



## Improving the Quality of Urban Spaces through Image Processing, Case Study: 17th-Shahrivar Street of Tehran\*

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**ABSTRACT:** Urban spaces are like a dramatic stage, in which buildings and street's facades are the actors. While people are passing through streets, they will communicate the information with the environment, as well as, explore and study the spaces. People transfer the greatest number of information from the urban space and the surrounding environment through their visual senses. Hiking determines one of the main movement pattern in residential areas. Pedestrian urban spaces are for people on foot in which visual aspect is one of the most important aspect that sometime ignored by designers. The views of the pedestrian areas are the most important factors of the urban spaces which can be attractive or even boring. This research has investigated the organization of urban spaces and street improvement by using the image processing method. In order to test this procedure, 17th-Shahrivar pedestrian, placed in the east of Tehran, has been studied. The main method of research is descriptive-analytical. This method emphasis on analysis of visual aspect of the content and continues by image fixation and then using the image processing through effective parameters of the visual mechanism. In conclusion, through image processing method one can improve the quality of built environment as a pedestrian area and motivate people to walk and enjoy watching the surrounding elements of an urban spaces by highlighting some of the hidden visual features.

**Keywords:** Urban space, Townscape, Pedestrian Areas, Image Processing, Visual Perception.

### INTRODUCTION

The environment includes everything surrounded us and it also is related to people in all possible ways, even if it may not be possible for human beings to achieve all existing information. Environment is somehow a condition in which all phenomenon or existents are living or working there. Environment includes all the information transferring in our surroundings. This information would be transmitted from both natural and artificial environment (Pourjafar and Sadeghi, 2008). Now, the perception can be considered as a purposeful process through which people can receive the

environmental messages, Moreover, perceptions are the advent of cultural and fundamental values of the societies. Therefore, the environmental perception is a process in which people receive mental suppositions and data from environment. This environmental perception follows the cognition of environment by the human beings which is the result of interaction between the sensory perception and recognition. In fact, environmental perception can be perceived as the human's perception of objective aspects of the environment. For achieving this purpose, the information is obtained from the environment by the human senses; the most important one is the visual sense which human beings have been experienced through evolutionary process (Khisti, 2011). We can explore the world and gain a lot of precise details of our environment only if we can change our viewpoints from places and

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move our eyes, head and body. Therefore, it will be possible to create an image out of the relation between surfaces and objects that are observable for us (Bell, 2007). As, the environment has a lot of information, it can be converted to reality due to its physical information and formed a townscape. The townscapes have an ability to influence the viewers, because they can make the environment to be readable as a text (Golkar, 2008). As mentioned, the citizens usually begin their dairy lives by entering to the townscapes and receiving information, which represents huge volume of information, achieved their attentions. In order to reach the destination, people need to move and naturally walk along the ways or paths which are built up to reach them to their intended places (Taylor, 2003). Path is a way where people can walk. Path is described by moving, the space becomes non dynamic and inactive if this process stop. Thus, one of the usual movement's patterns in these ways through living centers is hiking. Hiking is a natural, old and the most necessary form of human movement through environment which has fundamental role in communicating with environment and its perception (Ashoori, 2010). This movement is conducted by the visual sense by which most of the information received by the users and is done by it and its combination associated with townscape. The movement is accompanied by landscape observation and exploration. Therefore, what a pedestrian sees can affect and attract him or cause the monotony and boredom. In this movement, the free observation of landscape can create various eye movement patterns for viewer; however, the main problem that visual system confronts with is the huge amount of information existed in every landscape. The images which the pedestrian observes can be evaluated by the image processing method and the amount of spatial frequency can be figured out which leads to recognize the attractiveness or uniformity and ignorance according to the observed scene. The spatial frequency can expand the design principles because it can be occurred in different levels and also can influence the eye movements and its focus duration on the subject. Encoding the information of a scene at the early stage makes the aforementioned information to be represented in a more effective manner. As well, brain also represents the information in this way (Carlson, 2000). The objective of this study is to introduce the effective parameters on pedestrian crossing design using image processing method and its impact on the case study. By utilizing these factors, the professional analysis and assessment will be conducted.

## RESEARCH METHOD

The method of this research includes a descriptive (un-experimental) analytical method which is accomplished by surveying in libraries, searching in internet, studying the reference research articles and comparing them, and further analyzing the recorded images of the case study using image processing method. It is done by considering their visual features and accomplished by MATLAB<sup>1</sup> software, in order to take a step in finding out this method. Concerning the Image processing method characteristic, these principles made one of the important and newest methods for recognition of townscape, landscape and environment, utilized in this research for the first time. Using scientific and quantitative criteria together with empirical and qualitative factors make them effective this research. In this method, the image analysis is performed by collecting the information through fieldwork research of the case. The image is recorded by focusing on the landscape's basic elements including line, edge, surface, volume, and elements combination and moreover the influence of some variables on basic elements such as quantity, situation, direction, size, form, grain, texture, density, color, time, light, visual power and visual inertia. It is done by considering the spatial frequencies, produced saccades and the process of fixing them in the determined time. The analysis will be done by using filtration in frequency area<sup>2</sup> that consists of modifying the Fourier<sup>3</sup> conversion of an image and further reverses conversion in order to achieve the processed result. The edges and other sharp changes of an image attribute to the high spatial frequency of its Fourier conversion. Therefore, the smoothing process is attained by weakening the higher frequencies. In the other word, an image can be smoothed out using the low-pass<sup>4</sup> filter in which the higher frequency components of its Fourier conversion will be weakened. Due to the fact that edges and other abrupt changes in light intensity are related to the higher frequency components, the image sharpening can be achieved by using high-pass filter in the frequency range. The high-pass<sup>5</sup> filter weakens the low frequency components without disrupting the high frequency information in Fourier conversion. This analysis of users' perception in pedestrian areas can determine his concentrating or non-concentrating while using the urban space, as a result; perspective of the pedestrian can be discussed.



## THEORETICAL FRAMEWORK

### *Urban Space*

Urban space looks like a scene in which public urban life activities take place. Cities' Streets, squares and parks are forming the human activities. These dynamic spaces unlike fixed sedentary residence and office spaces are the main compositions to make up the life of a city. They also provide the: movement networks, communication centers, public playgrounds and parks of the city (Bahraini, 2007). Urban space has their own special applications and activities. The essential conditions to build an

urban space are activities and performances, not only in building stokes but also in spaces. The activities in streets or squares, cause crowd and motions in urban spaces, which prevent them from being lifeless and defenseless (Azizi and Motevasseli, 2012). In fact, the urban space is the most significant place to perform and emphasize on social events (Soltani and Namdarian, 2010). Buildings, trees, nature, water, traffic, signs etc. have to be linked and connected to realize an artistic display, because a city is an exciting event in environment (Kalen, 2008). In table 1 an overview of ideas about urban space is given.

**Table 1. Classification of Urban Space Vie**

General Feature of Urban Space	Opinions Assortment
<ul style="list-style-type: none"> <li>• Sensory Factors</li> <li>• Non-Sensory Factors</li> <li>• Active Factors</li> <li>• Sustainability Factors</li> </ul>	<p><b>* Sensory Factors</b> Size and correlation, symmetry and equalization between space and building. Good view, restrictive, impenetrable, disciplinary, original scale and equalization, visual pleasing, safety, availability, aesthetics principles, symmetry principle, coordination, sensory richness.</p> <p><b>* Non-sensory Factors</b> Memories, urban space construction, legibility, security, meaning, mental image</p> <p><b>* Active Factors</b> Culture, choice ,generality, relationship, connections (occasion), time, mixture and density</p> <p><b>* Sustainability Factors</b> Environmental, gradual growth, diversity, variability, flexibility and adaptability, democracy, vitality, continental comfort, green space.</p>

### *Townscape*

World is a theater scene in which building and streets' facades are the cast. In this scene, there are some parts that their features can be seen very clear but others are only some specified clear forms (Headman, 2008). Environments and landscapes are expression of the moment of ecological, cultural and technological factors (Tabibian, 2002). Townscapes are single element or elements, which have been constructed during several centuries. Except some of them, they may reconstructed (ibid). Hereby, urban design is managing townscapes (mental and objective) (Golkar, 2008). Basically, townscapes are the contact and communication surface of "human" and "town phenomenon". Therefore a significant portion of knowledge, emotions and environmental behaviors of the citizens are influenced by it, are taken

shape (ibid). Townscapes is composition of visual-skeletal and also non-visual aspects of environment which intensifies the consideration of various townscape types in the visual study of the city (Pourjafar and Sadeghi, 2008). Table 2 shows the summary of classification of opinions about the townscapes.



Table 2. Assortment of Theories About Townscape

General Feature of Townscape	Opinions Assortment
<ul style="list-style-type: none"> <li>• Skeletal Factors</li> <li>• Perceptive Factors</li> <li>• Human Activities</li> </ul>	<p><b>*Morphological Factors</b> Beauty, variety, skeletal and visual impermeability, coordination and balance, visibility, successive sight, basic elements, availability, regularity, clearance, objective features of purview’s environment, sensory receivers</p> <p><b>* Perceptive Factors</b> Legibility, meaning, mental image, identity, history, background, availability, art relations, role making, non-skeletal factors</p> <p><b>* Human Activities</b> Sensory receivers, time, walking, sitting, belonging color, necessary behavior, selective behavior, social-individual behavior, culture.</p>

**Pedestrian**

People need to move to reach their destination, and naturally they will use the ways or paths which are built up to aim these places. (Ashoori, 2010). One of these paths or ways is pedestrian. Pedestrian areas are solitary and separated streets which driving is removed through them. In other words, in the pedestrian areas the non-motorized vehicles have absolute priority to the others. However, the emergency vehicles (fire engine, ambulance and police) can drive in pedestrian areas and also other vehicles for service and trash trailers can pass these pedestrian in specific hours (Hosseinioun, 2004; Brambilla and Longo, 1977).

**Elements Affecting The Perception Of The Urban Townscape Pedestrian Areas**

According to the study by Rasooli and Rahim DokhtKhorram, (2009), the elements which should be considered in urban space perception of pedestrian are: passage, signs, the start point and destination, bodies and furniture which are explained as below:

1. A pass way is not a split between two walls which is designed for passing through, but they are series of differences. Differences between the inside and outside of it, is originated from curiosity and expectation of the human (ibid).
2. **Sign:** Prerequisite for recognizing and using the signs are factors, which have effect on viewer, appear more prominently. The factor is unique and memorable (ibid).
3. **Origin and Destination:** the fact that where the start point is and where is going to end is important for people. The paths that their beginning and ends are

obvious help the continuity of various factors of the city (ibid).

4. **Bodies:** If we consider the existence of a building as a member of city’s body, Façade of building is the most important element of it. Moreover, combination of this element and its characteristic is more attributed to mental and cultural values than other elements (ibid).
5. **Furniture:** One of the factors that influences organized or not organized street is its’ furniture design: choosing and arranging the urban furniture. Furniture design is neither repeatable nor imitative. In fact, selecting appropriate furniture design can help to preserve the place’s identity (ibid).

**Image Processing**

Image processing includes the process of signals that their inputs are similar to an image or video frames. The output of image processing can be an image or a set of image’s features or parameters (Woods, 2011). Since image interpretation needs many actions, their accomplishment is extremely difficult even without the intense limited time of eyes system. Therefore, no computational eye system which can evaluate our ability (in seeing) is considered yet (Holl, 2010). For this purpose, a new method such as image processing is required and some proceeding must be performed to utilize this method in urban design.



## ***Effective Parameters On Image Processing Method***

### ***Vision Mechanism***

The mechanism of how eyes work has a substantial role in people's experience of their environments (Hedman, 2008). The vision consists of some procedures and different actions: we directly experience the events happen around us, explore something which we have not cared about or even we had not followed before, but we will be informed by our visual experiences and patiently observe the development process of our environment's phenomena. The word vision and its procedure has various meanings, sometimes the meaning of vision is perception so a person who witnesses an event closely has deeper perception than the person who just heard something about it (Dondis, 2010). Essentially, a human builds his visual world not consciously but actively. There are few people who accept eyesight as an active phenomenon. In fact there are actions between human and his environment in which both of them are involved (Hall, 2009). However, the most interesting part of sight's purview is the point of view. What we intend to see is going to locate exactly in our yellow spot which is the most sensitive part of retina and includes the most precise vision (Grutter, 2009). The study of eye itself and also its performance in a city is complicated because of some variables such as vision of a place, vision of a context, angle, direction and distance, since most of the visions in a city have all of these variables (KarimiMoshaver, 2014). Thus, recognition and survey of these variables and their position is essential in urbanism.

### ***Saccade***

The first step of image processing in eye is checking out the subject by eye, then, the necessary information is transmitted to other parts. A mechanism that has a significant role in this step is a saccade movement which is one kind of eye movements (Pourjafar and AlaviBelmana, 2012). Our eyes constantly confront moving and stabile phenomena (Niroomand, 2013). The significant issue is that a saccade movement and fixation of eye are searching and investigating the environment for required information and send the messages to brain (Pourjafar and AlaviBelmana, 2012). Yarbus believed that there are two remarkable features of saccade movement (eye movement): (1) it has its own characteristic and identity in motion of eyes (2) high speed (the duration time of saccade is one hundred percent of a second).

The images of things reflected to the retina could not

be seen at once. We cannot feel it but our eyes scan the purview through sighting process continuously. Eyes accomplish three fixations per second and the fixations are connected to each other through very fast movements of eye called mutation. For integrating the information from the previous fixations, the vision produces perceptions through precise and open angle process (Pinel, 2008). Now it can be explained that the meaning of each point is its fixation, the point should coincide the yellow spot, another meaning of saccade is that the eye must make a new fixation point on yellow spot by its movement (Niroomand, 2013). What makes the study of saccade's movement actually important is the ability to determine which visual features may affect these movements of saccade while they are monitoring images and cityscapes.

### ***Spatial Frequency***

The previous studies by Cample and Robson (1968) and Graham and Nechmias (1971) show that: the human vision system contains numbers of selective discipline mechanisms with different spectrum and/or spatial frequencies and these mechanisms behave parallel to the processing of the spatial information (Wilson and Bergen, 1979). Spatial frequency is a theory which describes the receiving and analyzing the information by retina. Spatial frequency is a quantity which demonstrates the intensity of a signal represented in a period or line pair by the millimeter unit and is affected by two factors: density of lines and edge of sharpness (Pourjafar and Maryam AlaviBelmana, 2012). From technological point of view, differences in minor levels are reflected in spatial frequency of the image. When people move their eyes in a special direction the pattern is altered from light to darkness. Spatial frequency can be assessed in two ways: high spatial frequency and low spatial frequency. High spatial frequency contains the information of image details. The very high frequencies act as parasite and do not affect the vision system's neurons or entice them less and they are not compatible with vision standards (ibid). Low spatial frequencies are generated from information of image changes in a large scale (Hall, 2010). Also, the very low spatial frequencies do not motivate the neurons of vision system because they do not send sufficient signals to them (Pourjafar and Maryam AlaviBelmana, 2012). One of the most substantial subjects in spatial frequencies discussion is their relation with saccades and eye fixations. Ti Groner, Rodlef Groner and Von Mühlenen (2000) studied the "impacts of spatial frequencies content on eye movement parameters" and investigated the correlation between the images by considering the spatial frequency and eye movement



parameters. Their studies proved the correlation, however implementing and extending this correlation is one of the main objectives of this research. The correlation between effective parameters in image processing method and

importance of each factor is represented in Table 3.

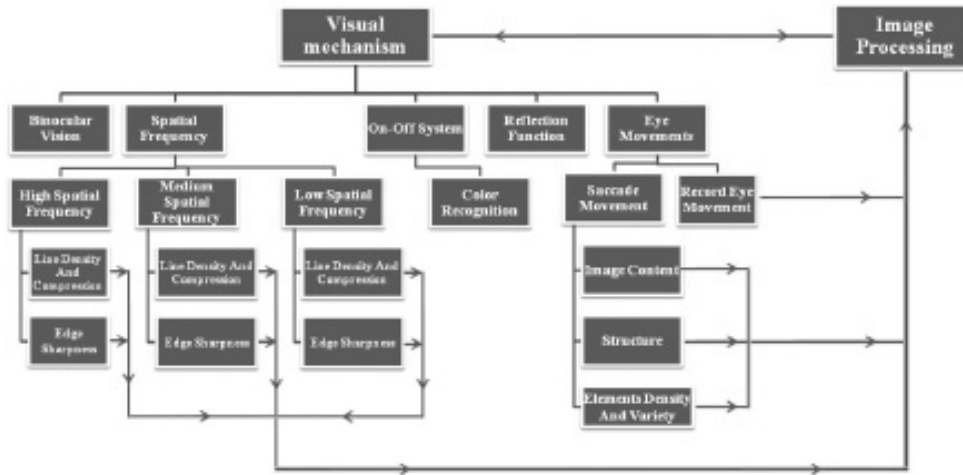


Fig 1. The Correlation Between Vision Mechanism, Eye Movement, Spatial Frequency and Image Processing Method

## LITERATURE REVIEW

Tucker investigated an interdisciplinary approach which uses architecture science and computational imaging in order to expand the analysis tools that can be utilized to describe the physical features of the streetscape (Tucker et al., 2005). The analysis method is outreached by an algorithm based on Hough transform which provides general measurement of the geometric figure of street space. The method recognizes and processes the good parts of an image in a suitable scale based on discontinuity and similarity which allows defining the features of built surface. Edges density in textured surfaces provides the quality measurement of visual details that are distributed throughout the image and shows its relation with Fractal geometry. The conception method is related to retrieval theories of explanations, facing configuration and ISOVIST of facing which discussed by Hiller (Tucker et al. , 2005). The image processing method is a new method that introduces the image in diagrams or graphs based on discontinuities and similarities and further troops the possibility of unfolding edges which defines the surface features. Tucker utilized the Hough transform based on software called Scape for visual analyzing of the streetscape. In this research, the street digital photo is taken by manual digital camera and

then processed by algorithms in computer, so that, the visual environment could be distinguished by boundaries formed surfaces, color, texture and intensity. The created software can determine the edges or boundaries in the image by considering general geometry. By using the method, Scape software is able to find the discontinuous boundaries which human supposed them as continuous edges. Based on Scape capability in visual feature analysis, Tucker (2005) and his colleagues processed the components of three samples existed in Australia's street (Fig. 2 and Fig. 3). Hough transform method is a quantitative method by which physical features of a landscape such as color and edges can be converted to quantitative data and then the amount of impacts and attraction on human behaviors can be investigated accordingly.



Fig. 2. The Street A, B and C Elevations (Tucker et al. 2005)

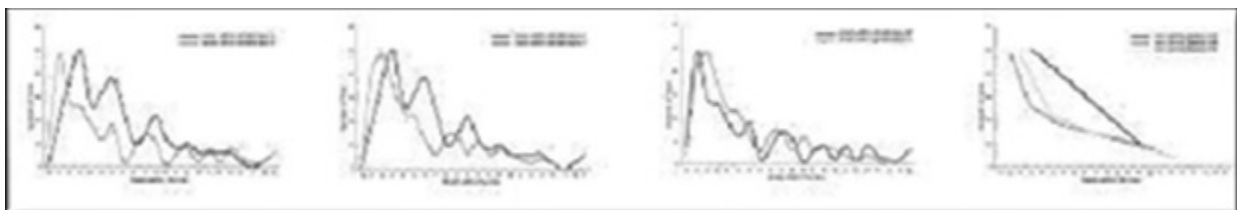


Fig. 3. The Graphs Processed by SCAPE Software (Elevations of Street A, B and C) (Tucker et al. , 2005)

## ANALYSIS AND ASSESSMENT

### The Statues of 17 Th Shahrivar Pedestrian

17th-shahrivar Street (Eastern edge of Tehran Naseri) between Imam-Hossein square and Shohada square with a length of about 1200 meter is one of the streets which is converted to pedestrian. This north-south street placed in east of Tehran, connects Imam-Hossein square in one side

to Shohada square and metro on the other side (Fig. 4) improving the organization and environmental quality of this street is due to its significance of where it is located (two squares and one street) in center of Tehran and also the other constructed or under construction ways. Furthermore, by directing the vehicles to the lower part of Imam-Hossein square, the opportunity of pedestrian passage is provided.

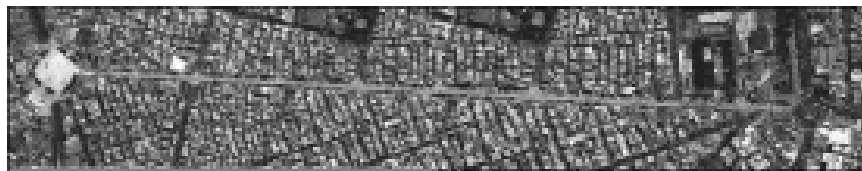


Fig. 4. Aerial Photo of 17th-Shahrivar Pedestrian (Googleearth.com, 2014)

### *The Analysis Of Case Study By Using Image Processing Method*

There are always different methods to achieve the purposes. To achieve the aim, this research uses image processing method which undoubtedly is a new method and a pioneer step in recognizing the urban space and urban design. In order to apply the image processing method to analyze the pedestrian, the photos are taken based on priority and space hierarchy and further converted to analyzable issues by using MATLAB program. The photos are shown in table 4 and 5 that


contain three sections including the original photo, low spatial frequency photo and high spatial frequency photo. By applying the low-pass filter on original photo, it eliminates its high frequency components which encompass various visual information and details; so just the main or strongest components will be remained which makes the photo to become opaque. In the other word, it omits the excessive photo elements, but by utilizing the high-pass filter, the photo is sharpened and photo details and elements are represented with all features. In fact, edges, volumes and other parts, are shown in each



photo. The white points and light lines in photo with high spatial frequency represents the lines that have the most visual attraction and man's vision involvement and after that, movement and the fixations on them. The

following photos are the analyzed Pathway from Imam-Hossein square to Shohada square (path's sequences) and Analyzed photos of the pathway from Shohada square to Imam-Hossein square (Path's sequences).







**Table 4. Analysis of 17-Shahrivar Pedestrian Pathway between Imam-Hossein Square and Shohada Square Using Image Processing Method**

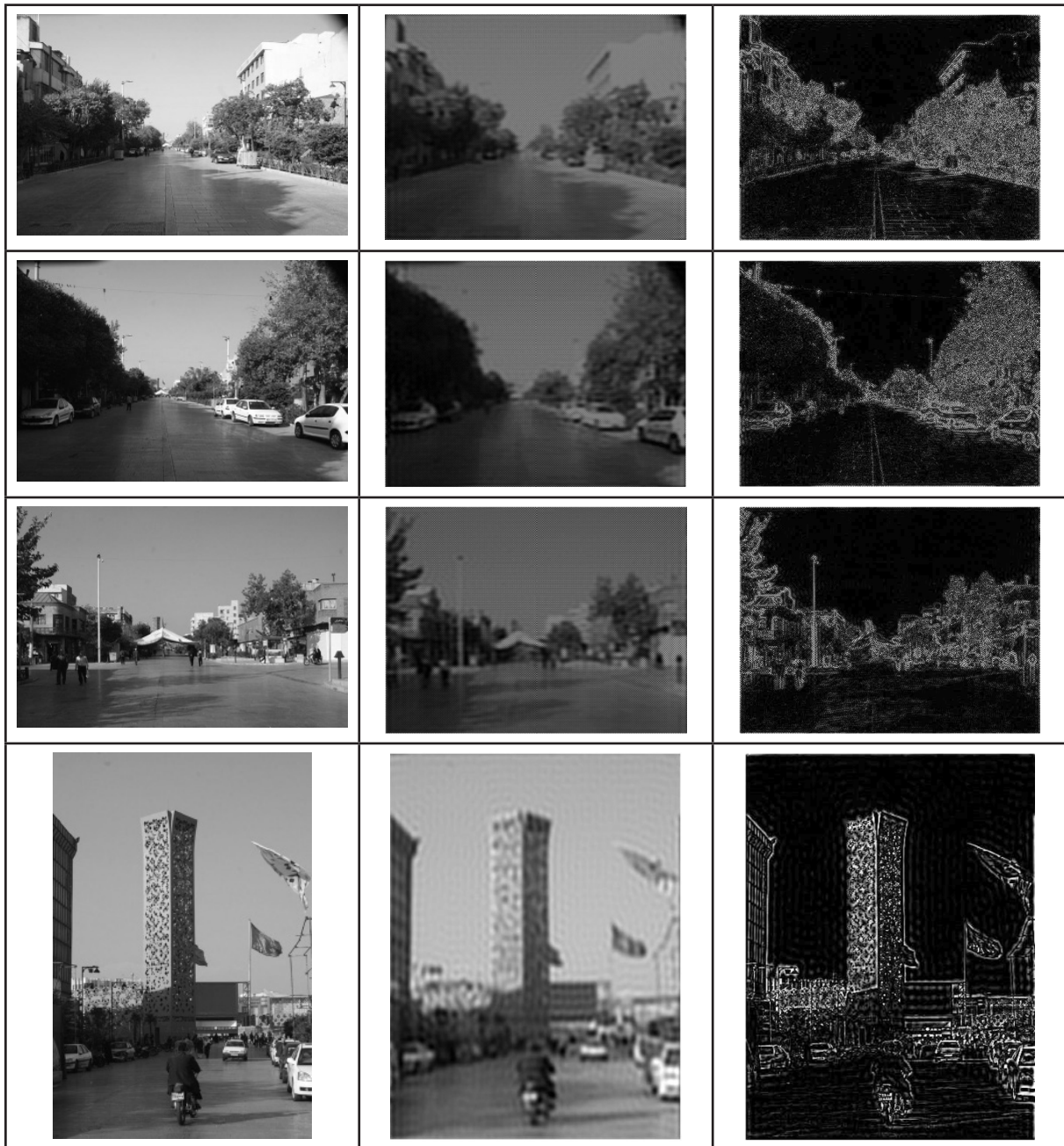
Sequences from Imam-Hossein Square to Shohada Square		
Original Photo	Low Spatial Frequency (Low-pass Filter)	High Spatial Filter (High Pass Filter)
		
		
		
		





**Table 5. Analysis of 17-Shahrivar Pedestrian Pathway between Shohada Square and Imam-Hossein Square Using Image Processing Method**

Sequences from Shohada Square to Imam-Hossein Square		
Original Photo	Low Spatial Frequency (Low-pass Filter)	High Spatial Filter (High Pass Filter)
		
		



## CONCLUSION

Image processing method has a lot of special features, that make this method as one of the most significant and new methods for urban space, landscape and environment recognition. This method has been used for the first time in this research. Utilizing scientific and quantitative

criteria accompanied with qualitative and empirical criteria makes this method remarkable. This method commences with a photo or video and continues by analyzing and applying various filters in different areas which leads to a precise and efficient investigation of urban spaces in the city. In image processing method, the assessment can be accomplished by recording the



images of landscape according to the effective parameters and further representing the visual and fabric features of townscape. Therefore, these principles which are obtained from the fixed space and environment images can be used to improve the organization and design of urban spaces and townscapes. The results shows that by considering the problems which 17-shahrivar pedestrian pathway suffers, the ignorance and weakness of visual field and visual features can be observed. The performed evaluations of photos by image processing method represents that ignoring of important visual features such as visual field, people's vision mechanism and spatial frequencies of spaces, will cause the failure of achieving good quality of visual attraction in urban projects. Thus, implementing the image processing can extract the hidden visual features and be used as a part of the future research in urban design.

## ENDNOTE

1. Software which is used for numerical calculations. It is a fourth generation programming language. The word "MATLAB" means both numerical calculation environment and also the programming language itself which consists of Matrix and Laboratory.
2. Frequency filters can be used for image improvement like smoothing, wiping out, sharpening and/or finding the age edges.
3. In mathematics, the Fourier series is a function which can be used to convert a periodic function to a set of simple oscillating functions sinusoidal, cosine or complex exponential function. The frequency components of a function can be achieved by expanding each function to Fourier series. Then, the more complicated calculation can be performed in frequency context.
4. Low-pass Filter: kind of filter which allows the passage of the signals less than a particular signal. This filter is very important in the areas of signal and periodic currents processing.
5. High-pass Filter: permits the passage of signals with frequency more than a particular signal and does not allow the passage of signals with lower frequency.

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