

The Artificial Intelligence with Architecture

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Abstract-Artificial intelligence is a very popular technology. At present, artificial intelligence has penetrated into countless fields and can be applied to challenges that have not been solved before in all walks of life. Although the application of AI in the field of construction is still in its infancy, it is promising and will even reshape the discipline of architecture. Artificial intelligence, machine learning, and generative design have begun to reshape the architecture as we know it. As systems and tools for reconstructing the built environment, they provide opportunities for us to rethink traditional work processes. Architectural circles are also beginning to focus on construction technology, and they are exploring future designs by developing software and practical projects. As an architecture student, this article will discuss the application prospects and development directions of AI technology in architectural technology, design, management, etc., and discuss the design of some artificial intelligence algorithms.

Index terms-Architecture, Artificial intelligence, future designs, application prospects.

I. Introduction

In the process of building design, it turned out that designers drew sketches or machines made two-dimensional graphics. Later, it was discovered that this model was not good, and it was not a real architectural model in a very sense. So in the early 1990s, a major American architect made a new concept-"Building Information Model".

Artificial intelligence, machine learning, and generative design have begun to shape the architecture as we know it. As systems and tools for reconstructing the built environment, they provide opportunities for us to rethink traditional work processes. Designers are also worried that these technologies may in turn affect practice, thereby limiting the services of architects. So the new company is now also starting to focus on construction technology, and they are exploring future designs through software development and practical projects.

As cities continue to develop, new tools continue to emerge to change the way architects, contractors, and consumers imagine and create the built environment. Building data and related program codes are becoming more and more accessible. At present, it has been able to reach such a degree that owners and developers can input a set of information and then obtain an optimal design. A startup company even said that they can "give the house you want without hiring an architect." So what is our position?

At present, the job of the architect is to define design goals and parameters, while artificial intelligence and machine learning algorithms generate various plans for the architect to consider. Although these are not really comprehensive yet, they are moving in this direction every day. Based

on functional models and programming models, machine learning can be extended to acquire socioeconomic, aesthetic, and ideological models. As a turning point in the history of architecture, design advancements based on artificial intelligence and machine learning have begun to profoundly affect the way we shape the built environment. The following article explores these ideas and new construction technology trends.

II. ARCHITECT'S AUTOMATED TRANSFORMATION

According to the economist, by 2037, 47% of human jobs will be replaced by robots, even those traditionally associated with college education. The WEF estimates that 7.1 million jobs will be lost globally between 2015 and 2020, as "artificial intelligence, robotics, nanotechnology and other socio-economic factors replace the demand for human employees." Nicolas Valencia discusses how automation and artificial intelligence will affect architecture and design, including how the discipline will undergo profound changes.

"The construction industry often takes a lot of time. It takes four or five years to build a building, which is too slow for the current change. " This is the concern raised by Rem Koolhaas, a famous architect and architectural theorist not long ago, about the development of traditional construction industry.

According to McKinsey's prediction in 2018, the popularity of artificial intelligence in the construction field will be mild in the near future. Nevertheless, change is taking place. The construction industry can no longer regard AI as a technology closely related to other industries. Engineering and construction will need to adopt AI methods and applications to cope with the fierce market competition. Therefore, when AI gradually infiltrates into the design, construction, management and other life cycle stages of traditional architecture, it may provide solutions to the deficiencies in the development of the current industry and the headache problems of architects.

III. APPLICATION OF AI IN ANALYSIS AND GENERATION OF BUILDING PLAN

Specifically: if we intend to apply AI to the analysis and generation of architectural floor plans. The ultimate goal is divided into three aspects:

- Generate architectural floor plans, such as optimizing the generation of a large number of highly diverse floor plans;
- Select qualified floor plans, such as providing appropriate classification methods;
- Allow users to "browse" the generated design options.

Our method mainly comes from two intuitions:

- Although standard optimization techniques are included, creating a floor plan is indeed an extraordinary technical challenge;
- Space design is a continuous process, requiring continuous design steps across different scales (city scale, building scale and unit scale).

In order to take advantage of the above two points, we can chose the embedded Generative Adversarial Neural Networks.

This model allows us to capture more complexity in the floor plan of the building we encounter, and solve these complexities through successive steps to solve the problem. Each step corresponds to a given model and is trained specifically for the specific task. The whole process can finally prove the possibility of human-computer interaction.

The floor plan is actually a high-dimensional problem, at the intersection of quantifiable technology and qualitative attributes.

Studying architectural precedents is often a dangerous process. When the analysis is not rigorous enough, the abundance of existing resources is ignored. Our method is inspired by current data science methods and aims to determine high-quality floor plans. By creating 6 indicators, we propose a framework that can capture the relevant parameters of floor plans.

On the one hand, the three indicators of footprint, orientation, thickness and material can be used to capture the essence of a given floor plan style; on the other hand, planning, connectivity and circulation are intended to describe the essence of floor plan organization.

In short, the machine used to be an extension of the pencil, but now it can be used to draw architectural knowledge and through training to help us create viable design choices.

A. The Adaptive plane: predicting spatial layout

At present, the algorithm has been developed by box bygg and wallgren arkitekter and published on grasshopper platform. If you change the total area of a space, the Finch algorithm generates different spatial layouts based on predefined parameters. This helps to plan areas at the initial stage of the project and then deepen them according to the specific requirements of the task.

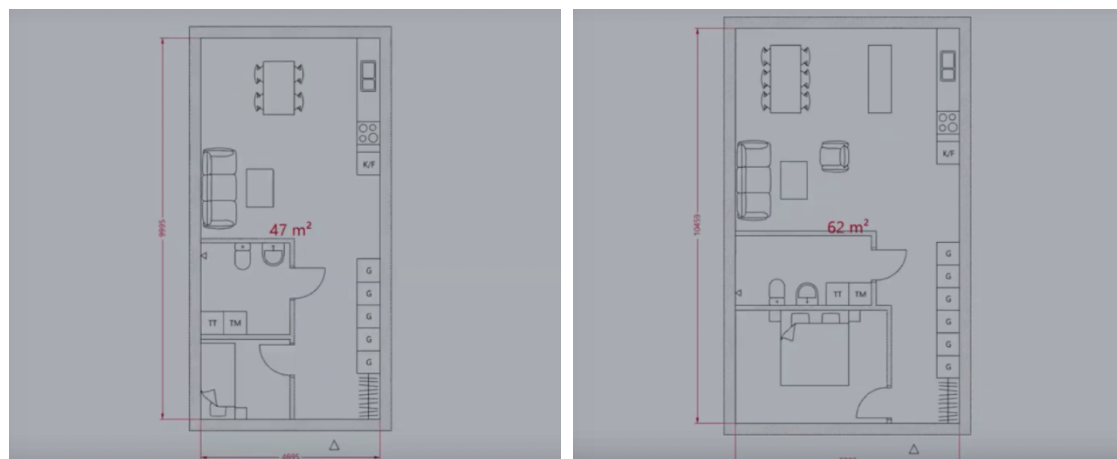


Figure 1 The Example of Finance

B. Artificial intelligence uses machine learning to create generative styles

Stanislas Chaillou, the designer and Fulbright Scholar, created a project at Harvard to explore the future of generative design, as well as the prejudices and architectural styles it creates. In the study of artificial intelligence and its application potential in architectural practice, Chaillou constructed a complete generation method using generated countermeasure networks (Gans). Chaillou's project explores the future of artificial intelligence through the study of

architectural style. His work proves that style has a profound influence on the composition of architectural plane.

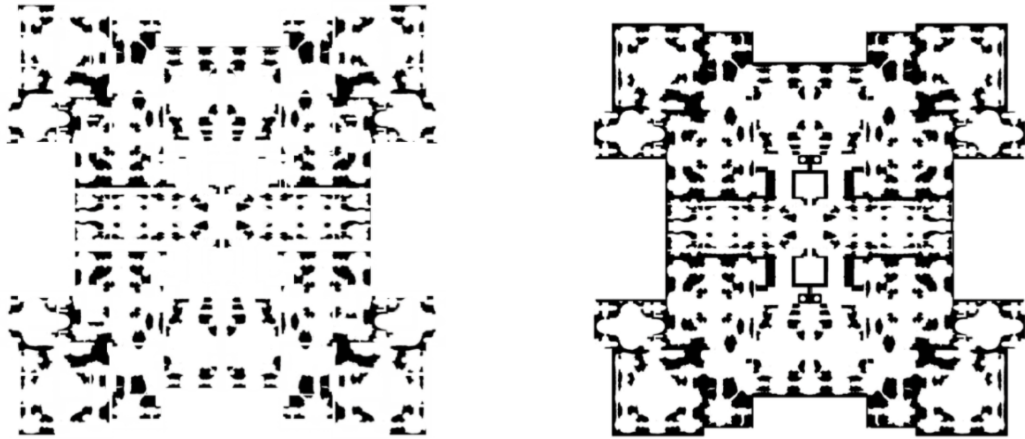


Figure 2 The Example of Chaillou's program

IV. THE CHANGE OF TRADITIONAL ARCHITECTURE WITH ARTIFICIAL INTELLIGENCE

A. Make the architectural design more efficient and accurate

At present, the contradiction in the field of architectural design is: on the one hand, the increasing demand of urban construction for the design industry; on the other hand, the traditional design method is more and more difficult to meet the higher needs of modern people for architecture due to its complex process and slow efficiency.

Today, with the rapid development of artificial intelligence industry, architects begin to understand and accept the relevant software of artificial intelligence in the construction field, and apply it to the process of auxiliary scheme design, so that they can focus on the scheme design itself and create higher value.

Ma long, deputy chief architect of Beijing Architectural Design and Research Institute, said in an interview with science and Technology Daily: "with the introduction of AI design method, all stages of architectural design, construction, operation and maintenance will be broken through one by one. Specifically, in the design of Z6 plot super high-rise project in Beijing CBD core area, we unified the design language and data carrier of 3D Integrated BIM model, providing key clues for the continuous development and promotion of AI design in all aspects, which is the prerequisite for the formation of fine design and high completion design. The project won the global BIM Architectural Design Best Practice Award in 2018. In addition, we have applied AI technology to different degrees in the design of Tencent Beijing headquarters, Xiaomi technology headquarters and Alibaba Beijing headquarters. "

The AI design method can also quickly convert the architectural design system or external resources into the design research object with component as the module, standardize and product

the complex design, and make the architectural design system highly integrated, which is conducive to improving the overall efficiency and reducing the difficulty of management.

In addition, AI design can carry out a lot of in-depth studies such as climate simulation, green energy-saving analysis, sunshine shading calculation, traffic flow statistics, etc. the information and judgment generated by the analysis is the most important data source for designers, which helps to dynamically adjust and quickly update the design scheme.

"Of course, this does not mean that artificial intelligence can completely replace the position of architects in the future. Instead, it summarizes and summarizes the architects' design wisdom, integrates the current logical style and design thinking, understands the architect's style in a deep learning way, and helps to complete the scheme creation. Architects of the future must coexist with robots, and more work is to make decisions and judgments. " Ma long stressed.

B. Break through the personnel barrier of construction industry

For a long time, the construction site has a "dangerous, complex, dirty, heavy" situation, with the accelerated trend of social aging, the number of working age staff will be sharply reduced, leading to the increase of construction labor costs. How to simplify or replace part of the labor force and break through the personnel barriers of the construction industry itself?

With the increase of labor cost, the choice of architectural design is turning to low efficiency but easy to build buildings. Recently, Katerin Mueller, associate professor of architecture at Massachusetts Institute of Technology and his student Ismail have developed an optimization algorithm to maximize efficiency and achieve the shape of design elements, reduce the number of reinforced concrete buildings in India, including calculating how much load a building can bear with the change of shape design. It takes only one hour to give a new design.

Through the AI design method, we can dynamically integrate and pre build the relationship between various parts and systems in architectural design, and can judge the risk and evaluate the efficiency of resource utilization in advance, so as to reduce the difficulty of actual construction and the uncertainty of time.

With the deepening of automation, artificial intelligence and automation equipment will gradually take over the construction site, and bring a new era of highly autonomous construction industry. Recently, Shimizu construction, a Japanese construction company, announced the construction site of an experimental facility, bringing together a group of construction robots who are going to work, including "ceiling installers", "welders" and "porters".

Because AI itself has a strong ability to analyze, organize and apply, it is bound to have a bright future in the construction industry. AI can simplify or even replace part of the labor force in the construction industry.

The substitution of AI for the construction industry is a gradual process. What we emphasize is not that AI completely invades and replaces traditional construction workers, it is just the complementary advantages of some processes and processes. In the future, AI technology will be used more widely in increasingly complex and high-end buildings, especially in smart buildings, where it can play the largest role.

V. A EXAMPLE OF ARTIFICIAL INTELLIGENCE USING IN THE ARCHITECTURE

A. Frame

"Architecture" here can be understood as the intersection of style and organization.

On the one hand, buildings are carriers of cultural significance. They express a certain style through geometry, taxonomy, typology and decoration - Baroque, Rome, Gothic, modern and contemporary. If you study the floor plan carefully, you can find many architectural styles. On the other hand, buildings are the product of engineering and Science, and follow strict framework and rules - Architectural norms and ergonomics Engineering, energy efficiency, exits and programs - all of which can be found when we read a floor plan.

This organizational requirement will help us define "architecture" and drive research.

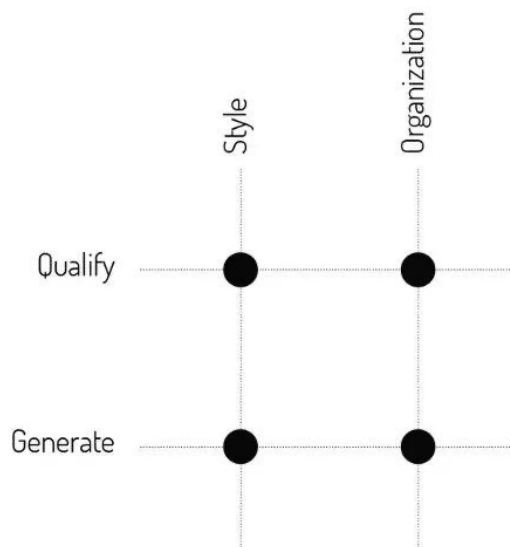


Figure 3 Frame matrix

Using Gans to apply artificial intelligence system in architectural design. It is assumed that the use of artificial intelligence can enhance the practice of architecture. It's a whole new field, it's still in the experimental stage, and it's got amazing results. We hope to be able to train artificial intelligence to draw real building plans.

Then, a powerful analysis framework is used to select and classify the generated plans. Finally, the results of GANs are obtained, which enables users to seamlessly browse various created design options. This kind of design meets with the artificial design, and the design is made through a framework

B. Artificial intelligence and generative countermeasure neural network

In the field of artificial intelligence, neural network is an important research field. Recently, the emergence of generative antagonism neural networks has proved the creativity of this model. As a machine learning model, Gan can learn statistical important phenomena from given data.

However, their structure represents a major breakthrough: Gan is composed of two key models: generator and discriminator. The feedback loop between the two models can be used to improve the ability of generating relevant images.

The discriminator is used to identify the image from the data. After proper training, the model can distinguish the real image extracted from the dataset from the "fake" image that is unfamiliar to the dataset; the generator is used to create images that are similar to those from the same dataset.

When the generator generates an image, the discriminator will feed back the quality of its output to it. In response, the generator takes this feedback to produce a more realistic image. Through this feedback loop, Gan slowly builds up its ability to create relevant composite images, taking into account the phenomena found in the data.

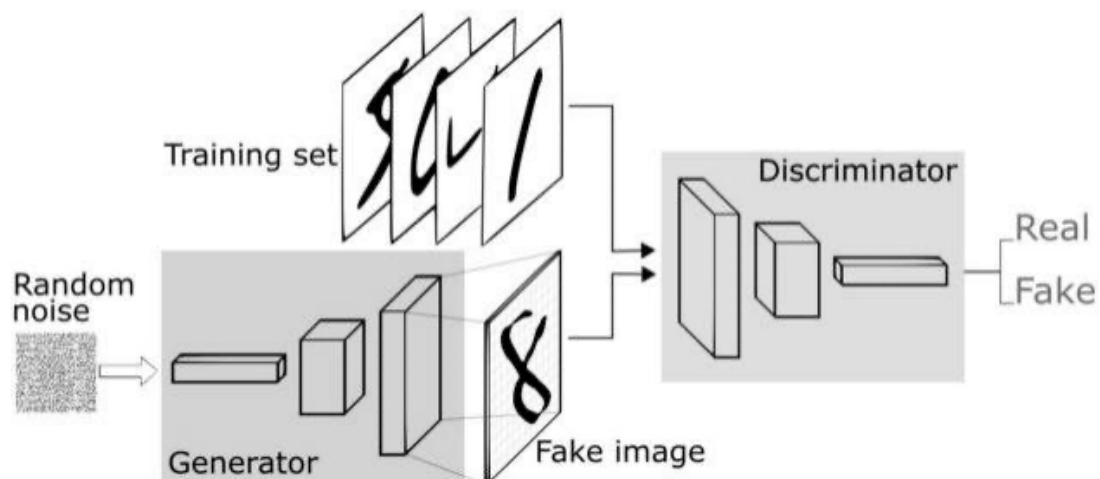


Figure 4 The Structure of GANs

1. A. Style change

In the architectural plan, the "style" can be determined by the shape and graphic plane of the wall.

Typical baroque churches are characterized by massive columns and circular indentations, while Mies van der Rohe's modern villas are characterized by thin, flat walls. Gan can recognize the jagged shape of the wall surface. By showing these two images and using one as a floor view wireframe and the other as an actual wall structure, a certain amount of machine intuition can be established according to the architectural style.

This part shows the results of model learning baroque style. Continue with the style transition by smoothing the thick walls of a given building plan (a) and then giving it a new wall style (b).

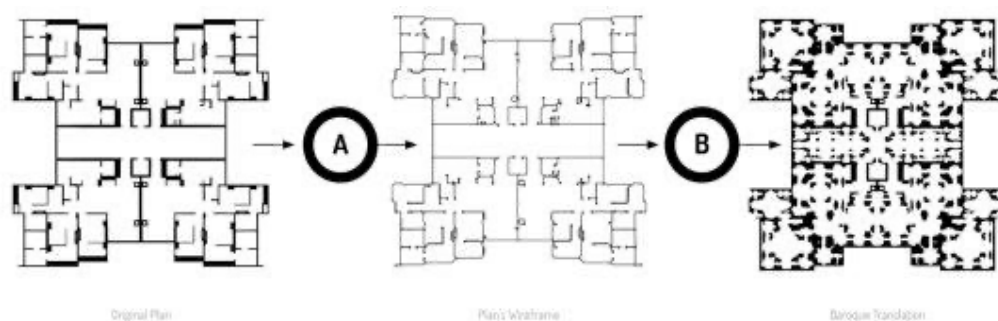


Figure 5 The change from modern to Baroque style

C. Layout assistance

A multi-step flow chart has been prepared, including all the necessary steps for drawing a building plan. It can imitate architects to draw plans according to different building sizes, and compress each step into a specific model for performing given operations.

From the plot to the architectural map, from the architectural map to the room map with walls and windows, and from the room map to the hardbound floor plan, every step has been carefully designed, trained and tested.

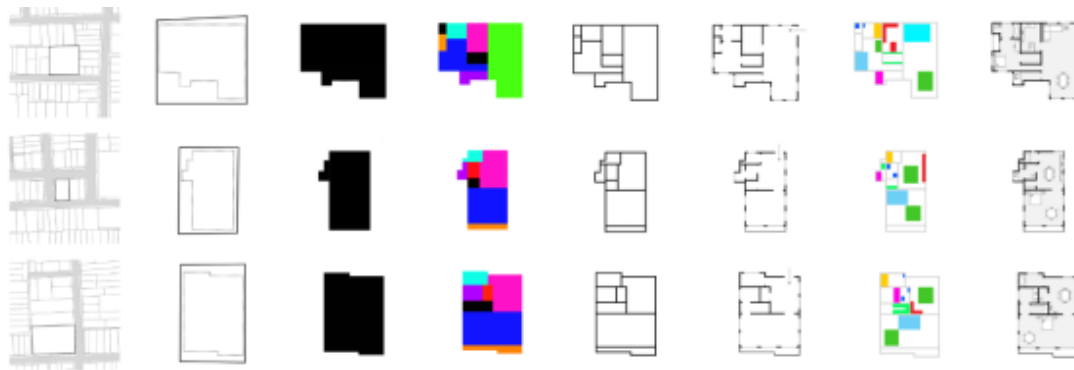


Figure 6 Layout assistance step by step process

V. CONCLUSION

Artificial intelligence technology as a cutting-edge technology, and architecture such a traditional industry formed a sharp contrast. It is because of the long history of architecture that brings endless space to the application of artificial intelligence.

At present, a large number of architects and related experts are focusing on intelligent design from traditional architecture. The emergence of GANs also gives people a great space for development in design. At present, there are many algorithms to achieve some specific functions. In particular, MIT projects can achieve a very complete design process from style recognition to graphic layout.

In the future, with the continuous development of technology, the application prospect of artificial intelligence can also be expanded. In the future, from a more macro perspective, AI can also help architects make more judgments and provide more basic basis. For example, the flow of people in Nantou ancient city was analyzed by xiaoku before. Artificial intelligence was used to guide the layout of format, streamline and node layout. These are things architects can't do by feeling.

Artificial intelligence can be extreme in some dimensions. Artificial intelligence can lower the threshold of scheme, construction, laws and regulations, and let some artists or experts from other relevant dimensions cross the threshold and become architects. The energy of artificial intelligence may change the current construction, and even change the form of architecture finally. It has a huge space for development; however, there is a huge space for development. On the other hand, architects will not disappear because of it. But to conduct a deeper level of research, in turn to lead the development of the construction industry. This is not an either or game, because the construction industry is still a very special industry.

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