Operational Research in Engineering Sciences: Theory and Applications
Vol. 7, Issue 1, 2024, pp. 176-196
ISSN: 2620-1607
eISSN: 2620-1747
DOI: https://doi.org/10.31181/oresta/070109

COMPUTATIONAL ANALYSIS OF TRADITIONAL ARCHITECTURAL ELEMENTS IMPACT ON AI-GENERATED DESIGNS

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Received: 25 October 2023
Accepted: 12 March 2024
First Online: 20 March 2024

Research Paper

Abstract: *Artificial intelligence technology and related industries have flourished in recent years, and the application of AI-generated design in architectural design has become more and more widespread. At the same time, today's society has higher and higher requirements for modern architectural design. In contrast, traditional architectural elements contain national characteristics and regional features and carry the excellent history and culture of humanity. In order to effectively inherit the superb culture, optimize architectural design, and promote the progress of modern architecture, it is imperative to integrate traditional architectural elements into modern architectural design. Based on this, the main research goal of this paper is to combine traditional architectural elements and modern architectural design with the help of computer neural network technology so as to make the contemporary architectural design style more diversified in order to provide more architectural design methods and architectural design concepts for the relevant staff.*

Keywords: *Traditional architectural elements; Computer neural networks; Architectural design; Artificial intelligence*

1. Introduction

Artificial Intelligence (AI) is a comprehensive high-tech science based on computer technology, which mainly studies machine intelligence and intelligent machinery and

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involves multidisciplinary knowledge such as psychology, logic, information science, biological science, and thinking science. Artificial intelligence is not a new technology that has been proposed only in recent years; it was formally proposed as early as 1950, during which it experienced many research highs and lows, and its focus is constantly evolving. After nearly 80 years of development, artificial intelligence has gradually developed into a dominant and advantageous discipline widely used in many fields, such as national economic life, industrial production and manufacturing, national defence construction and security, education, and information exchange.

From Turing's early concept that "machines can think" to experts systematically suggesting that AI can solve domain-specific problems, to artificial neural networks that mimic biological neural networks for machine learning and pattern recognition, to the rapid rise of deep learning and extensive data training and big model-based generative AI. Since 2012, the field of AI has been fully developed with deep learning, which can process big data, extract high-dimensional features, and significantly improve data learning. In recent years, generative AI (Brown et al., 2020; Vaswani, 2017) has become a representative technological advancement in deep learning research. Generative AI opens up new possibilities for intelligent design in various industries. Researchers in the AI community have made many efforts to generate data using deep learning techniques. A group of researchers at Stanford University used Generative Adversarial Networks to design shoes by using a trained GAN model with a footwear data set to generate the initial steps of a synthetic footwear design; a group of scholars at the Berkeley Air Research Laboratory proposed Cycle-Consistent Adversarial Networks for unpaired image-to-image translation.

The wave of artificial intelligence has swept across the world, penetrating many fields as a branch of computer science (as shown in Fig. 1) and providing new ideas and methods for solving the challenges faced by various industries. For example, intelligent diagnosis of medical images in the medical field (Sumangala, Kavitha, Kulkarni, Vikas, & Pavan, 2024), intelligent risk control in the financial field, intelligent transportation in the field of urban management (Wu, & Liao, 2023; Zhang, & Lai, 2024), intelligent classrooms in the field of education, and intelligent factories and intelligent logistics in the field of manufacturing.

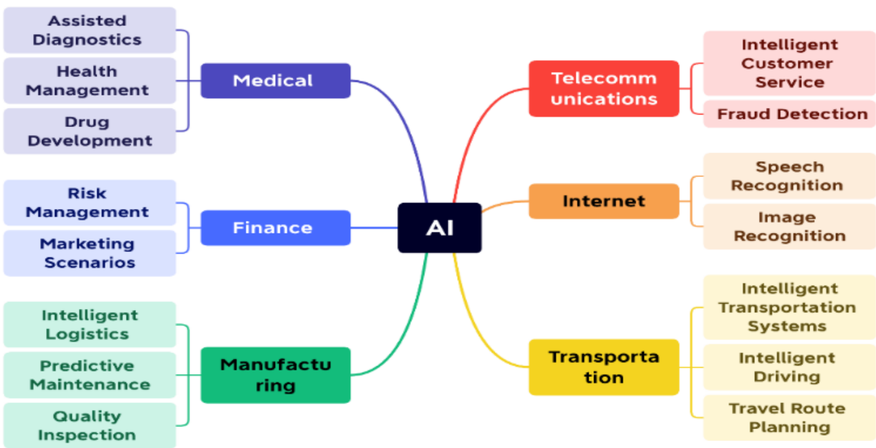

Figure 1 Artificial Intelligence in various industries

Table 1: Artificial Intelligence Penetration by Sector, 2021-2022(Samc.Co., 2022)-(Niisdrc, 2019; Frost & Sullivan, 2023,Bagherzadeh & Shafighfard, 2022)

Industry	Year		Growth Rate
	2021	2022	
Internet	81	82	1.23%
Finance	54	61	12.96%
telecommunications	45	51	13.33%
Manufacturing	40	45	12.50%
Transportation	35	38	8.57%
Medical	31	35	12.90%

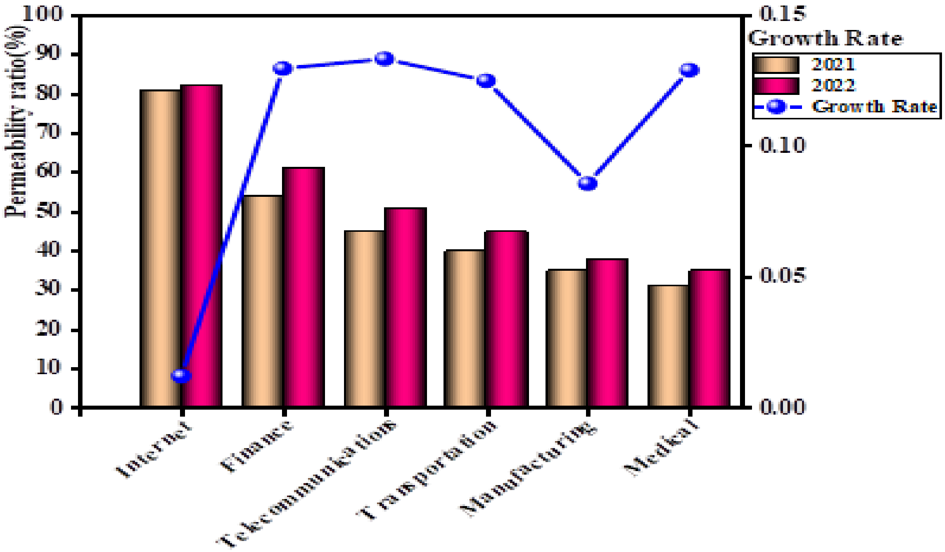

Figure 2 Degree of Artificial Intelligence Penetration in Various Industries (SAMC.Co., 2022)

Artificial Intelligence is constantly changing the traditional industry model, empowering various industries and bringing radical changes to the world's production and lifestyle. The deep integration of AI into multiple industries has become a meaningful way to promote technological development and industrial transformation. Generative AI as an innovation engine and critical basic technology has had a significant impact on major industries and even society, and the penetration of AI in various fields is shown in Table 1 and Figure 2,

Table 2: Global Artificial Intelligence Industry Development Scale, 2019-2023(Niisdrc, 2019; Frost & Sullivan, 2023, Bagherzadeh & Shafighfard, 2022.)

Year	China Market Size (USD billion)	Global Market Size (USD billion)	Percentage
2019	73.35	555.7	13.2
2020	107.1	718.2	14.91
2021	139.3	929.3	14.99
2022	193.5	1230.4	15.73
2023	276.5	1630.2	16.96

At present, AI has rapidly crossed over from scientific research to specific scenario applications, making a big splash on image classification, speech recognition, knowledge quiz, human-machine gaming, unmanned driving, and other fields, and becoming an indispensable part of many industries. The development scale of AI-related industries is getting bigger and bigger, and the proportion of the scale of AI-related sectors in China is increasing year by year (as shown in Table 2).

Moreover, artificial intelligence AI has been widely used in people's daily live (Liao et al., 2024; Shi, 2023). For example, real-time recognition and semantic segmentation technologies based on computer vision have enabled commercial automobile automatic driving to reach the L2 level; in the field of dialogue robots, natural language processing applications based on large models have demonstrated text comprehension and reasoning capabilities with a certain level of intelligence; in the field of intelligent drawing, image generation technologies based on diffusion models can generate images comparable to the works of human painters based on text.

With the development of big data, cloud computing, the Internet, and other information technologies, AI has now evolved from discriminate to generative and generalized and has become more and more mature in the generation of content such as text, images, code, and sound, and has demonstrated excellent application value and potential. In addition, the training data required for generative AI technology is also a vital industrial resource and even a strategic resource. The construction of data sets for related industries will undoubtedly accelerate the industry's further progress toward digitization and intelligence, thus speeding up industrial upgrading.

Generative AI technology has now expanded even further into higher dimensional data formats, such as video and 3D geometric models, and even more multidimensional models, such as building information models. In terms of application areas, the technology is also predicted to be directly applicable to work scenarios that require more sophisticated perception, creation, and judgment capabilities, such as the ability to realize the final draft of copy-writing and design, intelligent development of gaming platforms, and so on. As a result, "artificial intelligence," a term that was initially seen as still distant from creators and designers, has begun to permeate these groups, and architectural design is no exception. Modern AI methods have been widely used in the field of architectural design to effectively generate building layouts and architectural renderings and optimize structural designs. Within the field of architecture, AI is used as a generalized application technology to target building-related problems. The focus has gradually shifted to, for example, data training in the field of architecture and the integration of AI with related architectural design technologies.

For the generative task of architectural design, in addition to the direct use of generative AI output results, researchers, through the AI model combined with algorithmic design to solve the specific problem, often can form more compliant results specific application scenarios of the relevant research is becoming an essential cross-disciplinary research mode. According to the statistical analysis of the core ensemble of Web of Science databases by the bibliometric online analysis platform, the number of AI-generated design-related papers has continued to rise in recent years. Figure 3 shows the change in the number of research papers on AI-based architectural generative design, indicating that the research on AI generative design has been increasing over the years, with a significant increase in the number of research papers since 2020, and a substantial increase in the capability of generative

AI technology, which is developing in the field of architectural design in an ever-deeper way.

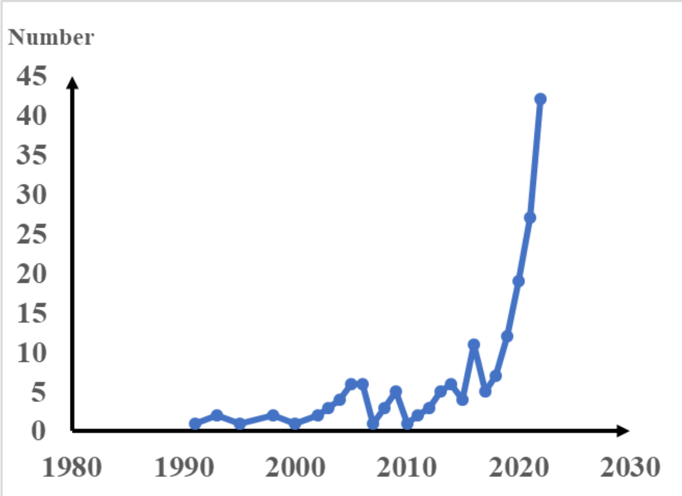

Fig. 3 Annual trends in the number of research papers on generative AI architectural design (Ferrando et al., 2019) (1991-2022)

Modern architectural design has been closely integrated with traditional architectural elements. The practicality of conventional architectural elements is strong, and some of the architectural elements can optimize the architectural design and improve the function of the building; for example, the patio in the traditional architectural system is still in use today, which can open up the internal space of the modern building to meet the lighting needs of the building; in the process of the construction of the Shanghai Urban Planning Exhibition Hall in the appearance of the magnolia flower as the prototype of the design, and take the Shanghai city flower as the primary conceptual carrier for the abstract design of the roof, and use exaggerated techniques to present the roof hollowing out. The Shanghai Urban Planning Exhibition Centre takes the magnolia flower as the prototype in the process of exterior construction, takes the Shanghai flower as the primary conceptual carrier for the abstract design of the roof, and adopts the exaggerated method to present the endoskeleton roof. The use of traditional architectural elements in modern architectural design can rely on building materials, building structure, building colour, and building appearance to present and shape architectural works of art visually. Building materials can reflect respect and adaptation to the environment, building structure because of its unique durability and stability to show the respect and inheritance of history; building appearance can add a unique visual aesthetic to the building; building colour also has a high cultural value and symbolic meaning. Through the rational use of traditional architectural elements, modern architectural design can meet functional needs while inheriting history and culture, enhance the recognition and cultural connotation of the building, and provide people with a sense of spiritual belonging and a pleasant visual experience.

1.2 Research purpose and significance:

Combining traditional architectural elements with modern AI-generated design can innovate modern architectural design concepts, inherit and innovate excellent traditional architectural culture, enrich modern architectural design materials, and create a sound architectural design system, which can generate more novel and creative architectural styles and promote the innovative development of architectural design.

2. Value and application of traditional architectural elements in architectural design

This part intends to explore the feasibility and advantages of the combination of traditional architectural elements and artificial intelligence, based on which the value and application of traditional architectural elements in modern architectural design are analyzed.

2.1 Concepts and characteristics of traditional architectural elements

Traditional architectural elements refer to a number of elements, such as components, forms, and decorations that are widely used in traditional architecture including architectural components, colour paintings, carvings, copper and ironware, wood, bamboo, stoneware, ceramics, and so on. Traditional architectural elements have the following characteristics:

Table 3: Common traditional building elements and their characteristics and uses

Traditional architectural elements	Specialties	Appliance
Wooden component	Lightweight, flexible, and aesthetically pleasing	Beams, columns, suspended ceilings, railings
Stone element	Sturdy, stable, and beautiful	Walls, floors, columns
tile	Lightweight, beautiful, and durable	Roofs, walls
Window lattice	Exquisite, unique, and beautiful	Windows, balconies
Carvings	Delicate, unique, and artistic	Walls, windows, doors, railings

Source: Author's organization

1) Colourful. Traditional architectural elements cover a wide range of architectural components, including colourful paintings, carvings, copper and ironware, wood, bamboo, stoneware, ceramics, brocade, silk, and other aspects of the rich and diverse form.

2) Deep cultural connotation. Traditional architectural elements are an essential part of the Chinese national culture, containing deep cultural connotations and historical value.

3) Exquisite skills. The production of traditional architectural elements requires high skill and exquisite craftsmanship, reflecting the essence of traditional Chinese craftsmanship.

4) Beautiful form. Traditional architectural elements in the form of high aesthetic value are beautiful and rich in decoration. They can add unique artistic value to the building.

Common traditional building elements and their characteristics and uses are shown in Table 3.

2.2 Application and value of traditional architectural elements in architectural design

2.2.1 Application of traditional architectural elements in architectural design

Traditional architectural elements have a long history and unique cultural characteristics, which can provide unique artistic value and cultural connotation for modern architectural design. The application of traditional architectural elements in contemporary architectural design involves the issue of architectural form and function. Traditional architectural elements are usually combined with specific architectural forms and functions, which may have been used in modern architecture.

When or where they are no longer applicable. For example, the roof and arch structures of traditional buildings are usually used to protect the building from rain and sunlight. Still, in modern buildings, these structures may impose restrictions on the ventilation and lighting of the building, resulting in the comfort and environmental friendliness of the building being affected. Therefore, when applying traditional architectural elements, reasonable trade-offs and innovations are needed to ensure that the design is practical.

1) Usability and functionality. When applying traditional architectural elements, the methods of re-deconstruction and reorganization can be used to recombine and innovate the traditional architectural elements to create a new architectural style with modernity and cultural characteristics. At the same time, conventional architectural elements can also be combined with the needs of modern architecture through the methods of combined application, symbolic application, and overall application to create a new architectural style with modernity and cultural characteristics to meet the needs and trends of modern architecture. The following are examples of the application of traditional architectural elements.

2.2.2 The value of traditional architectural elements in architectural design

1) They are enriching the cultural connotation of architecture.

Traditional architectural elements are an essential part of human history and culture, and they contain rich cultural connotations and historical value. The introduction of traditional architectural elements in modern architectural design can add unique cultural connotations to the building, enrich the artistic connotation of the building, and make the building have a more distinctive cultural personality.

2) Improve the artistic value of the building.

Traditional architectural elements in the form of high aesthetic value are beautiful and rich in decoration. They can add unique artistic value to the building. The introduction of traditional architectural elements in modern architectural design makes the building not only practical and functional but also ornamental and artistic. It can improve the artistic value of the building and make the building more ornamental and appreciable.

3) Enhance the character and quality of the building.

Traditional architectural elements have unique characteristics in form and material selection and are the essence of traditional culture. Introducing conventional architectural elements in modern architectural design can give unique features and quality to the building, making it stand out among many buildings with higher irreconcilability and competitiveness.

4) Promote the inheritance and development of traditional culture.

The application of conventional architectural elements not only helps to protect and pass on the cultural heritage of humanity but also promotes the inheritance and development of traditional culture. The introduction of traditional architectural elements in modern architectural design can make the conventional architectural elements get new applications and development, constantly enrich and improve the connotation and form of traditional culture, and promote the inheritance and development of human history and culture.

2.3 Application of Artificial Intelligence in the field of architectural design

Architecture has gone through the stages of modularization, computational design, parameterize, etc., and entered the stage of artificial intelligence. In recent years, thanks to the improvement of computer hardware, rich data sets in the era of big data, and the algorithmic superiority of artificial neural networks, artificial intelligence has developed from "design assistance" to "automatic design generation" by virtue of its powerful learning ability. 2014 Generative Adversarial Neural Networks, a new chapter in generative design, was proposed, which also further integrates architectural design with artificial intelligence. In 2014, the proposal of generative adversarial neural networks opened a new chapter of generative design, which also further combined architectural design with artificial intelligence. Today, machine learning and deep learning are widely used in the architectural field for data classification and prediction, such as building model classification (Turlock & Steinfeld, 2020; Yetkin et al., 2018; Zhang, & Lai, 2024) and program evaluation (Chan & Spaeth, 2020; Zheng, 2020).

Artificial Intelligence (AI) technology based on deep neural networks and deep learning is a fast-growing and popular field, and other subject areas are actively exploring ways to utilize AI technology effectively. Architectural design is no exception. In fact, various neural networks based on convolutional neural networks (CNN) in the field of computer image processing have begun to be applied to architectural design. The most typical example is the use of Generative Adversarial Networks (GAN) to generate architectural planes, and commercial software products have even been developed. (Chan & Spaeth, 2020) proposed the Cyclic GAN model, which can convert architects' sketches into photo-like effect images, helping architects visualize the real-life effect of their sketches. Das et al. (2020) designed a collaborative model for on-site construction, which utilizes a robotic arm to pick up and place building materials according to the architect's requirements.(Das et al., 2020; Fragkia & Foged, 2020) proposed a method for learning and predicting wood properties based on GAN. Fragkia and Foged (2020) proposed a GAN-based method for learning and predicting wood properties (Tian, 2021). At the level of urban design, GAN is mainly applied to feature recognition and mapping of urban form and plan generation.

Scholar TIAN R. trained the eGAN model to learn the mapping between city block boundaries and building layouts (Rhee et al., 2020) and other scholars used GIS technology to collect city building layouts and pedestrian street plans and realized automatic generation of pedestrian space by inputting building layouts through training GAN model to assist in the decision-making of pedestrian space planning (Shen et al., 2020) and other scholars collected data from eight cities. They trained the GAN model to realize the automatic generation of pedestrian space by inputting building layouts. Shen et al. (2020) and other scholars collected data from eight cities. They trained GAN models to generate building layouts based on the urban site environment automatically. They summarized the differences between different urban design strategies by comparing them (Chuang & Chien, 2021).

With the widespread use of generative neural network models and their derivatives for the generation of architectural floor plans, stylized drawings, renderings, and 3D forms, the capabilities of AI-assisted architectural design have been further expanded. The maturity and commercialization of generative AI based on large models today further reduce the difficulty for designers in using AI technology. Image-to-image (Chan & Spaeth, 2020; Hindupur, 2017), text-to-image, image-to-form, parameter-to-form, text-to-form, and even multimodal natural interactions make human-computer interactions more straightforward and more natural. Table 4 demonstrates the variety of tasks for which generative AI is used for architectural design. AI-assisted design has become another essential design paradigm following the rise of computer-aided design.

Table 4: Visualization analysis of artificial intelligence techniques for different building generation design tasks

Type of mission	Descriptive
Plane generation	Use GAN to reconstruct functional partitions and generate building plans based on building floor plans.
	Designing spatial layouts based on learning existing cases via GAN
	Transforming a planar graph into graph-structured data to accomplish deep learning training
Rendering	Implementation of sketch generation rendering using cycle GAN
	GAN models are trained using multimodal data to generate images of the appropriate style
	Using style to generate a series of architectural renderings with locally distinct attributes

Source: Author's organization

In summary, in the architectural design industry, GAN can use its efficient and convenient generative ability to provide generative plans and program visualization for architectural design, which is much more efficient than the current production efficiency of human beings, and the degree of detail completion is much better. The combination of artificial intelligence technology and the construction industry has become an unstoppable trend, and generative artificial intelligence has empowered architectural design. Even the entire design industry will undoubtedly greatly simplify the difficulty of design and accelerate the efficiency of design output.

3. Methods for the intelligent integration of traditional architectural elements into building Design

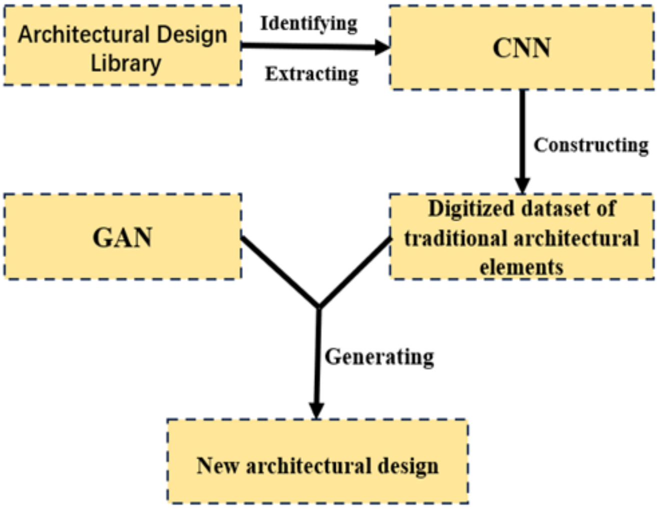

Fig. 4 Research framework for generating new building designs with the help of neural network technology

Figure 4 shows the research framework of this chapter, mainly helping neural network technology to identify and extract traditional architectural elements in order to construct a digital data set of traditional architectural elements. On this basis, with the help of neural network technology and the relevant design requirements of architectural design, we can intelligently generate a new architectural design that integrates traditional architectural elements with a new architectural style.

3.1 Grassroots Principles and Methods of Generative Design for Artificial Intelligence

3.1.1 Deep Learning

Artificial Intelligence generative design is mainly implemented using deep learning. Deep learning is the sub-field of machine learning that emphasizes its learning from successive layers of data. Deep learning is a concept in the field of computer science. Deep learning is a branch of machine learning that is an algorithm for learning to represent information using artificial neural networks as an architecture. The depth of a model refers to the number of neural network layers included in the model, so the term "deep" in deep learning can be understood as describing a neural network with a large number of layers. Deep learning models are considered to be systems inspired by the biological brain, which can build intelligence by mimicking the computational principles behind the brain, as well as a way to understand the brain and human intelligence. Deep learning was proposed by Hinton in 2006; however, due to the limitation of computational power and data volume, it rapidly developed after 2012 and solved many critical problems in the field of artificial intelligence, such as image analysis and speech recognition.

3.1.2 Neural Networks

Image generation under the deep learning framework utilizes existing images to generate brand new images by building the corresponding neural network and using the existing large amount of image data for training so that the network can get the mapping relationship through learning. Image generation using deep learning methods is no longer limited to the simple migration of low-grade colour information; the neural network is able to learn the texture of the artwork, semantics, and other high-grade details, which can cope with the needs of more tasks in real-life scenarios.

Convolutional neural networks are one of the most widely used network structures in the field of deep learning, and they have made certain breakthroughs in the fields of target detection, image classification, and face recognition. Convolutional neural networks (CNN) extract multi-scale image semantic features with the help of multi-level convolutional computation, which utilizes weight sharing and local connections to reduce the number of parameters. They have made good progress in the field of computer vision in recent years. The convolutional neural network mainly includes the convolutional layer, pooling layer, activation function layer, and upsampling layer. The primary function is to downsample and upsample the image feature map; downsampling shrinks the size of the feature map and encodes deep semantic features; upsampling expands the size of the feature map and recovers it as an image; its architectural principle is shown in Fig 5.CNN consists of multiple layers of filters; the filters effectively build a network that understands more and more of the image in each layer passed. For example, the first layer understands contours and borders, the second layer begins to understand shapes, and the third layer understands objects.

The convolutional layer is used for downsampling or upsampling image features, with learnable parameters, which can be learned through the network to obtain the optimal sampling method. The pooling layer is also used for downsampling or upsampling image feature maps, which is generally placed after the convolutional layer, which can reduce the redundant information of feature maps, expand the sensory field, and prevent the model from overfitting during the training. Unlike the convolutional layer, it does not have parameters that need to be learned through the network and will not bring computational consumption during model training.

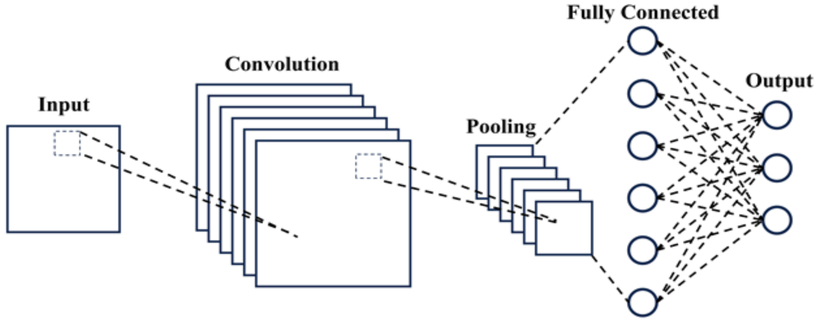

Fig. 5 Basic architecture of CNN

The other most widely used network structure in the field of deep learning is the Generative Adversarial Neural Network (GAN). Generative Adversarial Networks are good at processing very realistic images, speech, or videos, so they are more often used in visualization fields such as image generation and style transformation than other networks.GAN contains two neural networks: one is a generator G, and the other is a discriminator D. The generative model and the discriminator model often work together in practice, and the two models are optimized through adversarial training, which allows the generator to generate more realistic samples, and the discriminator can more accurately determine whether the samples are actual data, as shown in Figure 6.

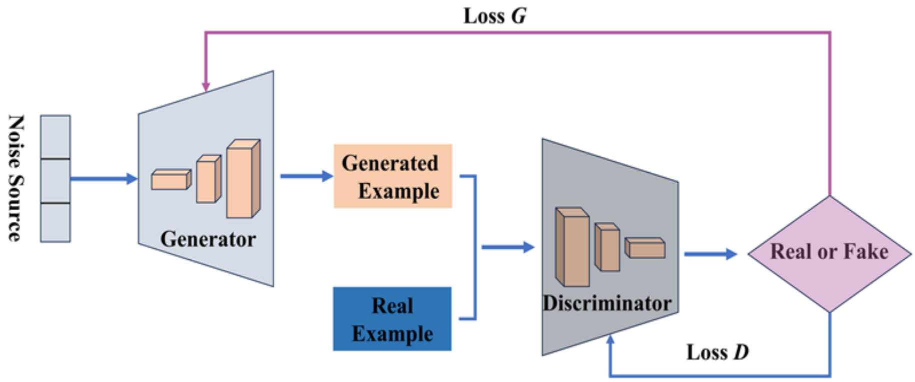

Fig. 6 Basic architecture of GAN

First of all, unlike convolutional networks, the overall structure of GAN is formed by two network frameworks through the mutual game of the two models to generate close to the actual data distribution or labeling classification of input data. So, GAN does not need to pre-build the model or data distribution like a convolutional neural network. Secondly, the purpose of the convolutional neural network is to predict the label of the input data according to the characteristics of the input data and does not participate in the generative task, i.e., the training goal of the pass CNN is unique, such as the recognition and classification of speech and images. Generative Adversarial Networks contain two training objectives: one generates data in an attempt to confound the judgment of the discriminator, and one discriminates the data and classifies the generated data for labeling (Real or Fake). Finally, when convolutional neural networks are trained, the model's accuracy in processing the input data is improved, and the update of the input sample parameters is dependent on the model's accuracy.

Meanwhile, the two training models in Generative Adversarial Networks are trained in a competitive and mutually enhancing relationship. The update of the output data is more dependent on the discriminator model. In other words, generative adversarial networks can realize higher performance of unsupervised machine learning than convolutional neural networks.

Currently, GAN is concentrated in the field of image processing and the field of speech processing, and a series of diversified GANs have been derived. According to statistics, as of 2018, more than 500 deformations of GAN have been derived (Liu et al., 2023). For example, StyleGAN can expand the image database by generating pictures that do not exist in reality based on the characteristics of a given image data set after learning it.

3.2 Computational analysis of AI building design

Computational analytics can deal with large-scale, complex data sets, both structured and unstructured. It can extract useful information and patterns from large amounts of data to support research objectives; computational analytics can automate and accelerate the research process, reducing the time and labour costs of manual analysis and processing. It accelerates research progress by efficiently processing data, performing model training, and making predictions; computational analytics can leverage machine learning, statistical modelling, and optimization algorithms to make predictions and optimizations in research. Therefore, this chapter adopts computational analysis in order to validate the feasibility of integrating traditional architectural elements with building design intelligence with the help of neural network technology.

3.2.1 Data collection, characterization of traditional architectural elements

A large number of sample images and architectural models are collected, including photos and models of various traditional architectural windows, doorways, carvings, colors, textures, and other features, as well as data related to traditional architectural elements, including images, floor plans, construction details, and scaling relationships, for subsequent machine learning and computational analysis. Since the emergence of deep learning technology, many tasks that require repetitive operations and experience, such as the recognition and classification of architectural elements, can be realized by training a convolutional neural network model. CAD drawings are vector images that have the characteristics of both structured data and image data. For example, a line segment in the drawing, from the perspective of structured data, is a line segment element determined by two endpoints; from the perspective of the image, it can be displayed as a line segment on the screen through the vector image engine. Based on these two characteristics, a convolutional neural network model is constructed, usually using a pre-trained model as the basis, on which it is fine-tuned to adapt to the specific traditional architectural elements for the feature extraction task, to extract traditional architectural elements from a vast amount of traditional architectural designs. Then, based on the digital model, the features of traditional architectural elements, such as shape, texture, and scale, are extracted using computer vision techniques and image processing algorithms. As shown in Fig.7.

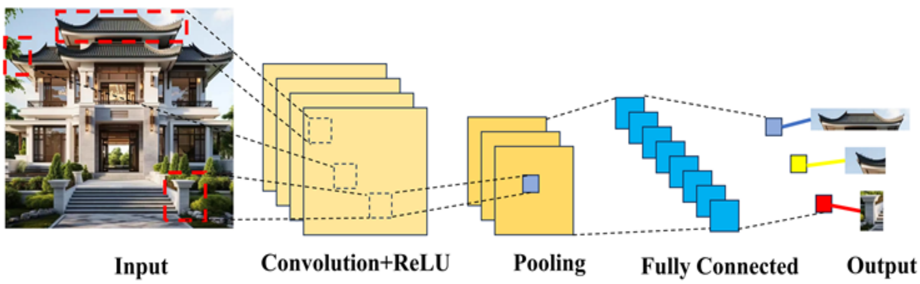

Fig. 7 Feature extraction and recognition of traditional architectural elements

Through the above traditional architectural elements feature recognition and extraction architecture, conventional architectural elements can be recognized quickly and efficiently, and the recognition accuracy rate is high. Table 5 shows the recognition results of some traditional architectural elements. From Table 5, it can be seen that the recognition accuracy rate of each traditional architectural element is above 80%, which indicates that the recognition of traditional architectural elements using artificial intelligence architecture is reliable.

Table 5 Results of Artificial Intelligence Architecture for Recognizing Traditional Architectural Elements

Form	AI recognition accuracy
Eaves	84.3%
Sloping roof	82.1%
Stone carving	89.6%
Woodcarving	87.4. %
Skeleton window	93.2%

3.2.2 Constructing a digitized data set of traditional architectural elements

From the perspective of deep learning, the model extracts the laws from the data set, so the data should follow the same intrinsic laws and be large enough. The application of deep learning in fields such as face recognition and automatic driving is based on massive data to realize accurate recognition. The model construction of traditional architectural elements also analyses the traditional architectural elements in them from the gigantic collected traditional architectural data, including the proportion, material, colour, and style of the elements, etc., and extracts the laws from the architectural elements data set. Therefore, it is necessary to take the extracted traditional architectural elements, label them with corresponding labels, and transform them into editable and operable digitized data so as to obtain the traditional architectural elements data set that meets the expectations.

3.2.3 Constructing an Architectural Design Generator

With the further emergence of generative AI, techniques based on generative models such as GAN, VAE, etc., can quickly realize the tasks of architectural appearance generation, such as intelligent generation of architectural appearance drawings and architectural renderings. The quality of image generation and even 3D generation tasks has been further improved in the last two years with the rapid maturation of large-scale language models for graphic alignment.

Through learning, the neural network is able to grasp the intrinsic connection between the input image and the output image. For example, suppose the land area of a specific type of building is used as the input image, and the actual general layout is used as the output image to train the neural network. In that case, we can get a general layout generator for that type of building, and the next time we encounter a new land area, we can use it to generate the general layout directly. The same principle applies to the design of the building's appearance and architectural rendering. Simply put, CNN extracts high-level semantic information from content images. For example, the composition of the building façade and the distribution of various openings while extracting low-level information, such as colour, texture, etc., from the database of traditional architectural elements and then re-synthesizing the new building façade image with an inverse CNN. It is equivalent to encoding traditional architectural elements and modern architectural designs as implied vectors, then re-calculating and designing the two implied vectors (e.g., simply adding them together) to obtain a new implied vector, and then generating a new combination of architectural elements based on the implied vector to generate a new architectural design drawing. The new architectural design has the characteristics of the original two objects at the same time. In this way, various characteristics of traditional architectural elements that are difficult to manipulate are combined with modern architectural design. Then, new architectural design drawings are generated. A simple neural network framework for an architectural design style is shown in Figure 8.

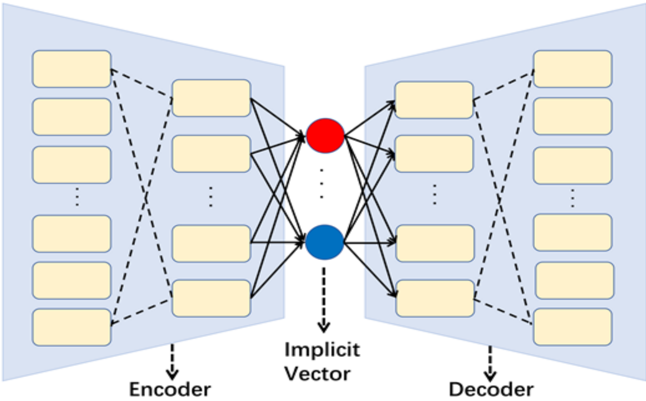

Fig. 8 Architectural design style transformation neural network architecture

To realize the automatic conversion of an architectural design style, the first step is to extract the local characteristics of the traditional architectural elements. Then, the architectural generation design model needs to learn different traditional architectural elements. Then, the learning law is applied in the module of generating the model to release more similar architectural elements and generate the design of similar architectural elements.

Table 6 Interstory displacement angle analysis of the building

Floor	The angle of displacement between building floors (rad)	
	AI Design	Designer Design
5	0.04071%	0.05534%
10	0.04622%	0.05946%
15	0.04233%	0.05557%
20	0.03600%	0.04645%
25	0.02619%	0.03490%
28	0.01814%	0.02685%

According to Table 6 and Figure 9, it can be seen that the buildings designed using the AI architecture outperform the designer's design in terms of specific mechanical properties.

While using artificial intelligence to generate the appearance of the building, the design and optimization of the building structure can also be efficiently completed. At the same time, the building design achieved through the AI building design architecture should also meet the corresponding building structure codes. Table 6 and Figure 8 shows some of the computational analysis data of the building inter-story displacement angle of the building design generated by using AI architecture.

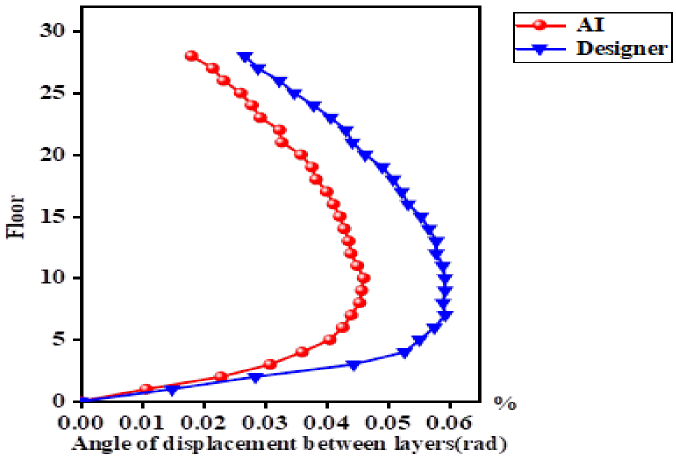

Figure 9 Angle of displacement between building floors (rad)

4. Case studies and discussions

4.1 GAN generation of new building design cases

Using Style GAN to control the image generation design in a new way, after encoding the image into the hidden variables of the hidden space, the features continue to be decoupled by encoding in fully connected layers, applying two AdaIN layers in each block in the generator for scaling and adding bias noise to adjust the detail information, while inputting the decoupled features to change the overall style. This method can generate images with specific details and overall target style from random noise with excellent image generation quality and style accountability (Figure 10). The principle of action is that when the architectural image generation model gets enough samples from the actual data set, it will analyze and learn the probability distributions related to the derived results and extract the distribution characteristics to create the results. This means that as long as a database with a certain number of samples is created, new design images with different traditional architectural styles can be generated by the established algorithm.

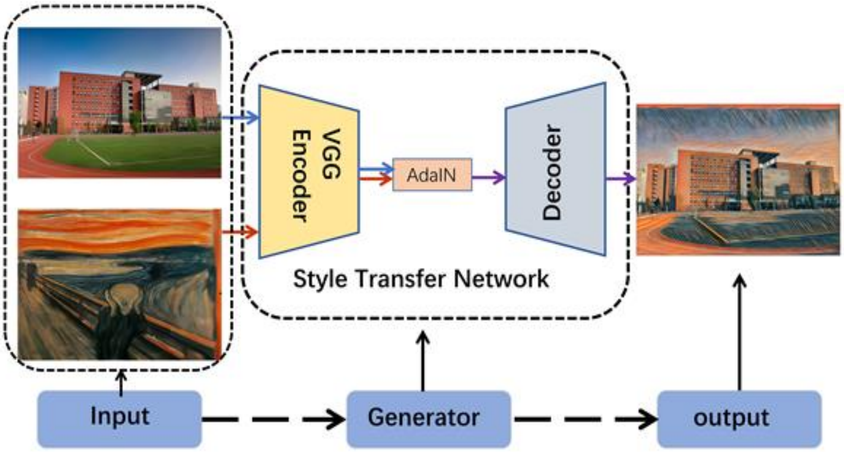

Fig. 10 Transformation of architectural design style framework using Style GAN

Based on the above innovative transformations of architectural design, when it is necessary to generate images with specific design elements, the designer can integrate his design intent, design style, etc., into the AI-generated design model in order to realize the accountability of the generated results (Dhariwal & Nichol, 2021; Luo et al., 2015). The generated images will faithfully follow the base image in terms of picture composition. In contrast, in terms of style, they will refer to the designer's design intent. Figure 11 shows an architectural rendering generated by combining traditional architectural elements and AI-generated design. Meanwhile, enhancing the AI-generated design capability is a gradual process, and the design algorithm model must continuously learn new design methods and explore different design styles (Chan & Spaeth, 2020; Gao et al., 2019).

Fig. 11 Architectural rendering generated by artificial intelligence design combined with traditional architectural elements

The rationality of the AI building design was examined using an engineer perception-based approach, and the rationality evaluation scores of the building design are shown in Table 7 (this methodology utilizes a questionnaire platform for online blind testing).

Table 7 Building Design Rationality Scoring Results (Scoring Range: 0-5)

Form	Score
Design of AI	3.614
Design of Designer	3.599

Table 7 shows that engineers' recognition of AI-generated architectural designs is close to designers' architectural design recognition, indicating that traditional architectural design based on AI can meet the requirements of architectural design recognition while improving design efficiency.

4.2 Exploration of Traditional Architectural Elements and Artificial Intelligence-Generated Designs

Using AI technology, designers can simulate and visualize the design scheme in 3D, allowing clients to have a more intuitive understanding of the form, space, and atmosphere of the building. This helps to make timely adjustments to the program during the design process and improve design satisfaction. By parameterize architectural elements with AI tools, I can break down the parts of a traditional building into adjustable and editable components. This will allow for increased design efficiency while ensuring that the proportions, shapes, and sizes of each architectural element component meet the architectural design requirements.

With AI design software, designers can combine and innovate traditional and modern architectural elements to quickly generate multiple architectural designs. By comparing and optimizing these solutions, I can find the best way to integrate the architectural elements so that the architectural design works have a traditional flavour but also meet the modern aesthetic. The integration of traditional architectural elements makes the AI-generated design more diversified, efficient, and prosperous in terms of historical and cultural connotations, which is conducive to cultural heritage.

5. Conclusion

By studying the characteristics and value of traditional architectural elements, as well as the principles and calculation and analysis methods of artificial intelligence architectural design, this paper utilizes artificial intelligence technology and traditional architectural elements to provide relevant staff with design methods and design concepts for architectural style diversification. At the same time, AI-generated design plays an irreplaceable role in the field of architectural design; the integration of traditional architectural elements and AI-generated design can effectively combine traditional culture and modern architecture, thus stimulating more novel architectural design solutions, improving the quality of architectural design, increasing the efficiency of architectural design, and contributing to the promotion and inheritance of traditional culture.

6. Future Research Perspectives

At present, there needs to be more datasets of traditional architectural elements, especially 3D datasets, for the generation of solutions for AI architectural design, which makes the quality of the generated solutions insufficiently high. Constructing datasets of traditional architectural elements and conducting relevant model training to enhance AI generation of high-quality architectural design solutions may become a significant research direction in the future.

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