The Past, Present and Future of Computer-aided Design

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Abstract. Under the background of rapid development of digital design, this paper systematically introduces the development origin and technical strategy of computer-aided architectural design, discusses the origin of CAAD thought in depth, puts forward CAAD influence factors, and makes clear the different influence degree of CAAD strategy on architectural design process, and looks forward to the future development direction of CAAD based on this.

1. Overview of CAAD Research

Computer-aided architectural design refers to the method of applying computer technology to the design process of city, landscape, architecture and interior, etc. It is an important branch of computer-aided architectural design. In 1956, Robert Heinlein, an American science fiction writer, proposed for the first time a kind of aided design "drawing robot", which became the earliest version of CAD software and the target prototype of current "intelligent design". In the 1990s professors Liebich and Steinman of the Bauhaus University in Germany divided CAD development into three generations. The first generation appeared in the early 1960s, driven by architects’ demand for design computing tools. The main characteristic of the second generation OF CAD is its development into independent application software. The third generation appeared in the early 21st century, which opened up the development direction for intelligent CAD and building information model system, and paid more attention to the information integration in various knowledge fields, so as to realize barrier-free communication and intelligent exchange among various professional information.

2. CAAD Strategy

After half a century of development, CAAD has gradually developed into three major directions: "design and generation", "information structure" and "expression and application".

2.1. Design and Generation

2.1.1. Parameter metaplasia

The strategy of "parameter metagenesis" is based on "rule based" and "knowledge based", and realizes the process and method of computer generating different output results according to adjusting input by establishing logical relationship between input and output. Different purposes, such as generating complex geometry and enriching information models, can be achieved by presetting rules and relatively simple input. Parametric design is essentially a component combination design, which simulates various real attributes of building components in the form of parameters, and conducts relevant data statistics and calculation. [1] In the building information model, the building component is not only a virtual visual component, but also can simulate some geometric properties other than geometric shapes. For example, in the building information model, for components with different...
properties of beams and pillars, the properties dialog box of beams will contain data such as their dimensions and forces in each direction, while the properties of columns are completely different from those of beams. The significance of defining attributes through parameters is that various statistics and analyses can be performed. In the building information model, the calculation and statistics of structure, economy, energy saving, evacuation and other aspects can be carried out, and even the simulation of the construction process can be carried out to finally realize virtual construction.

2.1.2. Artificial intelligence
The computer first generates a series of planes according to the functional bubble diagram, and then calls on the "memory" of other excellent cases in the "brain" to continuously optimize the scheme and finally achieve satisfactory results.

2.1.3. Rule-based
The "rules-based" strategy mainly focuses on the internal logical relationship of architecture, and realizes the effective communication between human and architectural scheme with computer as the medium. Mathieu and Veronique, a French scientist, proposed the "wall grammar" house on the basis of graphic grammar, and realized the automatic generation of the facade roof and window layout by pre-setting the window rules of the building walls.

2.2. Information Structuring

2.2.1. Knowledge based
The "knowledge based" strategy mainly studies how to organize loose information describing architectural features into "structure", so as to extract features from different aspects such as "geometric objects", "spatial relations" and "structural materials" in existing buildings, and establish an "expert system" to guide future design and construction [2]. Revit is a knowledge-based system that realizes the information structure of "geometric objects" and "structural materials", and one of the main directions of BIM research at present is the information structure of "spatial relationship".

2.2.2. Collaborative design
"Collaborative design" refers to the way design groups work together on the same design project, supported by computers. Its platform can be either a distributed network platform that supports multiple user operations or a real operating platform for multi-user real-time negotiation [3]. In the era of TWO-DIMENSIONAL CAD, collaborative design lacks a unified technical platform, but building information model provides a good technical cooperation platform for traditional construction work. Building information model not only provides a good cooperation platform for different production departments, even management departments. This not only changes the traditional work coordination mode of architects, structural engineers and equipment engineers. Moreover, owners, government departments, manufacturing and construction enterprises can all work together based on the same building model with 3D parameters.

2.3. Expression and Application

2.3.1. Expression tools
"Expression tools" are the expression and integration system of architectural geometry and information derived from "computer graphics" since the birth of "sketch board" in 1963. They include drawing software commonly used in current architectural design, such as AutoCAD, Revit, SketchUp and so on. SketchUp, for example, can produce intuitive 3D artifacts at any stage of the design process, even simulating the effects of hand sketching. Its simple interface allows beginners to get started quickly. At the beginning when CAAD system entered the architectural design classroom, the expression level of digital architectural design teaching was mainly associated with the drawing of two-dimensional graphics, and AutoCAD software was one of the most commonly used software at that time. Then, with the enrichment of CAAD software types and enhancement of functions, the
expression results of digital architectural design teaching are no longer limited to the drawing of two-dimensional graphics, but turn to the three-dimensional modeling of design schemes, and gradually reflect the difference from the traditional manual drawing.

2.3.2. Digital assembly
"Digital assembly" strategy is to im parameters into the complex form and space into the process of material entity, is based on the characteristics of material transport and assembly constraints, such as using the computer for the virtual design and optimization, the seemingly complicated chaotic model of whole into simple and orderly component method.

2.3.3. "Virtual reality"
The strategy of "virtual reality" refers to the use of computer simulation of the real world or virtual environment that cannot be realized in reality, and the realization of "human-architecture interaction", urban design and restoration and creative development through operation and control of the environment. Architects used to use sketches for conception, but now the surreal virtual environment formally USES the uncertain environment randomly generated by computers according to parameters to stimulate designers' creativity.

2.4. The Origin of CAAD Thought
Computer aided architectural design (CAD) exists for the different stages of the design process. All kinds of strategies have the same essence of thought: to achieve formal synthesis through logic. The key to digital design is not to play with complex forms, nor will the future of architecture be grotesque and void under the influence of the current so-called "technological revolution". The essence of digital design is still logic.

In order to provide guidance for the development of relevant design practice and research teaching, we analyzed and compared the influencing factors of different CAAD strategies. Thus, it can be concluded that "ai-based" strategy has the greatest influence on the design process, and has no influence on the "expression" stage in the stages of "analysis", "synthesis", "evaluation" and selection. Although "ai based", "knowledge based" and "collaborative design" have the greatest impact on the design process, they are still not widely applied in architectural design practice at this stage, while BIM technology based on "knowledge based" strategy is getting more and more attention and application. Parametric design belongs to the strategy of "parameterization and generation", which only plays an important role in the "synthesis" and "expression" stages of the design process. By establishing the abstract logic relationship between external parameters and internal generation, the integration of architectural forms is realized, but it has little impact on other stages.

3. Future CAAD Development
From the perspective of the development trend of CAAD technology, CAAD strategies such as "based on artificial intelligence", "based on knowledge" and "collaborative design", which have a high impact on the design process, will gradually play an increasingly important role in the practice of architectural design. After more than 20 years of development, CAAD research has indeed made great progress in formalization, automation and parametric design of design.

It is obvious to all that China's architectural design and construction speed are fast. How to apply CAAD tools developed according to China's special architectural needs and social development characteristics into architectural design practice on the basis of foreign research, so as to improve the design speed and ensure the design quality is an urgent matter for CAAD research in China. Western countries based on its own economic and social development under the background of the development of parameterized design of CAAD technology in developed countries, such as was the acceptance in our country, but CAAD really fashionable and advanced, concept, form of playing not to show off, but the maximum extraction in the design of repetitive work, hand it over to the computer accurately completed independently, so that the designer can have more energy into the traditional culture inheritance and derived under the modern technology. At present, BIM's all-directional information modeling idea of architecture and the top-down linkage generation technology of
parametric design are still facing many outstanding problems while making historical innovations on traditional design modes. Understanding these problems and studying solutions will be of positive significance to the future development of CAAD.

Therefore, the development of CAAD research in the future will include three parts: "mining the formal language of architecture", "building the spatial relation database" and "realizing the automation and generation of architectural scheme". Information-based architectural design can express the information of real buildings, and information-based architectural design can be truly realized, which breaks through thousands of years of using abstract visual symbols to express the inherent mode of design. Only by objectively understanding the starting point and purpose of BIM and parametric design can it fully tap its potential and exert its strength, avoid being overwhelmed by the current, and truly promote the development of CAAD and the progress of design theory.

4. Conclusion
Through the analysis and discussion of the nine main CAAD strategies, the basic ideas and fundamental goals of foreign cad architecture design are comprehensively presented, and the influencing factors of CAAD are put forward. The next stage of the research will focus on the following aspects:

1) The development of formal language of architectural spatial relations, and the extraction of architectural internal logic by using mathematical expressions describing spatial relations;
2) Using artificial intelligence technology, based on the building spatial relational database, the scheme is automatically generated and updated and optimized according to the adaptability function.

5. Summary
Today, after entering the digital age, due to the popularity of the representation of humanism ideological trend, interactive technology and computing industry developed, the next phase of the architectural revolution is done quietly, dynamic building by the simple and mobile space into a dynamic form depending on the design of the sustainable and interactive technology, the cooperation between architects and engineers will be more broad and deep "will be in the architectural experiments to explore the construction of conception, generation and manufacturing process". Accordingly, people's way of life and experiential cognition of space, time and materials have also changed, and the era of interactive life is coming.

6. References
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