E	F
1	Image	Built Score	Paved Sco	Human Sco	Visibility	Connectivity
2	A1	40.19	7.455	19.21	5.6	1215
3	A2	41.74	9.83	29.67	5.15	1140
4	A3	37.04	18.55	22.02	5.22	1172
5	B1	43.14	27.63	15.52	5.48	1221
6	B2	54.76	9.67	20.06	5.09	1019
7	B3	39.36	10.715	28.82	5.07	1004
8	B4	31.76	13.655	22.35	5.09	1165
9	C1	29.37	16.93	24.96	4.89	1031
10	C2	36.94	30.28	13.04	5.1	976
11	C3	39.03	14.75	12.47	5.33	683
12	C4	59.09	9.19	17.01	5.31	1157

Figure 6.1: The First Developed Excel Sheet of The Analysis Values.

Those values as shown clearly do not have any sort of interconnection, so in order to make the most of these values I had use the values normalization method which is basically the process of creating (clean data) which give us organized values that have a cohesion between them in order to have the ability to compare these values, these method is commonly used to organize the data conducted from different programs in the aim of creating form of clean data entry .

To normalize our conducted data that had been collected and arranged in the excel sheet a specific formula was applied to the values in order to have values that ranges from 0 to 1 which will make it more convenient while comparing the values that comes from the two different programmes used in the analysing process.

The normalization was done on excel using the equation 6.1

$$Y_n = (x_n - \min(x)) / (\max(x) - \min(x)) \quad (6.1)$$

And the resulted normalized values are shown in (Table 6.1) below.

Table 6.1: Resulted Normalized Values of the Analysis.

Image	Built	Paved	Human	Visibility	Connectivity
A1	0.3	0.16	0.44	0.98	0.84
A2	0.32	0.22	0.71	0.8	0.77
A3	0.25	0.44	0.51	0.83	0.8
B1	0.34	0.67	0.35	0.93	0.84
B2	0.52	0.21	0.46	0.77	0.68
B3	0.29	0.24	0.68	0.77	0.66
B4	0.17	0.32	0.52	0.77	0.8
C1	0.14	0.40	0.59	0.69	0.69
C2	0.25	0.73	0.29	0.78	0.64
C3	0.28	0.34	0.27	0.87	0.4
C4	0.58	0.20	0.39	0.86	0.79
D1	0.16	0.45	0.34	0.79	0.69
D2	0.33	0.35	0.46	0.79	0.72
D3	0.37	0.00	0.76	0.93	0.7
D4	0.23	0.24	0.84	0.85	0.73
E1	0.03	0.13	0.75	0.82	0.62
E2	0.24	0.42	0.56	0.82	0.61
E3	0.36	0.14	0.49	0.68	0.59
E4	0.28	0.30	0.39	0.82	0.64
F1	0.19	0.24	1	0.81	0.44
F2	0.19	0.22	0.58	0.74	0.57
F3	0	0.25	0.47	0.48	0.48
F4	0.22	0.17	0.56	0.74	0.57
G1	0.36	0.45	0.57	0.84	0.81
G2	0.33	0.45	0.49	0.81	0.78
G3	0.29	0.85	0.26	0.75	0.82
H1	0.31	0.36	0.48	0.74	0.73
H2	0.51	0.42	0.22	0.57	0.73
H3	0.1	0.51	0.46	0.75	0.75
H4	0.33	0.16	0.72	0.76	0.75

Table 6.1: Resulted Normalized Values of the Analysis “Table Continued”.

I1	0.29	0.52	0.16	0.82	0.83
I2	1	0.08	0	0.67	0.53
I3	0.21	0.65	0.27	0.81	0.79
I4	0.7	0.28	0.24	0.9	0.81
J1	0.5	0.31	0.21	0.75	0.5
J2	0.56	0.39	0.21	0.73	0.58
J3	0.12	0.14	0.52	0.74	0.58
J4	0.76	0.08	0.36	0.78	0.6
K1	0.31	0.31	0.27	0.73	0.57
K2	0.31	0.37	0.23	0.74	0.58
K3	0.46	0.04	0.14	0.73	0.58
K4	0.43	0.25	0.42	0.73	0.58
L1	0.47	0.33	0.4	0.66	0.42
L3	0	0.97	0.45	0.67	0.49
L4	0.19	0.37	0.39	0.67	0.48
M1	0.46	0.47	0.32	0.6	0.53
M2	0.2	0.30	0.66	0.6	0.56
M3	0.53	0.40	0.27	0.6	0.49
M4	0.38	0.78	0.26	0.6	0.55
N1	0.75	0.31	0.15	0.53	0.45
N2	0.23	0.25	0.44	0.53	0.45
N3	0.38	0.65	0.21	0.54	0.45
N4	0.12	0.52	0.43	0.43	0.46
O1	0.9	0.06	0.25	0.65	0.73
O3	0.51	0.17	0.77	0.65	0.73
O4	0.64	0.02	0.68	0.45	0.71
P1	0.67	0.26	0.29	0.55	0.29
P2	0.27	0.43	0.5	0.48	0.27
P3	0.72	0.23	0.16	0.53	0.3
P4	0.38	0.47	0.23	0.53	0.31
Q1	0.28	0.57	0.1	0.42	0.26

Table 6.1: Resulted Normalized Values of the Analysis “Table Continued”.

Q2	0.35	0.23	0.69	0.49	0.25
Q3	0.25	0.58	0.4	0.47	0.29
Q4	0.39	0.29	0.43	0.48	0.33
R1	0.62	0.25	0.21	0.4	0.19
R2	0.19	0.77	0.35	0	0
R3	0.32	0.51	0.21	0.41	0.21
R4	0.15	0.34	0.77	0.33	0.19
S1	0.43	0.32	0.44	0.95	0.95
S2	0.31	0.38	0.26	0.88	0.91
S3	0.37	0.44	0.3	0.79	0.97
S4	0.74	0.07	0.45	0.92	1
T1	0.55	0.31	0.21	0.88	0.76
T2	0.39	0.50	0.19	0.88	0.71
T3	0.23	0.24	0.58	0.81	0.71
T4	0.42	0.44	0.22	0.88	0.73
U1	0.56	0.31	0.24	1	0.81
U2	0.39	0.36	0.49	0.85	0.78
U3	0.34	0.21	0.61	0.93	0.8
U4	0.46	0.32	0.43	0.85	0.8
V1	0.29	0.60	0.54	0.29	0.22
V2	0.42	0.43	0.34	0.84	0.5
V3	0.26	0.17	0.67	0.83	0.53
V4	0.29	0.41	0.51	0.81	0.56
W3	0.41	0.41	0.27	0.81	0.38
W4	0.32	0.52	0.17	0.81	0.51
X3	0.69	0.26	0.25	0.43	0.22
X4	0.61	0.22	0.43	0.73	0.25

After we had the normalized values, the next step was to find a relation between the statistical values of semantic segmentation and the values of spaces syntax, in order to that correlation method is used, to apply correlation to the resulted values the most convenient way was to create a “correlation matrix”, which is a chart of the correlation scores among several variables. The correlation among any of the variables is presented in each field of the chart. This method often includes gathering large amounts of data from many sources and analysing it to uncover any relationships that may be a source for a more comprehensive analysis (Steiger,1980).

The main aim of assembling this matrix is to find the pattern of correlation between our analysis of semantic segmentation and space syntax. To create this matrix, the first step was to use the “data analysis” tool in excel, then to select “correlation” as the analysing tool after that the values of our analysis are selected, and the correlation matrix will be assembled.

The analysis of this massive amounts of data generates a massive dataset with the results. Incorporating these benefits in a short amount of time is challenging. A “heat map” of these data gives a comprehensive understanding of the full results. So, the next step is to apply a “heat map” to the matrix, to do this another excel tools is used which is “colour scales” using the “conditional formatting” feature, this tool applies a colour gradient to the selected values where each colour indicates where each value fall on the range.

As shown in (Table 6.2) the heat map shows the resulted values of the done analysis in a colour gradient of red, yellow and green. Where the red coloured cells indicate the lowest values and the green coloured cells indicates the highest values, which will reveal the pattern that our collected data is forming.

Table 6.2: Heat Map.

	Built Score	Paved Score	Human Score	Visibility	Connectivity
Built Score	1				
Paved Score	-0.39	1			
Human Score	-0.44	-0.32	1		
Visibility	0.02	-0.22	0.09	1	
Connectivity	0.03	-0.14	0.11	0.79	1

7. RESULTS

Within the scope of this study, which was carried out in the Grand Bazaar of Istanbul city, where two of the analyses used to understand the spatial organization of the grand bazaar were applied, after the semantic segmentation and space syntax analysis were done, the resulted data obtained from the analysis had to be applied on the plan of the grand bazaar in order to have a better understanding of the results. So, in order to do that I used the data from the excel chart to create different plans that each one represents a value from the chart.

As we can see in (Figure 7.2) that represents the human score from semantic segmentation analysis results applied on the plan of the grand bazaar, it is noticeable that the highest human score value is in C point which is at the intersection of Fesçiler street with Sipahi street, and the lowest human score value is in Q point which is at the intersection of Terlikçiler street with Sahaflar bedesten street. This can be explained knowing the fact that C point has an important location since the café that is one of the landmarks of the grand bazaar is located there so it's understandable that the human factor can be higher at this intersection point rather than the rest of the intersection points.

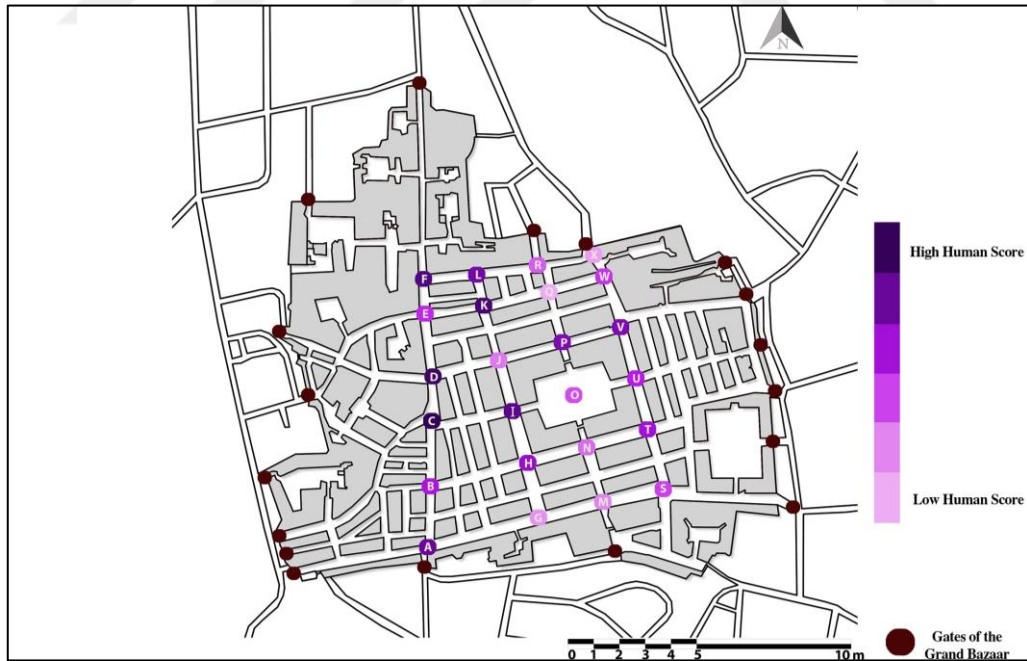


Figure 7.1: Human Score Plan.

While in (Figure 7.2) that represent the connectivity value from the spaces syntax analysis results applied on the plan of the grand bazaar, it indicates that the highest value of the connectivity value was found in B Point that is located at the intersection of Püskülcüler street with Sipahi street, and the lowest connectivity value was found in V point which is located at the intersection of Halıcılar street with Kuyumcular street.

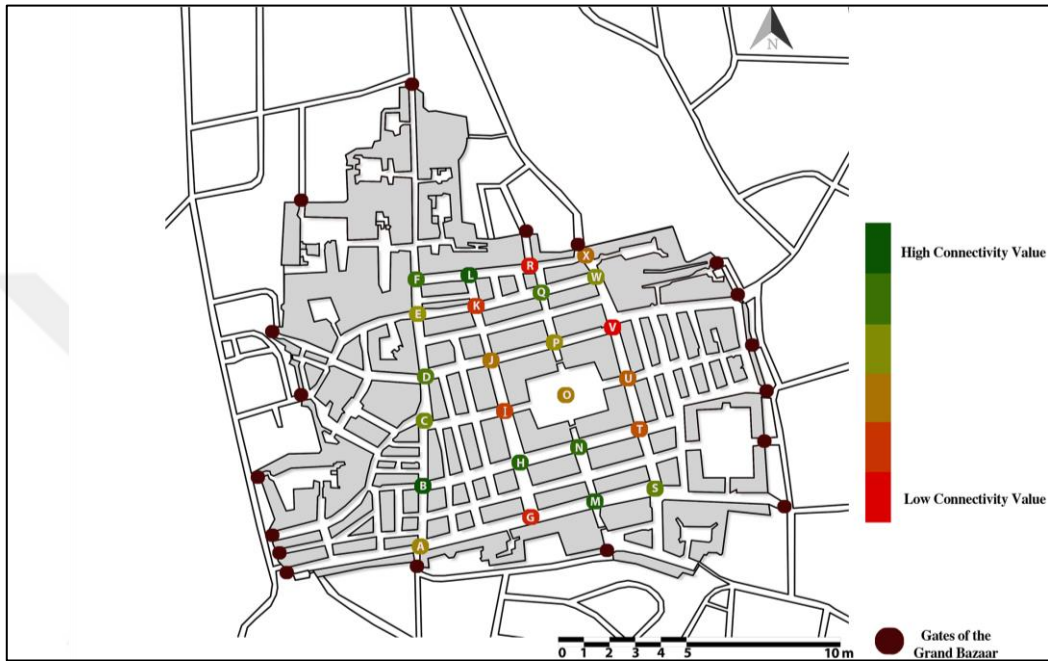


Figure 7.2: Connectivity Value Plan.

While in (Figure 7.3) that represent the visibility value from the spaces syntax analysis results applied on the plan of the grand bazaar, it indicates that the highest value of the visibility value was found in L point which is located at the intersection of Perdahçılar street with Takkeçiler street, and the lowest visibility value was found in V point which is located at the intersection of Halıcılar street with Kuyumcular street.

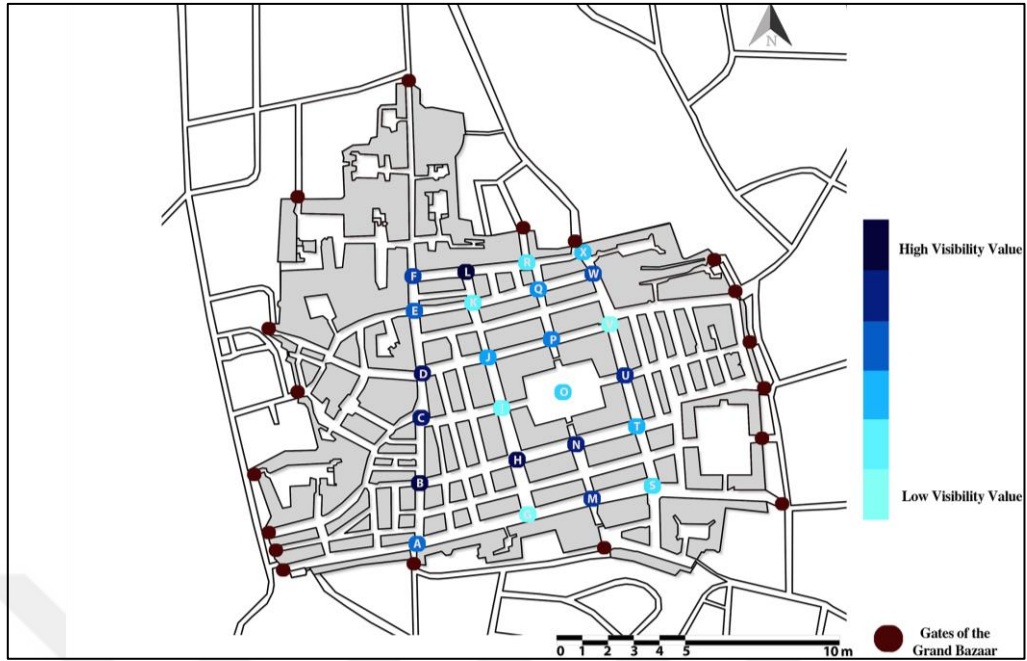


Figure 7.3: Visibility Value Plan.

so as a result If we come to compare the results after applying them on the plan of the grand bazaar as in (Figure 7.4) we can clearly notice the correspondence of the results of those analysis.

As the high value points are almost the same points in all of the plans which are the (B-C-D-L) Points , same as the mid value points which are the (E-O-P-X) and low value points which are the (G-R-V) they almost have the same location in all of the three plans.

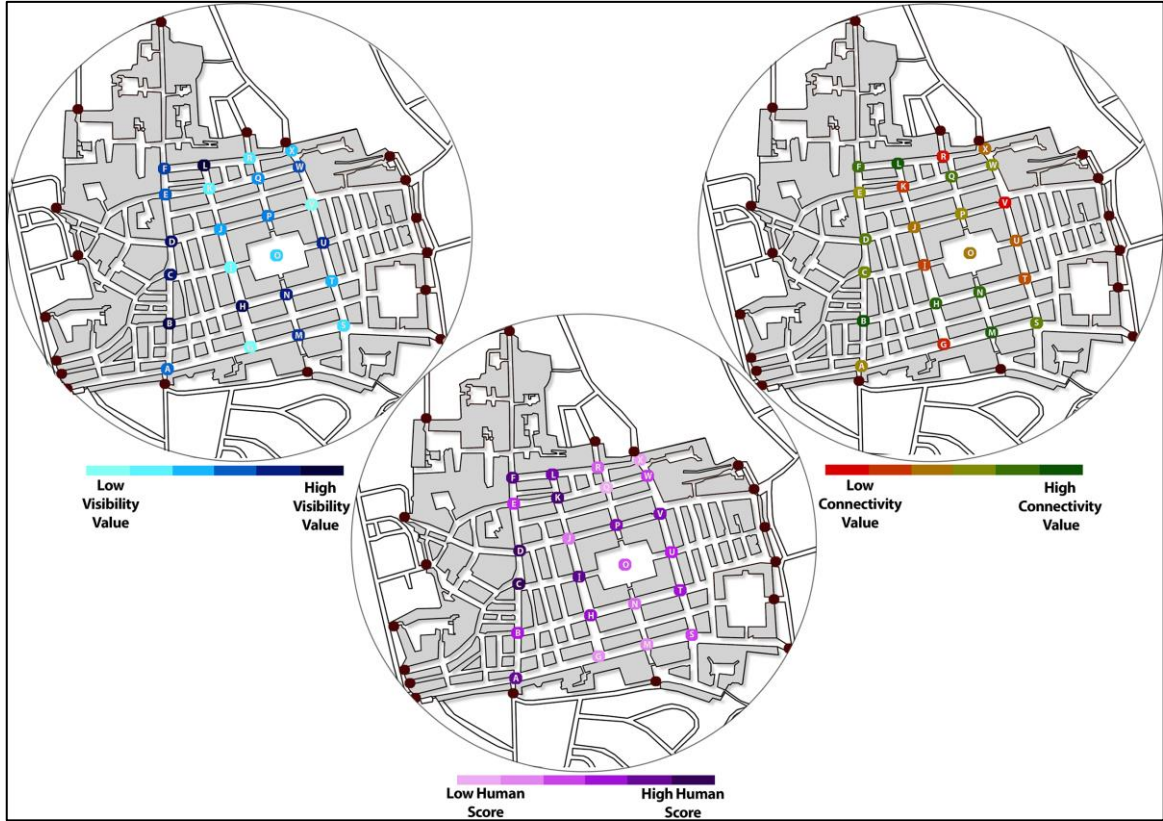


Figure 7.4: Comparison of Plans.

also, in (Figure 7.5), which is the 3D representation of the values compared to each other, it shows that there is actually sort of relation between the human existence with the connectivity and visibility ratio at a location inside the grand bazaar, since as seen in the 3d graph the highest values can be seen at the same area as well as the lowest values are mostly in the same areas.

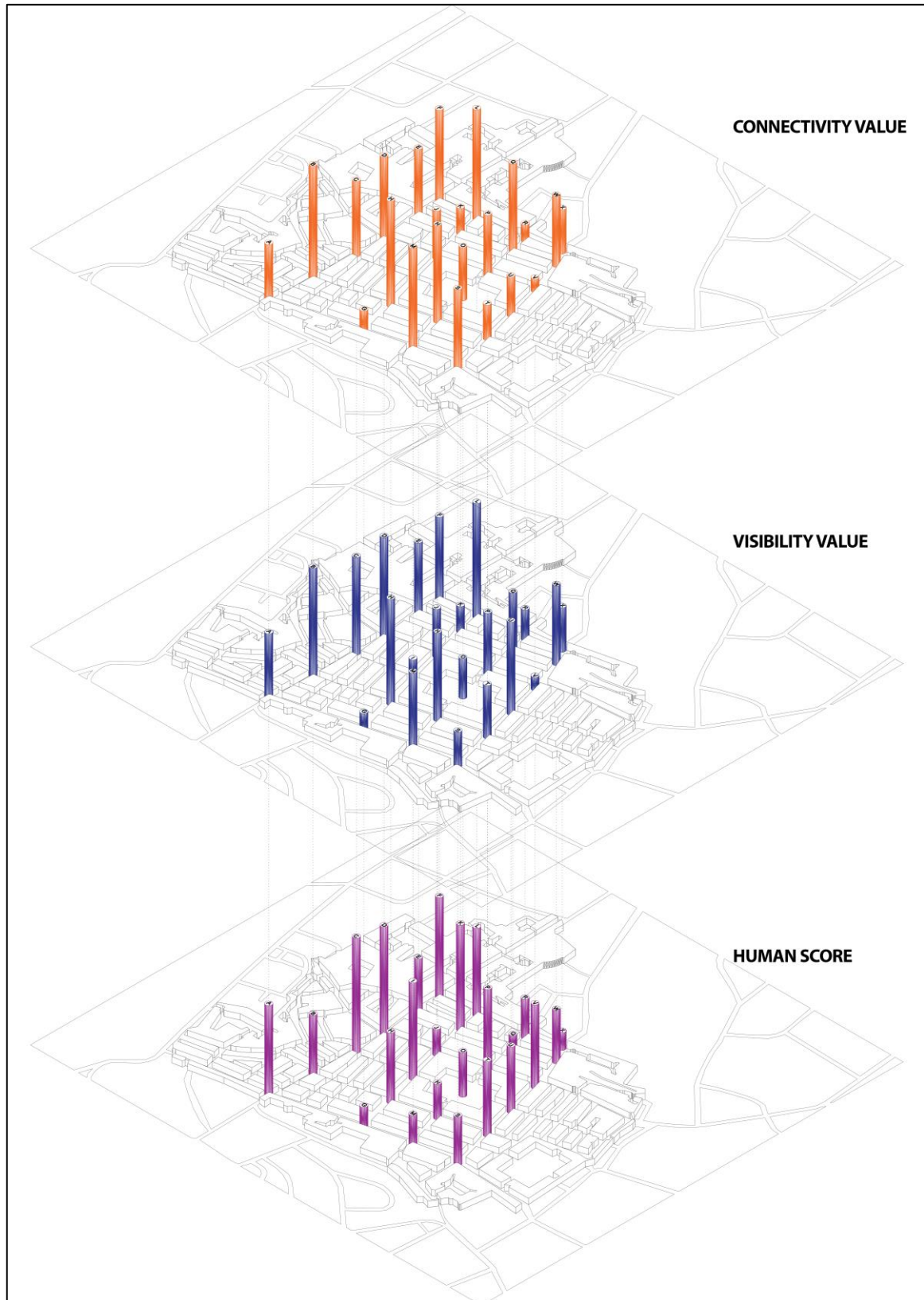
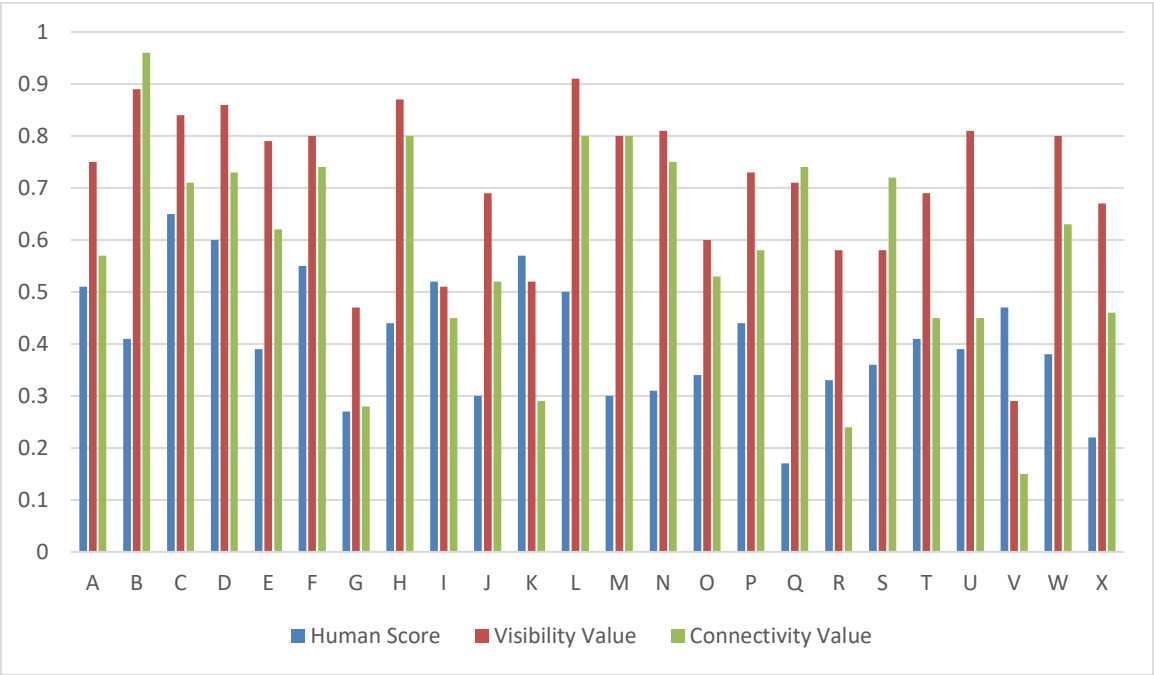


Figure 7.5: 3D Presentation of The Plans and Values.

Also, when the data obtained after the visual integration analysis are compared with the data obtained in the semantic segmentation analysis as seen in (chart7.1), we can obviously understand that there's actually a sort of correlation between the space syntax and the semantic segmentation analysis.

Chart 7.1: Values Comparison.



As shown in (Table 6.2), we can also notice that “visibility” has a correlation value of 0.02 with the “built score” which indicates a positive correlation, while it has a higher positive correlation value that is 0.09 with ‘human score’, while a correlation value of -0.22 with the “paved score” that indicates a negative correlation, this suggests that visibility hit its peak when the humans ratio increases at the same point of the grand bazaar.

On the other hand, “connectivity” has a correlation value of 0.03 with the “built score”, while it has a correlation value of 0.11 with the “human score”, meanwhile it has a correlation value of -0.14 with the “paved score”. This also suggests that connectivity correlation is higher where the human ratio is higher and it decreases where there is just built and paved structures at the same point of the grand bazaar.

Also, we can see that “visibility” and “connectivity” has a correlation value of 0.79 which is the highest positive correlation in the correlation matrix, which indicates that the more the visibility increases the more the connectivity increase as well.

Another thing can be noticed in the matrix, which is the negative correlation between each of the “paved”, “built” and “human” scores, since the correlation value between the “paved score” and the “human score” is -0.32, while it decreases to -0.39 between the “built score” and the “paved score”, then it deteriorates to -0.44 between the “built score” and the “human score”, which is the highest negative correlation value among the correlation matrix.

This shows that whenever the built and paved structure ratio increases at some point in the grand bazaar the human score decreases.

After comparing the plans and the correlation results it is obvious that the results of the analysis done in this research indicates that there is a direct relationship between the human ratio with the connectivity and visibility ratio in the grand bazaar, and it's clear through the analysis done that whenever the connectivity and visibility ratio increases at some point the human ratio also increases at the same point.

This can be a proof to our hypothesis that the circulation organization of the grand bazaar does actually affect the pedestrian movement in it.

At the end we can come to a conclusion that in a settlement, the social community that adapts to the physical structure of the city in proportion to it provides urban continuity by integrating with the space. This is indicative of a correct placement pattern. However, over time, the changes and articulations seen at the building scale or in the urban system cause the social community living there to also change. As cities have changed socially, culturally, and economically, so has the form of cities. In this context, the architectural identity, geographical structure and social environment of the grand bazaar is the front face of an urban memory that has been continuing from past to present. It is very important to protect this special formation with all its social, physical and perceptual features and to ensure continuity in the memory of the city.

This research can be a starting point to more in depth investigations that consider the grand bazaar circulation structure, and its integration with the urban tissue surrounding it.

Since there is no research yet that utilizes the pedestrian analysis to understand the circulation of the grand bazaar, this research can help the researchers to consider the grand bazaar spatial organization and turns their attention to the importance of it.

Also, this research demonstrates the potential advantages of employing space syntax and semantic segmentation in urban planning in the future. Maybe comprehensibility might be used as a predictor for the creation of spaces and choice-making stages by urban designers and architects.

In order to predict the potential urban shape of a city and to assess different urban planning or design suggestions with regard to urban living, this study can be extended to the developing of commercial centres, urban infrastructure, and urban areas or expansions.



REFERENCES

- Aygen, G. (2015). Languages of Kapalıçarşı/The Grand Bazaar. *Journal of The Ottoman and Turkish Studies Association*, 2(2), 401–419. JSTOR. <https://doi.org/10.2979/Jottturstuass.2.2.09>
- Asgari Taghanaki, S., Abhishek, K., Cohen, J. P., Cohen-Adad, J., & Hamarneh, G. (2021). Deep semantic segmentation of natural and medical images: A review. *Artificial Intelligence Review*, 54(1), 137–178. <https://doi.org/10.1007/s10462-020-09854-1>
- Albayrak, A. S. (2006). Uygulamalı çok değişkenli istatistik teknikleri. Asil yayın dağıtım.
- Bafna, S. (2003). Space Syntax: A Brief Introduction to Its Logic and Analytical Techniques. *Environment and Behavior*, 35(1), 17–29. <https://doi.org/10.1177/0013916502238863>
- Bildik, S. (1998). Değişen alışveriş alışkanlıkları ve Kapalıçarşı.
- Beginner's Guide to Semantic Segmentation [2023], from <https://www.v7labs.com/blog/semantic-segmentation-guide>
- Ceylan, O. (1989). Geleneksel Türk Osmanlı çarşı yapılarının oluşumu, gelişimi ve yakın doğu kültürleri ile olan etkileşimleri.
- Cezar, M. (1983). Typical commercial buildings of the Ottoman classical period and the Ottoman construction system: Publishing/Türkiye İş Bankası; 241: Art series.
- Cordts, M., Omran, M., Ramos, S., Rehfeld, T., Enzweiler, M., Benenson, R., Franke, U., Roth, S., & Schiele, B. (2016). The Cityscapes Dataset for Semantic Urban Scene Understanding. 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 3213–3223. <https://doi.org/10.1109/CVPR.2016.350>
- Dilaveroğlu, İ. & Pilehvarian (kara), N. (2022). İstanbul Kapalıçarşı'nın Sokakları ve Kapıları Üzerine Bir İnceleme . *Art-Sanat Dergisi* , (17) , 103-129 . DOI: 10.26650/artsanat.2022.17.889940

- Dalton, R. C., Hölscher, C., & Turner, A. (2012). Understanding space: The nascent synthesis of cognition and the syntax of spatial morphologies. *Environment and Planning B: Planning and Design*, 39(1), 7-11.
- Ergun Kocaili, B. (2010). Evolution of shopping malls: recent trends and the question of regeneration (Doctoral dissertation, Çankaya University).
- Ergün, R., Kutlu, İ., & Kiliç, C. (2022). A comparative study of space syntax analysis between traditional Antakya Houses and social housing complexes by TOKI. *Journal of Architectural Sciences and Applications*, 7(1), 284-297. [HTTPS://DOI.ORG/10.30785/MBUD.1068659](https://doi.org/10.30785/MBUD.1068659)
- Fridman, L. (2023). MIT Deep Learning [Jupyter Notebook]. https://github.com/lexfridman/mit-deep-learning/blob/c5cc240d3482889109c954eeac786522843b0b3a/tutorial_driving_scene_segmentation/tutorial_driving_scene_segmentation.ipynb (Original work published 2017)
- Gülersoy, Ç. (1979). *Kapalı çarşının romanı*. İstanbul Kitaplığı Limited Yayını.
- Gogtay, N. J., & Thatta, U. M. (2017). Principles of correlation analysis. *Journal of the Association of Physicians of India*, 65(3), 78-81.
- Hamza, N. (2022). *Architecture and Urban Transformation of Historical Markets: Cases from the Middle East and North Africa (1st ed.)*. Routledge. <https://doi.org/10.4324/9781003143208>
- Hasol, D. (1995). *Ansiklopedik Mimarlık Sözlüğü*, Yapı Endüstri Merkezi Yayınları 6. Baskı, İstanbul, 412.
- Hillier, B., & Hanson, J. (1984). *The social logic of space*. Cambridge: Press Syndicate of the University of Cambridge. P 48-51.
- Küçükkömürcü, B. (2005). *Geleneksel Türk Osmanlı çarşı yapıları ve günümüzdeki alışveriş merkezleri üzerine bir inceleme* (Master's thesis, [2005]).

- Küçükerman, Ö., & Mortan, K. (2007). Kapalıçarşı (Vol. 3097). TC Kültür ve Turizm Bakanlığı Yayınları.
- Kaur, D., & Kaur, Y. (2014). Various image segmentation techniques: a review. *International Journal of Computer Science and Mobile Computing*, 3(5), 809-814.
- Köroğlu, B. , Eceral, T. & Uğurlar, A. (2010). The Story of a Jewelry Cluster in Istanbul Metropolitan Area: Grand Bazaar (Kapalıçarşı) . *Gazi University Journal of Science* , 22 (4) , 383-394 . Retrieved from <https://dergipark.org.tr/en/pub/gujs/issue/7391/96836>
- Müller-Wiener, W. (2001). İstanbul“ un Tarihsel Topoğrafyası, Yapı Kredi Yayınları, İstanbul. (first published in German, 1977)
- Peker, A. U. (2016). Return of the Sultan: Nuruosmânîye Mosque and the Istanbul Bedestan. *Studi culturali*, 306, 21.
- Raj, B. (2019, March 4). A Simple Guide to Semantic Segmentation. BeyondMinds. <https://medium.com/beyondminds/a-simple-guide-to-semantic-segmentation-effcf83e7e54>
- Suver, H. (2019). Faith Kültür Mirası. Istanbul: Istanbul Faith Belediyesi Kültür Yayınları.
- Semantic Segmentation—The Definitive Guide for 2021. (2021, February 10). <https://cnvrg.io/semantic-segmentation/>
- Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological bulletin*, 87(2), 245.
- Semantic Segmentation: Uses and Applications. (2021, May 9). Keymakr’s Blog Features the Latest News and Updates. <https://keymakr.com/blog/semantic-segmentation-uses-and-applications/>

- Turner, A., Doxa, M., O'Sullivan, D., & Penn, A. (2001). From Isovists to Visibility Graphs: A Methodology for the Analysis of Architectural Space. *Environment and Planning B: Planning and Design*, 28(1), 103–121. <https://doi.org/10.1068/b2684>
- Turner, A. (n.d.). Depthmap 4—A Researcher's Handbook.
- The Theano Development Team, Al-Rfou, R., Alain, G., Almahairi, A., Angermueller, C., Bahdanau, D., Ballas, N., Bastien, F., Bayer, J., Belikov, A., Belopolsky, A., Bengio, Y., Bergeron, A., Bergstra, J., Bisson, V., Snyder, J. B., Bouchard, N., Boulanger-Lewandowski, N., Bouthillier, X., ... Zhang, Y. (2016). Theano: A Python framework for fast computation of mathematical expressions (arXiv:1605.02688). arXiv. <http://arxiv.org/abs/1605.02688>
- Wolfe, M. W. (1963). The Bazaar at Istanbul. *Journal of the Society of Architectural Historians*, 22(1), 24–28. <https://doi.org/10.2307/988208>
- Wohl, S. (2015). The Grand Bazaar in Istanbul: The Emergent Unfolding of a Complex Adaptive System. *International Journal of Islamic Architecture*, 4(1), 39–73. https://doi.org/10.1386/ijia.4.1.39_1
- Wu, J. (2017). Introduction to convolutional neural networks. National Key Lab for Novel Software Technology. Nanjing University. China, 5(23), 495.
- Yalinay, O., Baxter, I. W. F., Collinson, E., Curran, R., Gannon, M. J., Lochrie, S., Taheri, B., & Thompson, J. (2018). Servicescape and shopping value: The role of negotiation intention, social orientation, and recreational identity at the Istanbul Grand Bazaar, Turkey. *Journal of Travel & Tourism Marketing*, 35(9), 1132–1144. <https://doi.org/10.1080/10548408.2018.1475277>
- Yücel, G., & Arun, G. (2010). Istanbul Grand Bazaar Evacuation System Vulnerability Assessment. *Advanced Materials Research*, 133–134, 611–616. <https://doi.org/10.4028/www.scientific.net/AMR.133-134.611>
- Yücel, G. (2015). Deprem Tehlikesi ve Tarihi Çarşılar: İstanbul Kapalıçarşı.. Türkiye Deprem Mühendisliği ve Sismoloji Konferansı.

APPENDIX A

SEMANTIC SEGMENTATION RESULTS

A.1 CHART OF SEMANTIC SEGMENTATION RESULTS

Table A.1: Semantic Segmentation Results.

Image ID	Built Score	Paved Score	Auto Score	Sky Score	Nature Score	Human Score	Road Score	Sidewalk Score
A1.jpg	40.19	13.89	24.17	0.38	2.15	19.21	12.87	1.02
A2.jpg	41.74	14.68	4.44	0.38	8.84	29.67	9.70	4.98
A3.jpg	37.04	26.85	6.47	3.21	3.99	22.02	16.60	10.25
B1.jpg	43.14	29.63	3.14	4.10	3.93	15.52	4.00	25.63
B2.jpg	54.76	18.28	2.99	0.00	3.57	20.06	17.22	1.06
B3.jpg	39.36	14.92	10.92	0.63	4.60	28.82	8.42	6.51
B4.jpg	31.76	16.94	24.94	0.18	3.60	22.35	6.56	10.37
C1.jpg	29.37	23.30	5.66	10.35	5.60	24.96	12.74	10.56
C2.jpg	36.94	38.87	4.31	3.06	3.25	13.04	17.18	21.69
C3.jpg	39.03	26.18	2.51	0.60	18.94	12.47	22.87	3.32
C4.jpg	59.09	15.07	7.98	0.00	0.51	17.01	11.75	3.31
D1.jpg	31.23	34.85	5.29	5.32	7.40	15.27	30.63	4.22
D2.jpg	42.11	20.63	7.02	3.65	6.42	19.98	10.96	9.67
D3.jpg	45.12	2.23	12.15	2.72	5.36	31.97	2.18	0.04
D4.jpg	35.60	16.12	7.09	0.07	2.74	35.08	11.11	5.01
E1.jpg	22.10	10.86	19.82	2.27	12.86	31.26	9.03	1.83
E2.jpg	36.27	23.55	3.22	2.86	9.89	24.00	11.67	11.88
E3.jpg	44.29	12.50	14.57	3.12	3.78	21.18	11.71	0.79
E4.jpg	38.87	21.03	3.44	7.10	12.28	17.13	15.80	5.22
F1.jpg	32.99	13.25	4.74	0.57	6.64	41.30	5.44	7.81
F2.jpg	33.24	18.49	11.88	2.80	8.17	24.87	17.21	1.27

Table A.1: Semantic Segmentation Results “Table Continued”.

F3.jpg	20.60	14.76	33.72	1.79	8.47	20.43	7.51	7.25
F4.jpg	35.10	13.46	13.57	0.99	10.08	24.09	10.87	2.59
G1.jpg	44.19	23.43	2.72	2.08	3.01	24.43	9.31	14.13
G2.jpg	42.37	23.75	5.23	6.13	1.42	20.96	9.23	14.52
G3.jpg	39.54	41.29	1.12	4.77	1.01	12.18	12.61	28.68
H1.jpg	40.78	23.65	3.57	2.95	7.93	20.74	15.95	7.69
H2.jpg	54.21	23.59	7.97	1.65	1.53	10.62	11.18	12.40
H3.jpg	27.25	25.91	8.28	3.25	14.76	19.94	9.31	16.60
H4.jpg	42.24	11.00	6.70	3.36	6.27	30.36	7.20	3.79
I1.jpg	39.27	23.61	26.04	0.47	1.94	8.19	4.23	19.38
I2.jpg	86.71	5.73	1.03	2.69	1.80	1.74	3.02	2.72
I3.jpg	34.31	37.77	9.10	4.10	2.37	12.24	21.83	15.94
I4.jpg	66.97	16.36	3.67	0.01	0.22	11.27	8.01	8.36
J1.jpg	53.31	21.45	4.32	4.12	6.70	9.96	15.97	5.49
J2.jpg	57.45	21.50	5.33	0.47	4.49	10.00	10.01	11.49
J3.jpg	28.43	10.00	20.28	0.69	18.06	22.21	7.01	2.99
J4.jpg	70.75	4.45	7.08	0.01	1.66	15.92	0.47	3.98
K1.jpg	41.04	25.44	6.02	11.82	2.86	12.52	23.88	1.57
K2.jpg	40.74	29.35	4.76	1.03	12.99	10.77	26.19	3.16
K3.jpg	50.83	5.57	26.17	7.45	2.63	7.24	5.34	0.23
K4.jpg	49.10	18.71	7.07	5.43	1.26	18.28	14.82	3.89
L1.jpg	51.49	17.66	8.82	2.01	1.78	17.66	7.08	10.58
L3.jpg	20.35	40.40	7.61	7.13	4.12	19.50	2.27	38.13
L4.jpg	32.81	27.06	13.49	4.59	4.18	17.36	22.13	4.93
M1.jpg	50.65	30.00	1.44	1.62	1.62	14.57	19.88	10.12
M2.jpg	33.45	20.96	10.91	1.91	4.83	27.88	15.65	5.30
M3.jpg	55.59	26.48	3.26	1.04	1.36	12.23	18.86	7.62

Table A.1: Semantic Segmentation Results “Table Continued”.

M4.jpg	45.70	35.13	3.93	0.01	2.78	11.93	6.23	28.90
N1.jpg	69.86	17.84	2.01	0.06	1.75	7.78	8.66	9.18
N2.jpg	35.45	14.31	25.31	4.84	0.52	19.22	6.41	7.90
N3.jpg	45.83	30.24	9.61	0.00	3.53	9.93	6.63	23.61
N4.jpg	28.61	34.48	8.75	2.53	6.41	18.61	25.32	9.16
O1.jpg	80.19	5.28	2.58	0.03	0.03	11.72	3.52	1.76
O3.jpg	54.19	10.70	1.58	0.00	0.72	32.36	6.00	4.71
O4.jpg	63.11	2.63	5.30	0.01	0.15	28.65	1.56	1.07
P1.jpg	64.55	18.20	2.95	0.04	0.80	13.02	13.45	4.75
P2.jpg	38.18	28.96	5.06	0.86	4.86	21.53	21.39	7.58
P3.jpg	68.09	12.02	7.47	0.00	3.76	8.09	4.06	7.96
P4.jpg	45.72	24.96	11.58	0.91	5.72	10.74	10.26	14.70
Q1.jpg	39.15	29.47	10.56	8.01	6.84	5.53	11.10	18.37
Q2.jpg	43.84	12.34	11.30	0.03	2.97	28.94	4.34	7.99
Q3.jpg	36.96	26.64	6.44	8.06	3.69	17.76	5.23	21.41
Q4.jpg	46.47	21.26	10.78	0.07	2.43	18.57	17.01	4.26
R1.jpg	61.26	17.54	3.64	5.49	1.65	10.10	12.70	4.84
R2.jpg	32.74	43.30	2.60	3.67	1.80	15.61	23.12	20.19
R3.jpg	41.54	31.20	14.74	0.41	1.81	9.92	19.52	11.69
R4.jpg	30.23	21.01	8.25	2.60	5.16	32.35	13.01	8.00
S1.jpg	48.91	19.66	7.33	2.92	1.62	19.00	11.50	8.17
S2.jpg	40.92	32.69	9.56	2.14	2.53	11.89	31.71	0.98
S3.jpg	45.14	36.43	2.43	0.65	1.34	13.74	34.82	1.62
S4.jpg	69.21	5.79	3.05	0.00	1.58	19.61	4.30	1.49
T1.jpg	56.79	20.91	2.51	5.40	3.70	10.03	14.85	6.06
T2.jpg	46.29	38.41	0.45	0.27	5.42	9.06	34.09	4.32
T3.jpg	35.45	21.27	12.81	1.38	2.94	24.67	20.67	0.61

Table A.1: Semantic Segmentation Results “Table Continued”.

T4.jpg	48.54	31.26	4.37	3.70	0.62	10.41	25.20	6.06
U1.jpg	57.32	17.66	11.48	0.00	0.35	11.29	8.88	8.78
U2.jpg	46.55	27.88	0.95	0.07	3.36	21.15	24.42	3.46
U3.jpg	42.84	13.72	17.48	0.09	0.06	25.80	8.61	5.12
U4.jpg	50.76	19.03	7.14	0.46	3.37	18.87	10.59	8.44
V1.jpg	39.73	31.19	0.14	1.13	4.70	22.99	12.79	18.41
V2.jpg	48.29	27.84	6.19	0.70	1.31	15.24	18.99	8.85
V3.jpg	37.89	13.53	9.08	4.85	6.03	28.31	11.65	1.88
V4.jpg	39.79	32.40	1.46	1.00	3.35	21.98	28.94	3.46
W3.jpg	47.72	29.07	7.12	0.68	2.71	12.56	22.70	6.37
W4.jpg	41.83	31.87	13.46	3.43	1.03	8.33	19.95	11.92
X3.jpg	66.05	17.52	2.29	0.10	2.01	11.73	12.28	5.23
X4.jpg	61.04	15.97	1.74	0.13	2.33	18.73	11.98	3.99

A.2 SEMANTIC SEGMENTATION RESULTED PHOTOS

Those are the segmentation results of the taken photos in the grand bazaar, each segmented photo is placed next to the original photo.

As the Red colour in the segmented photos represents the Human factor, the Purple colour tones represent the Surfaces such as the paved and the sidewalk factors and the Gray colour represents the Built factor.





Figure A.2.1: Photos Segmentation.

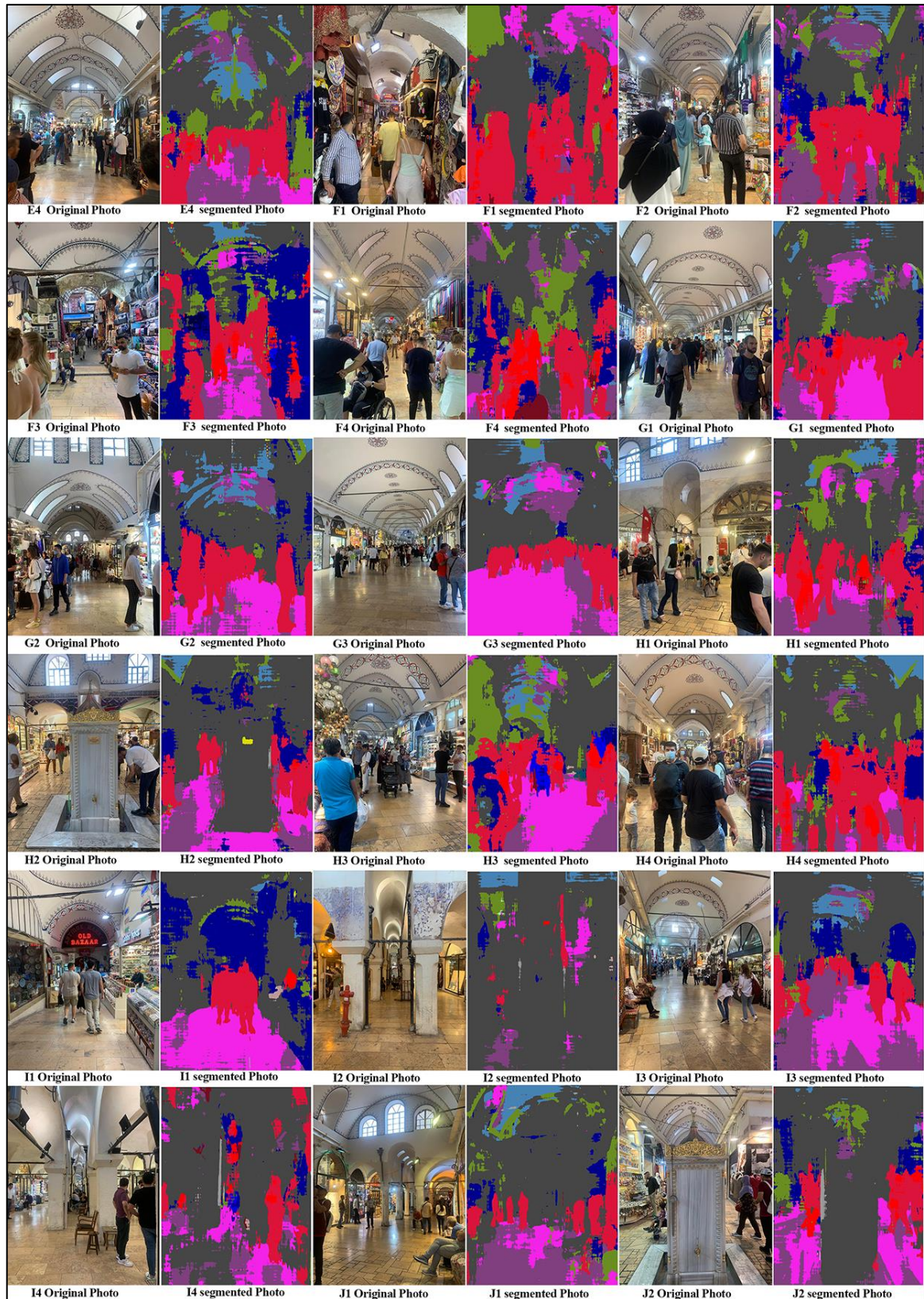


Figure A.2.2: Photos Segmentation.

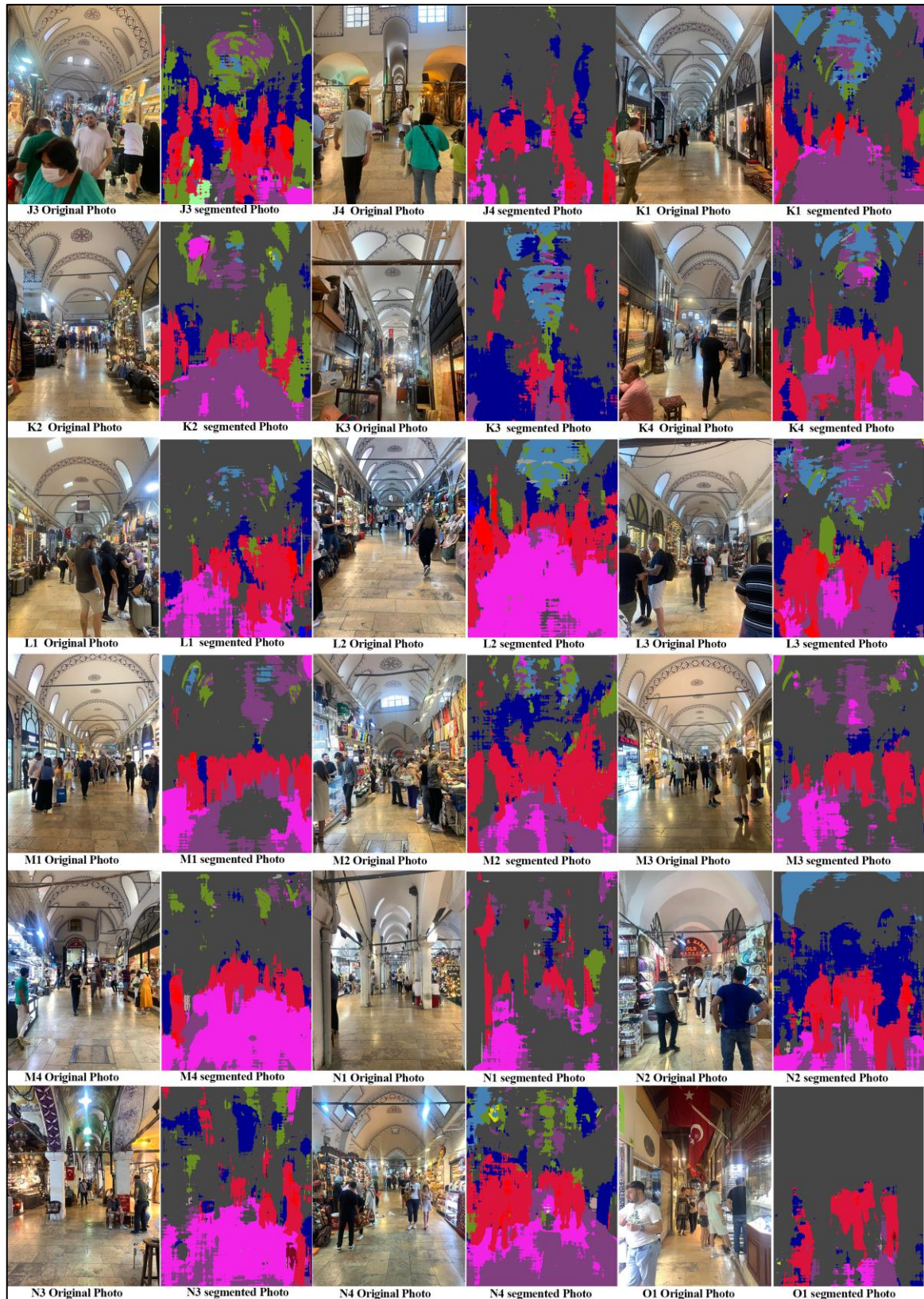


Figure A.2.3: Photos Segmentation.

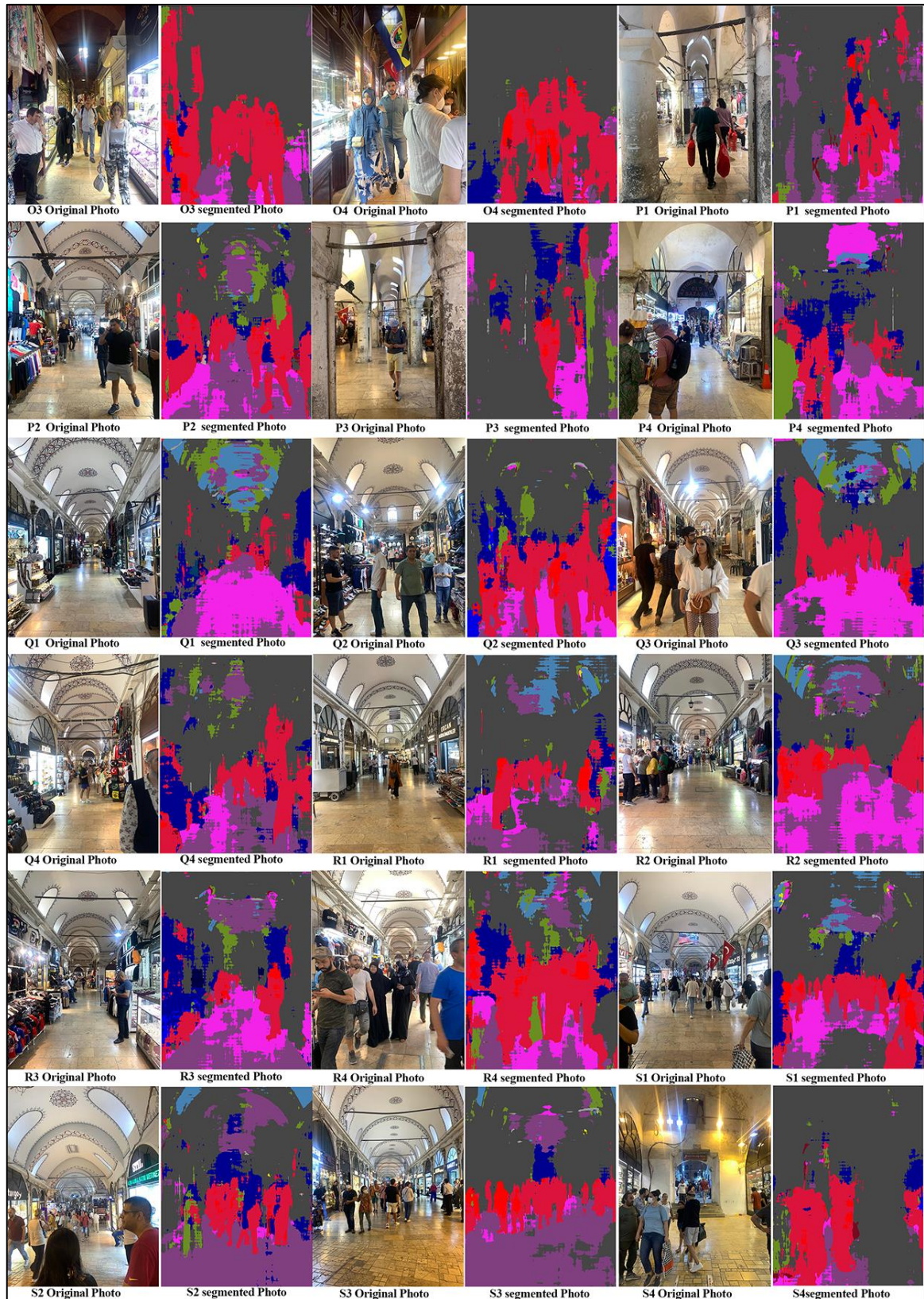


Figure A.2.4: Photos Segmentation.

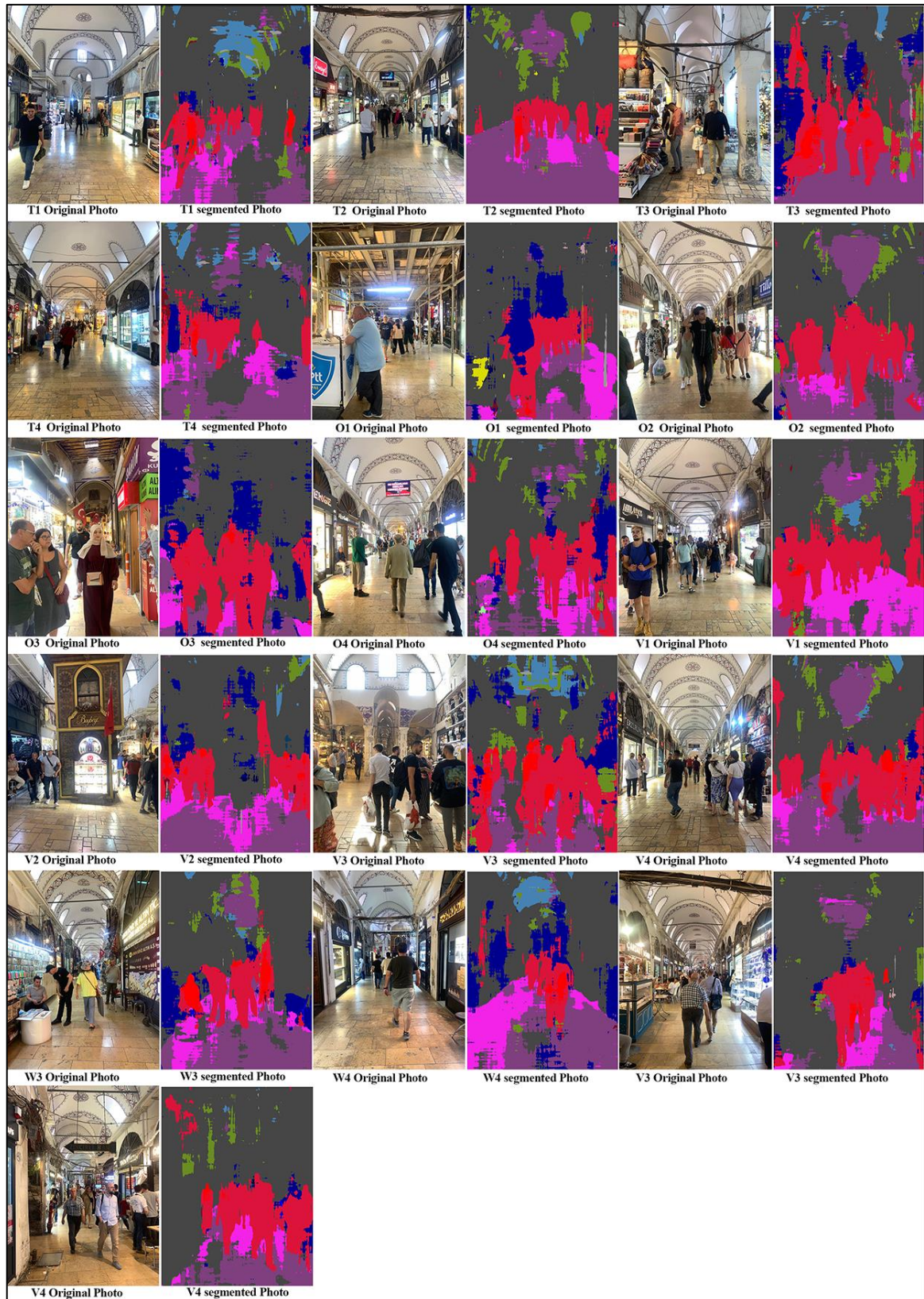


Figure A.2.5: Photos Segmentation.

APPENDIX B

RESULTS COMPARISON

B.1 VISUAL COMPARISON OF SPACE SYNTAX & SEMANTIC SEGMENTATION

Those are the resulted photos of semantic segmentation of each intersection point at the grand bazaar combined with the space syntax result of the same point.



Figure B.1.1: Photo Comparison of Space Syntax & Semantic Segmentation (A to F) points.



Figure B.1.2: Photo Comparison of Space Syntax & Semantic Segmentation (G to L) points.



Figure B.1.4: Photo Comparison of Space Syntax & Semantic Segmentation (S to X) points.

B.2 COMBINED NUMERICAL RESULTS

Table of the combined statistical results of semantic segmentation and space syntax where the (Built, Paved and Human Score) are conducted from semantic segmentation analysis and (Visibility and Connectivity) are conducted from space syntax analysis

Table B.2: Semantic Segmentation & Space Syntax Results Combined.

Image	Built Score	Paved Score	Human Score	Visibility	Connectivity
A1	40.19	7.455	19.21	5.6	1215
A2	41.74	9.83	29.67	5.15	1140
A3	37.04	18.55	22.02	5.22	1172
B1	43.14	27.63	15.52	5.48	1221
B2	54.76	9.67	20.06	5.09	1019
B3	39.36	10.715	28.82	5.07	1004
B4	31.76	13.655	22.35	5.09	1165
C1	29.37	16.93	24.96	4.89	1031
C2	36.94	30.28	13.04	5.1	976
C3	39.03	14.75	12.47	5.33	683
C4	59.09	9.19	17.01	5.31	1157
D1	31.23	19.535	15.27	5.14	1042
D2	42.11	15.15	19.98	5.13	1071
D3	45.12	1.135	31.97	5.46	1046
D4	35.6	10.565	35.08	5.28	1090
E1	22.1	6.345	31.26	5.21	948
E2	36.27	17.715	24	5.21	943
E3	44.29	6.645	21.18	4.86	919
E4	38.87	13.125	17.13	5.2	974
F1	32.99	10.53	41.3	5.19	727
F2	33.24	9.88	24.87	5.01	887
F3	20.6	11.005	20.43	4.38	784
F4	35.1	8.025	24.09	5.01	885
G1	44.19	18.78	24.43	5.25	1189
G2	42.37	19.135	20.96	5.19	1144
G3	39.54	34.985	12.18	5.03	1197
H1	40.78	15.67	20.74	5.02	1085
H2	54.21	17.995	10.62	4.6	1087
H3	27.25	21.255	19.94	5.03	1104
H4	42.24	7.395	30.36	5.06	1107
I1	39.27	21.495	8.19	5.2	1207
I2	86.71	4.225	1.74	4.84	836
I3	34.31	26.855	12.24	5.19	1162

Table B.2: Semantic Segmentation & Space Syntax Results Combined “Table Continued”.

I4	66.97	12.36	11.27	5.39	1181
J1	53.31	13.47	9.96	5.04	801
J2	57.45	16.495	10	4.99	903
J3	28.43	6.495	22.21	5.02	904
J4	70.75	4.215	15.92	5.1	920
K1	41.04	13.505	12.52	4.99	891
K2	40.74	16.255	10.77	5	900
K3	50.83	2.9	7.24	4.98	905
K4	49.1	11.3	18.28	4.98	906
L1	51.49	14.12	17.66	4.82	708
L3	20.35	39.265	19.5	4.85	788
L4	32.81	15.995	17.36	4.85	782
M1	50.65	20.06	14.57	4.66	838
M2	33.45	13.13	27.88	4.67	879
M3	55.59	17.05	12.23	4.66	787
M4	45.7	32.015	11.93	4.67	861
N1	69.86	13.51	7.78	4.51	746
N2	35.45	11.105	19.22	4.51	739
N3	45.83	26.925	9.93	4.52	746
N4	28.61	21.82	18.61	4.25	751
O1	80.19	3.52	11.72	4.79	1086
O3	54.19	7.705	32.36	4.79	1087
O4	63.11	1.85	28.65	4.3	1061
P1	64.55	11.475	13.02	4.54	552
P2	38.18	18.27	21.53	4.37	519
P3	68.09	9.99	8.09	4.51	555
P4	45.72	19.83	10.74	4.51	567
Q1	39.15	23.92	5.53	4.24	512
Q2	43.84	10.165	28.94	4.39	497
Q3	36.96	24.025	17.76	4.36	548
Q4	46.47	12.76	18.57	4.38	591
R1	61.26	11.19	10.1	4.18	422
R2	32.74	31.745	15.61	3.21	191
R3	41.54	21.445	9.92	4.21	443
R4	30.23	14.505	32.35	4	421
S1	48.91	13.915	19	5.52	1357
S2	40.92	16.835	11.89	5.34	1308
S3	45.14	19.025	13.74	5.14	1377
S4	69.21	3.64	19.61	5.44	1416
T1	56.79	13.485	10.03	5.35	1123
T2	46.29	21.365	9.06	5.34	1056

Table B.2: Semantic Segmentation & Space Syntax Results Combined “Table Continued”.

T3	35.45	10.94	24.67	5.17	1058
T4	48.54	18.66	10.41	5.34	1081
U1	57.32	13.22	11.29	5.64	1179
U2	46.55	15.67	21.15	5.27	1143
U3	42.84	9.42	25.8	5.47	1165
U4	50.76	13.735	18.87	5.28	1177
V1	39.73	24.8	22.99	3.92	463
V2	48.29	18.345	15.24	5.24	809
V3	37.89	7.705	28.31	5.23	846
V4	39.79	17.93	21.98	5.18	880
W3	47.72	17.72	12.56	5.18	660
W4	41.83	21.895	8.33	5.18	814
X3	66.05	11.375	11.73	4.25	464
X4	61.04	9.98	18.73	4.99	499