Route analysis in the architecture of museums and tomb buildings through space syntax case study: (Tomb of Nader Shah in Mashhad, Avicenna Mausoleum in Hamadan, and Mausoleum of poets in Tabriz)

Mohammad Nik Khas; Seyyedeh Faezeh Miralami and Zahra Poursafar

*Department of Architecture, Shahid Beheshti University, Tehran, Iran; *Department of Architecture, Lahijan Branch, Islamic Azad University, Tehran, Iran; *Department of Architecture, Islamic Azad University, Tehran, Iran

ABSTRACT

Historical memorials, in most parts of the world, represent and are associated with the cultures, arts, and architectures of the time they are born within. Examples of such structures which include museum-like settings are the Tomb of Nader Shah in Mashhad, Avicenna Mausoleum in Hamadan, and the Mausoleum of Poets in Tabriz. The objectives of the present study are to examine the concepts and criteria of routing and their function in architecture on one hand, and to signify the manifestation of routing in the mausoleums and memorial tombs of Pahlavi era on the other hand. The methodology is a descriptive-inferential one which follows the space syntax of Depth Map software to a qualitative and quantitative degree. According to the findings, it seems that the hierarchy of paths which leads to the tomb plays a significant part in routing. Moreover, main entrances, central lobbies, and corridors which are more peopled as compared with other sections, are exposed to visitation and provide social communication. In the end, the making of an intelligible circulation system, which is a method in architecture that facilitates routing unfamiliar places, has been acknowledged considerably in aforementioned memorial structures.

1. Introduction

Since ancient times, especially the last century, the issue of historical monuments and how to deal with them as historical memorials have been of particular importance (Aali and Tajik 2008). The architectural forms of the shrines of Iran in the contemporary era include the Tomb (Urban Symbol, Monument, and Remembrance), the complex of museum gardens, and tomb complexes. The complex of museum gardens includes a tomb, the garden space, and museum. Buildings such as the Tomb of Nader Shah in Mashhad, Avicenna Mausoleum in Hamadan, and Mausoleum of Poets in Tabriz are of such buildings. The behavioural patterns of people in the process of finding a path are distinct from each other (Mardomi et al. 2011). The direction of movement in public buildings can be thought of as an imaginary line that interconnects the outer and inner spaces. Since a person moves in time and in a sequence of space chains, he experiences a space where he is and where he wants to go (Ching 2006). Researchers in cognitive and environmental sciences believe that people’s ability to understand the environment and find a path is different (Mardomi et al. 2011). The role of architecture is providing pathways or guiding the individual who needs to find the route, and the role of the architect is designing of the route in the museum and the tomb.

The aim of the present research is to study the concepts and criteria of routing and its application in architecture. But, at a next stage, we will see how it manifests itself in the buildings of the museums and the tombs built in the Pahlavi era.

In this regard, this study tries to answer such questions:

1. What is the routing behavior of the visitors from the entrance of the mentioned buildings using targeted observation?
2. What is the movement circulation between the space of the museum and the tomb in each of the mentioned buildings?

2. Literature review

Design of the spaces have the undeniable impacts on the human’s feelings and functions. Due to the fact that people in the spaces are unconsciously aware about weakness and strength of the environment (Poursafar et al. 2019).

The space syntax method is developed by Bill Hillier in the late 1970s to early 1980s to understand the mutually constructive relation between society and space. It is a set of techniques for observing how these networks of space relate to functional patterns (Yamu et al. 2017). Space syntax is a simulated spatial
modelling approach in urban research (Hillier and Hanson 1984) the method is based around the concept of visual accessibility to represent the configuration of space and recommending quantitative analysis of graphs constructed from axial line.

Space syntax analysis as a movement economy has made major contributions to our understanding of the spatial structure of indoor and outdoor spaces and are enabled to produce distorted mapping at walkable scales (Pafka, Dovey, and Aschwanden 2018).

As reported by Ratti (2004) the reported topological representation by space syntax discards precious metric information and is rather limiting which new algorithms might allow a deeper understanding of the spaces.

Great variety of research reveals that the earliest space syntax works focused on physical ambience and attempts to identify the nature of man-made environments. By developing other techniques for the analysis of spatial patterns, recent space syntax works seek to arrive at a basis for predicting how physical environment would work (Dursun 2007).

3. Research process

The research is conducted quantitively with the Depth map Software using the Space syntax method, and the second section is also related to the qualitative analyses. The index related to recognizing the architectural components in the environment, which facilitates routing in space in the buildings (Avicenna Mausoleum in Hamadan, Tomb of Nader Shah in Mashhad, and the Mausoleum of Poets in Tabriz) will be studied, and finally, a comparative comparison is made between the results of the relevant section (Figure 1).

4. Definitions and concepts

4.1. Routing

In the 1960s, the term routing was coined by Kevin Lynch (Lynch 1993). Routing is defined as the process of using geospatial and environmental information to find the path in the artefact environment (Mardomi et al. 2011). An introduction to routing is a person’s spatial orientation, which this orientation or finding its location, is the constant relation of the individual with the location or surrounding environment. In this regard, the user has a general mental image, from the schematic schema of the environment that is called the cognitive map of the environment. Spatial cognition is important for measuring space configuration features. The cognitive map inside the user’s mind is the product of spatial cognition. Given that the cognition of space generally means understanding one’s geographical environment, but geographical space is a large-scale space whose structure is larger than the observations of each person at a moment on a significant scale. Therefore, in order to create a space that sticks into the memory easily will require signs of improvement in routing performance. Users have a cognitive map of environments like museum or gallery in their mind that is made up of these environment features and is a source for the precise understanding of the environment or the boundaries of

Figure 1. Conceptual model of the general structure of the research, Source: Author.
the building components. Therefore, these features are very important in designing the environment (Peyvastegar et al. 2017).

4.2. Routing design

Knowledge and art, which by putting the right information in the right places, creates an appropriate and legible environment for facilitating the routing of people in a complex environment (al-Hawaeji and Pournaghi 2014). Routing includes the two components of the physical environment and the user environment, which together facilitate the routing performance (Carpman and Grant 1993, 66). The problems of space routing have led to the assessment of space from various aspects in order to improve the routing performance till today. Some of these methods are objective, which investigate the body of the environment, and some others are mental assessment methods, which investigate a person’s mentality, focusing on the aforementioned level of cognition and emotion when routing (Daneshmand 2013). Routing information components, which include the graphical, verbal, and touchable components, play a reinforcing and complementary role in routing facilitation, and these components are not very effective in an environment that is architecturally and physically confusing and complex. They can even add to its complexity (Mardomi et al. 2011, 53). A detailed investigation of these components is beyond the scope of this study, and for this purpose, the facilitating components of routing that are related to the physical environment will be explained. Architecture has three roles in facilitating routing of individuals in the environment:

1. Creating a legible space
2. Separation and emphasis on the boundaries
3. Creating a readable circulation system

4.2.1. Creating legible spaces

Space legibility is the creation of a space that organizes its visual information in order to create a coherent basis for the behaviour and movement of individuals in the environment. Organizing spaces and paying attention to geometric spatial ideas is one of the most important factors in creating legible spaces (Mardomi et al. 2011).

(A) Classification of spaces and definition of spatial units

The layout of the spaces and their different parts relative to each other, is related to the distance travelled by the visitors in the building. If the attention is paid to connecting spaces where visitors are frequently traveling between them, the routing process will be less problematic. This type of spatial planning results in an increase of the readability in a building and the improvement of routing (Werner and Schindler 2004).

(B) Arranging the Space Layout

The composition of spaces is in different forms such as linear, radial, irregular networks, etc. Lack of complexity in the composition of spaces and the creation of regular patterns play an important role in the formation of a readable environment (Arthur and Passini 1992).

(C) Attention to geometry of spaces

One of the factors affecting space legibility is space geometry. Using regular forms creates more legible spaces. Also, spaces created from the intersection of the walls of the straight edge facilitate routing (Baskaya et al 2004).

4.2.2. Separation and emphasis on the boundaries

We can create spaces and areas where people can easily identify them and by reaching the destination, they can easily identify it. Using architectural capabilities, in different parts of the building, we can create unique features that are easy for people to understand. Also, we can separate the spaces and help the individual in identifying the destination. In addition, we can create clues along the way, so that the routing information are understood more easily. Of course, there are several approaches in this regard, one of them is the colour coding of spaces (Mardomi et al. 2011).

4.2.3. Creating a legible circulation system

Each building has a circulation system, which provides communication between sections and building spaces. The components of this system are horizontal (paths) and vertical elements (stairs, ramps and lift types). The composition of these elements in the design of the routing process is important and the circulation system must be designed in such a way that its elements can be readily identified and perceived. The shape of a path affects the pattern of the organization of the spaces it connects to, and also is affected by them. The shape and scale of a moving space should be in line with the types of movement of people, i.e., walking, pausing, resting, or watching the scenery of the path (Ching 2006). But what matters in this study is the emphasis on the legibility of the components and the overall system of the circulation. In the design of a legible circulation system, attention can be drawn to the hierarchy and the combination of routes and intersections, nodes in them, how to access the building from outside the building, the entrance and exit of the building, and so on (Mardomi et al. 2011).
5. Research methodology

Research methodology in the present study is descriptive-inferential, which is conducted in quantitative and qualitative approaches. Initially, data collection was conducted using the library method and field observations in order to obtain the sufficient information from the three mentioned buildings to know the types of building designs in the Pahlavi period and also to know the movement circulation system and routing behavior of the entrance visitors.

**The first method:**
The following measures were taken to record data from visitors’ movement routes and to collect the information:

1. Preparing a sampling plan from the users’ movement routes.
2. Identifying the different routes of movement on the floors of all three buildings and determining the station points on the movement routes in the form of a checklist.
3. Collecting the data related to the people’s movement in the different sections through observing and recording. (The research plan includes data collection in five one-hour-per-day periods. Instead of using random sampling, equal time intervals are used during the day).
4. In order to collect data, the researcher would sit in a place close to the entrance door and record the traveled path of each user by observation (the data collection tool was the checklist that the researcher had prepared from the building plans and had specified on them the important points of the users’ movements).

**The second method:**
Then, the relationship between all plan spaces with each other is analyzed with the help of the Depth map Software and the Space Syntax method, and the obtained results, including the Axial and Visual analyses in all three buildings, will be presented in graphical parameters. In doing this section of the research, the summarized following measures were taken:

1. Preparing the map of the mentioned buildings from the Cultural Heritage Institute in the provinces.
2. Modifying the maps according to the latest changes made in the buildings.
3. Drawing the maps of the mentioned buildings in the AutoCAD Software.
4. Analyzing the output maps inserted into the Depth map Software in Dxf format. (Firstly, the building is divided into a discrete system consisting of the longest Visual-Motor channels in which the users move and understand the structure of the environment; then, each of these Visual-Motor channels is shown with one line for the advanced analyses).

(5) In order to analyze the spatial structure of access, the Space syntax technique is used in the Depth map Software to prepare the diagrams to achieve the Axial and Visual analyses.

Then, the simulation method is used for the comparative comparison between the obtained analyses from the objective and software observations.

5.1. Space syntax

The advantage of the space syntax theory is that it does not leave the researchers and designers in the vacuity, and in order to better understand, the pedestrian movement gives them a tool called (space arrangement) or (space syntax). It can be named as one of the most important methods as the core of space morphology. First, it is divided into a discrete system consisting of the longest visual-motional channels in which the audience moves and understands the structure of the environment. Each of these visual-motional s channels is then shown for advanced analysis with a line, and in the next step, based on mathematical analysis and graph, the intersection of these lines with each other is examined (Rismanchian and Bell 2011). This theory believes that space is the primary and fundamental core of how social and cultural events occur. However, since space itself is formed through social, cultural, and economic processes, it is usually considered as a platform for social and cultural activities, to the extent that its form is not usually considered and assumed to be invisible (Rismanchian and Bell 2010). In the method of space syntax, according to its theoretical foundations, parameters are defined, each of which specifically analyzes the space. In the present study, three of these parameters were selected for analysis and comparison of the space, their functional characteristics are summarized as follows:

5.1.1. Connectivity

It is defined as the number of points that a point communicates directly with other points (Kamalipour et al. 2012). It is one of the clearest concepts of spatial analysis, which means spatial relationship. It means that the greater the number of connectivity, the more relationship with other spaces (Rismanchian and Bell 2011). The axes that have more communication value will be more accessible in different ways and will give people more choices, and they are more used by the people. It can even be assumed that the physical elements in these spaces have a more colourful presence in the cognitive maps of people (Didieban, Pour Deyhimie, and Rismanchian 2013).
5.1.2. Integration
Integration is the most important factor in Space syntax, which implies spatial coherence. Integration is a point indicating the relation of that point with the structure of the whole set or its subsets. If it is possible to reach a space by moving fewer spaces, then that space has more integration and vice versa. By increasing a space integration, the coherence of that space with other spaces increase (Rismanchian and Bell 2011).

5.1.3. Mean depth
It is the number of steps that must be taken to pass from one point to another (Bemanian, Jelvani, and Arjomandi 2016). It is the basis of the formation of depth. A point is called deep when there are numerous steps (levels) between it and the other points. Depth is not the main parameter in the space syntax, but it is nevertheless an important variable for calculating the integration of a point (Rismanchian and Bell 2011).

6. Findings of the research
In the mentioned tombs, the spaces syntax such as museums, tombstones, entrances, libraries, and so on, which has a geometric form, and the existence of regular patterns and the lack of complexity in the composition of the spaces, makes routing easier and create a more readable environment. In these buildings, components such as height change, porticos, rows of columns, color change and materials, etc., have led to an emphasis on routing purposes. According to the results obtained in the following tables, integration in the lobby and entrance spaces, as well as main access corridors, has a high value compared to the other spaces, indicating high

Table 1. The architecture of the buildings of Avicenna.
The Museum and Tomb of Avicenna in Hamadan, (Architect: Houshang Seyhoun)
Hamadan City, 1951

| Building architecture |
|-----------------------|
| Entrance space |
| Tomb space |
| Museum space |
availability and relationship in these places. Tables 1–3 show some information about the architecture of the three buildings of Avicenna, Nader Shah, the Mausoleum of Poets.

In the existing plans (Tables 1–3 – visual and axial analysis), the red color indicates the maximum relationship and the blue color indicates the minimum relationship. In the following analyzes, the intersection of both lines indicates their relationship with each other. A line that has more intersections with other lines is associated with more elements in the network and therefore is more accessible. In order to analyze the spatial structure that represents the relationship between the spaces, the visual and axial analysis was prepared from tomb buildings using space syntax. The tombs of Nader Shah, Avicenna, and Mausoleum of Poets have a lot of visual and axial relationship at the main entrance of the building and at the intersection of the axes that arrive at the tomb or the museum. However, this visual connection to the tomb space is

**Table 2. The architecture of the Tomb of Nader Shah.**

| Building architecture | Entrance space | Tomb space | Museum space |
|-----------------------|----------------|------------|--------------|
| The building is designed based on the two main geometric shapes, namely square and triangle. | ![Entrance space image](image1.png) | ![Tomb space image](image2.png) | ![Museum space image](image3.png) |
| - The central square is based on the modulation of square and consists of five squares in each row. | | | |
| - The flooring lines and the column proportions to the plan environment are also consistent with the military arrangement (Ramazanian 2014). | | | |
less than other spaces to some degrees, and the reason is that the movement hierarchy in the architectural design for reaching the tomb requires spaces and levels of understanding and mental readiness in the people, which can also be seen in these buildings. According to the results obtained in the following tables, integration in the space of the lobby and the entrance, as well as the main access corridors, have a higher value in comparison to other spaces. This shows the highly suitable access and Visual-Motor communication in these spaces. The rate of integration in a place is related to the rate of people’s movements in that place, so that the higher the level of integration in a place, the higher the movement potentiality and thus the more pleasant the space for the users. The type of the geometry and the layout of spaces in all three buildings is such that it guides people to choose and recognize the routes. And also, the readability of

| Building architecture | Entrance space | Tomb space | Museum space |
|-----------------------|---------------|-----------|-------------|
| - The architectural structure located in the middle of the areas of the cultural and historical complex of the Mausoleum of the Poets in Tabriz is designed in such a way that, besides the novel design, a sense of creating a connection is always felt between the viewer and the structure (Rajaipoor and Sadeghi 2013). |
| - The design of the building plan has axial symmetries. |
spaces in the three buildings causes the desired spatial quality, which will increase social interactions in this part of the spaces.

Then, according to the research question, i.e. what is the routing behavior of the visitors from the entrance of each building using the targeted observation? The findings indicate that the desired movement relationship between the sections and the interior spaces of all three buildings are available. The results obtained from the checklist indicate that people are not confused in choosing and recognizing the paths to reach the spaces, and the way the spaces are located and their readability have facilitated people’s routing in the buildings. A comparative comparison between the obtained analyses on the objective and software observations shows that the routing process is very important in the design of all three buildings and the existence of readable routes has led to people’s satisfaction, which facilitates the routing process and the satisfaction feeling when visiting the building. The components of the circulation system are the communication elements of horizontal (paths) and vertical (stairs, ramps, and a variety of elevators). The way these elements are combined is important in designing the routing process, and the circulation system must be formed in such a way that its elements are easily understandable and identified. The creation of a readable circulation system, which is one of the architectural methods in facilitating people’s process of routing in unknown environments, is very important in the aforementioned tomb buildings (Table 7).

7. Conclusion

With the conducted studies by (Al-Hawaeji and Pournaghi 2014) in relation to investigating the routing behavior of
Table 7. Comparative comparison between the objective and software observations (movement of people in space).

| Results | Analysis | Observations |
|---------|----------|--------------|
| As known, people do not experience any ambiguity or confusion in choosing the routes in the three buildings, and this route choice in order to reach the space of the museum and the tomb, as well as the way to walk in them, is in accordance with the results of the analyses. Movement communication is very convenient in the entrance space. Also, this communication happens easily in the space of the museum and the tomb. |

the visitors from the Central Library of Tehran University using the spatial information system, the findings indicate that the entrances have the most movements and that the most social interactions happen in these parts of the spaces. It is believed that knowing the most-travelled routes in the libraries will have many benefits for organizing the spaces as well as making the access easier. Meanwhile, other researchers such as Mardomi et al. (2011) have achieved similar results in relation to the routing in the architecture of medical buildings, which indicates that routing in these buildings, in addition to facilitating people’s routing in hospitals, can improve safety, performance efficiency, and user satisfaction. Also, the results in an article entitled “The Analysis of Routing Process Using Space Syntax Method in the Museum of Contemporary Art” indicate that an increase in the readability of space, spatial cognition, and creation of cognitive maps along the way in the buildings with museum usage encourages people to continue to go on the path and creates a pleasant feeling along the way for those people, which has similar results to this study. In summarizing the above materials, it should be noted that the existence of the routing components generally leads to the “organization of behavior” of human beings in the environment and that the principles of routing in public buildings are very important. Since the behavior patterns of individuals vary in the process of tracking routes in public buildings, the main purpose of the research is to investigate the importance of routing in the architecture of the tombs, so the routing method of people in an unknown and complex environment that is a challenging issue is to be determined. According to the results, it seems that in the tombs, the hierarchy of movement to reach the tomb, which required the presence of spaces and a measure in terms of the perception and mental readiness of individuals is important. Spaces like the main entrance, the central lobby, and corridors, which are part of spaces with more social interactions, have the highest levels of visual and motional relationship. Also, according to information obtained from researchers regarding the role of architecture in facilitating the routing process, it is obvious that creating a legible space organizes visual and motional information. One of the most important factors in creating legible spaces are spatial planning, organizing space syntax and paying attention to space geometry. Due to the fact that the creation of legible circulation system is one of the architectural methods in facilitating the routing process of people in unknown environments, in the mentioned tombs, the principles of hierarchy and circulation are important about routing these buildings.

Disclosure statement

No potential conflict of interest was reported by the authors.
Notes on contributors

Mohammad Nik Khah is an Iranian-Canadian researcher, teacher and architectural designer. He has master degree in Architecture from Shahid Beheshti University, Tehran, Iran. His researches are mostly focused on social aspects of architecture and urban design. In a former life, he worked on the history of Architecture and was engaged in restoration and rehabilitation of the historical buildings in his home country, Iran.

Seyyedeh Faezeh Miralami completed the Bachelor of Science in Architectural Engineering with merit in 2014 and continued higher education just to graduate in 2018 with her M.A. in Interior Design. Her graduate thesis is among the distinguished projects archived in the National Cultural Heritage Organization of Iran. Active in the field of Interior Design, she has been granted the National Work Permit of the Engineers’ Organization of Iran and has published numerous articles in accredited journals.

Dr. Zahra Poursafar is an assistant professor at the Department of Architecture, Islamic Azad University, Iran. She is a post graduate in advanced design (M.Arch) and Ph. D. in Architecture from Faculty of Architecture, Manipal University, Manipal. Her areas of research interest include interior spaces, with the consideration of psychological issues. She focuses on her Ph.D. in this topic and also published few papers in this scope in some journals.

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