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# Designing Tomorrow: AI and the Future of Architectural Design Process

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**Abstract**
*This essay explores the transformative role of Artificial Intelligence (AI) in the field of architecture, focusing on the impact on design innovation, production processes, as well as the ethical implications arising from inherent biases within these technologies. As AI becomes increasingly integrated into architectural practices, it offers the potential to revolutionize the discipline by enhancing efficiency, creativity, and sustainability. This investigation delves into the history and evolution of AI in architecture, tracing their journey from early computational design experiments to their current applications in generative design and robotic construction, which exemplify the shift towards more innovative and sustainable architectural practices. Furthermore, the essay highlights the involvement of the INNEN research team in integrating AI into academic and research activities within and besides the curriculum. It delves into the ways in which AI technologies are reshaping the boundaries of architectural design and construction, emphasizing on practical applications of AI in architectural design in education and professional work. This analysis uncovers the profound possibilities of AI in formulating groundbreaking design approaches and construction methods, underscoring research's role in propelling architectural thinking and practice forward through the use of technology.*

**Keywords**
AI; architectural design; transformation; sustainability; innovation

## Introduction

Current trends, available tools and methodologies used by architects have a prevalent impact on the way the built environment is designed. The use of digital tools by architects is not a new concept and started in the 70's, with the introduction of CAD software. Ever since, the architecture design toolkit has been constantly updated with new computational methods that have been enabling higher complexity and efficiency during the design process. Nowadays architects use specific tools tailored to their needs spanning from 2D and 3D design to rendering and BIM software (Cudzik et al,2018,77-84). The rise of artificial Intelligence (AI) technologies is providing significant improvements in several scientific fields including architecture. AI applications in architecture are manifested through many different forms, from producing intricate blueprints and visualizations to generating endless variations of architectural forms. In addition to the revolutionary possibilities in design and manufacturing processes, this integration highlights an urgent need to address social, cultural and ethical biases embedded in the data driving these technologies. The aim of this essay is to investigate the intricate involvement of AI in the area of architecture, looking at both the ethical implications of these technologies and their potential for transforming the design and construction field.

## Background

The architectural sector is experiencing a significant transition towards creative, effective, and eco-friendly design methodologies with the incorporation of AI, robotics and other state of the art applications. The origins of these advancements can be found in the early computational design experiments of the mid-20th century, when pioneers started investigating how computers can improve architectural creativity and design. Improvements in technology over the years have driven the industry into new areas, with robotics and artificial intelligence now being key components of everything, from the conceptual design phases to the actual construction process. AI and related applications are currently being used in architecture in a wide range of innovative ways. Generative AI platforms are being used by architects and creatives across disciplines to create elaborate images from simple text descriptions. The simplicity and efficiency of these new AI tools makes them easy to use through the concept design procedure. Such a process could be paralleled to the early stages of architectural design that involves multiple data collections from different sources, sketching, concept creation and finally design and modeling. (Ploennigs, 2023). Despite its many advantages, designing architecture using conventional design methods poses multiple challenges as it involves a significant amount of manual drawing and design modifications resulting in low efficiency.

The most popular AI platforms today are mainly diffusion models and they could assist in addressing the low efficiency in architectural design. These diffusion models are trained by learning from large datasets in order to be able to generate diverse images based on text descriptions. (Chen et al, 2023). However, current AI applications such as Stable Diffusion, Midjourney, and DALL-E 2 do not come without limitations, especially in architectural design, as these models, regardless of their extensive training datasets lack the ability to generalize, create, and simulate abstract information and are not capable of perceiving semantic information. This might, for example, include the meaning of line thickness in a floor plan, or an architecture style element in the generated architectural design. Thus, along with the rapid progression of AI enhancements in educational models and strategies in architecture, designers capable of effectively utilizing these tools with critical thinking should be cultivated.(Zhang et al, 2023, 1863). The idea for these diffusion models was first introduced by Sohl-Dickstein in (Sohl-Dickstein et al, 2015, 2256-2265). The main concept was to systematically and slowly 'destroy' the structure in a data distribution (i.e. image) through an iterative forward diffusion process that inserts noise into the data and then with a reverse diffusion process to 'restore' structure in a new form. This reverse process generates completely new (image) data, as the original structured information was fully destroyed and rearranged. (Sohl-Dickstein et al, 2015, 2256-2265). Under the prism of architecture design, stable diffusion models might reflect intriguing parallels with conceptual principles underlying the architecture of deconstructivism, as we know it from the relevant architectural discussion. In both cases, there is a deliberate emphasis on the controlled deconstruction, redistribution and organization of elements within a system. An insightful approach might point out that, just as stable diffusion models aim to evenly distribute data within a given space, deconstructivist architecture has been seeking to challenge traditional notions of form and structure by fragmenting, dispersing, and reassembling architectural elements in unconventional ways. As a concept of architectural design, Deconstructivism is not perceived as demolition but rather an enhancement of the structure by challenging the values of harmony, unity and stability. It instead proposes an approach of a structure that embraces its 'flaws', by creating new, skewed geometric compositions. (Johnson et al, 1988). Assessing architecture designs generated by AI presents a unique challenge. Unlike traditional 'handmade' architectural designs created by human architects, AI generated designs may lack historical and cultural context, as well as practical feasibility. Evaluating the aesthetic appeal and functionality is also difficult as these models produce images based on learned patterns and large data rather than human intuition and preferences. There are studies aiming at assessing the quality of architecture designs produced by AI in comparison to human-made designs with selected evaluation metrics such as Authenticity, Attractiveness, Creativity, Harmony, and overall Preference as Zhang suggests, (Zhang et al, 2023, 1863), some of the values deconstructivism was trying to break away from, raising concerns of how valid could such metrics be as global design evaluation metrics. The study highlighted that AI produced designs exhibit a competitive performance in terms of attractiveness and creativity but was limited in achieving unique attributes of human designs, therefore lacking authenticity and harmony. This is highlighting the inherent subjectivity in design and stressing that individual aesthetic preferences are pivotal in design perception.

Other studies focusing on urban design and the built environment evaluated AI models on their ability to handle challenges in urban design and planning. The findings suggested that the tested AI model was able to effectively generate images in multiple settings of the built environment, including natural real-world or abstract representations. However, it showcased weaknesses in creating realistic scenes with a high level of detail and struggled with compositionality in some scenes. Overall, the assessment revealed that 'text to image' AI models can satisfy the need of speeding up the design process of certain disciplines (such as graphic design and artistry), but for scientific design disciplines, such as urban planning and design, it indicated that further domain-specific research may be required. (Seneviratne et al, 2022). These findings highlight that existing AI concepts may not be fully applicable in architecture and its design procedure. A lot of research done so far in the design field, reuses tools developed to solve other problems. This raises critical questions about similarities of the nature of a design problem to the ones such algorithms were developed for. These point

to the need for a more intentional and tailored utilization of AI design tools, so as to cater to diverse aesthetic preferences. Furthermore, it stresses the need of developing new AI tools specifically for solving design problems. (Zwierzycki, 2020). Even though the discussion is mainly focused on generative text to image AI models, these aren't the only AI tools that could be utilized within architecture and design in its several stages. Aside from image representations, AI models can assist in structural analysis and optimization, automating drafting processes, material selection and many more. Moreover, despite the 'text to image' tools' popularity, text is also not the sole input to such AI models. There are also 'image to image' and sound to image' algorithms amongst others. Specifically, 'sound to image' algorithms could potentially further enrich the design process by enabling architects to translate auditory stimuli from the built environment into visual representations, thus enhancing overall spatial awareness during the design process.
In a similar vein, robotic technologies, further fueled by AI capacities, are transforming the building industry. Over the past few years, construction robots have been present in construction due to recent developments in microprocessors, low-cost computers, sensing technologies and AI techniques amongst other innovations. Several case studies have demonstrated the advantages of construction robots in steel and wood structure welding, interior and exterior inspection and maintenance and material handling. However, the adoption of robotics in the construction and design industry still faces many challenges due to the unique characteristics of the construction and design process. (Heyaojing et al, 2023). In the broad spectrum of emerging and innovative computer-related technologies, robotics is one of the most promising advancements of the Architecture, Engineering and Construction industry (AEC) transformation. Nowadays, the application of robotic methods is growing in architectural design and construction in a diverse manner ranging in a variety of scales, the automation of processes, 3D printing and self-assembly architecture. Robotic advancements are increasing building efficiency, decreasing waste while enabling the creation of advanced architectural morphology. Despite the active employment of robot machines and technological advancements on the engineering side of AEC, it is still new to architecture and building design and raises challenges of proper use in order to exploit the full potential of such technologies in the respective sectors. (Yi, 2021). The evolution in architecture toward robotics and AI reflects an overall shift towards embracing digital innovation to address modern issues. Apart from contributing to improving the skills of architects and designers, this change has the potential to completely rewrite the rules of what is conceivable in terms of architecture, liberating energy and potential to an era in which design will be more inclusive, sustainable, and responsive to the changing demands.

**Academic Courses**

As the use of new technologies and artificial intelligence (AI) continues to increase, INNEN's research team, led by Professor Anastasios Tellios, at School of Architecture, Aristotle University of Thessaloniki (AUTH), has been experimenting with AI tools in design courses and participated in research projects utilizing such technologies. This active involvement showcases a commitment to integrating state-of-the-art technological advancements into the academic and research domains of architecture. Through dedicated courses such as the 'Spatial Investigations' design studio, students were introduced to a curriculum that encouraged experimentation with current 'text to image' and 'image to image' AI tools. The objective was to articulate proposals for different design agendas, including smaller scale object design, design of interior spaces, urban design as well as experimental abstract solutions in order to assess the usability and efficiency of AI tools in different scales and contexts. The course required the articulation of a consistent narrative and suggested the use of several means like text, sketches, collages etc, which, through the use of AI tools, would create image representations of their spatial stories. In further steps, images produced from AI were used either as inspiration or blueprints for the 3D modeling of their proposals. This included the use of parametric design tools and automated design methodologies. The spatial models produced were afterwards articulated and fabricated as physical models as well, requiring additional 3D optimizations that would allow the models' printability. The overall design process showcased great potential in the conceptual development of design as student work produced very diverse projects despite the common origins. However, it also highlighted several weaknesses. On larger scales AI tools have been challenged to produce useful representations and fragments of such spatial images were rather preferred and put together at a later stage manually. Moreover, it also raised the issue of 2D to 3D transforming and the loss of semantic information within the generated design product. In general, this initiative not only equipped students with valuable technological proficiency but also fostered an environment that encouraged innovation and creativity, positioning them at an updated position within the related discourse.

**Research Projects**

Besides academic curricula, the INNEN research team's have further focused on implementing innovative technologies through participation in numerous European research projects. These initiatives, funded mostly by the Horizon frame by the European Commission, demonstrate how essential international cooperation is in advancing architectural research and practice. Projects such as V4Design, MindSpaces and ReSilence represent an example of the research activity co-implemented by INNEN. They all include various applications of advanced technology, parts of AI modules and attempts to relate to architecture, among other fields, and improve the architectural procedure. The 'V4Design' initiative aimed to integrate state of the art technologies in order to transform visual and textual data into 3D models and designs. This program seeked to reinterpret existing visual materials, such as paintings, photo-

graphs, and videos, into new architectural and design inspirations, resembling and simulating the way AI tools operate. This innovative approach enhanced creativity and innovation in the field. 'MindSpaces' focused on the intersection of technology, architecture and the arts to create immersive and responsive environments. These environments were able to adapt to the emotional and cognitive states of their participants. By exploring how AI-driven modules can tailor architectural and urban spaces to human needs and experiences, MindSpaces encourages a more intimate connection between the built environment and their users. 'ReSilence' uses new technologies such as AI & XR to explore the borders between noise and music in the rapidly changing environments by producing acoustic awareness in urban spaces. In ReSilence technological applications including AI tools are utilized in several domains such as natural language processing as well as 'sound to image' translation in order to visualize sonic stimuli of urban spaces. Additionally, the project aims at creating new types of sonic urban experiences that expand possibilities for accessibility, active participation and engagement, sustainability, and social inclusion. Additionally, the 'ReSilence' project requires the involvement and collaboration of artists, which is considered as pivotal in order to establish interdisciplinary collaboration schemes, exploiting the full potential of AI and XR technologies.

**Conclusion**

In conclusion, this essay tries to discuss the yet undisclosed intersection of AI as well as other state-of-the-art technologies with architecture. It explores the evolution of technologies from their foundational role in computational design to its transformative impact on modern architectural practices and construction. This exploration uncovers how AI and state of the art procedures not only enhance design and construction processes through innovation and efficiency but also to point out conceptual and ethical complexities and biases yet uncovered and not fully evaluated. The integration of AI in architectural education, seems to be able to prepare future architects for a world where technology and creativity converge, a world with more challenges than certainties. Technology and advances can definitely transform architectural design, they have done so repeatedly in the last decades. Wishfully, they would be directed towards a more sustainable, more inclusive, and more human-centric built environment. However, this future necessitates a balanced, resourceful approach that takes into account ethical dimensions of technological integration. Collaborative efforts of educators, researchers, and practitioners play a vital role in shaping an architectural landscape that harnesses the power of technology while remaining grounded in ethical principles. The work of the INNEN is aligned with current discussion on the topic and operates towards positively exploiting new tools in the design process of innovative, dynamic, thoughtful environments. In this framework, this essay attempts to provide guidance for navigating the complexities of technological frontiers, AI among others, with foresight and responsibility.

**Reference List**


Chen, J., Wang, D., Shao, Z., Zhang, X., Ruan, M., Li, H., & Li, J. (2023). Using Artificial Intelligence to Generate Master-Quality Architectural Designs from Text Descriptions. *Buildings*, 13(9), 2285. https://doi.org/10.3390/buildings13092285

Cudzik, J., & Radziszewski, K. (2018). Artificial Intelligence Aided Architectural Design. *Computing for a Better Tomorrow*, 77-84. https://doi.org/10.52842/conf.ecaade.2018.1.077

Heyaojing, H. et al. (2023). Exploring a Design for Robotic Construction Approach: Two Case Studies Matching Robot Construction Design Features. Presented at the *40th International European Conference on Computing in Construction*, July 10-12, Heraklion, Crete, Greece. http://www.doi.org/10.35490/EC3.2023.202

Johnson, P., & Wigley, M. (1988). *Deconstructivist architecture*. Museum of Modern Art, pp. 11-20.

Ploennigs, J., & Berger, M. (2023). AI art in architecture. *AI in Civil. Engineering*., 2, 8. https://doi.org/10.48550/arXiv.2212.09399

Seneviratne, S., Senanayake, D., Rasnayaka, S., Vidanaarachchi, R., & Thompson, J. (2022). DALLE-URBAN: Capturing the urban design expertise of large text to image transformers. In *International Conference on Digital Image Computing: Techniques and Applications* (DICTA), Sydney, Australia, pp. 1-9. https://doi.org/10.1109/DICTA56598.2022.10034603.

Sohl-Dickstein, J., Weiss, E., Maheswaranathan, N., & Ganguli, S. (2015). Deep Unsupervised Learning using Nonequilibrium Thermodynamics. *Proceedings of the 32nd International Conference on Machine Learning*, in *Proceedings of Machine Learning Research*, 37, pp. 2256-2265. https://doi.org/10.48550/arXiv.1503.03585

Yi, H. (2021). Robotics application for the advanced integration of design and technology in architecture. *Computer Applications in Engineering Education*, 29(5), 1146–1162. https://doi.org/10.1002/cae.22370

Zhang, Z., Fort, J.M., & Giménez Mateu, L. (2023). Exploring the Potential of Artificial Intelligence as a Tool for Architectural Design: A Perception Study Using Gaudí's Works. *Buildings*, 13(7), 1863. https://doi.org/10.3390/buildings13071863

Zwierzycki, M. (2020). On AI Adoption Issues in Architectural Design Identifying the issues based on an extensive literature review. *Proceedings of the 38th eCAADe Conference held at TU Berlin, September 16-18, Volume 1*, pp. 515-524, Berlin, Germany. https://doi.org/10.52842/conf.ecaade.2020.1.515