AI-Design: Architectural Intelligent Design Approaches Based on AI

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ABSTRACT

Artificial Intelligence (AI) is playing a more important role in architectural field. Based on three schools of AI, this paper proposes an AID Model of architectural intelligent design, aiming at establishing a thinking system to understand the inter-crossing of AI and architectural design. According to AID Model, a series of AI methods applied into architectural design, analysis and fabrication are discussed. By summarizing an overview of AI methods, it is possible to explore the future development of architectural intelligent design and provide reference for future design work.1

ARTIFICIAL INTELLIGENCE: THREE SCHOOLS

Permeating into almost all areas, Artificial Intelligence (AI) is also playing a more important role in architectural design field. First we summarize a brief history and introduction of AI’s three schools: Symbolism, Connectionism and Behaviorism.

-Symbolism: expressing the formation of thinking and produces human-like intelligence by logical symbols in mathematics and physics. It is a top-down process including expert systems, knowledge engineering and so on;

-Connectionism: considering intelligence comes from neutral connections, it simulates brain neutral network and its connection mechanism by computer. It is a bottom-up process including artificial neural network, machine learning and so on.

-Behaviorism: based on the perception-action control system, it makes every basic unit optimize, adapt and organize itself. It is a bottom-up process including evolutionary algorithm, multi-agent, cellular automation and so on.

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AI-DESIGN MODEL

Based on the above, this paper proposes an AI-Design Model (Fig.1), aiming at establishing an AI concept system in order to make a better understand of the inter-crossing between AI and architectural design.

AI-Design Model:

\[ T = i \cdot G \cdot E \cdot T \]  (1)

Or

current solution state = index \cdot God-driven \cdot Environment-driven \cdot previous solution state

\[ (2) \]

Figure 1. AI-Design Model.

Among these driving forces in AI-Design Model, ‘God-driven’ is a top-down process in which ‘God’ could not only be designers, but also be senior roles such as developers and government as well as technical details such as design code and material properties. ‘Environment-driven’ is a bottom-up process in which ‘Environment’ could be interactive constraints such as behavioral rules and material properties as well as external factors such as location and climate. In a word, ‘God’ control design and ‘impose’ a direction on a macro level, while ‘Environment’ allows agents to develop freely or even disturbs agents to change their behavioral rules, thus realizing their variation and diversity.

SYMBOLISM: DESCRIPTIVE GRAMMAR

According to AI-Design Model, a series of AI methods applied into architectural design, analysis and fabrication are then discussed. In 2006, Mathieu L. proposed ‘wall grammar’ based on graphic grammar. He pre-defined several styles of windowing rules and applied Procedural Modeling method to
automatically generate architecture façade, roof and windowing layout plans [7] (Fig.2).

![Figure 2. Procedural Modeling.](image)

**CONNECTIONISM: ARTIFICIAL NEURAL NETWORK (ANN)**

ANN is also a system of knowledge and rules. However, these rules are not artificial definition but the weight information stored in the connection of every two neurons after ANN experiences many trainings. In 2013, with the help of neutral network system, Mehanna R. in University College London designed the elastic-structure robot which was adaptive to environment and never fell down. Every neuron is a servo motor directly acting on robots’ supporting frames rather than a mysterious element in virtual world. It keeps balance and remains upright of elastic structure by controlling wire tension like muscle contraction [9] (Fig.3).

![Figure 3. Neural Network Structure.](image)

**BEHAVIORISM: MULTI-AGENT**

Multi-agent in which complex actions are divided into simple interactive rules so as to realize self-adaption, self-organization and self-learning. If the multi-agent method mentioned above is restricted to design itself, then the following...
‘soft robot’ based on behavioral and environmental perception completely serve as an agent of overall fabrication process. In 2016, Brugnaro G. in University of Stuttgart gave an example of weaving rattan. Without presetting its action route, the mechanical arm equipped with Kinect360 could shoot and sense surroundings in real time. [10] (Fig.4).

Figure 4. Artificial Intelligent Weaving.

CONCLUSIONS

From Symbolism to Behaviorism, from controlling every rule to letting it go properly, AI methods make rooms, robots and even the whole design processes become ‘conscious’ agents. We fully realize that the convenience for architects AI brought and the great potential of technological revolution AI caused. Harari Y.N. says in Homo Deus: A brief history of tomorrow at the end of the book, ‘Organisms are algorithms and life is data processing…Non-conscious but highly intelligent algorithms may soon know us better than we know ourselves’ [11]. From the point of Dataism, we should be more aware that artificial intelligence is historically inevitable. Architects design our world, while AI might design our future.

REFERENCES