Sigma Journal of Engineering and Natural Sciences
Web page info: https://sigma.yildiz.edu.tr
DOI: 10.14744/sigma.2025.1932

Research Article

The role of artificial intelligence in rooting local architecture

Israa Mohammad A. AL-SAFFAR[1], Osamah Abdulmunem AL-TAMEEMI[2], Fawzia Irhayyim AL-ASSADI[2]

[1]*Department of Construction and Projects, University of Baghdad, Baghdad, 10071, Iraq*
[2]*Department of Architecture, University of Baghdad, Baghdad, 10071, Iraq*

ARTICLE INFO

Article history
Received: 03 July 2024
Revised: 14 August 2024
Accepted: 25 October 2024

Keywords:
Artificial Intelligence (AI); Local Architecture; Morphology; Rooting; Traditional Building

ABSTRACT

This paper investigates the application of artificial intelligence in modeling the morphologies of architectural designs, primarily looking at traditional Iraqi architecture of the 1960s and 1970s. The research employs morphological clues based on buildings still standing to compare AI-created models to those traditionally conceived by architects. It assesses morphological characteristics in both AI-generated and human-designed architectures during the stated times using the Jaccard similarity approach. Accordingly, the problem was identified, with a lack of knowledge represented by the role of artificial intelligence in shaping Iraqi architecture preserving local architectural roots, and achieving a balance between technological innovation and authentic architectural identity. Based on that problem, the aim is determined is to provide knowledge represented by the role of artificial intelligence in shaping Iraqi architecture preserving local architectural roots, and achieving a balance between technological innovation and authentic architectural identity. The results indicated that the two had a strong similarity, demonstrating well that AI may be able to successfully emulate traditional architectural forms and materials with good effect.

In particular, it is focused on the ways AI can be employed to preserve and improve the local architectural identity, recognizing that while AI has an immense potential to mimic and maintain cultural heritage within architecture, its scope may well be limited by geographical and cultural specifics. Such limitations make it clear that findings cannot possibly find wide applicability for other regions or architectural styles. The research, however, suggests that a broader extent of the research coverage will overcome such limitations and may even provide wider applicability and insights.

The scores are highly significant, with most AI models scoring higher than 0.5 on the Jaccard index, representing adequate morphological conformity to conventional designs. This therefore implies that AI can greatly aid in preserving local architectural features while bringing efficiency and creativity to the design process. It is therefore hugely important for the future practice of architecture and educational curricula; this is evidence that AI may likely play a critical role in filling the gap between traditional architectural values and modern technological advancements.

Cite this article as: Al-Saffar IMA, Al-Tameemi OA, Al-Assadi FI. The role of artificial intelligence in rooting local architecture. Sigma J Eng Nat Sci 2025;43(6):2031–2049.

***Corresponding author.**
*E-mail address: osamah.al-tameemi@coeng.uobaghdad.edu.iq

This paper was recommended for publication in revised form by Editor-in-Chief Ahmet Selim Dalkilic

INTRODUCTION

The introduction of Artificial Intelligence (AI) is one of the advancements in artificial intelligence, and it introduces a new dimension into the field of architecture, mainly in the optimization of designs through generative design. Roéfero, Sharma, and others pointed out a few works have been done to foster creativity in architecture through Artificial Intelligence (AI) implementation, where the main contributions are in the aspects of generative adversarial networks on image generation and machine learning algorithms for structural analysis. [1]. Yet, research is wanting concerning the application of AI technologies to preservations and reinforcements of local identities in architecture, especially in culturally significant regions. The body of work that exists is more centered on the innovative and streamlining possibilities of AI for existing, contemporary architectural practice; very little attention has been paid to critical needs in the area of cultural conservation in architecture. It is this gap that the current study fills by looking at ways in which AI could be used to anchor local architecture in history and cultural context. The case in point here is Iraq, wherein architectural heritage continues to be one of those important components of cultural identity. [2,3]. This is seen from the instance of Iraqi architecture dating back to the 1960s and 1970s. While qualitatively assessing the similarity between traditional Iraqi architectural forms and examining AI-generated designs via the Jaccard similarity index, the current research is unique in marrying review with comparison [4]. Ertunç and Rathour et al. pointed out that it is hoped that this combined approach will not only break new ground in terms of understanding AI in architecture but also lead to some practical tools for heritage architectural preservation in a globalizing world. Ertunç and Rathour et al. pointed out that it is regarding the current research within the AI and cultural conservation discourse, the paper relates closely to the specific topics of interest in the journal about innovative methodologies and their application in the conservation of cultural heritage. The conclusions bear a special significance for architects, urban planners, and cultural heritage professionals trying to integrate modern technologies with traditional design principles [5,6].

Novelty in this research is dual: first, the use of AI-generated architectural forms reflecting traditional Iraqi ones and materials; second, the use of the quantitative method, the Jaccard similarity index, to compare these AI-generated designs against historical examples. It is novel in the way that it preserves architectural heritage and also very critical in the general discourse on the role played by AI in the conservation of culture. The need for this research is underscored by the latent threat of cultural homogenization in architecture that is driven by designs dominated by globalization, erasing local identities. Architecture and AI can advance in preserving and improving the forms of traditional architecture through this research. Its practical implications will be important for architects, policymakers, and cultural heritage professionals, giving them a new tool with which to balance innovation and the preservation of cultural identity.

MATERIALS AND METHODS

This paper is based on:

A. The main question in the study is: How is artificial intelligence applied to rooting local architecture? To achieve an answer, this study employs mixed methods, first, a descriptive qualitative method was employed, then a quantitative method that relied on using the Jaccard similarity method to compare the results., to the effect of the artificial intelligence technique in rooting the local architecture. It provides a new theoretical horizon for a better understanding and serves as essential to the knowledge of the application of this technique in architecture. Therefore, the investigation is an attempt to initiate an effective link between the design process and architectural principles to develop an approach that draws inspiration from the local elements and is applied in contemporary architectural productions through artificial intelligence to root local architecture
B. The current study will focus on the literature review books, academic journals, conference papers on artificial intelligence and architecture, and morphological aspects within Iraqi architecture. This study employs mixed methods, first, a descriptive qualitative method was employed, then a quantitative method that relied on using the Jaccard similarity method to compare the results [7].
C. Practical application by applying theoretical framework indicators extracted from local buildings dating back to the contemporary period, limited to the 1960s and 1970s of the twentieth century, and applied in two different prompts with artificial intelligence sites, and Comparison in application between local architectural elements and AI-generated elements.
D. Discussion of previous literature and drawing out the research problem:

Past literature generally highlights the significant impact that AI has had on modern architectural practices globally, thereby presenting a considerable opportunity to integrate it with traditional architecture linked with local cultures.

However, most such studies tend to give a general overview of concepts; hence, the emergence of overlapping ideas, and the development of partial aspects in AI applications in architecture without going into the depth of cultural and local dimensions. In fact, the absence of this holistic analysis leads to a gap in understanding how AI can be used effectively to improve the local architectural identity, especially that of historical contexts. Critical analysis of the related literature shows a deficiency regarding the depth of insight about AI's capabilities; most research lacks the emphasis that this technology deserves in the preservation

and promotion of local architectural heritage. Some, for instance, might focus on innovations within their technical dimensions but rarely extend to the way such technologies coexist with and further support conventional architectural forms, such as the specific ones found during the 1960s and 1970s in Iraq. The literature also shows incomplete strategies for balancing technological developments regarding preserving authentic architectural identity.

This research tries to fill these gaps through a critical approach that puts into one piece how AI can shape and develop local architecture in Iraq, considering its historical significance and its modern adaptation. A review of the related literature indicates that while various aspects of AI in architecture have been addressed, focused research on the role of AI in maintaining architectural continuity remains scarce, with a mad rush toward embracing innovation. This work, therefore, aims to find its place within this gap by exploring the causal and logical relationships between AI and the evolution of Iraqi architecture with a view to furnishing a solid bedrock of material upon which new contributions within this subject area will be established.

Artificial Intelligence and Architecture

Until recently, the conventional definition of AI was that it sought to do what human minds can achieve, but that concept is clearly out of date. Del Campo & Leach pointed out that AI is already capable of outperforming humans in a variety of ways [8].

In the same context, Mishra and Mohammed defined artificial intelligence. defines AI as a field of study in computer science. It entails creating computer programs to perform things that would otherwise require human intelligence. AI algorithms can be used to solve problems in learning, perception, problem solving, language understanding, and/or logical reasoning [9,10].

Kaplan and Haenlein define AI as "a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" [11].

As Bartnek et al. mention "AI is the study of [intelligent] agents that receive precepts from the environment and take action. Each such agent is implemented by a function that maps percepts to actions, and we cover different ways to represent these functions, such as production systems, reactive agents, logical planners, neural networks, and decision-theoretic systems" [12].

As AI advances in capability, today's architect is presented with a variety of potential sources of intelligence to deploy in the service of the craft;

1) own talents, skills, and experience (as certified, for example, by their professional registration) ;
2) an array of hard-coded computer programs that achieve specific ends (such as energy analysis or structural engineering);
3) machine learning systems (which may learn from data derived from their design projects, or even sensors within finished buildings and provide insight);4) ultimately the speculative prospect of cognitive systems that can reason within context (only seen in science fiction today) [13,14].

Borglund explains that in the fields of architecture and engineering, artificial intelligence and machine learning play a crucial role through a concept known as generative design. This technique primarily focuses on identifying optimal design solutions, diverging from traditional design simulation that relies heavily on extensive, result-oriented data. The generative design takes this simulation process to a higher level, as it does not respond to well-defined questions on functionality, changes, mechanism, or whatever. It provides suggestions in a continuous process that learns and improves through each cycle using set inputs subject to defined constraints and objectives. In this method, the designer changes from an inquirer to a demander. Researchers in design thinking also view generative design tools as creative enablers. They support the ability to explore many alternatives in the early design process to develop creative potential through divergent thinking, an essence of creativity [15]. Figure 1. shows the flowchart of AI and its relation with architecture**.**

Artificial Intelligence Hallucinates Images

Machine vision, also known as image recognition, is a notable achievement in the realm of machine learning. A more advanced development is the ability to 'hallucinate' images, a concept realized in 2015 by Google engineer Alexander Mordvintsev. Merizio et al stated that discovered how to reverse the function of neural networks from merely recognizing to generating images. This innovation led to the creation of Deep Dream, a computer vision program

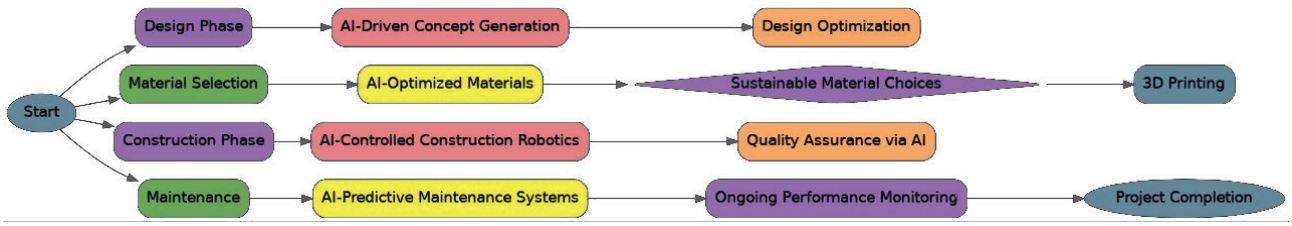

Figure 1. Flowcharts showing the integration of AI in architectural processes. Source: Authors.

that garnered significant attention in artistic communities for its unique, dream-like images. [16]. In the same context, del Campo & Leach pointed out that paved the way for style transfer techniques, such as overlaying zebra stripes onto a horse or interpreting images through neural networks trained on specific art styles, like Van Gogh's paintings. However, the landmark advancement in image generation came in 2014 with the invention of generative adversarial networks (GANs) by computer scientist Ian Good Fellow. GANs operate through the interaction of two neural networks: one generates images (the generator), while the other (the discriminator) evaluates these images against a training dataset. This process resembles an art forger attempting to deceive an art critic with a counterfeit work. The discriminator rejects images until they match the quality of the dataset. Once adequately trained, the discriminator can be removed, allowing the generator to autonomously produce convincing images [8].

Artificial Intelligence Affects Architectural Morphology

Artificial intelligence is also revolutionizing architecture with new and innovative ways of designing and making. One way through which AI impacts architecture is through the morphology of the buildings. AI algorithms can generate designs that are optimized for function. Designs for energy efficiency and design for stability can result in artificial structures that, though within the language of the systems that they represent, have never been seen before in the annals of architectural history. Similarly, designs that are similar to the branching of trees or the logic of water courses will impact the morphology of the building envelope. In a similar vein, AI processes information to make design decisions. These lead the archittes to make sound decisions about the shape and functional schemata of a building [17]. Kumar & Bernstein mention that AI tools, on the other hand, differ from these automatic tools in the way that they process and come up with their output without the direct intervention of the designer [13,18].

Maltret and Zoller suggest that architectural morphologies can be equated to a cosmos—a well-structured composition of elements. The elements are generic, recognizable objects that can produce definite objects by their genealogy. Their system of knowledge is divided into:

- Physical objects and Architectural elements.
- Relationships that link the elements, and in the actual, the elements are differentiated by:
- Characteristics, such as morphologic attributes, architectonical features, or positional characteristics.
- Their parts, and graphical representations.

The two principal inter-object associations as Maltret & Zoller say are filiation with its specialization, and composition relationships managing associations of objects according to a set of rules [19]. From Ismael and Roberts, it is understood that AI has to deliver this wave of change, to revolutionize architectural design and its construction. But Artificial Intelligence (AI) cannot match the human brain for creativity and adaptability. Nevertheless, AI could be used to further improve efficiency at work and must be engaged to extend the design limits [20,21].

Maltret describes what must be perceived as root level attributes for architectural objects:

- A 3D morphology, which in essence is a geometrical primitive from the modeler, which is exemplified by a 3D geometrical volume, or a combination of volumes, each of them defined by their own attributes and performances.
- A 2D morphology, which is the planar projection of the 3D form.
- A typology, which when not specified defaults to 'Notype›.
- An owner, which represents a composition relationship.
- A list of elements, which again is a composition relationship, and when not specified defaults to an empty set.
- The size: for instance, height, width, and length [19].

The following Figure 2 shows some of IA potentialities in the design process.

Rooting Morphology Aspects In Architecture

Based on the Oxford dictionary the word root is defined as 'establish deeply and firmly', or 'have as an origin or cause' [22].

In a broad definition of rooting the term "root architecture" is used in the biological field referring to distinct aspects of the shape and the spatial configuration of the root systems [23,24].

In architecture, rooting refers to the way a building is anchored or rooted to the earth. According to a Quizlet article, architecture can be rooted in the earth's rich resources, allowing buildings to act as a "natural symbolism". The site is the place where a building rests, with its submission to gravity, its raw materials, and centrality in outer space. The way a building is rooted in the earth can have a significant

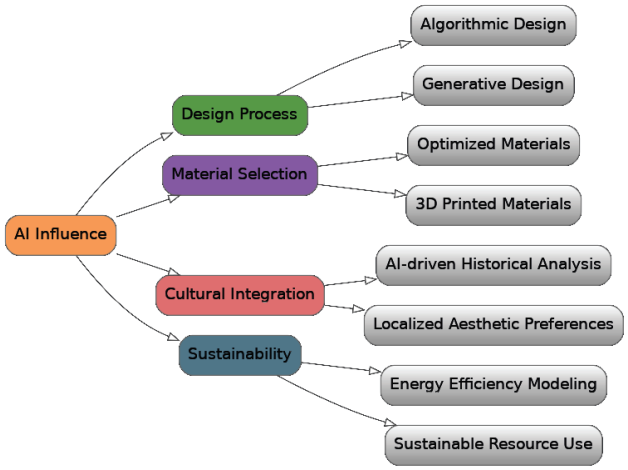

Figure 2. Conceptual models depicting the influence of Artificial Intelligence (AI) on local architectural styles.. Source: Authors

impact on its design and function. For example, Deckker discusses buildings that are rooted more firmly to the earth and may be more stable and better able to withstand natural disasters such as earthquakes [25].

Attributing Research or Examples from Other Regions: The previous application of artificial intelligence in Japanese architecture has been done using similar methodologies as described in this paper. These are examples that restate the fact Artificial Intelligence (AI) might well be a universal tool for cultural identity in architecture.

Rooting Morphology of Local Iraqi Architecture

Contemporary Iraqi architecture dates back to the beginning of the twentieth century, at the end of Ottoman rule and the beginning of the British occupation, with the coronation of King Faisal I as King of Iraq in 1921 (the establishment of the Iraqi state). Al-Assadi et al. state that Iraqi architecture has gone through many stages, numerous political events, and economic, social, and other changes. With the existence of these variables and events, it is noted that new architectural styles entered the local arena, accompanied by the emergence of clear architectural trends or styles that could generally be classified accordingly [26]:

The first stage: Represents the period of the twenties and thirties.

The second stage: Represents the period of the forties and fifties.

The third stage: Represents the sixties and seventies.

The fourth stage: Represents the eighties and nineties, when Iraqi architecture began to deviate from its path that was drawn in the previous period because of multiple wars and economic blockades that led to the isolation of Iraq from the world during that period. Only the first three phases will be investigated for their importance in determining the course of contemporary Iraqi architecture [27].

The first stage: Was characterized by the quality of the buildings constructed during this period, including the dominance of the British classic style, with the use of brick as a basic construction material within the architectural formations of a classic character. Since these architects designed in India with the British Army, the most prominent influences on the orientations and ideas of these architects were:

- Prevailing architectural trends in Britain (conservative classicism).
- Local traditional architecture of Iraq and neighboring Arab countries.

Among the most prominent buildings executed during that period is the General Ports Directorate building in Basra 1927 designed by Wilson and the Al-Zuhur Palace 1932, as in Figure 3. Shows examples of Iraqi architecture during that period.

The second stage: The most significant characteristic of the architecture in this period is represented in its artistic language that approached the propositions of what is known as "modern architecture". The architecture of this phase widely employed modern construction methods and materials.

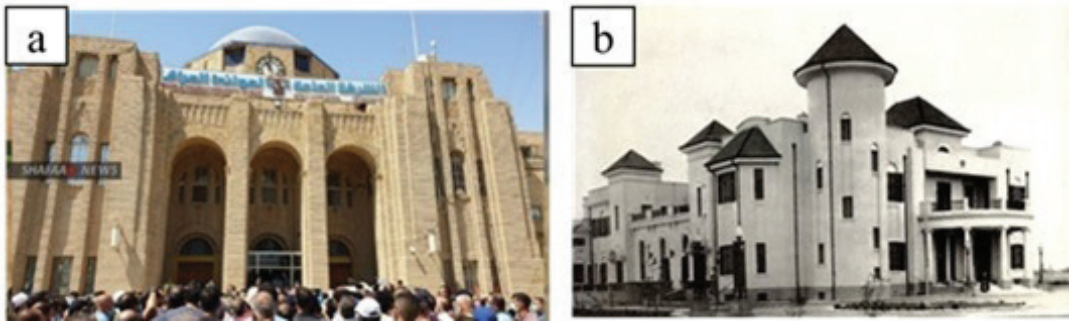

Figure 3. (a) Al-Zuhur Palace building. (b) General Ports Directorate building, [28] with permission from Shafaq News.

Figure 4. (a) Damarchi building. Source: Authors. (b) Sofair building. Source: Authors.

In the same context, Al-Sultani pointed out that: Distinguishably Baghdad skyline began to change through the emergence of multi-story buildings, such as the administrative building of the Sofer Building in Al-Rashid Street in 1946, designed by (Medhat Ali Mazloum, followed by the construction of the Damerchi Building, which was implemented by Niazi Fatou in 1948 and consisted of six floors [29]., as in Figure 4.

The third stage: Marked the beginning of the heritage-oriented stage (the sixties), it witnessed a trend towards the concept of architectural heritage and adhered to it, later in the seventies it expanded and prevailed. It was for the works of Muhammad Makiya and his trends that were reflected in the buildings of the Caliphs Mosque 1964, Al-Rafidain Bank 1968, and the Endowments Library. He used the heritage vocabulary and adapted it to coexist with contemporary ideas at the time. Thus, it was the beginning of an architectural movement that adhered to the local identity and led to the prominent outcome of creating an Iraqi school. As for the most important features of this approach as Al-Assadi & Al-Dewachi also searched is [30]:

This trend affected buildings' shapes and the use of heritage elements and details such as arches, shanasheel, inner courtyards, and others. The return to the use of bricks again in many buildings of this stage in addition to the presence of concrete materials, as in the projects of (Rifaat Aljaderji). Figure 5 shows the use of these elements in buildings of that period.

Nasir & Khudhair explained the existence of human scale in buildings and the use of simple heights and brick details in this period, in addition to the attempt to achieve traditional local character, with the presence of tall buildings at this stage such as communication centers and some ministries and administrative buildings, but the material and the details that were used in facades mitigate the massiveness and height of its construction (Nassir & Khudhaeir, 2010).

Iraqi architects adapted modern architecture in a local style through the use of treatments, details, and building materials such as lifting buildings on columns or using screens in the facades, as in Al-Founoun Institute by Saeed Ali Madhloum, and Al-Mustansiriya University by Qahtan Awni that was distinguished by Iraqi modernity through the employment of heritage in a contemporary style, as the designer resorted to using the brick screen with inscriptions from Iraqi heritage, hanged on concrete structure.

Scientific artistic dissertations tendencies appeared in Iraq towards the attraction of what was new in the field of environment. This concept was limited to the microbiological perspective on the local Baghdadi heritage environment or the folklore forms as metaphorical units, as in the exploitation of the folklore form of the Iraqi carpets in the facade of the University of Al-Mustansiriya or (the use of artistic elements in the design). Table 1.

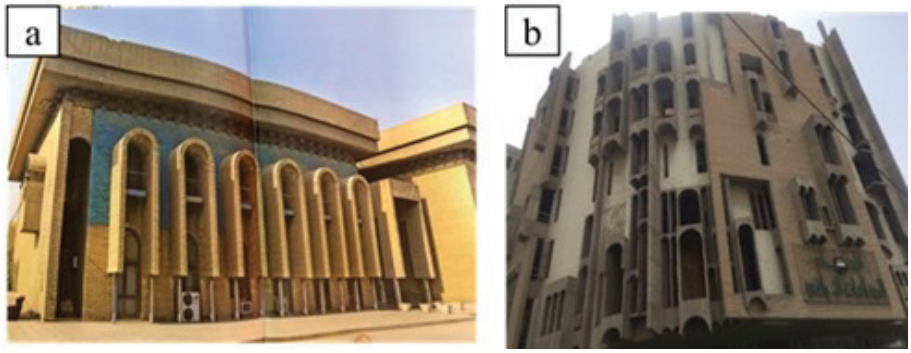

Figure 5. (a) Scientific complex building [31] with permission from the author. (b) Industrial union building. Source: Authors.

Table 1. The most important phases and the characteristics of architectural production within those stages. Source: Authors

Phase	Morphological level	Materialistic level	Scale level	Examples
First	British classical architecture and some features of local traditional architecture	The use of brick material, limited as the main finishing material	Characterized by proportionality and exclusivity	- Al-Zuhur Palace building. - General Ports Directorate building.
Second	Modern architecture and global style	Iron and concrete	Enormity in scale both horizontally and vertically	- Damarchi building - Sofair building
Third	Orientation towards traditional forms	Back to bricks	Human scale	- Scientific complex building - Industrial union building - Al-Mustansiriya University

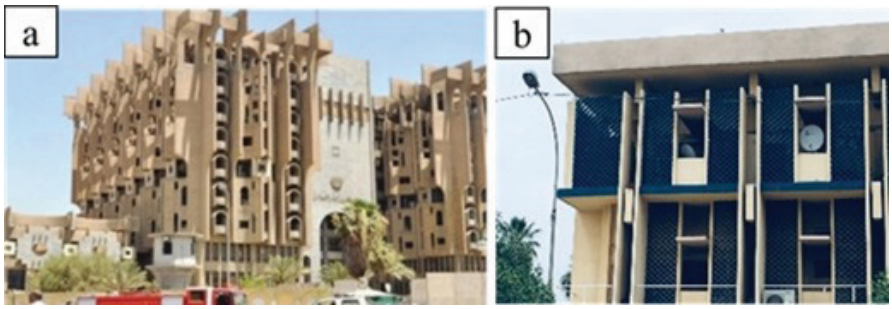

Figure 6. Use of bricks and concrete**.** (a) Ministry of Industry (Bricks). Source: Authors. (b) Awqaf Library (Concrete). Source: Authors.

Figure 7. Use of folkloric forms. a & b Source: Authors.

Figure 8. Use of ceramic (greenish blue). (a) Liquefied water building. Source: Authors. (b) Scientific Complex [31]. with permission from the author.

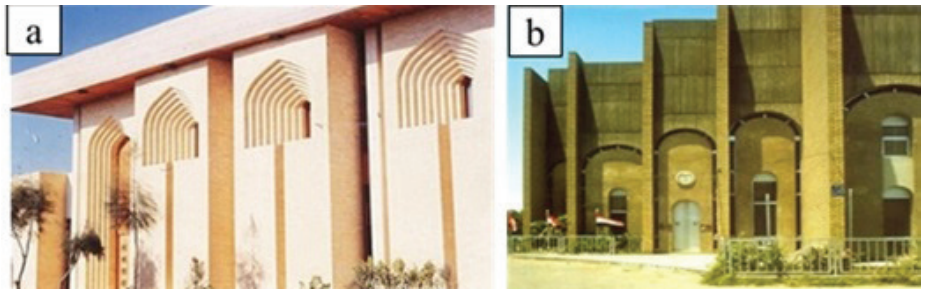

Figure 9. Use of arches. (a) Al-Rafidain Bank/Kufa [35], reproduced with permission from the author (b) Al-Rafidain Bank/Baghdad. [36], reproduced with permission from the page owner.

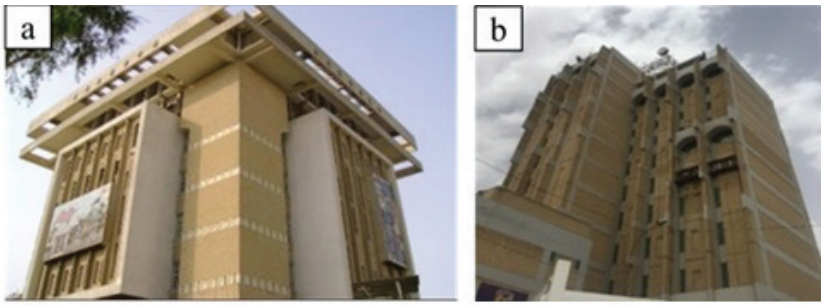

Figure 10. Use of local material (bricks). (a) Real estate Bank. Source: Authors. (b) Al-Sinak call center. Source: Authors.

Figure 11. Use of Abbasid arch in College of Education building. (a) Real Abbasid arch. Source: Authors. (b) Abstract arc to triangle. Source: Authors.

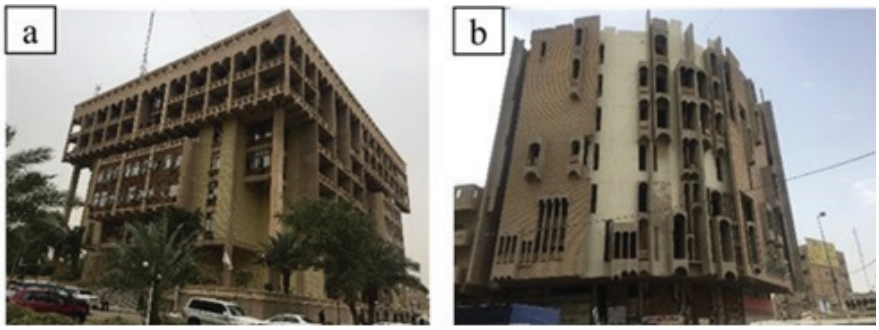

Figure 12. Use of shanasheel. (a) Liquefied water building. Source: Authors. (b) Industries union building. Source: Authors.

Figure 13. Use of portico. (a) Al-Mustansiriya University. Source: Authors. (b) Baghdad Municipality Building. Source: Authors.

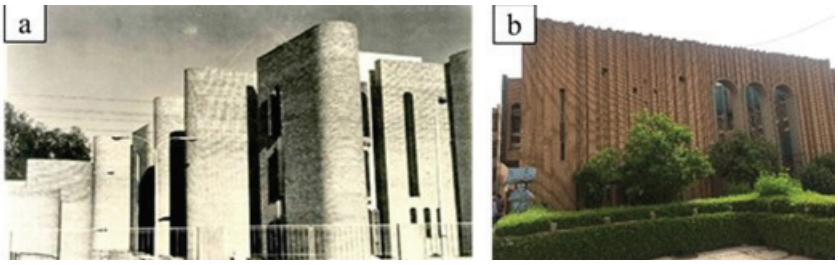

Figure 14. Use of Mesopotamian forms. (a) Semicircular towers. [37] reproduced with permission from Al Mada newspaper. (b)The system of fluting and protrusions. Source: Authors.

Figure 15. Use of (hat) on top of buildings. (a) Ministry of Interior, [38] (used for academic purposes only). (b) Baghdad Municipality Building. Source: Authors.

Characteristics of the Formal Structure of Iraqi Architecture

Al-Saffar suggests that the Local Iraqi architectural features came as a result of circumstances and interactions that include many factors and variables, both physical and non-physical, and what was left of this architecture is a fraction of these overlaps, eventually some features and characteristics can be extracted to compare Iraqi architecture with other civilizations, namely [32]:

- The characteristic of the human dimension.
- Harmony with the content.
- Emphasis on the principle of enclosed space (inner courtyard), whether it is solo or within a group.
- Use of local material (bricks).
- Utilization of stylistic details such as (arch, portico, the system of fluting and protrusions, brick screens, semicircular towers, shanasheel...etc.)

On this basis, the research concludes that as Al-Tameemi shows, the most important stage that characterized contemporary Iraqi architecture in terms of production is the third stage (the sixties and seventies), which stemmed from the beginnings of the emergence of an Iraqi architectural school. This stage can be considered as the distinction of the "heritage" concept on the intellectual scene to a wide extent, coinciding with the emergence of the post-modernism trend, which calls for returning to the past and history and for inspiration [33].

This period witnessed a widespread interest in "heritage" and the means to reflect it in architectural production, architectural experiments emerged to embody inspiration from the materialistic aspect and its presence through traditional heritage elements, while other experiments considered that the issue of inspiration from heritage means reviving the spiritual and historical aspects. Despite the evolution of the heritage notion at this stage, modernist thought was still represented as a contemporary conception that must be followed, but with a heritage vision related to the place, that is, attempts to create a global, regionalized architecture. With this trend, reflections of the architectural concept of heritage began to appear through attempts to draw inspiration from some heritage details such as (arches, and decoration, in addition to the use of brick material and the inner courtyard...etc.) [34], as in Figures 6-15. Shows the most important architectural achievements at that period.

Based on that, the research concludes the most significant indicators of the theoretical framework of Iraqi architecture for the third stage (the sixties and seventies), Table 2. Also, Figure 16 shows the most important elements that give Iraqi architecture its identity.

Regarding the experimental data obtained from models of contemporary Iraqi architecture, the research believes that the benefits will be derived from applying advanced data analysis techniques by using machine learning algorithms able to process small datasets and others. It is possible to use cross-validation techniques or bootstrapping to obtain optimization of the predictive capacity of the available data, even though it was limited.", as well as "The

Table 2. The most significant indicators of the theoretical framework of Iraqi architecture for the third stage (the sixties and seventies) Source: Authors

Third stage	Form level	Material level	Scale level	Detail level
The sixties and seventies	Orientation towards traditional forms	Focusing on the material (brick) as well as concrete and iron	Human scale	Abbasid quadrilateral arch The abstract arc of the triangular shape Using brick material as: Brick decoration Brick screens Use of shanasheel (explicit or abstract form) Using ceramic material in the facades and the details Use of the inner courtyard Using the porticos The cubic or rectangular shape of the building block Use a concrete crown or hat at the top of the building Focus on the design of the corner of the building (smashing, grading, or deletion) The use of concrete and bricks in the details of the facades (in arches, shanasheel, etc.) Use of Mesopotamian details such as: System of fluting and protrusions. Use of square or semicircular towers.

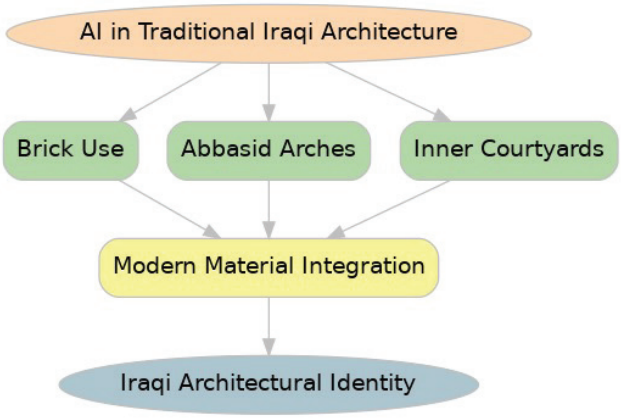

Figure 16. the elements that give Iraqi architecture its identity. Source: Authors.

collection and analysis of larger datasets should be pursued for the improvement of accuracy and generalization of AI-based predictions in local architecture. The approach will lead to a more solid foundation for the application of AI in this field and an improved level of the reliability of architectural practice."

Research Methodology

This study employs a method, first, a descriptive qualitative method was employed to investigate the similarity of the morphological representation of the indicators that can be found in local Iraqi architecture and the AI-generated examples [39]. Then a quantitative method relied on using the Jaccard similarity method to compare the results. Every variable with the value 1 which is considered positive represents the visual morphological representation of the indicator, and the value 0 represents the negative i.e. the absence of the visual depiction of the indicator [40]. It then adopted a numerical scale by calculating the Jaccard coefficient index ratio of the size of the intersection between each AI model and the Iraqi local architecture indicators to obtain a solid base to be able to draw a clear conclusion. The researcher carried out this task and has set the following rules to consider the results as an acceptable or unacceptable role AI towards rooting local Iraqi architecture:

1. The Jaccard coefficient index under 0.5 is considered an unacceptable result.
2. The Jaccard coefficient index of 0.5 and above is considered an acceptable result.

The Jaccard variables are 0 (refers to negative) and 1 (refers to positive). When calculating the Jaccard coefficient index the highest possible result will reach the value 1, and the lowest possible value is 0, therefore it is only reasonable considering the value 0.5 as the cutoff between 0 and 1.

Practical application

The application was carried out by using a set of keywords extracted by the indicators derived from the theoretical framework from Table 2, which represents the morphological aspects expressing the local aspect of Iraqi

architecture, it was applied in two different prompts and used in several artificial intelligence sites to obtain the following results. Table 3.

The models were developed using AI online sites represented by Gencraft AI image generator, lexica AI image generator, and LimeWire. blue willow AI image generator

Models A, B, and C have the same prompt but each one of them was generated using a different Artificial Intelligence (AI) site, and the same process was applied to the models D, E, and F.

Keywords: contemporary, traditional styles, 1960s and 1970s architecture, brick screens, concrete, iron elements, central four-arch Abbasid arch, ceramic facades, inner courtyards, semi-circular towers, Mesopotamian-inspired recesses, square towers, traditional and modern fusion, Iraq's architectural identity.

Prompt: Create a contemporary architectural design inspired by Iraqi traditional styles from the 1960s and 1970s. Incorporate brick, concrete, and iron elements along with the central four-arch Abbasid arch, ceramic facades, inner courtyards, and semi-circular towers. Integrate modern materials while preserving the essence of Mesopotamian-inspired recesses, projections, and square towers. Emphasize traditional and modern fusion, reflecting Iraq's architectural identity with a fresh perspective. Figure 17-19. show contemporary architectural design inspired by traditional Iraqi styles from the 60s and 70s using artificial intelligence**.**

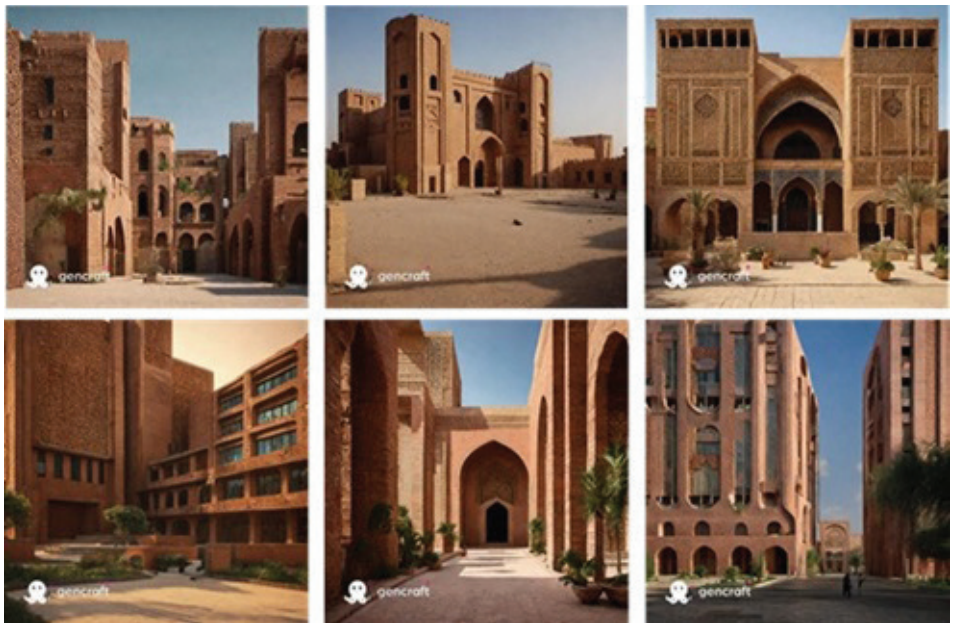

Figure 17. Artificial Intelligence (AI) simulation model A (predicted). Source: Created by the authors using Gencraft AI image generator.

Figure 18. Artificial Intelligence (AI) simulation model B (predicted) Source: Created by the authors using lexica Ai image generator.

Figure 19. AI simulation model C (predicted) Source: Created by the authors using LimeWire. bluewillow Ai image generator.

Table 3. Jaccard similarity for AI models A, B, and C. Source: Authors

Indicators		Iraqi Architecture (Actual)	AI simulation model A (predicted)	AI simulation model B (predicted)	AI simulation model C (predicted)
Orientation toward traditional forms		1	1	1	1
Focusing on material (brick)		1	1	0	1
Focusing on concrete material and iron.		1	0	1	1
Human scale		1	1	1	1
Morphological Details	Abbasid quadrilateral arch	1	1	1	1
	The abstract arc of the triangular shape	1	0	0	0
	Use of shanasheel (explicit or abstract form)	1	0	0	1
	Using ceramic material in the facades and the details	1	0	0	0
	Use of the inner courtyard	1	0	1	1
	Using the porticos	1	0	0	0
	The cubic or rectangular shape of the building block	1	1	1	1
	Use a concrete crown or hat at the top of the building	1	0	0	0
	Focus on the design of the corner of the building (smashing, grading, or deletion)	1	1	1	0
	The use of concrete and bricks in the details of the facades (in arches, shanasheel, etc.)	1	1	0	1
	Use of Mesopotamian system of fluting and protrusions.	1	0	0	0
	Use of Mesopotamian square or semicircular towers.	1	1	1	1

Table 4. Jaccard values for AI models A, B and C. Source: Authors

		AI simulation model A		AI simulation model B		AI simulation model C	
		negative	**positive**	**negative**	**positive**	**negative**	**positive**
actual	negative	0	0	0	0	0	0
	positive	8	8	8	8	6	10

Jaccard Similarity for model A

$$\frac{\text{Overlapping positives}}{\text{total positives}} = \frac{8}{16} = 0.5$$

Jaccard Similarity for model B

$$\frac{\text{Overlapping positives}}{\text{total positives}} = \frac{8}{16} = 0.5$$

Jaccard Similarity for Model C

$$\frac{\text{Overlapping positives}}{\text{total positives}} = \frac{10}{16} = 0.625$$

Below is another example of AI-generating pictures. Models (D, E, F). And Jaccard Similarity for Artificial Intelligence Table 5,6.

Keywords: contemporary, traditional styles, 1960s and 1970s architecture, brick screens, concrete, iron elements, ceramic facades, semi-circular towers, Mesopotamian-inspired recesses, square towers, traditional and modern fusion, Iraq's architectural identity.

Prompt: a contemporary architectural design inspired by Iraqi traditional styles from the 1960s and 1970s. brick screens, concrete, and iron elements, ceramic facades, and semi-circular towers. Integrate modern materials while preserving the essence of Mesopotamian-inspired recesses, projections, and square towers. Emphasize traditional and modern fusion, reflecting Iraq's architectural identity. Get inspiration from Mustansiriya University building design, the Iraqi Industrial Union building, Mohammed Makkiya's work, and modern style. Figures 20-22. these elements are embodied in them using artificial intelligence.

Figure 20. Artificial Intelligence (AI) simulation model D (predicted) Source: Created by the authors using Gencraft AI image generator.

Figure 21. Artificial Intelligence (AI) simulation model E (predicted) Source: Created by the authors using lexica Ai image generator.

Figure 22. Artificial Intelligence (AI) simulation model F (predicted) Source: Created by the authors using LimeWire. bluewillow Ai image generator.

Jaccard Similarity for Model D

$$\frac{\text{Overlapping positives}}{\text{total positives}} = \frac{8}{16} = 0.5$$

Jaccard Similarity for Model E

$$\frac{\text{Overlapping positives}}{\text{total positives}} = \frac{2}{16} = 0.125$$

Jaccard Similarity for Model F

$$\frac{\text{Overlapping positives}}{\text{total positives}} = \frac{11}{16} = 0.6875$$

The following diagram illustrates the practical results for models (A,B,C). (Fig. 23).

RESULTS AND DISCUSSION

This study, conducted in 2024, aimed to understand the role of artificial intelligence in rooting local Iraqi architecture by analyzing the extent to which AI can reproduce the morphological elements of traditional Iraqi architecture. The study employed a mixed-methods approach, beginning with qualitative descriptive analysis to compare the morphological forms found in Iraqi architecture with those

Table 5. Jaccard similarity for AI models D, E and F. Source: Authors

Indicators		Iraqi Architecture (Actual)	AI simulation model D (predicted)	AI simulation model E (predicted)	AI simulation model F (predicted)
Orientation towards traditional forms		1	1	0	1
Focusing on material (brick)		1	1	0	1
Focusing on concrete material and iron.		1	0	1	1
Human scale		1	0	0	1
Morphological Details	Abbasid quadrilateral arch	1	0	0	1
	The abstract arc of the triangular shape	1	0	0	0
	Use of shanasheel (explicit or abstract form)	1	0	0	0
	Using ceramic material in the facades and the details	1	0	0	0
	Use of the inner courtyard	1	0	0	1
	Using the porticos	1	1	0	1
	The cubic or rectangular shape of the building block	1	1	1	1
	Use a concrete crown or hat at the top of the building	1	0	0	0
	Focus on the design of the corner of the building (smashing, grading, or deletion)	1	1	0	0
	The use of concrete and bricks in the details of the facades (in arches, shanasheel, etc.)	1	1	0	1
	Use of Mesopotamian system of fluting and protrusions.	1	1	0	1
	Use of Mesopotamian square or semicircular towers.	1	1	0	1

Table 6. Jaccard values for AI models D, E and F. Source: Authors

		AI simulation model D		AI simulation model E		AI simulation model F	
		negative	positive	negative	positive	negative	positive
actual	negative	0	0	0	0	0	0
	positive	8	8	14	2	5	11

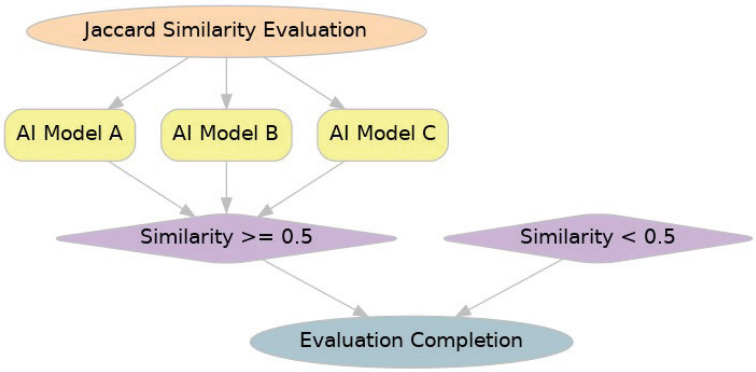

Figure 23. Shows illustrate the practical results. Source: Authors.

Table 7. The final results for all AI models. Source: Authors

	AI simulation model A	AI simulation model B	AI simulation model C	AI simulation model D	AI simulation model E	AI simulation model F
Jaccard coefficient index	0.5	0.5	0.625	0.5	0.125	0.6875

generated by AI, followed by the use of the Jaccard method to measure similarity between them. The results showed that AI is capable of accurately representing some visual aspects of local architecture, though it cannot sometimes fully grasp the cultural and historical depth of architectural elements. The study concluded that AI can be an effective tool in enhancing and developing local architecture if properly guided, with careful consideration of the cultural and historical context in which it operates. Based on that and the comparison between local architectural elements and those generated by AI as shown in Table 7, the following conclusions can be drawn:

Two different AI prompts were applied in the study in order to generate six different models of architecture. The models were in turn evaluated according to their morphological similarity with local Iraqi architecture from the 1960s and 1970s with the Jaccard similarity index. The AI -based models have been compared against a set of morphological indicators directed to be derived from traditional Iraqi architectural elements: the use of bricks, concrete, iron elements, Abbasid quadrilateral arches, inner courtyards, and Mesopotamian-inspired forms. The overall result was that five out of the six models—that is, A, B, C, D, and F—returned Jaccard similarity indices of 0.5 and above, which denotes high morphological similarity with local Iraqi architecture of the studied period. More specifically, Model A scored an index of 0.5, Model B also 0.5, Model C 0.625, Model D 0.5, while Model F was the best with an index of 0.6875. These indices are high and signal that AI can be used in reproduction of such important architectural elements and styles to capture the traditional forms, materials, and design principles that are usually attributed to any given culture. On the other hand, the Jaccard index of morphological resemblance was very low, at 0.125, suggesting that the morphological match and adequacy to represent the architecture of local Iraq is very poor. In this particular model, the major critical tectonic details that denote traditional styles from the 1960s and 1970s were not reflected. The indication is that AI-generated designs can go a long way to ensure that local architectural identity is preserved and anchored by making true imitations of traditional structures and including them in contemporary forms. It also has the implication that it necessitates human intervention during the design process to ensure that such cultural and emotional nuances are captured sufficiently, which AI can miss. This duality approach is a way of embodying efficiency and innovation in AI while structuring the rich cultural heritage and emotional significance of traditional architecture. The research concludes that while AI is bound to revolutionize architectural design, a human touch tends to make authenticity and profound depth of cultural expressions in architecture indispensable. Table 7. represents the final results for all AI models. In other words, this result has practical application in that AI can be used as a powerful tool in developing architectural designs that are efficient and, at the same time, aesthetically pleasing, with traditional aspects and cultural identity. These technologies may be applied in an architectural restoration project or in designing a new building to align with local characteristics, thereby increasing the acceptance of the local community towards these buildings. Table 7.

Thus, five models out of six displayed an acceptable similarity approach towards generating close morphological results of Iraqi architecture.

Expanding the Application of the Results: While the study will be geared toward applying AI to traditional Iraqi local architecture, these results can, to a practical extent, be general in their findings. These principles put in place in this study to evaluate the similarity between traditional Iraqi architecture and AI models can be used in other completely different situations. For example, architectural designing in other parts of the world can use AI. One such part of the world is South Asia or North Africa, where the basis for traditional architecture is based on some unique features that can easily be integrated into modern designs through AI.

RESULTS AND DISCUSSION

As a result, the morphological resemblance of AI-generated architectural forms can be similar to the traditional Iraqi architecture forms of the 1960s and 1970s. Five out of the six models returned Jaccard similarity indices of 0.5 or more. This means that AI can duplicate the form of traditional architecture and materials with a cultural heritage element in a faithful manner. These findings agree with some of the previous works in the literature in which the use of AI has been studied in the context of architecture, especially generative design. For instance, [15] outlined that AI can be used for obtaining design solutions optimized through generative design processes not limited by conventional architectural norms. Along the same lines, the work of Kaplan and [11]underscored the idea that AI can interpret and learn from data so that it can come up with designs in consideration of specific goals and contexts. Still, different from these studies which lean more toward

innovation and optimization, this research takes a special focus on the aspect of keeping or maintaining local identity in architecture and filling in the gap that has resulted from previous works.

Additionally, the findings of the study provide further insights by showing that AI can not only innovate but also succeed in the re-creation of traditional forms with a high degree of accuracy. This is quite contrary to the fears expressed by [20], who feared AI was likely to miss out on some of the nuances within cultural and emotional dimensions of traditional architecture. The results of the current research demonstrate that AI can indeed replicate the known models of traditional architectural forms, but human intervention is very much needed to give real meaning to those cultural and emotional factors. In comparison to previous studies, the present research was conducted using a novel quantitative measure based on the Jaccard similarity index in judging the level of similarity of AI-generated designs to traditional architectural forms. This methodological innovation opens a new tool for researchers and practitioners who seek to balance innovation with cultural conservation in architecture. In this manner, the results of this study contribute not only to the ongoing debate on the role of AI in architecture but also provide practical implications for its application in heritage preservation. That said, a high degree of morphological similarity obtained by AI models underscores the potential for embedding AI in culturally sensitive design processes, provided they are carried out under the guidance of a sophisticated understanding of local architectural traditions.

Loss of the human touch: Although AI can replicate and improve traditional designs such as the Abbasid quadrilateral arch, it may lack the human and emotional touch that gives local architecture its unique character.

Potential neglect of aesthetic and cultural aspects: AI tends to focus on functional and structural efficiency, as in the design of shanashil and the materials used in facades, which may lead to neglect of aesthetic and cultural aspects that are essential to local architecture.

Functional improvement versus tradition: In the case of courtyards and arcades, AI can improve elements such as airflow and sunlight, but it may overlook the social and cultural dimensions that make these elements an integral part of the urban fabric.

Balancing authenticity and efficiency: While AI can enhance the thermal and structural efficiency of a building form, such as a cubic or rectangular one, it may conflict with architectural traditions that carry cultural and historical symbolism.

Accurately reproducing historical details: AI can accurately reproduce fine architectural details such as Mesopotamian architectural elements, but without being able to fully capture the historical and cultural context.

In short, the research demonstrates that AI has great potential to improve the efficiency and functional performance of architectural elements, but may require additional human intervention to ensure that the cultural and aesthetic identity of local architecture is preserved.

CONCLUSION

- **Management of the Ability of AI to Reproduce and Enhance Classical Randomness of Iraqi Architecture:** AI has been shown to have the capability to reproduce and enhance classic architecture of the 1960s and 1970s in Iraq and this has been well shown in this study. The application of AI to preserve cultural heritage has been made strong and properly methodological the first time, and this seals a massive gap in the state-of-the-art. The Jaccard similarity indexes in the models generated by AI are high, which means that AI can play a significant role in protecting local architectural identity. Nevertheless, this research is also suggestive of the fact that, despite the fact that the AI offers potent means of architectural innovation, on the other hand, it should also be supervised by humans to ensure proper capturing of cultural and historical specifics. This extends to Iraq and develops a model which can be utilized in other cultural settings where architectural heritage conservation is an issue.
- **High Fidelity of AI-Generated Architectural Prototypes:** This research has shown that an AI model could produce architectural prototypes that have high fidelity to the form of the original Iraqi architecture that was created in the 60s and 70s. The A, B, C, D, and F AI generated models share morphological features with human designs of that time period and may be the cause of the Jaccard Similarity Index reaching up to 0.5. These parallels justify the fact that AI can integrate indigenous architectural features in contemporary designs and, at the same time, recreate the traditional forms, materials, and design principles. The notable architectural elements that the models have been allowed to take are the use of concrete, brick, elements of iron and heritage ones such as palisades, Abbasid quadrilateral arches and Mesopotamian shapes. Such integration can attest to the fact that AI can be used to aid in maintaining cultural identity in architectural activities, which is evidenced, through incorporation of traditional elements of architecture into present-day design tools.
- **The Significance of Human Control in the Architectural Design Processes with AI Support:** The role of human control in architectural design processes with the assistance of AI is hard to overestimate, and its significance in terms of preserving cultural and emotional nuances in the blueprinting process is difficult to overestimate.
- **Greater International Operational Value:** The results of the research include a source of reference in other cultural backgrounds where architectural heritage conservation is of significance. The AI used in this research indicates that local features can be improved in designs to assist in saving the cultural identities in the context of

global transformations. This is especially relevant to the modern discussion of the global cultural sustainability, where AI is regarded as the means of assisting the preservation of cultural heritage as well as introducing modern architecture practice.

- **AI as a Tool to Enhance Architectural Efficiency and Preserve Cultural Heritage:** Further findings of this research affirm that AI can support architectural design through the integration of traditional architectural elements with modern designs through simulation. It adds another feather in the hat—increased work efficiency in design and, furthermore, more sustainability in cultural heritages and local architectural identity. AI technologies keep on coming with new improvements and embedding themselves within the mainstream procedures for design. However, this research insists on human intervention because designs must encompass the cultural and emotional aspects linked with the people who live near or use such buildings.
- **Future Research Directions on AI in Architectural Design:** This research contributes a preliminary understanding of the incorporation of AI into architectural practices for improving the design process with retained local architectural legacies. Further research has to focus on developing refined AI algorithms that could incorporate cultural and emotional aspects, ensuring holistic approaches to architectural design that are respectful and retentive of local identities. These developments would help to promote more holistic and culturally sensitive applications of AI in architecture.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

STATEMENT ON THE USE OF ARTIFICIAL INTELLIGENCE

Artificial intelligence was not used in the preparation of the article.

REFERENCES

[1] Roéfero LGP, Chavarette FR, Outa R, Merizio IF, Moro TC, Mishra VN. Optimal linear control applied to a non-ideal capsule system with uncertain parameters. J Appl Math Inform 2022;40:351–370.

[2] Sharma MK, Bhargava AK, Kumar S, Rathour L, Mishra LN, Pandey S. A fermatean fuzzy ranking function in optimization of intuitionistic fuzzy transportation problems. Adv Math Model Appl 2022;7:191–204.

[3] Sharma MK, Dhiman N, Kumar S, Rathour L, Mishra VN. Neutrosophic monte carlo simulation approach for decision making in medical diagnostic process under uncertain environment. Int J Neutrosophic Sci 2023;22:8–16. [CrossRef]

[4] Sharma MK, Chaudhary S, Rathour L, Mishra VN. Modified genetic algorithm with novel crossover and mutation operator in travelling salesman problem. Sigma J Eng Nat Sci 2024;42:1876–1883. [CrossRef]

[5] Ertunç HM. A combined decision algorithm for diagnosing bearing faults using artificial intelligent techniques. Sigma J Eng Nat Sci 2018;36:1235–1253.

[6] Rathour L, Singh V, Yadav H, Sharma MK, Mishra VN. A dual hesitant fuzzy set theoretic approach in fuzzy reliability analysis of a fuzzy system. Inf Sci Lett 2024;13:433–440. [CrossRef]

[7] Gaffar A, Joshi AB, Kumar D, Mishra VN. Image encryption using nonlinear feedback shift register and modified RC4A algorithm. J Appl Math Informatics 2021;39:859–882.

[8] del Campo M, Leach N. Machine hallucinations: Architecture and artificial intelligence. Chichester: John Wiley & Sons; 2022.

[9] Alzubaidy DM, Al-Tameemi OA. Evaluating the perception of virtual reality in historical sites. In: BIO Web Conf. Les Ulis: EDP Sciences; 2024. p. 82. [CrossRef]

[10] Mishra LN, Raiz M, Mishra VN. Tauberian theorems for weighted means of double sequences in intuitionistic fuzzy normed spaces. arXiv preprint arXiv:2103.15585. 2021.

[11] Haenlein M, Kaplan A. A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. Calif Manage Rev 2019;61:5–14. [CrossRef]

[12] Bartneck C, Lütge C, Wagner A, Welsh S. An introduction to ethics in robotics and AI. Cham: Springer Nature; 2021. [CrossRef]

[13] Bernstein P. Machine learning: Architecture in the age of artificial intelligence. London: RIBA Publishing; 2022. [CrossRef]

[14] Kumar D, Joshi AB, Singh S, Mishra VN. Digital color-image encryption scheme based on elliptic curve cryptography ElGamal encryption and 3D Lorenz map. In: AIP Conf Proc. Melville: AIP Publishing; 2021. [CrossRef]

[15] Borglund C. Artificial intelligence in architecture and its impact on design creativity: A study on how artificial intelligence affect creativity in the design process. KTH Royal Institute of Technology; 2022.
[16] Merizio IF, Chavarette FR, Moro TC, Outa R, Mishra VN. Machine learning applied in the detection of faults in pipes by acoustic means. J Inst Eng Ser C 2021;102:975–980. [CrossRef]
[17] Dreith B. How AI software will change architecture and design. Available at: https://www.dezeen.com/2022/11/16/ai-design-architecture-product/ Accessed on Nov 07, 2025.
[18] Kumar D, Joshi AB, Mishra VN. Optical and digital double color-image encryption algorithm using 3D chaotic map and 2D-multiple parameter fractional discrete cosine transform. Results Opt 2020;1:100031.
[19] Maltret JL, Zoller J. Simulation of architectural and urban morphology. In: OEEPE Workshop on 3D-city models. Hanover: Citeseer; 1996.
[20] Ismail Agha D. The impact of artificial intelligence on the future of architecture and architects: The revolution of artificial intelligence. International Conference on Planning, Architecture and Civil Engineering At: Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh 2019.
[21] Outa R, Chavarette FR, Gonçalves AC, da Silva SL, Mishra VN, Panosso AR, et al. Reliability analysis using experimental statistical methods and AIS: Application in continuous flow tubes of gaseous medium. Acta Sci Technol 2021;43:e55825. [CrossRef]
[22] Oxford Languages. Oxford Languages and Google. Available at: https://languages.oup.com/google-dictionary-tr/ Accessed on Nov 07, 2025.
[23] Lynch J. Root architecture and plant productivity. Plant Physiol 1995;109:7.
[24] Outa R, Chavarette FR, Mishra VN, Gonçalves AC, Garcia A, da Silva Pinto S, et al. Analysis and prognosis of failures in intelligent hybrid systems using bioengineering: Gear coupling. J Eng Exact Sci 2022;8:13601–1373. [CrossRef]
[25] Deckker T. Architecture and the humanities. arq Archit Res Q 2014;18:47–54. [CrossRef]
[26] Al-Assadi FI, Najah FT, Al-Saffar IMA. Alienation in contemporary Iraqi architecture: The questions of space–time communication and style. J Int Soc Stud Vernacular Settle 2022;9:387–407.
[27] Al-Assadi FI. Bio-metaphor in Iraqi architecture: Date palm as model. J Eng Res 2022;10:15–31. [CrossRef]
[28] Shafaq. Available at: https://shafaq.com/ar//مجتمع صور - مئات - الموظفين - يحتجون - بتظاهرتين - في - البصرة Accessed on Nov 07, 2025
[29] Al-Sultani K. The architecture of modernity in Baghdad: Years of foundation. Amman (JO): Dar Al-Adeeb Press; 2014.
[30] Al-Assadi FI, Al-Dewachi MH. The role of brick in determining features of Iraqi architecture. In: IOP Conf Ser Mater Sci Eng 2020;88:12018. [CrossRef]
[31] Al-Chalabi MR. Iraqi architecture encyclopedia. 1st ed. Baghdad: Ma'na Publishing & Translation; 2022.
[32] Al-Saffar M. Globalization and its impact on the urban system. Iraqi J Archit Eng 2010;21:277–292.
[33] Al-Tameemi OA, Abdul-Qader S. Constructive truth and creativity in contemporary Iraqi architecture. IOP Conf Ser Mater Sci Eng 2020;745:12120. [CrossRef]
[34] Al-Tameemi OA, Toma TA. Automation in architecture and its effect on the regeneration of traditional buildings: Al-Shawi House as a case study. IOP Conf Ser Mater Sci Eng 2020;881: 012027. [CrossRef]
[35] Manifest05. Rafidain bank in Kufa. 2020. Available at: https://www.tumblr.com/manifest05/148439817089/rafidain-bank-in-kufa-iraq-by-mohamed-makiya Accessed on Nov 07, 2025.
[36] Old Iraq. Old Iraq. 2017. Available at: https://www.facebook.com/oldiraq/posts/مصرف-الرافدين-فرع-المنصور-واتحاد-الصناعات-العراقي-ونصب-الجندي-المجهول-من-تصميم-ر/644816512379784?locale=ar_AR Accessed on Nov 07, 2025.
[37] Almadapaper. Tobacco restriction building. 2014. Available at: https://almadapaper.net/102098/ Accessed on Nov 07, 2025.
[38] Iraqi News Agency. Ministry of interior. 2020. Available at: https://www.ina.iq/116903--.html Accessed on Nov 07, 2025.
[39] Ayub M, Ghazanfar MA, Khan T, Saleem A. An effective model for Jaccard coefficient to increase the performance of collaborative filtering. Arab J Sci Eng 2020;45:9997–10017. [CrossRef]
[40] Gupta AK, Sardana N. Significance of clustering coefficient over Jaccard index. In: 2015 8th Int Conf Contemp Comput (IC3). Piscataway (NJ): IEEE; 2015. p. 463–466. [CrossRef]