Towards “Autonomous”: A review of the “stereotypical” behaviors in Robotic construction

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Abstract. With the development of digitalization in the architecture industry, robotic construction is now attracting attention as a new technology in the architecture industry. As the number of research cases increases, some people question whether robotic construction is really an efficient and autonomous construction process. The purpose of this paper is to point out the "stereotypical" behavior of robots in autonomous construction in the architecture industry and to question the repetition of a single action by robots in terms of architectural theory and its history. It attempts to outline an objective relationship between robotic construction and architecture and to give architects a warning and advice. It is hoped that in the future, architects will be able to realize autonomous from the perspective of architectural theory and history, rather than simply being limited by the technical constraints of computer language translation and programming.

1 Introduction

Over the past few decades, the construction industry has suffered from poor efficiency, labor shortages and high accident rates at construction sites [1, 2]. In the context of industrial automation, robotic construction has received much attention as a potential solution to improve construction efficiency, reduce accident rates, perform complex tasks, and increase worker safety [3]. Institutions such as ETH z have set up digital construction labs for a lot of experimentation and research, and believe that robots will be a key element in the future of construction [4, 5]. At this stage, the use of robots in the construction industry has been demonstrated to contribute to a more thriving automation of the construction industry [5]. However, at the same time architects are constrained by the technology and mindset of construction, which is technically programmed to input commands to the robot, where the robot's job is only to materiality the output through code, essentially repeating the work and actions that humans have already done, i.e., performing "stereotypical" behaviors and repeating a single action [6]. This leads directly to the loss of traditional architectural language and craftsmanship, and in the long run to a lack of reflection by architects on architectural design and autonomous construction [4, 7]. In this way, we are closer to buildings that need more attention and research effort for autonomous robotic construction[8]. This article reviews and analyses the stereotyped behavior of autonomous execution in digital and robotic construction. Afterward, a dialogue on the potential problems of robotic construction based on architectural theories and

historical perspectives will be organized, then a discussion and hypothesis on the orientation of the improvement of autonomous construction will be presented. In this article, we aim to provide some theoretical support for the design theory of autonomous construction and the direction of its technological advancements [8].

2 Autonomous Robotics and Architecture

2.1 Autonomous in Architecture

With the objective needs of industrialization, automation, and industrialization, the application of numerical control machines in the field of architecture is emerging [5]. The 1990s attempted to introduce robotics into the construction industry, but the limitations of control technology led to highly specialized standardized manufacturing that was very expensive and inflexible, ultimately leading to the failure of traditional industrial production techniques to digital manufacturing and the first attempt in history for robotics to cross over into the construction sector [4, 9]. In 2005, ETH z established the world's first robotics laboratory dedicated to architectural design and manufacturing, reintroducing robotics in the field of architecture and signalling the beginning of architectural autonomy[9]. Over the next 10 years, the ETH has conducted a number of construction experiments to convert standardized industrial manufacturing techniques into unstandardized digital manufacturing techniques, making significant contribution

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ions such as Gramazio, Fabio, Yuan, Phillip F., or Mario Carpo[8, 10]. From wavy silk walls to complex pavilions, robotic fabrication technology excels in connecting elements and polymerizing generative materials, depicting the inherent stability of architecture and construction through the means of technical construction (Fig. 1) [11, 12]. Demonstrating the crucial importance of robotics in the architectural construction process, robotic construction reveals its hidden "constructiveness" and establishes a direct link between design and construction, showing the most relevant constructive expression of our time [13]. However, in the meantime, a large number of scholars have argued that robotic construction is merely an "Exotic" machine, a temporary mode [8]. Others interpret it as a superficial investigation, based on a "decorative" study, especially the case of Gantenbein Vineyard Facade (Fig. 2) in Gramazio's earlier book, *The Robotic Touch* (Foged 2016). These questions concern purely superficial properties of the discussion, subjective assertions and comments under visual feedback [14]. Originally, objectively analyzed from the perspective of architectural theory and its history, the practice of architecture has been transformed at a rapid pace with the development of digital technologies in the field of architecture, but the definition of this direction, the original vision that introduced the discipline to the discipline, has been partially lost, resulting in cases of automated construction that indulge in a strange kind of "Rushinianism," where architects are essentially using robots to complete the construction process taking the place of and replacing former craftsmen[8]. As robots follow the instructions and generate data, they have no process knowledge, experienced judgement or creativity [8]. They are developed for specific construction processes such as picking up, placing... Ultimately, they are rigid, developed as tools for executing commands to increase the productivity of "humans" instead of craftsmen [15]. Consequently, as a means to achieve design and construction, robots do not perfectly fit the vision of integrating design, the construction and materials for the autonomous construction that was initially proposed at the introduction of architecture (Fig. 3) [13].

Fig. 1. Brick Labyrinth, Zurich, 2017

Fig. 2. Gantenbein Vineyard Facade, 2006

Fig. 3. ETH Zurich, Fabio Gramazio and Matthias Kohler

2.2 Autonomous Robotics

Autonomous construction is not a single act accomplished through the repetition of an action that mimics a human action [9]. On the one hand, such "stereotypical" behavior creates ambiguity about autonomous construction, and on the other hand, traditional building techniques lose their oral tradition of craftsmanship, forgetting to update craftsmanship techniques, which gradually results in the disappearance of traditional craftsmanship, and may result in a uniformity of architecture without individual expression [16]. This lack of spirituality in the architecture of the era had occurred in the late stages of modernization and industrialization, but was noted by Ruskin [17]. But now, in the era of digitalization and autonomy, we are faced with the same problem: architecture, as a medium that has been handed down for thousands of years and that records history, cannot lose its soul because of innovations in construction technology, a development that is counterintuitive in the disciplinary dimension [8]. Objectively, the demands of construction technology go far beyond imitating existing construction technologies [18]. But robotic construction is not about imposing barriers to the building process, but rather about becoming more self-aware and contributing to the autonomous and responsive performance of the architectural discipline[8, 19]. To achieve autonomous robotic construction should not be obsessed with the output of complex geometries and mindless repetition of single actions, repeating "stereotypical" behaviors (Fig. 4) [2, 16].

Fig. 4. UCL The Bartlett school.

In the field of architecture, robots should be based on a rational consideration of architecture itself in the process of "materiality" [8]. Robotic construction technology is a powerful tool in building development, and architects should consider construction, materials, technology, processes and design holistically [2, 18]. In this process it is necessary to explore the theoretical essence of architecture in response to the contribution of the "heritage" of architectural history, and the most important contribution of both to the discipline is the capacity for rational meditation that they cultivate. At the same time, robotic fabrication and robotic architecture are, in fact, linked by these intangible "nostalgic" (theoretical and historical) connections [8, 11]. The best way to achieve a truly autonomous construction based on robots in this context is to think according to the logic of the discipline. In the future, robotics in architecture will require "fundamental changes in the early design stages as well as during construction that go well beyond imitating existing building technologies" [6]. Autonomous construction based on robotics should also reflect on the output process, possibly through innovations in machine learning, human-machine interaction, and artificial intelligence, and other technologies that attempt to go beyond the ability to mimic and repeat a single human action or task to achieve "autonomous" construction, exploring more possibilities for architectural design that are not available to humans. many possibilities to truly complete autonomous construction in the field of architecture (Fig. 5) .

Fig. 5. Human- machine interaction

3 Conclusion

The purpose of this review is to provide an objective architectural theoretical and historical perspective on robotics and its achievements and to point out that its current repetitive and uniform behavior, the performance of "rigid" tasks, and the autonomy it was intended to

achieve when it was introduced to the discipline are at odds with each other. At the same time, the limitations of this paper are that it does not take into account the limitations of today's robotic technologies, and it also incorporates research that focuses solely on mechanical and computer technology in the perspective of architectural science. Robotic construction is the foundation of research on autonomous processes. It is hoped that in the future, architects will take into consideration the process, design, construction, materials and other factors related to the origins of architecture through robotics. Robots are more than capable of imitating human behavior and doing more than humans have yet to build, a truly autonomous construction.

Figure resources :

Fig 1:

<https://gramaziokohler.arch.ethz.ch/web/e/lehre/327.html>

Fig 2:

<https://divisare.com/projects/260919-gramazio-kohler-raplph-feiner-gantenbein-vineyard-facade>

Fig 3:

<https://divisare.com/projects/260919-gramazio-kohler-raplph-feiner-gantenbein-vineyard-facade>

Fig 4:

<https://www.ucl.ac.uk/bartlett/about-us/our-resources/b-made-bartlett-workshops/b-made-robotics>

Fig 5:

<https://iaac.net/educational-programmes/masters-programmes/master-in-robotics-and-advanced-construction-mrac/>

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