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Research article

The Role of Artificial Intelligence in Architecture: The Case Studies of Star Architects

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Abstract

This research examines the projects of star architects who develop architectural designs using artificial intelligence and the impact of this technology on changing the role of the star architect. In this context, nine prominent architectural groups—Zaha Hadid Architects, Coop Himmelblau, Morphosis, Foster & Partners, Skidmore, Owings & Merrill, Vincent Callebaut, Arup, MAD Architecture, and UN Studio—are analyzed to demonstrate how these architects integrate artificial intelligence into the creative process and how the traditional role of the architect has changed. The originality of the research lies in its focus on the relationship between artificial intelligence and the star architects standing at the intersection of architecture and technology. Star architects shape architecture with their productions and discourses. The study is based on qualitative analysis, and the documents and publications of the projects of star architects were evaluated by the content analysis method. Our findings indicate that artificial intelligence has expanded the architect's role in creative processes. With artificial intelligence, each star architect is rediscovering the boundaries of architecture and creating innovative and creative designs. Consequently, the study examines how artificial intelligence influences architectural practice by analyzing the works of renowned star architects.

Keywords*:* Artificial intelligence, AI in architecture, AI technology, architectural design, star architect

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1. Introduction

In the 1960s, the relationship between technology and architecture radically changed the design process. Designing with computers and the development of computer-aided software has not only facilitated but also accelerated complex and complex business processes. The dominance of technology in the field of architecture has also shaped the role of the architect in the process. The architect started to share his superiority in professional production with technology. Thus, architects began to be referred to as 'civil servants', 'partners', 'accountants', 'magicians', and 'proxies' (Vardouli, 2012). Since the 1980s, the relationship between architecture and technology has become stronger with the increasing prevalence of digital tools.

Frank Gehry, the 1989 Pritzker Prize winner, who produced symbolic works that explored the relationship between technology and architecture, consciously avoided the use of computers, initially calling them 'nonsense' (Gershenfeld, 2007). Frank Gehry's embrace of digital technologies began in the 90s with the Guggenheim Museum Bilbao project. Similarly, Norman Foster began using digital technologies later in his career. From this perspective, it can be said that architects did not initially adapt to the new transformation process. In addition, the impact of computers on the roles of architects has been a subject of debate for a long time. Since the 2000s, architects have developed approaches such as hybrid and virtual architecture in response to technological change, and have subsequently integrated advanced technologies, including parametric design and artificial intelligence, into their practice. Similar to the debate on the impact of technology on the architect's role in the past, how artificial intelligence shapes the role of the architect today is a current topic of discussion (Şenyapılı, 2015).

Artificial intelligence is effective in various aspects of architecture, including design processes, analysis of building materials and systems, construction processes, building management systems, and documentation of buildings (Rice, 2019). Although it has only recently been invented, the impact of artificial intelligence is spreading very quickly along with the diversity it brings to design processes. In technology-centered research institutions, such as the Massachusetts Institute of Technology (MIT), artificial intelligence-focused course content is being developed, and university education curricula are being updated. Artificial intelligence is one of the most current topics of discussion in conferences, symposiums, architectural events, and graduate research. In addition, it is predicted that in a few years, education in all disciplines will be based on artificial intelligence (Leach, 2022).

Star architects have incorporated AI-based techniques into their design strategies. Tom Mayne of Morphosis uses the potential of AI to increase the diversity of design options. Wolf Prix, one of Coop Himmelb(l)au's key figures, prefers artificial intelligence tools to improve the design process. Patrik Schumacher of Zaha Hadid Architects (ZHA), on the other hand, uses artificial intelligence to optimize designs, create complex and innovative forms, and simulate the behavior of building users. One of the leading names in sustainable architecture, Foster+Partners uses artificial intelligence to develop energy-efficient designs, urban planning, mobility, and energy optimization (Leach, 2022). In this context, it is obvious that artificial intelligence is used in a wide spectrum of star architects' work. The integration of artificial intelligence (AI) and machine learning (ML) into architecture is creating a paradigm shift in the industry. From improving design efficiency to promoting sustainability and personalized user experiences, AI-driven technologies offer

architects unprecedented opportunities for innovation (Kaarwan, 2022). The increasing use of artificial intelligence expands the role of the architect in this process. AI-based data analysis, design tools, and documentation possibilities enable architects to undertake more diverse and strategic tasks. New roles such as innovative designer, data analyst, sustainability specialist, project coordinator, and user experience specialist are emerging. This study analyzes the changing architectural roles of star architects within the framework of the possibilities provided by artificial intelligence technologies. It investigates how star architects make a difference in the use of artificial intelligence and their contributions and potential to the discipline of architecture in this regard.

2. Literature Review: Artificial Intelligence and Star Architect

Artificial intelligence is one of the most popular fields of study of the 21st century. AI is defined as the ability of a system to correctly interpret external data, learn from that data, and use that data to achieve specific goals and tasks through flexible adaptation (Kaplan & Haenlein, 2019). Although its hypothetical roots date back to ancient times, its actual development dates back to the late 20th century. From artistic fields to marketing, from health sciences to tourism, many different disciplines use artificial intelligence as a supportive and impressive force for their innovative work (Haenlein & Kaplan, 2019). The ability of artificial intelligence (AI) to generate, evaluate, develop new algorithms, and use data is considered the "next level" in visual arts, engineering, architecture, construction, and real estate management (Sourek, 2024). Undoubtedly, architecture is one of the disciplines most affected by developments in artificial intelligence technologies. With its advantages in building information modeling, data analysis, simulation, optimization and advanced visualization techniques, artificial intelligence has important implications for the present and future of architectural practice. In a world driven by the latest technologies, integration with artificial intelligence is important for the progress of the field (Vitcu, 2023). Artificial intelligence is expected to evolve as an integral part of the overall design process (Dreith, 2022), offering opportunities to significantly transform the current workflow within the architectural profession (Cutieru, 2020).

In this context, it is necessary to define the framework of the concept of star architecture in order to evaluate the reflections of artificial intelligence technologies on architecture. Although scientific research is still hesitant to use the term star architecture, terms such as the Bilbao effect, iconic architecture, signature architecture, and flagship architecture have entered the architectural literature (Alaily-Mattar, et. al., 2022). Among scientific articles, the first source where the term "star architecture" is used is Evans' (2003) article 'Branding the city is hard'. According to Evans, being unusual, recognized and having established international ties are the characteristics that define a star architect (Alaily-Mattar, et. al., 2022). One of the conditions of being a star architect is to be widely covered in the architectural press and to be in close contact with the media. At this point, Rem Koolhaas evaluates star architecture as a concept produced by the media (Koolhaas, 2017). In this context, the products created by star architects are iconic buildings with brand value where commercial concerns override architectural features. Gehry's Tiffany venture, inaugurated with massive advertising campaigns, turned Gehry into an icon of consumption. Similarly, the Guggenheim Museum Bilbao has been featured in the media as an architectural icon. When

defining the concept of a star architect, in some cases the individual comes to the forefront (as in the case of Zaha Hadid), while in others the institution/brand (SOM) comes to the fore (Alaily-Mattar, et. al., 2022).

Star architects shape modern architecture with their social, cultural and innovative approaches. They play a pioneering role in contributing to the discipline and legitimizing competition. They also pioneer important paradigm shifts, especially with the way they use technology. According to McNeill (2009), star architects have a number of distinguishing characteristics. These characteristics are listed as having at least one book written on the star architect, having a certain charisma, their marketing skills and their conceptual architectural approach. Sklair (2017) explains the common characteristics of star architects as having a certain reputation, developing a brand, being well-known and globalization.

In addition to these characteristics, another strength of star architects is that they are closely associated with the media (Alaily-Mattar, 2020). Colomina (2013) defines this relationship as the media transforming architecture into an image that spreads worldwide. Similarly, Foster (2008) emphasizes that the media is an important force that enables iconicization. On the other hand, Ponzini and Nastasi (2016) emphasize the technical aspect of star architects and state that they prioritize technological innovations and follow different strategies, such as following current developments, in order to contribute to the discipline and compete. One of these innovations is the use of artificial intelligence technologies that have become widespread today. In 2022, the rapid use of artificial intelligence has affected many disciplines, especially architecture. Although the literature on this subject is quite new, studies examining the relationship between architecture and artificial intelligence are gaining popularity.

Taş et al. (2024) examined the role of the architect evolving from craftsmanship to artificial intelligence in the historical process and defined this change in terms of the role of the architect according to each period. In a book edited by Del Campo (2024), the impact and applications of artificial intelligence in the field of architecture are discussed. It includes various research and case studies that examine how AI technologies can be integrated into design processes, project design and construction practices. On the other hand, Neil Leach (2022) discusses the impact of AI in architectural culture and predicts the future of AI in architecture. In the article written by Irbite & Strode (2021), the impact of artificial intelligence on design practice is investigated, and a literature review and analysis method is used to examine this impact on current design practices and the contributions of artificial intelligence. In these studies, it was determined that the use of artificial intelligence by star architects was not addressed. In this context, unlike the literature, the study focuses on the use of artificial intelligence tools by star architects and architectural offices.

As a result of the literature research, no studies on the relationship between star architecture and artificial intelligence were found. In this context, this study investigates how star architects use artificial intelligence tools in their projects. Within this framework, the main research projects in which star architects use artificial intelligence tools in architectural design processes are analyzed. Especially the ways in which famous architects and architectural offices, who are called star architects and who shape architecture, use artificial intelligence tools and methods are important for understanding the future of the architectural discipline.

3. Methodology

Within the scope of this research, in which artificial intelligence studies developed or used by star architects were evaluated, the use of artificial intelligence in the projects of star architects was analyzed, thus revealing the development of this subject. This method reveals potential areas of discussion for research. When the internet databases with the current works of star architects were examined and the literature on the field was reviewed, it was found that Foster + Partners, Zaha Hadid Architects, Skidmore, Owings & Merrill, MAD Architects, Coop Himmelblau, UNStudio, Morphosis and Winsent Callebaut actively used artificial intelligence tools in their projects. Projects where the change in the role of the architect in terms of artificial intelligence tools can be observed are discussed. The use of artificial intelligence by Jean Nouvel, Rem Koolhaas/OMA, Herzog and de Meuron, as well as star architects such as Foster + Partners, Zaha Hadid Architects, Skidmore, Owings & Merrill, MAD Architects, Coop Himmelblau, UNStudio, Morphosis and Winsent Callebaut was investigated, but no direct data on the use of artificial intelligence by these names was found in the literature. Through the analysis, the impact of the artificial intelligence programs used on the role of the architect was opened to discussion and the contribution of this impact to the literature was evaluated through projects (Table 1).

Table 1. Steps followed to analyze the research of The Role of Artificial Intelligence in Star Architects' Project Production Period

Step	The state-of-the-art AI analysis through star architects design steps	To the Topic
1	Research question	What role does AI play in transforming the role of the star architect?
2	Review area	Architectural databases (architectural literature, Archdaily, Dezeen, Star architects' personal websites)
3	Limitations	Star architects incorporate artificial intelligence in their projects
4	Sample	Identifying projects that have an impact on the role of star architects produced with artificial intelligence tools
5	Analyses	Determining the purposes and methods of using artificial intelligence in the projects of star architects
6	Result	Presentation of subjective discourse The role of artificial intelligence in the projects of star architects

4. Analysis

Artificial intelligence technologies that are transforming industries worldwide are also being used by architects. Famous architecture firms such as Foster + Partners, Zaha Hadid Architects, Skidmore, Owings & Merrill, MAD Architects, Coop Himmelblau, UNStudio, Morphosis, ARUP and

Winsent Callebaut are involved in this transformation. These studios have adopted the use of AI tools such as Stable Diffusion, Midjourney and DALL-E 2 for the initial ideas and design phases, and have also developed their own AI modules (Creative Unite, n.d.). This section examines ten (10) selected star architects' integration with technology and their use of AI in their projects.

4.1 Zaha Hadid Architects

Zaha Hadid's relationship with technology has shaped almost her entire professional life. Her mathematics education brought Hadid closer to algorithms, mathematical models and technology in architecture (Aycı, 2001; Hadid, 2012). The most important feature of Zaha Hadid's designs is her effective use of computer-aided design. Computer technologies play an important role in the background of Hadid's complex, multidimensional geometries (Yavuz, 2007; Tagmet, 2004). After Zaha Hadid's death, the office maintained its strong connection with computer technology. In 2016, Patrik Schumacher took over the office and uses artificial intelligence for spatial optimization and the impact of spaces on social behavior. Computational models produced with AI tools are preferred to simulate social scenarios (Leich, 2022). Schumacher states that the use of artificial intelligence is especially important in competition projects and preliminary idea generation. The incorporation of AI tools into the architectural design process is an important tool to sustain Zaha Hadid's brand and to effectively share ideas with clients (Barker, 2023).

Patrik Schumacher states that they use AI-supported text-image tools such as Midjourney and DALL-E 2, Stable Diffusion to generate design ideas for projects. Figure 1, 2, 3 shows a presentation of Schumacher's works on artificial intelligence (Barker, 2023; Parametric Architecture, n.d.). According to this, the studio does a lot of modeling with artificial intelligence. They develop their own 3D models by choosing “10% to 15%” of these models as a base.

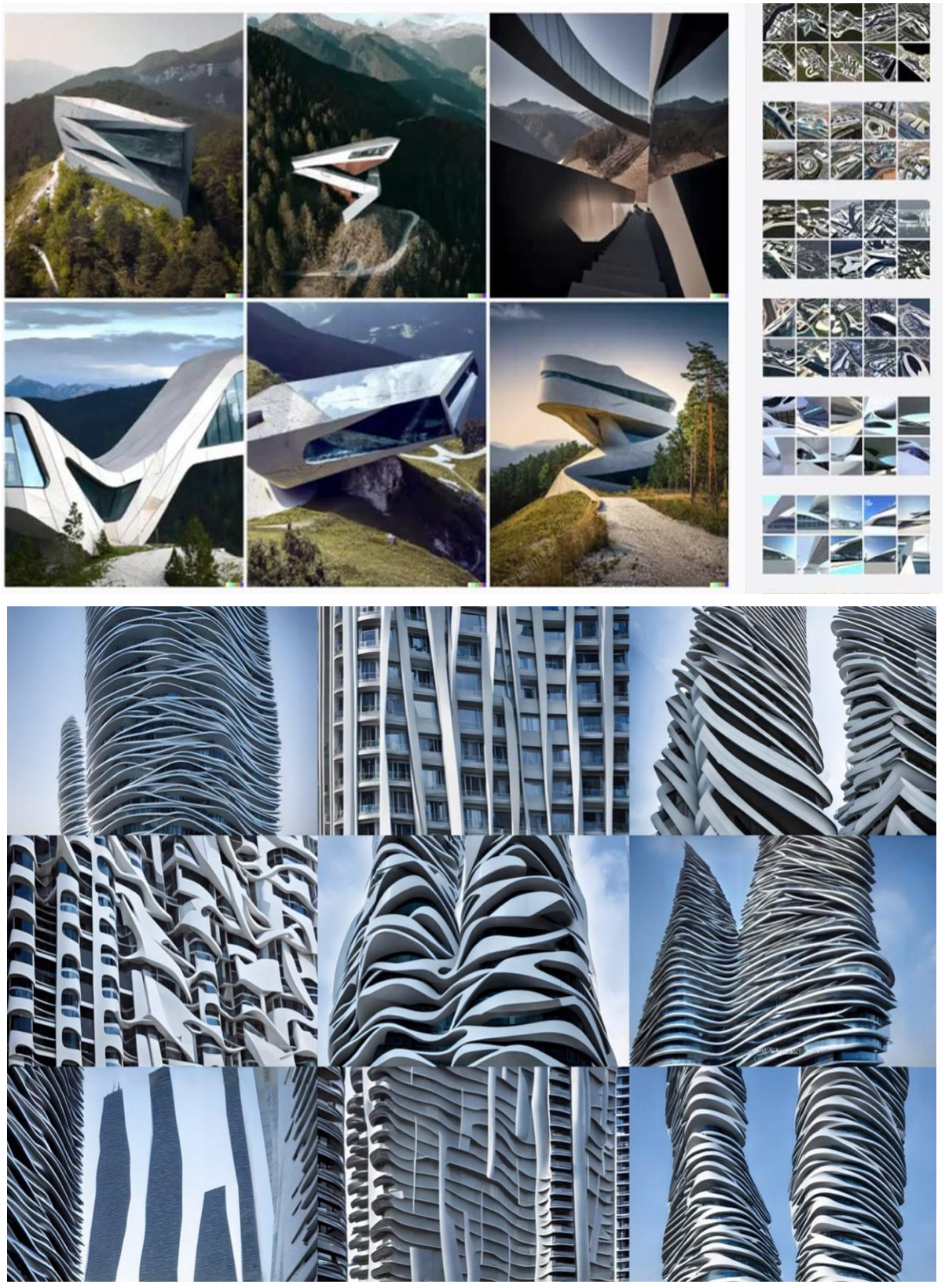


Figure 1, 2, 3: Designs produced with artificial intelligence tools by Zaha Hadid Architects (Barker, 2023)

4.2 Coop Himmelblau

Coop Himmelblau was founded in Vienna in 1968 by Wolf dPrix and Helmut Swiczinsky and is an office known for its radical and innovative approach to architecture (Johnson and Wigley, 1988). In the 1980s, with the development of Cad technologies, it began to rapidly adapt to this technology. In the 1990s, they produced complex organic and dynamic forms through computer-aided design, parametric design, and modeling techniques. After the 2000s, with the great advances in computer technologies, they included virtual reality, augmented reality and artificial intelligence tools in their design portfolio. Coop Technology is an important tool for Himmelblau, which adopts an experimental architectural vision. It utilizes the possibilities of technology at every stage of the design process. According to Coop Himmelblau, technology is intertwined with architecture and is a tool that allows architects to expand their boundaries and pave the way for new insights. They have been actively and effectively using artificial intelligence since 2022 to improve the design process (Noever, 1991).

The Office was initially skeptical about AI, and notes that there are still uncertainties about what Ai's role in this new order will be in terms of creativity. The Office is particularly concerned about the relationship between AI and creativity. According to Himmelblau, while advances in AI have shown that computers can be trained in certain criteria of creativity, the extent to which AI can develop its own creativity remains to be explored. Teaching computers to be creative is inherently different from the way humans create, but not much is known about our own creative methodology (Himmelb(l)au, n.d.). One of Himmelblau's concerns about AI is its power to control everything. It is the possibility of replacing architects. He warned architects about this and said: "Be suspicious! Be critical! Architects should remain in control. The architects should be in the front seat, and Ai in the back." (Leach, 2022, p. 102).

Himmelblau not only distances itself from artificial intelligence, but also sees it as a very promising future. According to Wolf dPrix, the co-founder of the office, AI is a tool that will one day enable architects to fly, just as feathers were developed by nature without dinosaurs ever thinking of flying, which he likes to call "Architectural Intelligence". dPrix elsewhere emphasizes the importance of AI, saying 'Ai is just a tool. But the most important co-worker in our office is Ai' (Leach, 2022, p. 102). They also believe that artificial intelligence can discover perceptual deficiencies in humans. In this way, they think that artificial intelligence will act as an important design assistant in increasing the creativity and interpretation of the designer (Leach, 2022).

In this context, the office developed the Deep Himmelblau project in 2019 (Figure 4). With this project, it is aimed to question the relationship between architects and artificial intelligence, enrich the design processes, and increase the design workflows and the creativity of the designer. It also questioned how artificial intelligence provides a solution to tasks such as interpretation, perception, creativity, and proposing new building designs. The project outperformed the architects in terms of interpretation, speed, and amount of data. However, the most important limitation of the project is that the videos are based on 2D images. In order to develop a holistic approach, they need to be 3D. This requires much more data to be processed. Another limitation of the project is that it cannot be converted into architectural technical drawings. However, despite its limitations, the project is a pioneering work in terms of analyzing artificial intelligence-architect interaction (Leach, 2022).

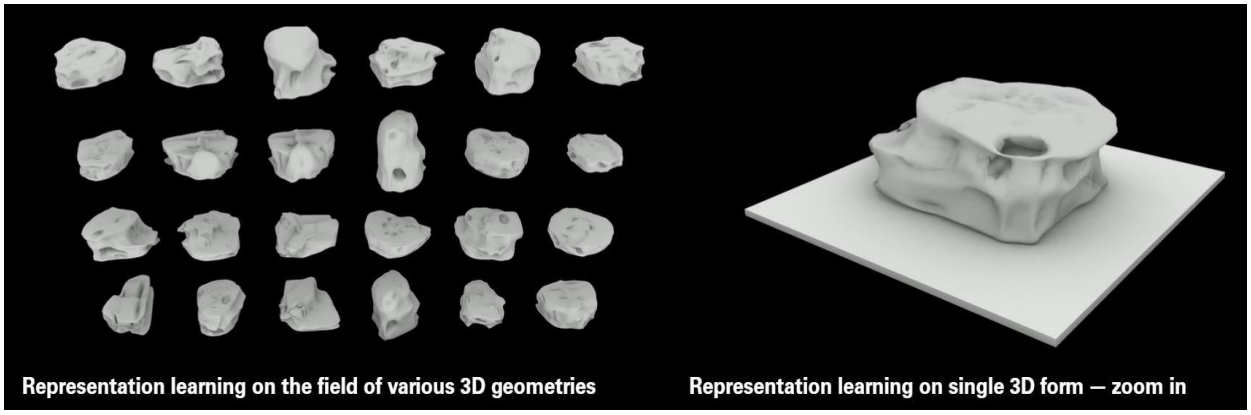
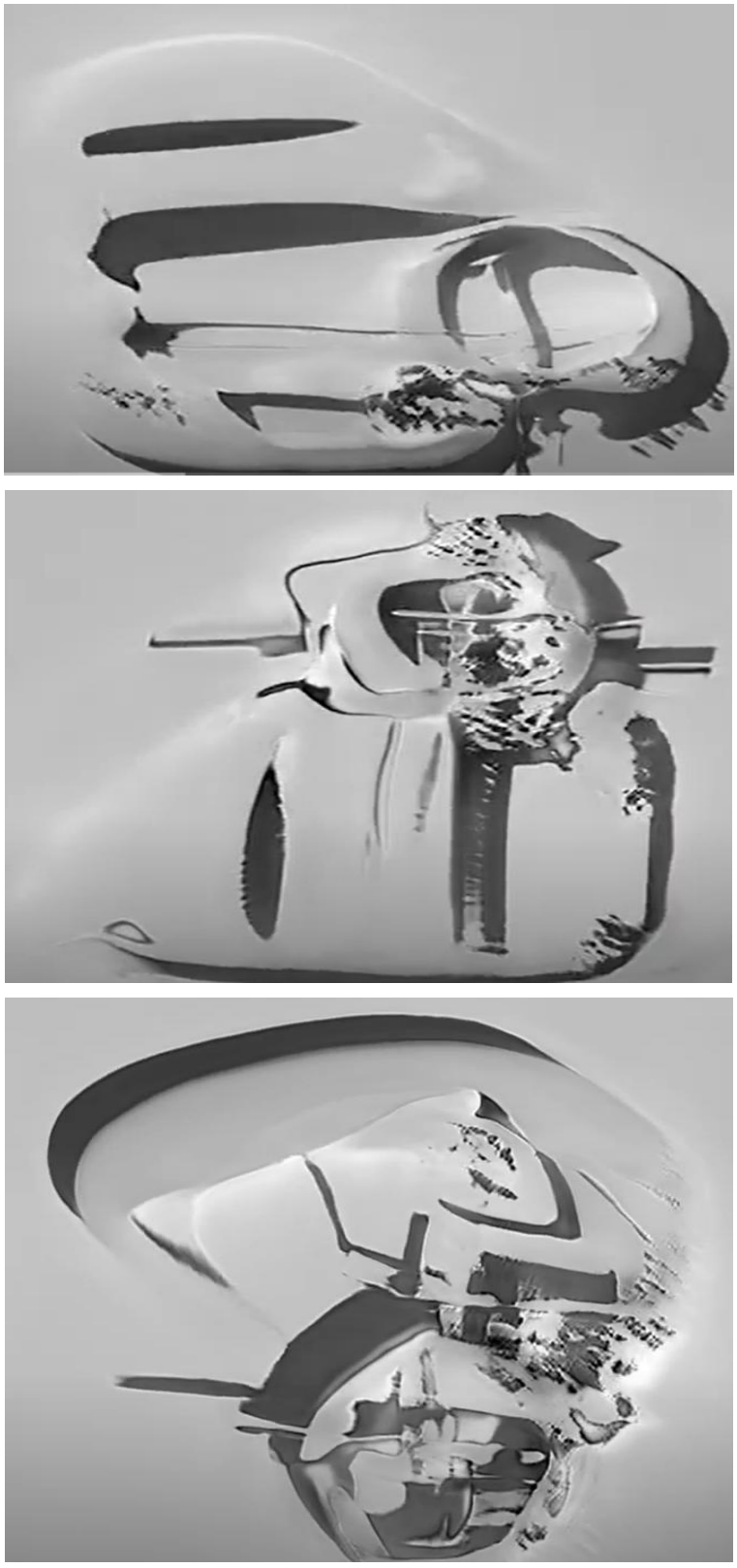


Figure 4. Designs reproduced with artificial intelligence tools by Coop Himmelblau (Coop Himmelb(l)au, (n.d.)

4.3 Morphosis-Tom Mayne

Pritzker Prize winner Tom Mayne states that the use of AI tools and technology expands the way of thinking. In this context, he sees artificial intelligence as a tool that opens new paths for architects. According to Mayne, the spatial relationship between objects can only be revealed through an algorithm-based design method. Therefore, artificial intelligence tools have an important potential for revealing the relationships between objects. In this framework, artificial intelligence tools help the designer to produce unimaginable surprise results. Another strong reason for Mayne's interest in artificial intelligence is that artificial intelligence tools can produce fast and creative geometries, provide ideas about new materials, and allow for different variations and typologies (Leich, 2022). One of the purposes of Tom Mayne's use of artificial intelligence in architecture is to scientificize the design process and design with an organized method beyond intuition. Architects normally shape the design process through mental processes to arrive at judgments and choices. According to Mayne, artificial intelligence externalizes the design process and makes it more objective.

Morphosis explores the possibilities of artificial intelligence with the Combinational Design Studies (CDS) project. In this project, similar digital alternatives are produced based on Morphosis' physical productions. Using programs and tools such as Midjourney and Grasshopper, artificial intelligence functions as an instrument of creativity. While it takes 5 days to produce a few alternatives in traditional production, 100-200 alternatives can be produced in a very short time with CDS. As a design assistant, design automation is realized with CDS without the need for a large number of designers and time (Figure 5, 6, 7) (Joyce & Nazim, 2021).



Figures 5, 6, 7: CDS ile GAN tasarım alternatifleri (Leach, 2022: 106)

4.4 Vincent Callebaut

Vincent Callebaut is a pioneering architect in the field of eco-architecture, selected by "Green Planet Architects" as one of the top fifty (50) architects for his work in sustainable design (Callebaut, n.d.). Callebaut Architects also actively utilizes the possibilities of artificial intelligence in its eco-architectural work. They use technology in sustainable cities, eco-friendly designs, smart buildings and ecological building design projects. In this context, artificial intelligence has started to shape Callebaut's projects as an important technological innovation. He uses AI in design processes to produce innovative designs, including efficiency, biomimetic and eco-friendly structures, data analysis, energy simulations and environmental analysis. At the same time, Callebaut has expanded the possibilities of using artificial intelligence not only in visual design but also in energy management and climatic optimization (Çamuşoğlu, 2023). In this context, Callebout sees AI as an alternative to BIM and uses it to produce efficient designs by combining 3D modeling and AI (Callebaut, 2023).

Vincent Callebaut Architects has developed a series of projects based on Baron Hausmann's work for the urban transformation of Paris between 1853-1870. Using artificial intelligence tools, this project, called "Hausmanian", prioritizes sustainability as the primary project goal. The project, which aims to produce its own energy and use waste as a resource, uses organic ingredients such as compressed soil, bamboo, microalgae and straw. This project encompasses a series of green buildings spread across Paris. Developed in a way that is sensitive to the historical heritage, the project creates urban breathing zones. Callebaut used artificial intelligence tools such as Midjourney and Dall-e to render the visuals of the Haussmann project. In this project, Ai was an effective tool both in the development of form and function inspired by nature and in sustainability (Callebaut, 2023) (Figure 8, 9, 10).

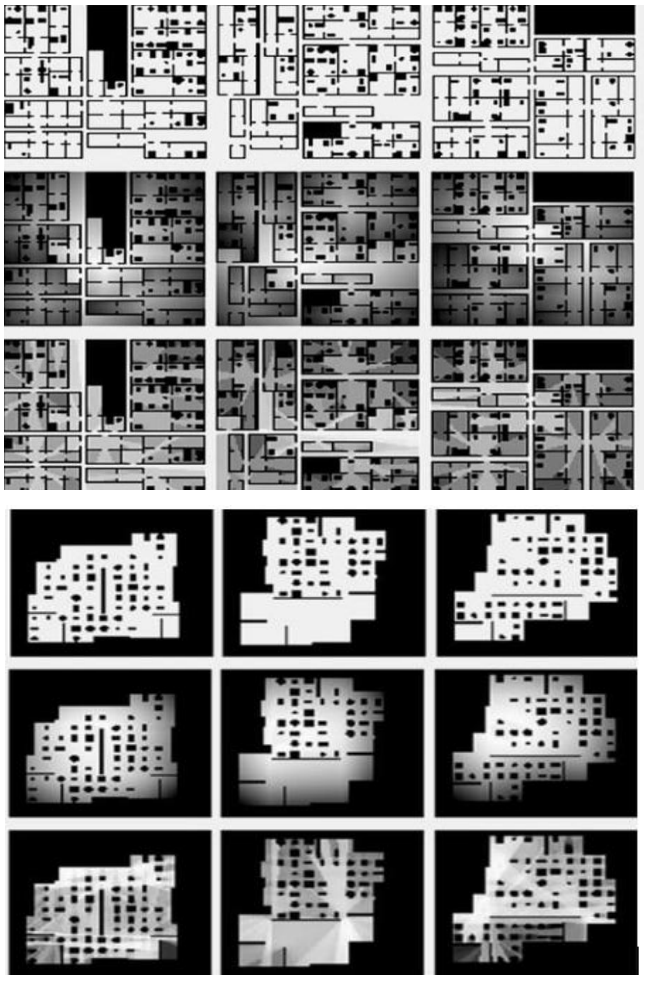
Figures 8, 9, 10: Sustainable Haussmann design developed with artificial intelligence tools by Vincent Callebaut Architects (Callebaut, n.d.).

4.5 Foster and Partners

Foster and Partners is an architecture, engineering, and industrial design firm founded by Norman Foster in London in 1967. Having produced a large number of architectural projects of different types and contents from the late 1960s to the present day, Foster and Partners (renamed after 1999) stands out in terms of architectural innovations and the use of technology (Sudjic, 2010). Foster and Partners has adopted a vision to break down negative stereotypes about artificial

intelligence. According to Foster, AI should be used to increase knowledge, intuition, and precision, to break free from routine tasks, and to optimize and push the boundaries of design. New technologies, when treated as an opportunity rather than a threat, provide the possibility to explore new ideas, increase creativity, and continuously optimize and expand the boundaries of designs (Tarabishy et al., 2021).

In this context, Fosters has established the Applied Research and Development Team (ARD) to conduct research on artificial intelligence. The team identifies specific problems and tries to solve them with artificial intelligence. For this purpose, it creates data sets of a certain quality and architecture and analyzes them. According to ARD, artificial intelligence has the ability to analyze designs faster and at lower cost. It can quickly perform simulations such as structural deformation, access to daylight, pedestrian movements, and climatic effects. In this context, the ARD team has developed the "Surrogate" model for the solution of large-scale, complex projects that require different expertise. This model, which provides real-time results, accelerates decision-making processes. This model performs spatial and visual graphic analysis simultaneously. For this, a parametric machine learning model that can generate basic office floor plans was trained. Spatial and visual analysis is performed on a dataset of thousands of floor plans. In this way, the effect of any change made to the floor plan can be seen instantly (Figure 11, 12) (Foster + Partners, n.d.).

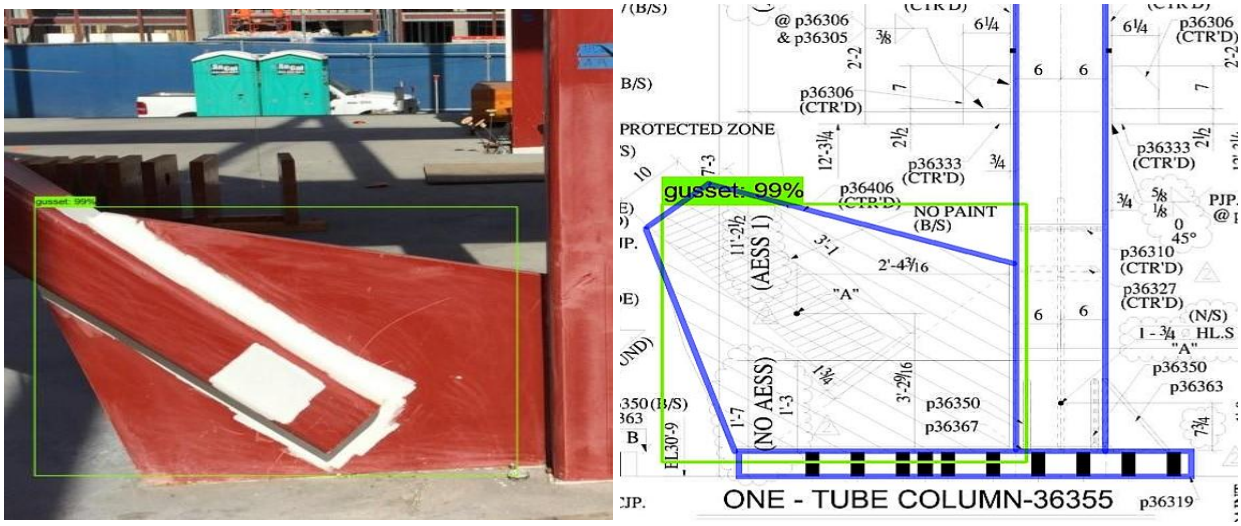


Figures 11, 12: Floor plans developed by ARD team with machine learning (Foster + Partners, n.d.)

4.6 Skidmore, Owings & Merrill (SOM)

Founded in 1936, Chicago-based SOM is a firm that provides architecture, urban planning and engineering services (Adams, 2015). SOM's use of technology in its designs goes back a long way. It was a pioneer in computer-aided design in the 1960s, developing digital tools for office use before CAD software. Throughout the 1970s and 80s, SOM's computer team worked to integrate the capabilities of the computer into various stages of the design process. The use of the computer gradually gained value in the firm as a tool for architectural innovation and became an important part of production. In the 80s, they established Architecture Engineering Systems, a forerunner of BIM for complex structural systems and energy analysis (Adams, 2019). In the late 2010s, SOM started to incorporate artificial intelligence into design processes. They produced various models to make structural analysis faster and more efficient.

An artificial intelligence model based on machine learning was developed to detect damage after a 7.1-magnitude earthquake in Mexico City in 2017. Building damages were identified and classified based on photo documentation. Thus, the post-earthquake damage detection process of buildings became faster and more efficient. With the model they developed, the team was able to detect a slow potential deterioration with artificial intelligence. They trained the model to recognize signs of change. In this way, damaged buildings as well as old and aged buildings can be monitored and documented with the model. The model can also be used to convert images into drawings and make changes where necessary. Inspections can be carried out remotely thanks to the model and the structures can be easily mapped. After this experience, SOM also used the model to document and analyze structures completed years ago. SOM has applied this new machine learning-based technology for earthquakes to other areas of construction. At the Billie Jean Library in Long Beach, California, machine learning was used to detect separations between laminated wooden beams. Dozens of images of the beams were taken and then a machine learning model was developed to analyze the separations through object detection. It was found that the separations in the beams developed due to temperature and humidity differences during transportation and installation. This model was then used to regularly monitor the separation of the beams (Figure 13, 14, 15) (Skidmore, n.d.).



Figures 13, 14, 15: An analysis with SOM's machine learning model for structural damage (Skidmore, n.d.)

4.7 ARUP

Since 1946, Arup, a UK-based architectural, planning and engineering services firm, has been using artificial intelligence for experiments related to airflow simulations in buildings (the interaction of wind with buildings). The office states that this new approach using AI offers much more freedom to explore options and arrive at the best solutions faster (Chan & Lam, 2020; Walker, 2022).

Together with the Venturous Group, the Arup office has developed the software "Neuron" (NeuronCloud.ai, n.d.) to utilize artificial intelligence in creating more sustainable and healthy buildings, neighborhoods, and cities (Figure 16). Neuron is an application that includes systems related to the built environment and combines digital technologies on a single platform. The software uses 5G, the Internet of Things, and Building Information Modeling (BIM). Neuron software also uses artificial intelligence and machine learning to analyze, optimize, and automate processes. The software includes applications to control the energy used, the health and well-being provided and the carbon emissions produced. Neuron maintains a comprehensive record of emissions from a building's entire ecosystem, encompassing both direct, purchased energy sources, such as generators and cooling systems, as well as water, materials, and waste recycling. The analysis provided by Neuron's algorithms helps to set targets and implementation plans, reduce carbon, and provide an evidence base for carbon credits (Arup, n.d.).

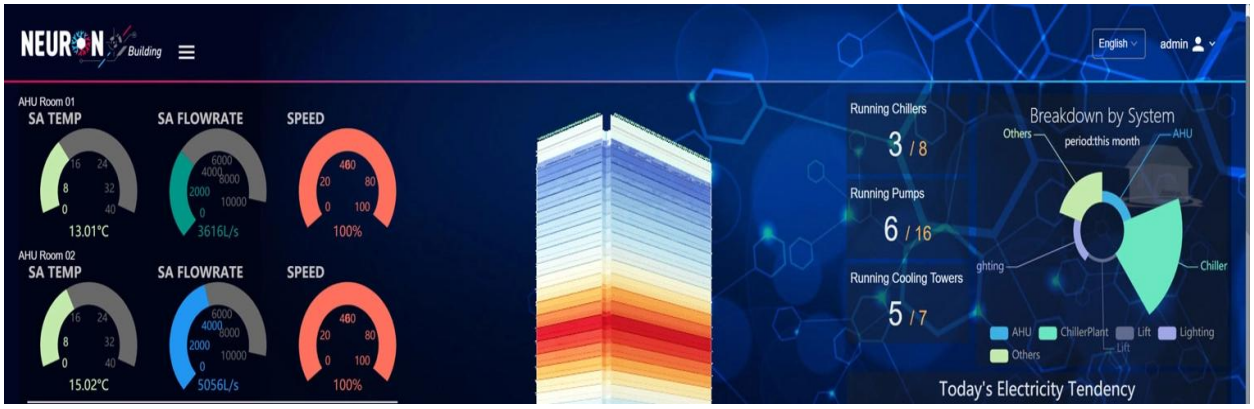


Figure 16: Neuron (Arup, n.d.)

4.8 MAD architecture

In 2004, Ma Yansong, founder of MAD Architecture in China, stated that he used AI tools to improve his designs (Taylor-Hochberg, 2022). He utilized artificial intelligence (AI) and machine learning (ML) to design the iconic Lucas Museum of Narrative Art in Los Angeles, California. The museum's innovative structural design and organic form were optimized using computational algorithms powered by AI. MAD Architects explored numerous design iterations, capitalizing on the opportunities offered by machine learning (ML). The result is a harmonious synthesis of form and function that engages visitors and redefines the architectural landscape of the city (Figures 17 and 18) (Kaarwan, 2022).

Figures 17, 18: Lucas Museum of Narrative Art (Los Angeles)

4.9 UN Studio architects

UNStudio is a firm founded in 1988 by Ben van Berkel and Caroline Bos, specializing in architecture, decoration, industrial design, urban planning and infrastructure projects. With a mission to develop solutions to social problems, UNStudio has long utilized the possibilities of digital technology. For UNStudio, which works with diagrams, computer technologies are a fundamental tool for the production and organization of design (Clercq, 2009).

UNStudio, which actively uses technology, has developed a digital module in the field of 3D architecture with the development of artificial intelligence tools (Figure 19). This digital module is an AI-supported system for product shots (UNStudio, n.d.). The system, whose working principle is simple and practical, consists of a creation phase, editing, scene addition, and finally production. In this stage, the image is transformed into a photorealistic image, allowing for modifications. Another stage is the enhancement of the image. Here, too, the system allows for increasing the resolution of the image and making it more detailed. In the final stage, the image is saved and can be downloaded (UNStudio, n.d.). Thus, 3D models are created for products and designs with this system developed by the UNStudio team.

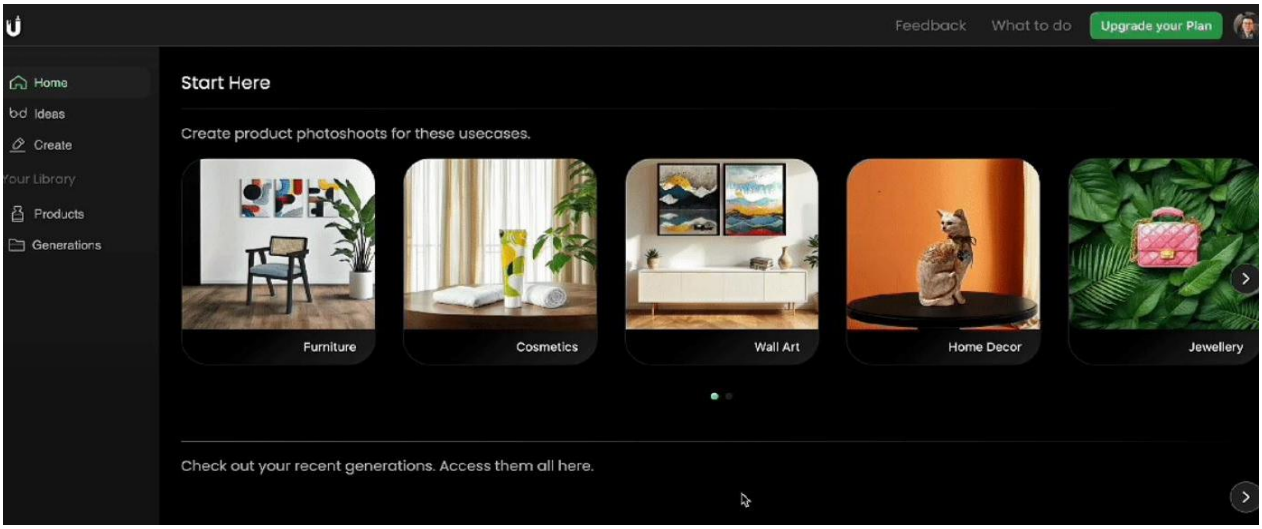


Figure 19: An image of the system's interface

A summary evaluation table has been prepared for the star architects examined within the scope of the research. In this framework, the artificial intelligence tools used by star architects, the designs they produced, the stage in the design process where artificial intelligence was used, and the evaluation information, including the role of artificial intelligence, are presented in Table 2.

Table 2. Use of artificial intelligence in star architects' projects

Architect	Artificial Intelligence Tool	Design	Using Artificial Intelligence in the design process	The Role of Artificial Intelligence
Zaha Hadid Architects	DALL-E2 Midjourney Stable Diffusion	Zaha Hadid Museum	Idea generation (Competition, project start) Social scenario generation in spatial solutions Interaction with customers	Sustainability of Zaha Hadid brand
Coop Himmelblau	Midjourney, Dall-e 2, Stable Diffusion	Deep Himmelblau Projesi	Enhancing creativity Gestalt Augmentation Representation Deep learning	Design assistant
Morphosis	Midjourney Grasshopper	Combinatorial Design Studies (Leach, 2022)	Boosting creativity Form development Optimization of design processes	Design assistant
Foster+Partners	Masque	Surrogate ve Design assistance	Early design processes Data analysis Design support model Optimization Peer/real-time support	Design and application assistant

Skidmore, Owings & Merrill	Machine learning	Earthquake analysis of Mexico City Billie Jean Library	Stages of structural analysis (post-earthquake damage assessment) Sustainability analysis Pre-production processes	Structural engineering
Vincent Callebaut	Midjourney, Dall-e 2	Haussmann	Design phase The search for nature-inspired forms Data analysis Energy simulations Environmental analysis	Sustainability assistant
Arup	Machine learning Internet of Things BIM	Neuron	Simulation Optimization Automation	Implementation and visualization Supervision and utilization process assistant
MAD Architects	Machine learning	Lucas Narrative Museum	Design phase Innovative building design Organic form production	Design assistant
UN Studio	unstudio.ai	3d AI Studip 2002 model	Modeling phase Interaction phase with users	Visualization assistant

5. Conclusions

Within the scope of the study, it has been determined that star architects use artificial intelligence in different ways, but actively in their productions. Each office adds a new and unique perspective to artificial intelligence. In this sense, the fact that star architects are pioneers in the use of technology also applies to the use of artificial intelligence technologies. Star architects have already begun to explore the possibilities and potential of artificial intelligence and are developing initiatives to become authorities in this field. At the same time, star architects make a difference in the use of artificial intelligence and lead the architectural discipline in this regard.

Each star architect has used AI for different purposes in their work and developed a new perspective on it. Callebaut uses AI as a support assistant for ecological solutions; Tom Mayne uses it as a creative design tool to increase the architect's speed; and Zaha Hadid uses it to maintain the office brand image and revitalize the design approach of a deceased architect. On the other hand, Himmelblau sees AI as a design assistant that facilitates complex tasks and replaces office workers, while SOM sees it as a structural engineer. ARUP uses AI as a sustainability tool and UNStudio as a 3D modeling tool. As a result, artificial intelligence has shaped architectural work as an important tool for star architects. While in the past, star architects stood out with their individual creativity and innovation, today the concept of a star architect has gained a new meaning with artificial intelligence. Artificial intelligence shares the central role of the architect in decision-making and even overshadows him at some points. Artificial intelligence makes the heavy lifting of data analysis, rapid development of design alternatives, and the generation of complex algorithms easier for architects. Thus, the concept of the star architect is evolving from the individual genius of the past to a technology coordinator.

Today, designers and professionals use AI largely for concept generation. Since AI still requires a user with knowledge and skills to produce useful results, it is useful to see it as a powerful tool rather than a replacement for architects. In this transformation process, being a star architect has become both partially easier and more difficult than in the past. Artificial intelligence allows architects to produce remarkable structures with design alternatives, creative solutions, and data analysis. It goes beyond individual skill and enables innovative productions to be realized. On the other hand, today, not only are creative and innovative designs not enough on a global scale, but the star architect is also expected to develop a unique vision. Star architects are asked to offer new perspectives and possibilities by directing technology. As a result, the relationship between star architects and artificial intelligence plays a critical role in the future of architecture.

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