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A Review of AI Image Generator: Influences, Challenges, and Future Prospects for Architectural Field

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ABSTRACT

Recently, the topic of text-to-image-based GAI *(Generative Artificial Intelligence)* or AI Image Generators became so popular because of its sophistication in creating images based on human natural language messages in a short time. On the other hand, the presence of the AI Image Generator is enough to reap various opinions, including in the field of architecture. Therefore, the purpose of this paper is to present a review of the influences, challenges, and prospects of AI Image Generator technology in the architectural design process. The research method used is a systematic literature review by reviewing 12 scientific articles, five books, and five official websites. The results of the study explained that the AI Image Generator could provide one step forward to expand the design imagination by presenting several design alternatives with high-quality visuals. The challenge lies in the user's proficiency in providing text commands that AI programs can detect. The prospect of this program, if developed in more depth, is to become a rendering tool that can release dependence on devices with high specifications and additional editing applications.

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1. INTRODUCTION

The advancement of information and communication technology (ICT) science has brought all aspects of life to a new era. Technological developments are happening everywhere, and almost everything has become fast-paced and modern [1]. The world of architecture is one of the professional fields currently enjoying the impact of advances in computer system technology, one of which is the presence of Artificial Intelligence [2]. According to John McCarthy, one of the "founding fathers" of Artificial Intelligence, AI is a system of statistical approaches that aims to know and model human thought processes. The artificial intelligence system is then used to design machines or neural networks that can adopt human behavior in making decisions and taking actions with good morals. Astute means knowledge coupled with experience [3].

The presence of AI has become phenomenal and continues to be a hot topic because AI is claimed to help architects, designers, and students manage any information related to 3 Dimensions. Besides that, simulating building design analysis to the stage of visualizing design work results in a more efficient work travel time than in previous times [4] [5]. The researchers also predict that the current and future fields of architectural work will be heavily integrated with AI technology, primarily when operating intelligent computers to use architectural design software [6].

The year 2022 has become a trend of the GAI (Generative Artificial Intelligence) program based on text-to-image, the AI Image *Generator* [7]. Active users of social media, of course, will be aware of the large number of image uploads resulting from AI Image Generator technology, which makes several people curious

and even addicted to using the tool [8]. Since the OpenAI research lab launched the AI Image Generator-based tool DALL-E, AI technology has further riveted and surprised the public with its ability to automatically create images in a few seconds using only user-given textual commands. Referring to OpenAI company data from April to September 2022, it is recorded that there are already 1.5 million application users and can generate an average of 2 million images per day [9]. The AI image generator allows anyone to realize the wild fantasies of the human mind into amazing, detailed digital images that have never even been thought of before.

Before this text-to-image-based AI technology was famous, there was already an Ai-Da robot, the world's first ultra-realistic artist, created in February 2019 [10]. Ai-Da robots can create drawings, paintings, and sculptures to the latest, making poems quickly [11]. Then in August 2022, the Colorado State Fine Arts competition attracted many controversies because the painting created by AI used by a participant named Jason M. Allen, a game designer, came out as the winner of the event competition. The image, entitled D'opéra Spatial, was created using AI-based Midjourney tools.

(a) (b)

Figure 1. (a) Ai-da Robot Creates Queen Elizabeth II painting, (b) AI Painting
Sources**:**[12], [13]

AI image generator technology is also applied to architecture as an experimental tool to present several design alternatives. Within this year, several leading companies have released updated versions of text-to-image free AI tools, such as Mid Journey and DALL-E [14]. Both softwares are beneficial in the design industry in creating great architectural concepts [15]. Users only need to input a list of the desired architectural design criteria, and in a few seconds, the software will present several alternative design drawings. With such an automation system, anyone can create architectural designs without significant requirements and effort.

Thanks to this sophistication, there is currently a lot of criticism caused by AI Image generators, be it about ethical issues, impact, to concerns about replacing the figure of the architect [16]. Based on the discussion above, this scientific article reviews the influence of AI Generator Architecture technology in helping the architectural design process. This paper aims to look at several aspects consisting of (1) Influence, (2) challenges, and (3) prospects of these technological systems in the world of architecture.

1.1 Natural Intelligence and Artificial Intelligence

In general, intelligence is divided into two types: natural and artificial. Artificial Intelligence (AI) is a computer science that focuses on the ability of machines to mimic human behavioral intelligence. Ai allows computers to process and infer much data information in a relatively short period displayed through a program or machine system [17]. Kelley & Knowles defines AI as a set of techniques, machines, or programs that he names *"human and machine crossover"* as a combination of man and machine [18]. Despite having a myriad of advantages, AI has limitations compared to the natural intelligence (Human Intelligence or Natural Intelligence) obtained from the process of life revolution.

The explanation above is also based on the statement of the intelligent robot Sophia who said that humans have advantages that do not have robots, such as sympathy, empathy, artistic spirit, and natural creativity that is true. Robots are indeed more involved in processing numbers and repetitive programs. Still,

robots can only work optimally to become teachers or leaders if they need to understand what others think and feel natural. Robots result from human creation that works limited to managing data inputted and understood by programs [19]. The following is a table showing the comparison between natural and artificial intelligence.

Table 1. The Difference Between Natural Intelligence and Artificial Intelligence

NATURAL INTELLIGENCE	ARTIFICIAL INTELLIGENCE
Natural Intelligence resides in the human brain.	Artificial Intelligence is applied to robots, programs, or machines [20].
Humans think naturally, starting from the eyes. Then, the visual information is sent to the brain for processing or manipulation [21].	A system that thinks "like a human being." Information stored on a computer is used to answer questions and create a new report [21].
Very quickly experiences changes in memory (because humans are forgetful)[21].	It tends to be permanent because the stored data will stay the same as long as the creator and the computer system do not change it [21].
Transferring knowledge from one person to another requires special skills. This process is not short, and no certainty distributing knowledge will be successfully shared or duplicated precisely the same [21].	Specific designs and experiments on machine systems or devices should be carried out to add new knowledge. If the experimental results are successful, the opportunity for data transfer and duplication will get the same results, making duplicating and deploying easier. Therefore, the intelligent machine or computer's intelligence network can quickly transfer to other programs or devices [21].
Have a nature of sympathy and empathy [19].	It's neutral because it doesn't see who is using it.

1.2 A Brief History of AI Involvement In Architecture

Architecture is a field of work that is in the field of design and construction [22]. Art and architecture are like symbiotic relationships that are difficult to separate [23]. It was during the invention of computers in the 1950s to 1960s when the resulting patterns and shapes were simple, implied by the history of AI that produced artworks. In 1970, AI-made artworks began to be widely used in CAD software programs. CAD devices allow users to create and manipulate complex and realistic 3-dimensional shapes. In the 1990s, AI-generated artwork was no longer just for visual effects. The artists started using AI algorithms to generate movies, music, poetry, and more [24].

AI algorithms can create images or animated videos that look very realistic based on a set of parameters to create new images by combining, transforming, and generating image data. The neural network can also create a work that mimics a particular artist's figure or style. This technique creates new artworks by adopting other pre-existing art styles through Generative Adversarial Networks (GANs) to transfer art data using Deep Neural Networks. Generative Adversarial Networks (GANs) are typical networks that are often used to stigmatize data from the conceptual stage [25]. Therefore, GAN is a potential candidate for producing images or videos with a series of networks that control it [26].

In Gatys and his team's research paper entitled A Neural Algorithm of Artistic Style, the main idea is to use the Convolutional Neural Network (CNN) system. Figure 2 describes the flow of CNN's program in visualizing images. The first thing to do is design a feature space with multiple network layer responses to capture various image style information, forming a correlation network. The entered images serve as image data sets which are then filtered at each processing stage in the CNN system. The construction of the drawing style in parts (a), (b), (c), (d), and (e) creates an image that is integrated with a particular drawing style (the initial data section), thereby creating a new picture style. These experimental results found that the system can independently manipulate representations to produce new, perceptually meaningful images. The results of this study are one of the bare references used in AI technology networks to create art, especially digital images.

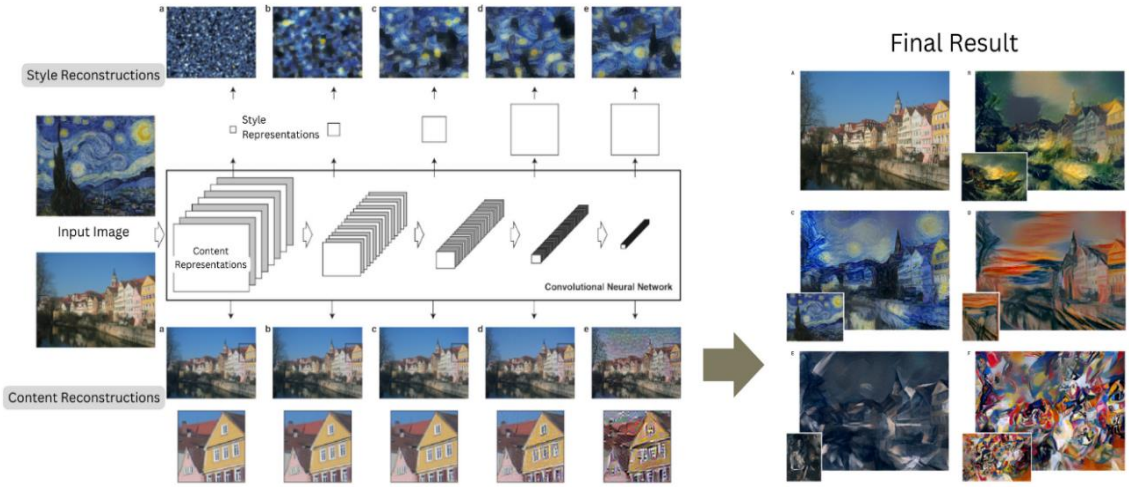

Figure 2. *Convolutional Neural Network* (CNN) To Visualize Images.
Source: [27]

1.3 AI Image Generator (Text-to-image generation)

Recently, GAI tools based on text-to-image generators have significantly progressed [28]. The beginning of 2021 will be when advances in AI research can create a device called the AI Image Generator. This progress is due to the text-to-image synthesis used as a transformer method to achieve the best performance in terms of image quality, text-image relevance, and analysis of the scope of the domain [29]. Specifically, an AI image generator is a computer program that uses deep learning algorithms and text-to-image generation. This algorithm is trained on various image data and parameters to learn to generate new images that match the user's text descriptions. In the world of research, the technique of producing images like this is called text-to-image synthesis, which represents a complete set of textual information so that it is easier to understand [30].

The generation of a text-to-image program is the opposite of the generation of an image-to-text. This latest program answers current work needs requiring more unified framework modeling [31]. Figure 3 and Figure 4 show the sophistication of AI system technology to provide several alternative architectural facade designs for one building. We are not only experts in providing alternative building facade designs, but we can also offer alternative designs for interiors and furniture.

Figure 3. Design Results From The AI Image Generator Program Instructed By Tim Fu (Designer At Zaha Hadid Architect)
Source: [32]

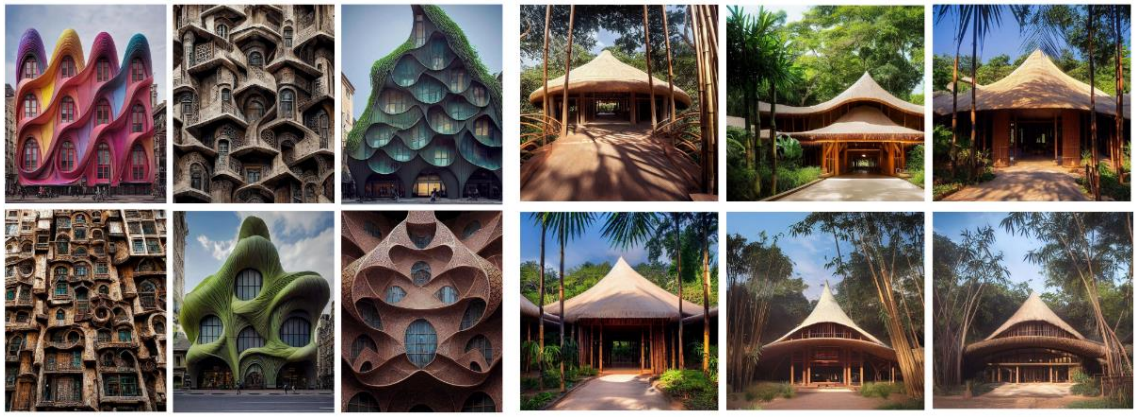

Figure 4. AI Image Generator Design Results Instructed By The Parametric Architecture Bureau Team And AI Metaverse
Sources:[33], [34]

2. RESEARCH METHOD

This paper uses a systematic literature review method by examining 12 journal articles indexed by Google Scholar, ScienceDirect, Springer, or other journal article media, filtered using the Publish or Perish application to find relevant articles to the topic discussed. According to research conducted by Sulaksono and Nursyamsi, a systematic literature review consists of several steps, including (1) compiling research questions, (2) identification of article keywords, (3) screening of articles, (4) analysis of results and discussion and, (5) conclusion [35].

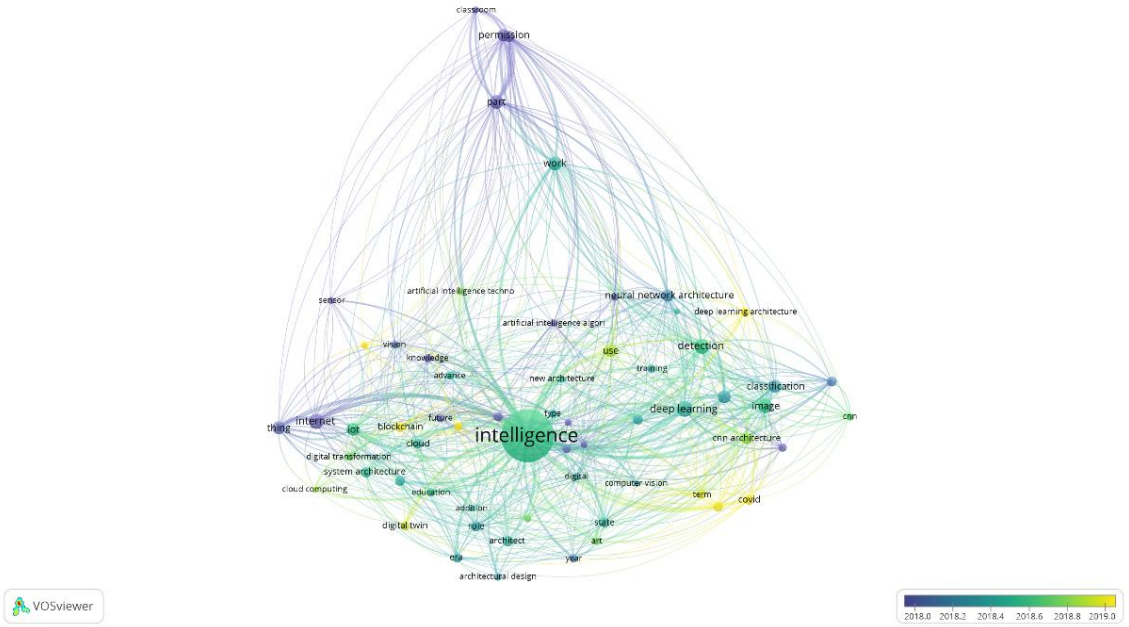

Figure 5. Vosviewer Analysis

Figure 5 is the result of bibliometric analysis using VOSViewer from RIS data containing 79 articles which aims to find the latest research scope. The results of the data mapping show that the novelty of research topics regarding AI tends to lead to the issue of deep learning architecture (yellow color).

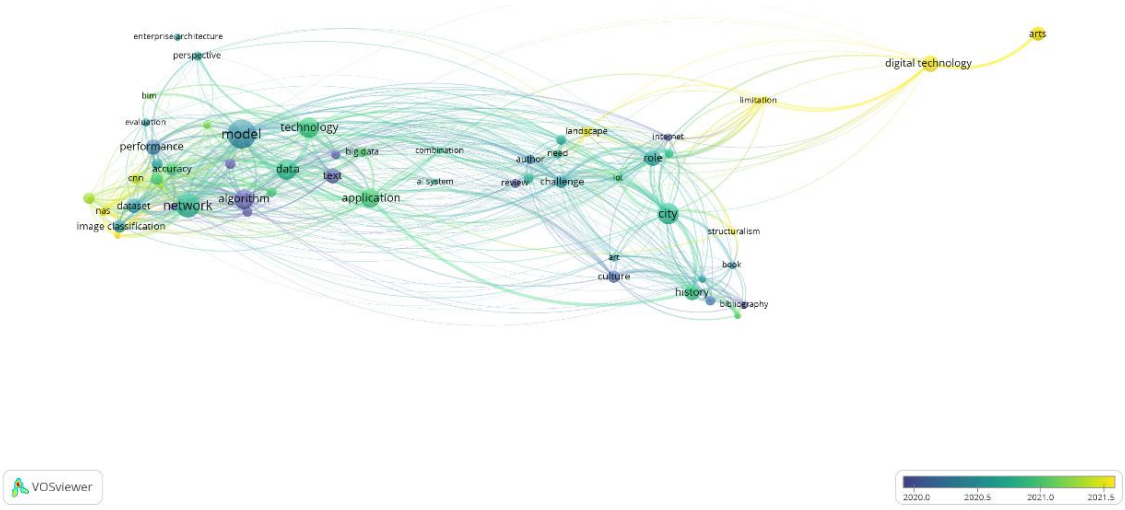

Figure 6. VOSviewer-Overlay Visualization

Figure 6 is an advanced mapping based on more specific keywords related to AI and deep learning architecture. The final results of the VOS viewer's analysis explain the relationship between the topic "AI System" from 2020 until now, discussing issues regarding algorithm text, perspective, image classification, technology application, and digital technology that led to the arts.

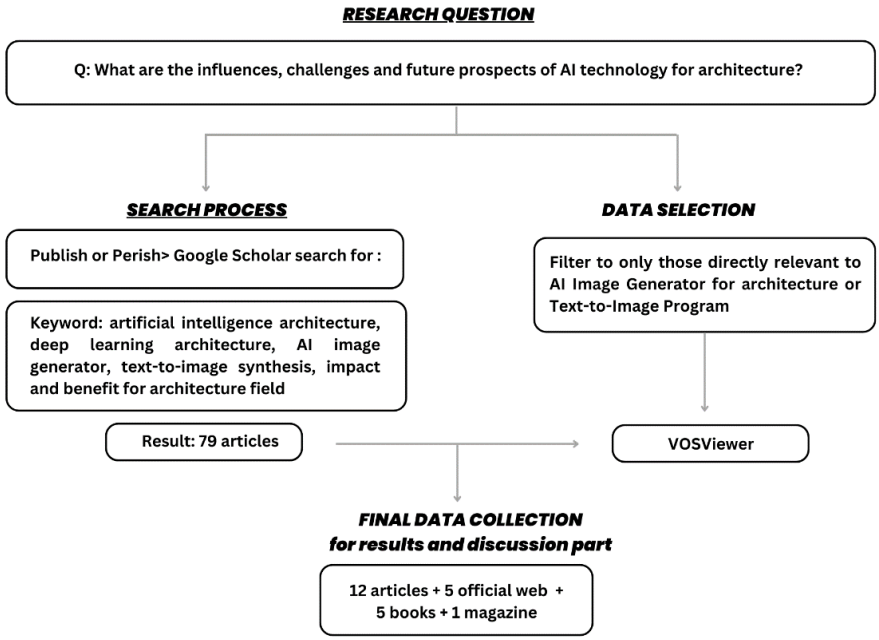

Figure 7. Diagram of Methodology

Figure 7 depicts the research methods workflow as a systematic literature review of this paper. In the initial section, 79 articles intersect with keywords. Furthermore, screening was carried out according to the research topic related to "AI Image Generator and based on text-to-image programs," obtained only 12 relevant articles. Then the final data collection is expanded again by utilizing various other library sources. The reason for development is that the AI Image Generator topic is still very new, so only a few journal articles have reviewed it. Therefore, official websites (not blogs) such as Microsoft, ArchDaily, OpenAI, and Midjourney are also used as supporting data to find more up-to-date reviews about the impact, challenges, and prospects of the AI Image Generator program, especially in the architectural environment.

3. RESULT AND DISCUSSION

By the research objectives, this section will explain the influence, challenges, and prospects of the AI Image generator program for the world of architecture.

3.1 The Influence of the presence of AI Image Generator on Architectural Design Stages

The AI image generator is a tool for converting text into images, objects, or scenes that are nearly accurate and realistic based on the user's imagination [30]. The AI image generator provides time efficiency because it generates images from text descriptions in a few minutes by relying on a data set of text and image pairs so that users can type prompt text using natural language. The program will automatically create architectural design drawings. Architect Maria Christina Florian believes that this technology makes it easy for architects to combine the abstraction of complex thought concepts into visible relationships in tangible design results. This idea inspires and encourages architect designers to explore more design alternatives from new perspectives. Kory Bieg, director of the architecture program at the University of Texas at Austin, said this technology allows for practical and unlimited capabilities design. Architect Manas Bhatia thinks it will allow architects to explore new design ideas without spending too much time developing the vision and mission of design [36]. Text-to-image synthesis is a step forward in realizing and expanding the human imagination [2].

Architecture involves many stages of work to translate client needs and aspirations into building forms by creating drawings and specifications that determine the outcome. With a process of work stages, the work process will become focused. It will lead to reduced quality of work, so accuracy is required and very important to achieve successful results. The stages in the design process, according to the Association of Indonesian Architects in the book *"Guidelines for Work Relations Between Architects and Service Users"* Article 36, are as follows:

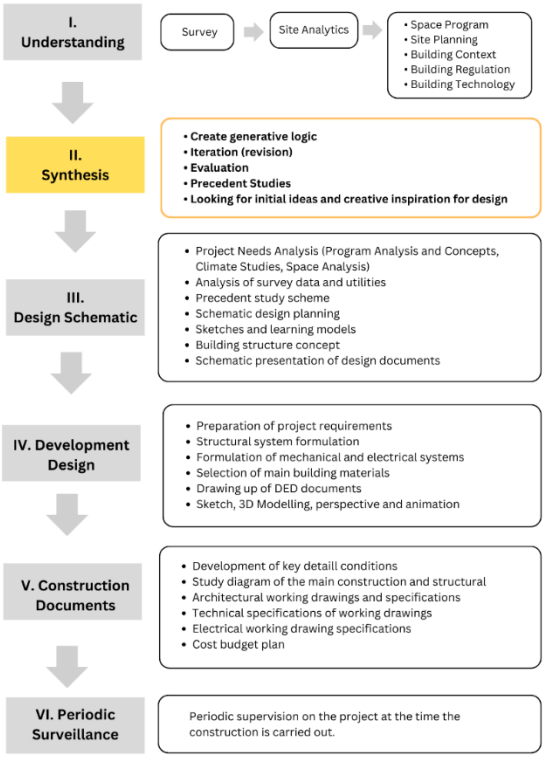

Figure 8. A Brief Schematic Of The Architectural Design Process According To IAI.
Source:[37]

Based on the description of the tasks and functions of the AI Image Generator program, this technology is currently contributing to stage 2 (synthesis) of the architectural design process, which is presented in Figure 8. At this stage, generally at both the professional and educational levels, most use social media such as Pinterest, Instagram, or websites to work on design projects by seeking presidential studies or creative ideas. The site is a facilitator that provides users with data in images according to the topic or keyword search the user has written [38].

The image data universe is then used as a processed material for visual inspiration media or mood boards. By definition, a mood board is a set of color, texture, material, or design style design elements to form the identity of a project. These elements are often collected during the early stages of the design process, especially in seeking ideas and serving as inspiration for what the project will look like or where it will go [39]. The limitations of the current image facilitator application are that it can only display images in general. This limitation is because users cannot directly enter specific image boundaries or criteria, and there is no auto-edit feature to remove or add components from ideas that have been presented. By looking at the current limitations, the presence of an AI image generator can answer the needs of recent work that requires more 3D modeling for a unified framework [31]. In the near term, it will significantly assist the acceleration of work, especially in the early stages of the design process, as a facilitator of design alternatives.

3.2 The Challenge of the Presence of AI Image Generators in the Architectural World

Apart from the benefits, the AI image generator's presence has also drawn much criticism. Many argue about the threat of losing several types of jobs because of this automation program [40]. Based on the explanation of the differences between natural and artificial intelligence described in table 1, it is explained that the advantage of artificial intelligence is in the ease of transferring, duplicating, and adding new knowledge quickly [20], [21], [41]. However, technical constraints also cause factors inhibiting the development of AI in architectural design. Both are from the ability of human resources who have not kept up with trends in technological developments or from the hardware used to use the AI Image Generator Software and relatively expensive software prices and the translation of building designs that are not yet technical [42].

The AI Image generator does look very attractive. However, the limitations of this automation program lie in the network system, which requires hundreds of millions of high-quality image and text data to learn to create new images that are not available to the public and, of course, requires a lot of budgets in the process of updating the data [31]. Figure 9 shows one of the chatbot service features of the AI image generator program. Apart from that, it also shows how the real challenge lies with humans as users who act to give text commands so that they can be understood by AI programs so that the resulting images can accurately reflect the intent of the underlying text commands [29]. The more proficient the user is in composing text commands; the better the alternative design results will be.

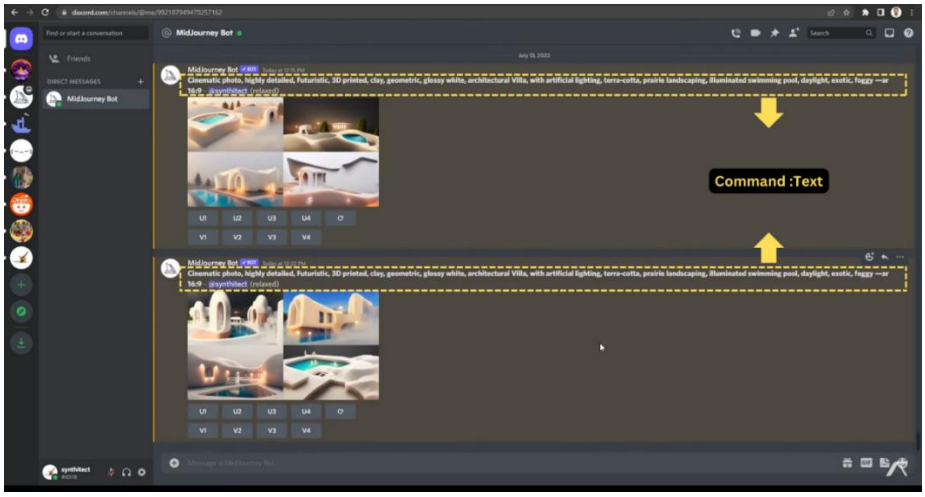

Figure 9. The AI Program Chatbot Service's Features Can Realize Designs from Natural Language Text Commands. Source:[43]

In addition to program technical matters, architects as a built environment must be careful and consider other architectural aspects, such as several possibilities to be realized in actual development combined with issues of clever city design and sustainable architecture. They are the main aspects of concern in various fields of action currently [44]. So that the design results created are magnificent aesthetics, low carbon emissions, and friendly to the environment. According to Cynthia G. Wagner in writing future world society, there are three approaches that architects can take to deal with current technological conditions, namely: (1) retrofitting, adding expertise to the current field of work, (2) blending, namely combining skills and benefits from current job to a different industry to find a new specialization, and (3) problem-solving, namely solving future-oriented problems as one of the new and unlimited needs [45].

There has been much discussion about whether machines can replace the architect profession. According to Frey and Osborne's research on fields of work that are very vulnerable to being replaced by computers, the research results show that the architectural profession is ranked 82 out of 700 types of work that are the research sample. In contrast to the masonry profession, which has a rating of 455/700 with a probability level of 0.82, architects still have an opportunity to play an active role [46]. Anyone can do design, but each designer's ability distinguishes it. The ability to design is part of human intelligence, and that ability is natural intelligence [47]. Humans have a history that is not short to be able to have the ability to design, as evidenced in history, where architecture is part of the artifacts of previous civilizations and has become a design tradition that will continue [48].

3.3 Summary Of Human Workflow and AI Systems Using Image Data

Undeniably, the digital visual aspect is one of the essential points for presenting design results and portfolios for architects. However, the thing that still needs to be solved for architectural stakeholders is realizing the visualization of the design itself because it requires a computer or laptop with high specifications, and the rendering process still takes hours or even days to get it right. So, instead, produce quality 3D images or animations that look realistic [49], [50].

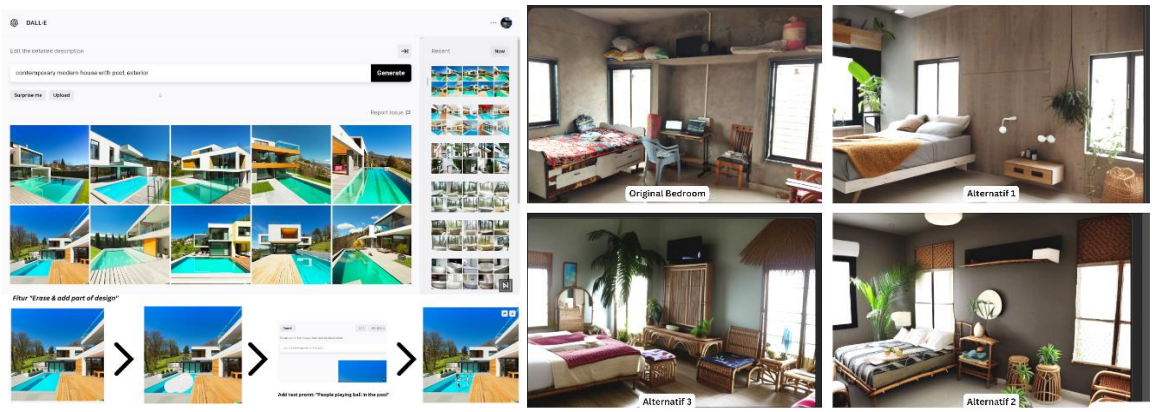

Figure 10. Erase And Add Part of Design Features and Generate Design Results In Programs Based On The AI Image Generator. Sources: [51], [52]

Looking at the technological power offered by the AI image generator to make significant changes in creating images in terms of exterior, interior, and furniture details [53]. If studied more deeply, it can become an AI Architecture Generator program that provides superior all-in-one rendering features in the future. Helpfully assist architects, designers, or students in rendering and automatically editing quality results. Efficiently, quickly and can be done on any device. Thus, this technology will not only be in the position of stage 2 but can spread up to stage 4 of Architectural Design (Figure 8). Currently, AI image generator-based programs still provide broad free access for users. If the world community shows increased enthusiasm, no one can confirm whether this program will continue to offer free services or incur additional subscription fees for some unique features.

3.4 Summary of Human Workflows and AI Systems in Using Data Image

Referring to all the reviews in the previous section, a summary of human workflow and the AI image generator system is obtained, presented in Figure 11. The description in table 1 regarding the differences in natural and artificial intelligence shows the difference between humans and the AI image generator program in using and processing image data collections. Humans use images to find inspiration and increase creativity in designing. All these images are processed in the human brain and mind based on feelings and memories of existing experiences [38]. Meanwhile, the AI image generator program uses a cloud database-based data collection as samples or datasets to translate and combine images based on human text commands [42]. When a human or user gives an order in the form of text, the AI program will read and start searching for a collection of data universes that have been arranged in such a way as to create several alternative new design drawings. Therefore, humans act as operators who create and operate AI systems as a tool to find inspiration and alternative architectural designs that are more sophisticated, fast, and close to precisely because they match the design parameters inputted into the cloud database platform.

Regarding the role of humans as operators and AI as software, they can divide their respective roles. For example, humans (architects and designers) who have a working code of ethics and excel in analyzing essential aspects of the design can become coordinators who provide design boundaries and parties who validate and provide decisions [54], [55]. Meanwhile, the AI image generator, an expert in processing computer program data, can act as a tool for the architect.

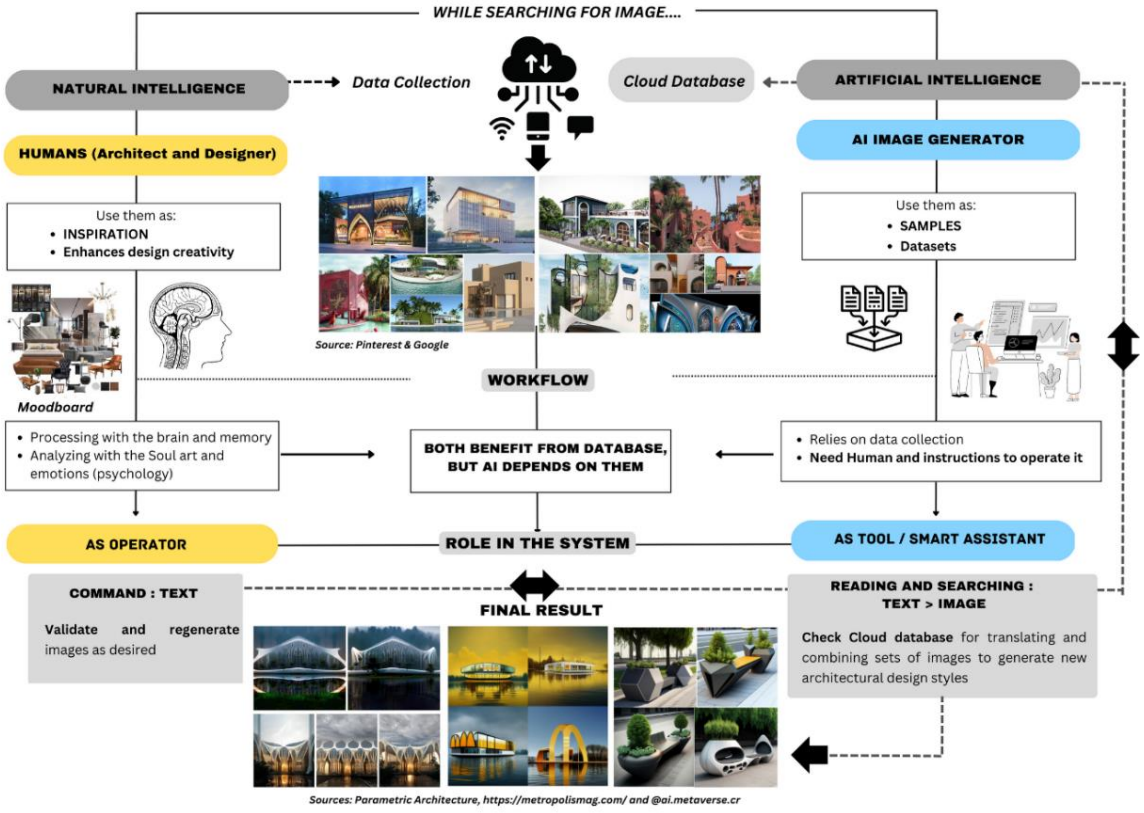

Figure 11. A Brief Schematic Of How Humans Work With The AI Image Generator System

4. CONCLUSION

The text-to-image generation that is currently stealing the attention of architects and designers has succeeded in exploring the current generation's design ideas that are so practical and look natural with only textual commands. The literature review shows how the impact of AI as a whole when looking at the perspective of goals and some of the existing technologies, has a positive effect on the stakeholders of various architectural projects. It also provides one step ahead to realizing and expanding design imagination.

However, this technology also poses a challenge to architects as built environment designers whose job is to create beautiful buildings and pay attention to the welfare of the environment and its surroundings. Another challenge lies in humans as Users who act to provide a series of text commands so that they can be understood by AI programs so that the resulting images can accurately reflect the intent of the underlying text.

If developed in more depth, the prospect of an AI Image generator will enable architects to accelerate their practice so that they no longer need to spend too much time looking for design alternatives. In the future, it will allow architects to be tasked with validating and developing imaginative design ideas in a digital environment before entering the actual design or construction phase. With the early stages of digital environmental studies through the architect's AI Image generator, designers or students can seek inspiration for alternative designs and visualize and plan arrangements from small, medium, to large-scale projects more effectively and efficiently in terms of time use. These factors allow the design team to present several design alternatives in a more riveting manner but still depend on each user's ability to instruct the AI program in the form of textual messages.

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