Minarets Progression to the Contemporary Era in Iran Using ANN: A Comprehensive Individual Classification

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DOI: https://doi.org/10.51244/IJRSI.2025.12030031

Received: 04 February 2025; Accepted: 08 February 2025; Published: 02 April 2025

ABSTRACT

Today, minarets emerged before Islam are known as the oldest minarets from the Achaemenid era. This study aims to determine the functional root of these minarets and classify them chronologically from the Achaemenid era to present-day. Accordingly, related data were collected using comparative analysis; afterward, new clustering was obtained by ANN. Findings demonstrated that single minarets or guide bars were used to guide passengers and sustain related symbols in ancient times. It is notable that minarets used to play a stand-alone, individual role; following the advent of Islam, sometimes, these minarets were integrated with mosques and schools under the new dominant of Islamic architecture. After the Qajar era, the minarets were often used for decorative and symbolic purposes. Moreover, findings indicated that the plan shape of minarets did not necessarily bear any relevance to their historical era. In addition, although ANN clustering has similarities with plan-based categories, it is subject to differences, too. As a result, proper knowledge about and an in-depth understanding of the minarets can lead us to the further preservation and appreciation of these old elements and, perhaps, to their combination with the contemporary architecture.

Keywords: minaret, cluster, ANN, contemporary time, Islamic architecture, classification.

INTRODUCTION

Background

According to Dehkhoda's viewpoint, a minaret means the location of light at the height [1]. Further to this, a minaret is locally used for calling to pray and worship [2]. Plagued by the lack of availability and the loss of many historical monuments, this study decided to refrain from investigating the status of primary minarets. Memarian [3] argued that the minarets were deemed to be divine-light revelation or used as a spiritual shining image in symbolic interpretations.

Stone rocks (Behistun Inscription), large stone columns, and long slabs were frequently found as the first hand-made signs throughout Iran's roads [4]. Robert Hillenbrand & Rogers [5] reported that the construction of individual minarets was a continuation of the architecture's pre-Islamic minarets in Iran serving in the form of guidance in the early centuries of Islam. Furthermore, to support Hillenbrand's point of view, Pope [6] stated that some of the minarets located along the main roads of the desert reinforced the view that one of the functions of the minarets was the role of sign and guidance as in the cases of Khosrogerd Mile in Sabzevar, the Mill of Ziar in Isfahan, and the Naderi Valley in Narmasir Bam, Iran. Architectural historical heritage like minaret is one of the issues agreed in importance world widely. thus, considering the importance of minarets in Islamic architecture, several Iranian famous minarets are studied in this research.

LITERATURE

Concerning the lexical root of minaret, Hillenbrand [5] believed that the inspiration source of the place of fire originated from the lighthouse of Alexandria, not from the Iranian monument. Hartmann [7] and Gottheil [8] stated that the genesis of the minaret was rooted in the history of the use of fire signs by Sami Primitive Families. On

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

the other hand, the Indian and Aryan emphasized the development of the minarets in the territories of ancient Iran, characterized by their proud ancestors. Further to that, minarets were used for navigation, too [9].

However, Hillenbrand [5] assumed that the early Muslims were ready to take on other forms of religion; therefore, the function of towers and its relation with fire was a cause for choosing minarets' names from light and fire, then initiate their own identity and shape in Islam. Afterward, minarets joined mosques and schools and bore the representative weight of worship meanings [10]. Indeed, the minarets have managed to keep their presence as a religious indicator and a symbol for the city identification [11]. However, care must be exercised not to take the role and meaning of minarets in purely religious terms, since it is absolutely a misperception. Thus, minarets and mosques should be considered as a node within the network of daily life in the city [10].

According to the minarets without mosques, Batuman [10] discussed that single minarets were recognized as symptoms of the urban revolution led by neo-liberal Islamism in Turkey. In addition, the minarets without mosques are discovered in regenerated Turkish squatter regions. Furthermore, single minarets not only have their symbolically religious role in the modern world, but also represent the architectural elements as the reminder of the past.

Minarets can be discussed by many point of views. Nobody can tell the exact role of minarets during the decades. It is rooted in many factors as shape, height, materials, local culture and their era. The minarets of Antalya`s mosques had been designed to be very different from each other in terms of size, ornamentation and quality [12]. These minarets are designed by woods and completely different from Iranian minarets.

In another research, the context of the architecture of the old Islamic minarets in Al-Andalus was evaluated from an archaeological point of view. The minarets were classified based on their dimensions and inner disposition accordingly. The results helped reconstruct the minarets by their dimensions and revealed the correlation between political and warfare transformations [13]. Furthermore, Sayed Soliman [14] considered minarets as the most important parameter of Islamic architecture. The minarets' top design was evaluated based on their shapes, styles, and names.

In this research, a new approach is presented for classifying the minarets.

Artificial neural network

Artificial neural network was inspired by the human brain for dealing with the issue of problem solving in a manner different from predictable computation [15]. Many aspects of buildings were evaluated by ANN techniques such as prediction of energy consumption, optimization for building renovation, and even the classification of Al-Andalus' minarets [13,16,17]. ANNs are assumed to be the most fascinating classification application, which is prevalent in almost every field [18]. Moreover, learning to distinguish patterns and being able to make correct decisions about categories of patterns by machine is defined to be part of a pattern recognition process. Considering the role of ANN in assessing the minarets, Ortiz-Cordero and Hidalgo Fernandez [13] classified the Al-Andalus' minarets based on their ground plans, the base dimension (MB), and the staircase diameter by using the pattern recognition of ANNs. Furthermore, clustering is another method for classification by which the machine classifies the inputs by itself. Clustering ascertains some essential contemporary structures in a set of matters based on a similarity measure [19].

Objectives and contribution

The appearance of minarets depends on many reasons; therefore, they cannot easily state which one is the main reason. Therefore, there are many questions such as: what is the main reason for the emergence of the minaret? how should they be classified? The main objective of this study is to investigate and identify the involved effective reasons/factors for the appearance and formation of the minarets. Based on Hillenbrand (2010), three approaches to evaluating the minarets root are:

- Study of the initial minarets
- Finding the minaret lexical root

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

- Morphology of the early minarets

In this research, the data were studied by comparative analysis and, then, the neural network clustering was used for investigating the new classification of the minarets. The main objectives and novelties of this study may be summarized as follows:

- Ascertaining the classification parameters of minarets
- Presenting the new classification by using ANN clustering for minarets
- Evaluating the details of plans and shape factors for the Iranian minarets
- Determining the role of single minarets over the course of the Iranian history

MATERIALS AND METHODS

Thirteen minarets and one tower were selected for this research. These minarets are located in Iran from the Achaemenid era till the contemporary century. These chosen minarets are counted as famous minarets with reliable measurements, as can be seen in Figure **1**. Other omitted minarets are not completely accessible, or they suffered from the lack of complete dimensions. Moreover, this research only focuses on single minarets, which are limited in number. Considering that the objective of this research is to classify the minarets, three different ways for classification were proposed. Firstly, the classification was done with respect to the historical periods. Secondly, the minarets were classified based on their plan. At last, the classification was conducted by ANN with clustering based on the measurements of minarets; hence, a new classification was produced as a result of the artificial neural network. The involved historical periods are divided into four time zones as follows: imperial era, middle centuries, initial contemporary, and contemporary, as listed in Table **1**.

Table 1 Century classification

century		**classification**
Imperial era	Achaemenid	IIIIX
	Parthian	IIX
	Sasanian	IX
middle centuries	Ghaznawi	X
	Saljoughi	XI
initial contemporary	Zandieh	XII
contemporary	Islamic republic	XIII

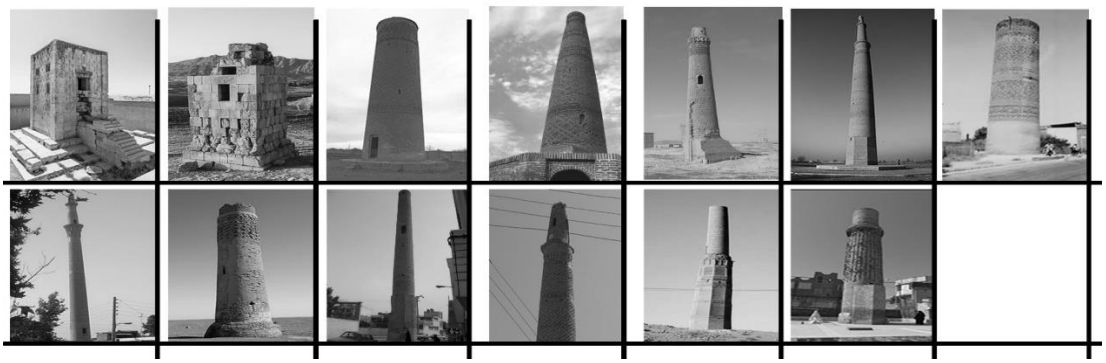

Figure 1 Studied minarets: 13 chosen minaret from different era

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

Artificial Neural network

In order to have a satisfactory ANN model, the application of a sufficient body of data is necessary for enabling the model to classify a continuous function. In this research, 13 minarets were chosen with different input values, since the creation of the ANN models was essential to conducting the analysis. Afterward, various ANN modes were created, trained, and tested based on the results of the current data of minarets. Neural Network Toolbox in MATLAB software was employed to simulate ANN models; for learning the related algorithm by clustering, a self-organizing map was used. Therefore, in this paper, the effect of several neurons in the hidden layer was evaluated, and the prime performance of the final model was selected as the best and most suitable ANN model. In this research, clustering network was used for investigating the new classification of minarets.

Clustering

Self-organizing map (SOM) was used for clustering algorithm. The objective of learning in the self-organizing map is to apply necessary modifications to the network to respond to the corresponding input patterns. The formula for a neuron v with the weight vector, $W_v(s)$, is as follows:

$$W_v(s+1) = W_v(s) + \theta(u, v, s) \cdot \alpha(s) \cdot (D(t) - W_v(s)) \qquad (2)$$

where s is the step-index, t is the index of the training sample, u is the index of the BMU for the input vector D(t), α(s) is the monotonically decreasing learning coefficient, and ɵ (u, v, s) is the neighborhood function that contributes to the distance between the neuron u and the neuron v in step s. Figure **2** shows the topology of the ANN clustering in this study.

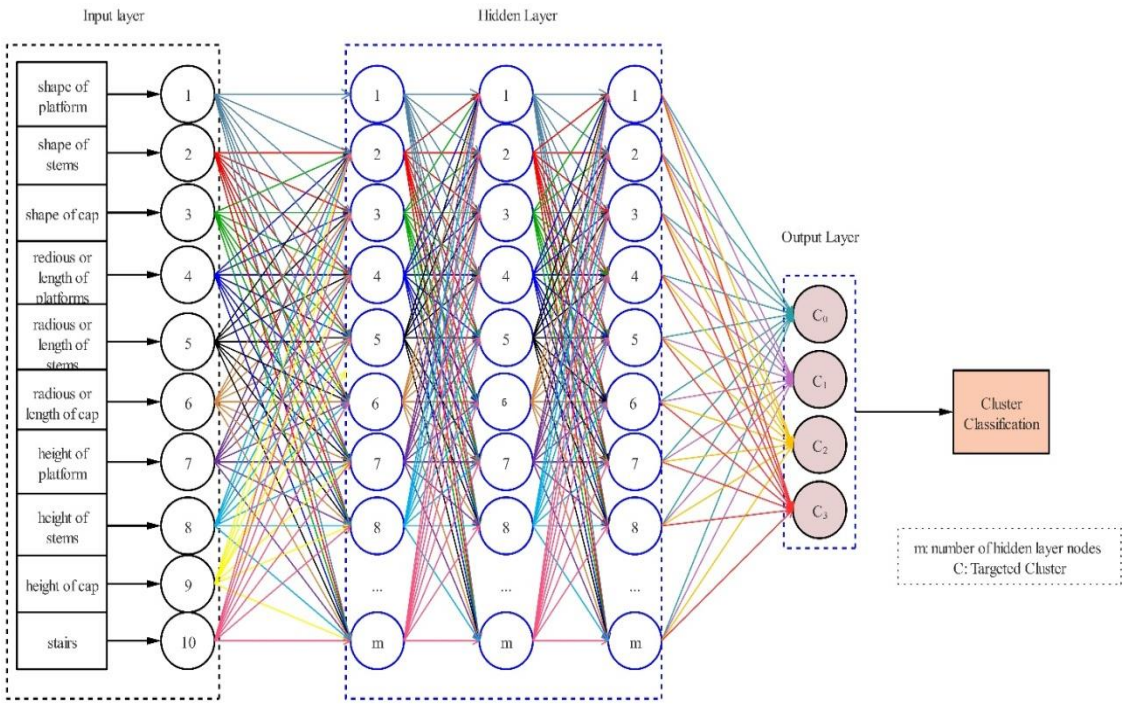

Figure 2 Topology of the ANN clustering for this study

RESULTS

Considering Table **2**, minarets are categorized based on their historical constructed dates. In addition, regarding the plan category, minarets are divided into seven groups. The plan category for Milad tower is not included. The plan category is shown in Figure **3**. Khosrogerd minaret, Ziar minaret, Saveh minaret, Sareban minaret, Naderi minaret, Cheldokhtaran minaret, Rahrovan minaret, and Karat minaret are classified into the category of Saljoughi era. For plan category, Iyaz minaret, Sareban minaret, Naderi minaret, and Shams minaret belong to a similar plan category. Moreover, Ziar minaret and Cheldokhtaran minaret have a similar plan, too. Results indicate that Khosrogerd minaret is classified into c plan category as the only minaret accordingly.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

Table 2 details of minarets

ID	Minarets' name	Height (m)	Radios and length of side (m)	Inside Stairs	Date Century	Plan Category
1	Kaaba Zarathushtra	12	7.3	No	IIIIX	a
2	Dragon minaret	7	4	No	IIX	a
3	Firuzabad minaret	24	4	Yes	IX	b
4	Khosrogerd minaret	26	4.95	Yes	XI	c
5	Iyaz minaret	40	5.5	Yes	X	e
6	Ziar minaret	49	4	Yes	XI	d
7	Saveh minaret	14	3.5	Yes	XI	b
8	Sareban minaret	54	4.2	Yes	XI	e
9	Naderi minaret	40	4.5	Yes	XI	e
10	Cheldokhtaran minaret	29	4	Yes	XI	d
11	Rahrovan minaret	35	4.8	Yes	XI	g
12	Karat minaret	25	2.5	Yes	XI	f
13	Shams minaret	17	3.4	Yes	XII	e

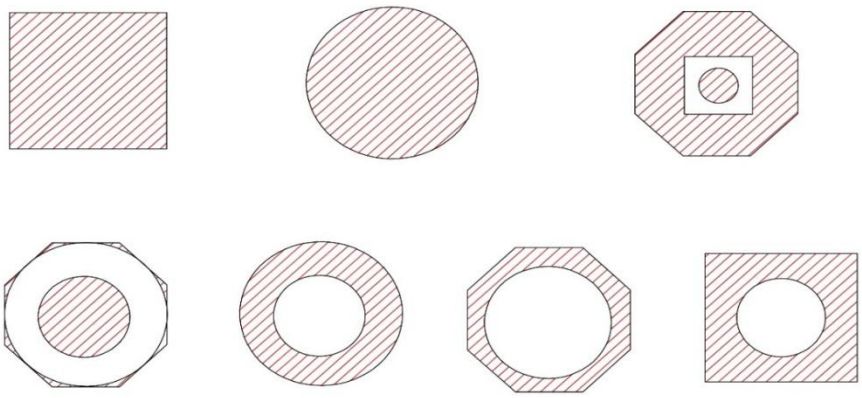

Figure 3 The plans of studied minarets: a to g from left to right above to below

In order to find a new category, ANN model was created, trained, and tested. created and, thereafter, simulated with only one hidden layer and many hidden neurons. The proposed cluster model has 4 classifications for the input minarets. As can be seen in Figure **4**, results indicate that two of all examined groups share one minaret, and the rest of the minarets are classified into groups 5 and 7. Based on Figure **5**, minarets are classified as follows:

Group 1: Sareban minaret and Naderi minaret

Group 2: Firuzabad minaret

Group 3: Kaaba Zarathushtra, Dragon minaret, Saveh minaret, and Karat minaret

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

Group 4: Khosrogerd minaret

Group 5: Ziar minaret

Group 6: Iyaz minaret

Group 7: Cheldokhtaran minaret**,** Rahrovan minaret, and Shams minaret

The proposed category for Khosrogerd minaret is the same as the plan category classification with one member. As Figure **5** shows, the proposed ANN classification (circle mark) covers a plan-based category (plus mark) for minarets with ID from 1 to 6; yet, there are differences with respect to other minarets. Although both classifications organized Sareban minaret and Naderi minaret as in a group, the plan category group has another member like Iyaz minaret and Shams minaret. Thus, the proposed network of minarets can be used for classifying other minarets.

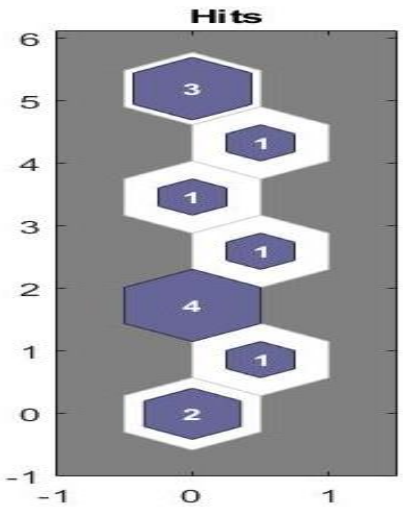

Figure 4 The result of ANN clustering

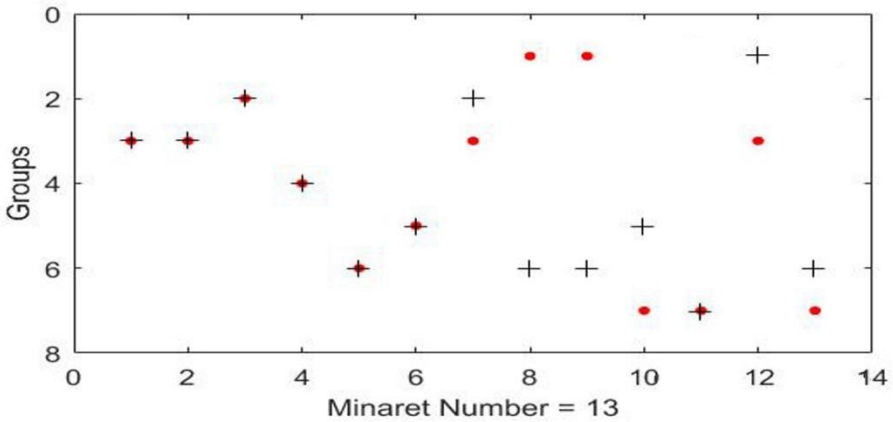

Figure 5 Comparison of Cluster classification and plan category

CONCLUSION

This paper scrutinized the classification of three minarets, considering the history and plan shape of the minarets located in Iran. Subsequently, clustering method was used, and the collected data were analyzed using Matlab software to accomplish the research goal. Accordingly, it was proved that machine learning presented a new classification for minarets that considered all the inputs. Although plan category and ANN cluster shared the same classification for some minarets, a discrepancy was seen regarding the categories. The main conclusion of this paper may be drawn as follows:

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

- Some of the most famous minarets of Iran were evaluated based on their plan shapes.
- Single minarets were constructed to serve as guidance and signs for passengers or people.
- The plan shape of minarets was not related to their history era
- ANN clustering considered measurement factors and classified in a way more different from architects' perspectives.

The results of this study can highlight the importance of minarets and their investigation. Meanwhile, single minarets should receive greater attention for assessment apart from mosques' minarets. A future study should include the materials of minarets and the reason why they were created in the Iranian context. Furthermore, the comparison of other country`s minarets should be discussed.

Conflict of Interest

No conflict of interest was declared by the authors.

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