Konsep Pengembangan Kecerdasan Buatan sebagai Representasi Arsitek: Kajian Literatur

The Development Concept of Artificial Intelligence as an Architect's Representation: Literature Review

Johan Agung Pramono Hambadjawa[1], Khaerunnisa[2]
Departemen Arsitektur Universitas Atma Jaya Yogyakarta
Jalan Babarsari No. 44 Yogyakarta, Indonesia 55281
[2]khaerunnisa@uajy.ac.id

[Diterima 5/07/2023, Disetujui 10/03/2024, Diterbitkan 22/03/2024]

Abstrak

Arsitek Manusia tidak dapat digantikan, bahkan dengan kecerdasan buatan, tetapi kecerdasan buatan dapat mewakili seorang Arsitek, terutama dalam pemecahan masalah. Seorang arsitek tidaklah abadi. Ide-ide cemerlang lenyap bersama dengan bentuk fisik seorang Arsitek. Dengan menghormati Arsitek yang telah meninggalkan dunia ini sekaligus menjaga ide-ide briliannya tetap hidup, kecerdasan buatan dapat merepresentasikan Arsitek sebagai warisan yang selalu hidup melalui solusi pemecahan masalah yang unik sesuai dengan masing-masing individu. Dengan menggunakan metode yang telah dilakukan di masa lalu, seperti GAN, penulis merancang bentuk dari sebuah *Artificial Intelligence* dengan menggunakan metode pengumpulan data seperti input manual, kemudian merealisasikan Artificial Intelligence tersebut melalui *machine learning*, dan nantinya akan tersedia dalam bentuk aplikasi digital seperti buku. Buku ini dapat berinteraksi dengan pembacanya. Penelitian ini menggunakan metode kualitatif deskriptif berdasarkan tinjauan literatur mengenai *Artificial Intelligence (AI)* dan dunia arsitektur. Hasil yang didapatkan adalah manusia akan hidup berdampingan dengan teknologi, dan di masa depan.

Kata kunci: arsitek; buku; kecerdasan buatan; peninggalan; representasi

Abstract

Human Architects cannot be replaced, even with Artificial Intelligence, but Artificial Intelligence could represent an Architect, especially in problem-solving. An architect is not eternal. Brilliant ideas vanished alongside the physical form of an Architect. By respecting the Architect who had left this world while simultaneously keeping the brilliant ideas alive, Artificial Intelligence could represent the Architect as a legacy that always lives through unique problem-solving solutions according to each individual. Using the methods done in the past, such as GANs, writers design the shape of an Artificial Intelligence by using data collection methods such as manual input, then realizing the Artificial Intelligence through machine learning, and later will be available through a digital application like a book. This book could interact with its reader. This research uses descriptive qualitative methods based on a literature review on Artificial Intelligence (AI) and the world of architecture. The results obtained are that humans will live side by side with technology, and in the future,

Keywords*: architect; artificial intelligence;book; legacy; representation*

p-ISSN 2580–1155
e-ISSN 2614–4034

Introduction

Architects are mortal, so brilliant ideas are often wasted because of the limitations of the human life span. Technology was created to cover human shortcomings, co as an extension of the human hand and brain, artificial intelligence computers were created as an extension of the human hand and brain, and artificial intelligence was created to help humans think and innovate. In the architecture field, the adaptation of technology is still in its early stages, even though the expected results are quite promising. This technology is more than just an opportunity and is a decisive step forward that can change architectural practice (Ichi.Pro 2020). Architectural books are basic things that become a reference for architects and become a legacy of previous architects' works (Prijotomo 2015). In its development, the book was transformed into an E-book or Electronic Book, which has the advantage that it does not require paper as a medium for the book (Prakoso Bhairawa Putera 2011). As technology develops, supporting facilities are needed that can assist the activities of the current architects and can be a representation of the previous architects. Facilities such as books and e-books have the potential to be developed to be more interactive with the help of Artificial Intelligence technology.

The History of Artificial Intelligence in Architecture

For over the last 100 years, the systematization of architecture has been made up of 4 steps: Modularity, Computational Design, Parametricism, and Artificial Intelligence. Artificial Intelligence is the latest development of this stage effort. (Ichi.Pro 2020) The following are descriptions of the 4 steps:

1. Modularity
   Modularity serves as the foundation for systematic architectural design. Walter Gropius introduces the concept of the Modular Grid during the 1920s at the Bauhaus, offering a vision of technical simplicity and the potential for cost-effective architecture. With modular, environmental dimensions can be aligned with key metrics and ratios derived from the human body scale (Ichi.Pro 2020).
2. CAD (Computer Assisted Drawing)
   In 1959, Professor Patrick Hanratty unveiled PRONTO, the inagural prototype of computer aided design (CAD) software developed specificially for the design of engineering components (Setyoadi 2015). Frank Gehry championed the utilization of computational methods to explore innovative forms and geometries in architecture. During the 1980s, Gehry and Jim Glymph established Gehry Technologies, employing early computer-aided design and computer-aided manufacturing (CAD-CAM) software, including Dassault Systems 'CATIA, to address intricate geometric challenges (Mark 2003) as time passed, it became evident that this technology had limitations, including the repetitive nature of certain tasks and the inadequate handling of intricate geometric forms. In response to these shortcomings, a novel paradigm emerged beyond CAD, known as Parametricism (Ichi.Pro 2020).
3. Parametricism
   Parametricism is employed to effectively handle intricate forms and eliminate repetitive tasks. This innovative approach transforms each task into a straightforward procedure, known as a rule (Schumacher 2010). Architect Luigi Moretti conceived the fundamental concept of parametric architecture, exemplified by his project "N Stadium", which marks the initial manifestation of parametricism (Ichi.Pro 2020). The resulting form

represents an early embodiment of this novel parametric aesthetic. Zaha Hadid Architects exemplifies the application of architectural parametrization. Hadid integrates mathematics and architecture through the utilization of parametric design. Her architectural achievements stem from the implementation of encoded rules within the program, where each architectural decision is translated into a distinct set of parameters, ultimately giving rise to unique building forms (Atthaillah 2014).

4. Artificial Intelligence
   The concept of Artificial Intelligence (AI), which involves emulating human brain processes for machine logic, was initially discovered by American mathematician John McCarthy. AI enables computers to generate intermediate parameters by analyzing collected data or information provided by users. In the early 1980s, two significant revolutions took place: the emergence of expert systems and inference engines. A notable advancement during this period was the development of Cyc, a project by Douglas Lenat that focused on incorporating machines into inferential reasoning processes and utilizing knowledge bases (Ichi.Pro 2020).

In the development of the times, especially in the 21st century, artificial intelligence (AI) technology had been assisting the construction industry. Artificial intelligence over the years has changed many things in several sectors (Haryanti 2018), such as:

1. Planning
   This technology can determine construction sites and obtain information to create 3D map designs, blueprints, and construction plans. This technology can save time and save costs (Haryanti 2018).
2. Simplify Administrative Aspects
   For this aspect, project employees are facilitated to manage the attendance list to the data system and A.I is also used to manage and control every work process (Haryanti 2018).
3. Help Determine Steps
   Can be taken in the new bridge project, the A.I system is able to provide suggestions and descriptions of how the bridge should be built. In addition, GPS and Sensor technology are also used to make it easier for field workers to calculate and determine safe routes in a construction site (Haryanti 2018).
4. Technology After The Construction
   An example of the use of this technology is the Wyn Hotel project, by using the Amazon Echo product into every room of its hotel. The technology offered by this smart speaker can control every room, such as lighting, temperature, and all audio-visual equipment in the room. This system can also be used in private residences, so that homeowners can freely control every aspect of the house, with only one of these technological devices (Haryanti 2018).
5. Building Information Modeling and Virtual Assistant
   BIM or Building Information Modeling has an important function in the transformation of the construction world. This technology can help to cut time, errors, and costs very well (Sangadji 2019). Meanwhile, VA or

Virtual Assistant is used to add a natural conversational feel to the BIM information system (Nur Fitri Lathifa 2017). By combining VA and NC (Near Field Communication), this technology provides timely direction and information (Rizal 2018). For example, VA users in a building can help technicians to get a quick information when there are problems in the building in a fairly short time (Haryanti 2018).

Every Architect has a unique way of thinking, the same thing that Artificial Intelligence and an Architect have in common is a way of solving problems. The appearance, speech, accent, and language used can be different, but the method that used, the problem-solving algorithm of an Architect will always live in the form of Artificial Intelligence that represents an Architect (Novianti Indah Putri 2019).

Artificial Intelligence

The term of Artificial Intelligence or AI defined as a machine or computer that can imitate human cognitive abilities such as learning and solving problems (Russell and Notvig 1995). Even though AI can be defined as a machine to complete a task, the ability does not always belong to the AI Class (ThinkAutomation, n.d.). There is 6 requirement for a machine can be classified as AI. It should can give reasons, represent intelligence, plan, learn, process natural language and have perception. (Russell and Notvig 1995), for example a machine that can beat a professional go player, AlphaGo (DeepMind, n.d.).

Artificial Intelligence in the architecture field has begun to develop, for example BIM (Building Information Modeling) software is a digital representation that is used together to facilitate a design (ISO 19650, n.d.) to increase effectiveness, artificial intelligence had been used. (Myeers 2020). Finch, a software developed to assist initial design through adaptive design (Finch, n.d.), works as an extension or plugin to existing CAD/BIM software with the aim of providing freedom for an architect who is comfortable working on a particular program, said Jesper Wallgreen, 3D Finch inventor (Franco 2019).

AI Development in Architecture:Generative Adversarial Neural Networks (GANs)

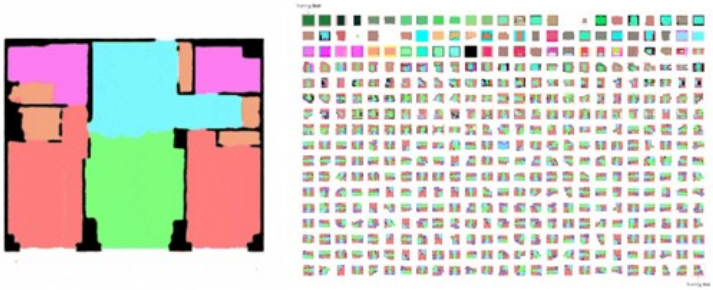

Figure 1. Image-Based Plan Recognition Process by GANs
source: (Chaillou, 2019)

In his thesis, Stanislas Chaillou discusses about the use of Generative Adversial Neural Network (GANs), an artificial intelligence that can assist architects in designing a floor plan. GANs work by analyzing the image (image based) and then projecting it into a new floor plan. GANs consist of 2 part, the first one is Generator that in charge of replicating the floor plan based on the existing data and the second one is Discriminator that in charge of evaluating the image produced by the Generator whether the image is

relevant or not based on the existing data. GANs have the ability to leart directly form the existing models, which then will be developed by an architect. (Chaillou 2019).

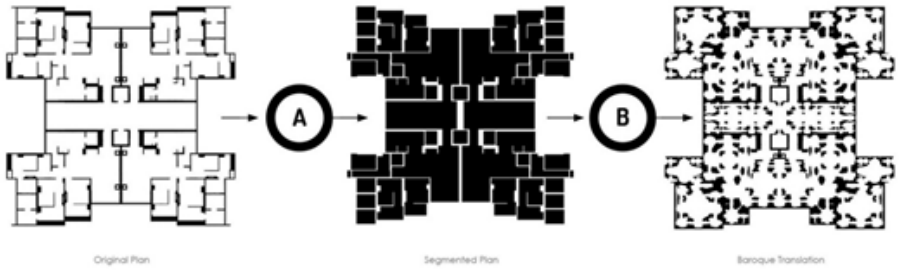

Figure 2. Modern-to-Baroque, Transition plans using GANs
source : (Chaillou, 2019)

GANs can understand the style of a plan by observing the geometry and planes of a plan. GANs work with two images, which is the original floor plan, and the floor plan that has been split into several parts. (Chaillou 2019)

Figure 3. Modern-to-Baroque on Apartment Plans using GANs
source : (Chaillou, 2019)

GANs can also arrange the layout of a floor plan through the following stages: 1. Analyzing the land; 2. Turn the land into space, then divide the space with walls and openings; 3. Placing furniture (Chaillou 2019).

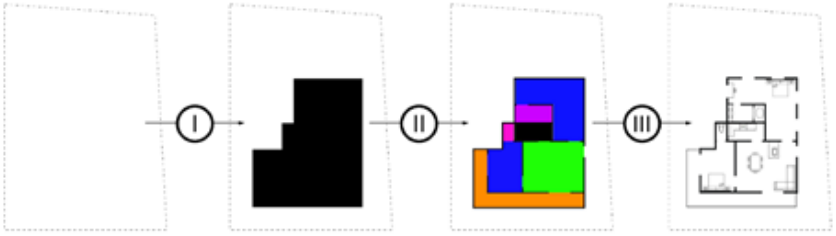

Figure 4. Work Stages of GANs as Layout Assistant
source : (Chaillou, 2019)

GANs use existing data, with a regular training they can produce high-complexity plans. The user's ability to adjust the position of the openings makes it possible to produce plans on a larger scale (Chaillou 2019).

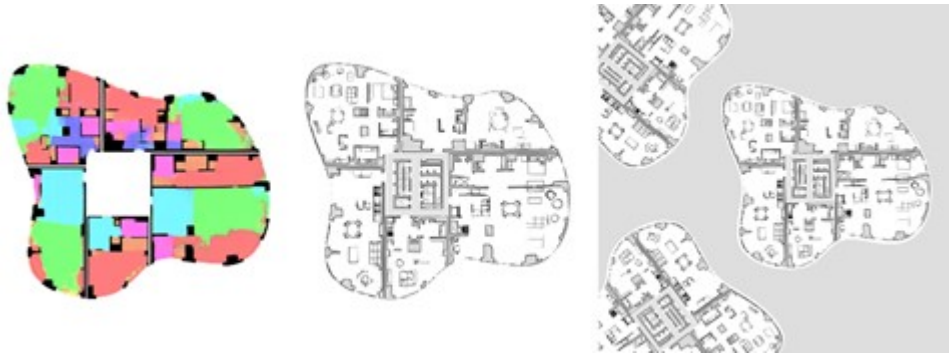

Figure 5. Example of a High Complexity Plan using GANs
source : (Chaillou, 2019)

GANs have 6 metrics that work together in processing the given data, which is Footprints, Program, Orientation, Thick & Text, Connectivity, and Circulation. These six metrics work together in determining style and spatial planning in producing a new floor plan (Chaillou 2019).

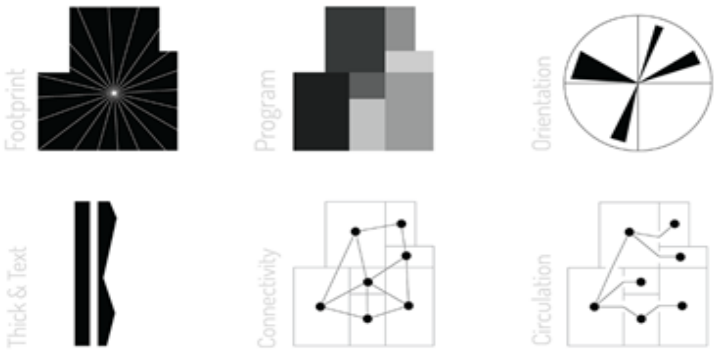

Figure 6. Metrics used by GANs
source : (Chaillou, 2019)

Human Brain Replication

Actually, humans' shape is like a computer, associate body parts with components on computers (hardware), and our minds with software on computers. If it is considered the same, then how do you transfer a human to a computer? It's easy, just copy the software. But uploading human minds is not that easy. An experiment was conducted on uploading a mouse brain of 1 cubic millimeter, which took 3 months and used a storage capacity of 2 petabytes (2,000,000 gigabytes) (DeWeerdt 2019) and there was also a study discussing the use of FIBSEM (Hayworth 2012). The purpose of this study is to replicate the brain in a digital form, so that it can be used as in humans, but in this case, it is used on computers. fMRI is often used to map surgical planning in humans and with the development of fMRI, fMRI can be used to replicate the human brain into a digital form (Glover 2011). Replicating the human brain seems like an achievable idea, but not anytime soon and although the human brain can be digitally replicated, for the purposes of data retrieval, targeting a person's memory will require more in-depth learning related to the memory, but for the data retrieval needed to develop AI in this paper, the method that has been applied by GANs can be used, by inputting the data manually.

Memory Storage in Digital Form

Like humans, a mind must have a physical place, in this case Artificial Intelligence requires a storage place. Digital data storage in general, can be done in several ways, such as: 1. Using an independent infrastructure (on-premises); 2. Using Cloud (Public or Private); 3. Using a hybrid system, a combination of on-premises and cloud (ebc group, n.d.). Some Artificial Intelligence may be deployed in the cloud, but most of the data remains on the on-premises infrastructure (Slattery 2018). The on-premises system uses facilities that are managed independently, which is by having hardware in the form of a private server, while the cloud system is more like renting a server from another company, but the stored data has unlimited access (Team Cleo, n.d.). The integration of Artificial Intelligence data with public clouds is important, innovations related to the development of artificial intelligence do occur on-premises, but the flexibility of data and information received through the cloud can also provide innovation to Artificial Intelligence.

Method

This research use exploratory research method by using literature review of previous research to determine trends and issues by referring to the development of AI, especially in the architecture field, and also the development of architecture towards digital architecture. The Literature review were used to identify the development of AI in architecture's field, development of AI, and the ability of AI to digitize the human mind. This step also identified how data storage works and its system.

The Discussion includes the offering of Artificial Intelligence-based solutions based on trends and issues that have been found, with reference to the literature review that has been explored, resulting in concepts that refer to Artificial Intelligence development as an architect representative.

Describes about the findings based on the Literature Review, about how an Artificial Intelligence and the world of architecture can coexist.

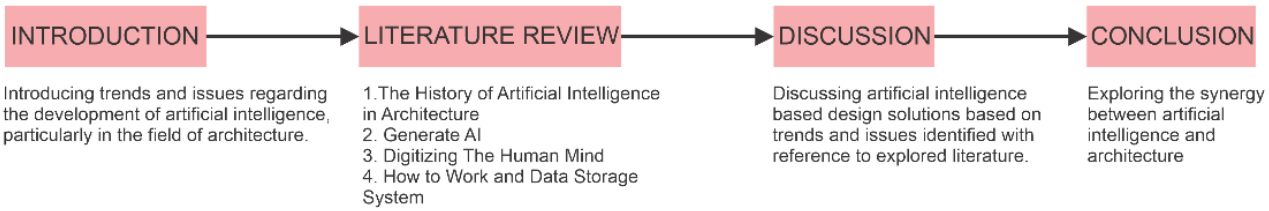

Figure 7. Metrics used by GANs
source : author's document

Findings and Discussion

Books are human heritage; great figures write their thoughts and ideas into a book. Architects often leave legacies that can be found in their work, mostly found in the form of a book, along with the times and trends, traditional books have begun to be abandoned and the trend of e-books has begun to circulate. In the future, it is not likely that AI is used like a book to represents an architect, but with AI, the book can interact with its users, provide feedback, and even read itself to many people.

The most effective way to use it is for architects to continue writing their thoughts into AI, with manual input methods assisted by technicians from the field of Information Technology (IT). The method used is practically similar with writing a book.

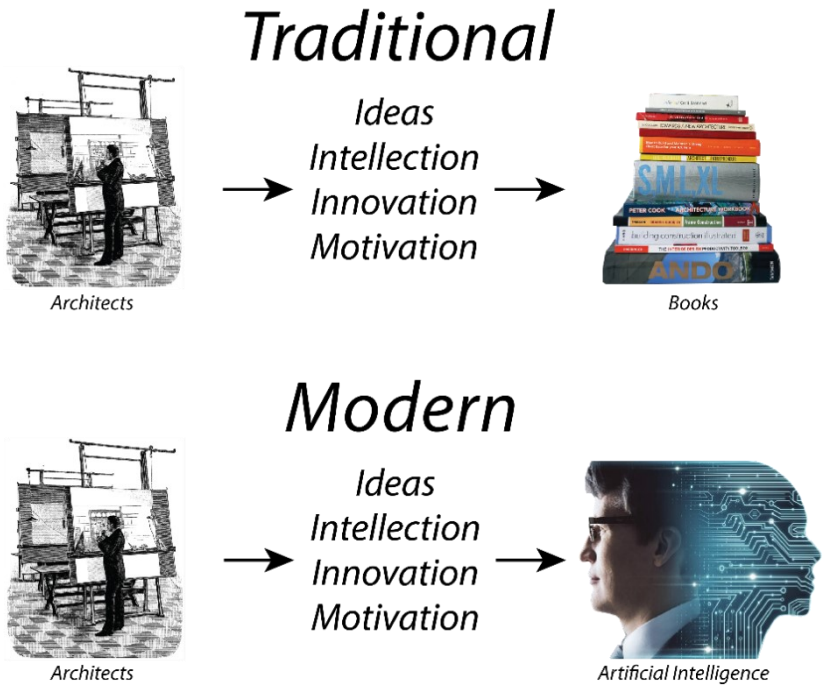

Figure 8. Visualization of the idea of using Artificial Intelligence as an alternative form of Books
source: author's document

Referring to several book sources (Groat and Wang 1946) (Plowright 2014), it was found several thought processes of an Architect. This thought process is an essential data that will be used by AI in the future as learning material, of course this data will be filled in by an architect manually with the help of IT technicians. The first generation of the design method (Plowright 2014) featured a process starting from problem identification to proposing a solution. An Architect will be faced with several problems which then will be resolved, the solutions and processes that have been generated are learning materials that will be used by AI in developing itself.

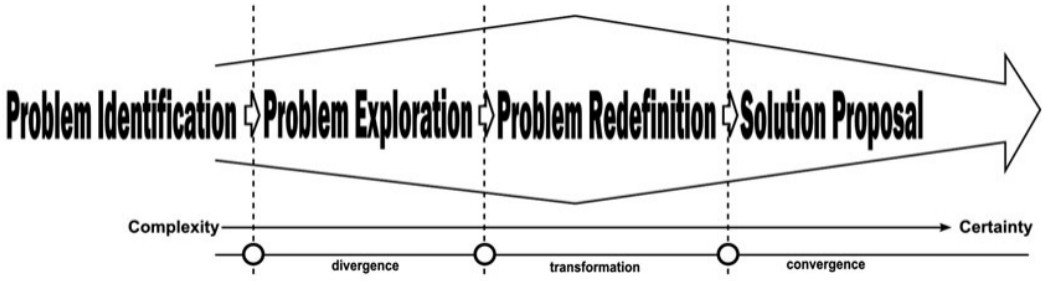

Figure 9. First-generation design method based on J. Christopher Jones
source: Plowright's Book, Revealing Architectural Design (Plowright 2014)

AI development is often actualized in several programming languages such as Python and Java (Zola 2018) to developments of the architecture's field using GANs (Chaillou 2019). AI, especially in the architectural world, has been widely encountered, such as BIM-based software (ISO 19650, n.d.), depthmapx (UCL Space Syntax © 2021, n.d.), and Finch3D (Finch, n.d.). The existing AI does have an identity (name) according to their respective advantages, but the purpose of this paper is to represent human thought into an AI that functions like a book.

The visual data input method that used is the same method as the GAN, using image-based learning but with a twist, where the inputted data is not just any data but the original image of the Architect who wants to be represented. The depiction of an Architect which includes style, floor planning, and grouping of spaces can provide an identity of itself in the form of AI. The data that has been collected will be given to Machine Learning which then will become an AI.

The steps taken to realize this AI are to prepare the data that will be used as AI learning material in the future, the data includes aspects of the design problems and design embodiments. The data that has been prepared will be submitted to Machine Learning which will produce Artificial Intelligence. This AI in the future will be stored in a cloud and can be accessed through digital applications. Users can use AI like books, but books that can interact with their readers.

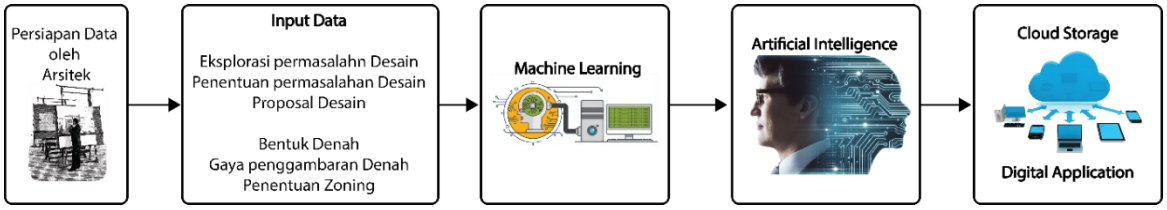

Figure 10. Schematic of the realization of the idea of Artificial Intelligence as a representation of an architect
source: author's document

Data Storage of Architect's Mind in the form of AI is stored in a cloud that can be accessed at any time and has a high level of digital and physical security. Interaction with the architect can be done through a cloud-connected application where the Data of Architect's Mind is stored. Users can choose the AI they want to interact with.

Artificial Intelligence was developed as a branch of education in 1955 with the aim of simulating intelligence that has been described in as much detail as possible using machines (McCarthy et al. 1955). In the end, AI is human intelligence that exists in the digital form (Fridman and Stevens 2019), artificial intelligence is no different from human intelligence, only the form and presentation is different.

Currently, there are various AI applications available for design, such as ArkDesign.ai, Maket.ai, ARCHITEchTURES, Sidewalk Labs, and Luma,ai. The use of AI in design is quite diverse. For example, Maket.ai offers alternative design services that allow architects to explore their ongoing designs more deeply. ArkDesign.ai provides schematic design services, ARCHITEChTURES specializes in residential planning and Sidewalk Labs offers urban planning services. It seems that the diverse needs of architects are being met with the presence of artificial intelligence, which greatly assists architects throughout the entire design process, from initial stages to the final stages.

However, AI in design also has its limitations. For instance, AI requires up to date and powerful hardware and software, which can result in high costs. Additionally, AI operates based on algorithms and input commands, which can limit its creativity and innovation. In this regard, AI is considered to have shortcomings, as the evaluation of designs created by humans and AI can be distinguished by their unique and creative aspects.

Conclusion

In the present era, AI is already being used in various construction projects and industries, Here are examples of AI applications in different projects:

1. Utilization of construction robots: Construction robots controlled by AI are employed for tasks such as bricklaying, steel structure installation and concrete pouring
2. Structural analysis: AI is utilized to analyze structures and design optimal and functional solutions, resulting in cost reduction and tome optimization.
3. Energy optimization: AI assists in automatically regulating HVAC systems based on environmental conditions and requirements, leading to energy optimization.
4. Design innovation: AI generates innovative design by leveraging algorithms and specific parameters to meet project objectives and functional requirements.
5. Construction monitoring: AI is employed to monitor projects by analyzing data form sensors and cameras installed on-site. It helps identify potential issues, track project progress and improve safety.

The realization of AI that represents an Architect indicates that in the future humans will coexist with technology, not only physically but intellectually.

In the future, AI that developed can think with humans in solving design problems as a legacy that has been left by an architect for the future generations.

References

Atthaillah. (2014). Arsitektur Parametrik dengan Rhinoceros dan Grasshoper : Kajian Workflow dari Desain, Fabrikasi hingga Hitungan Kebutuhan Material. *Jurnal Arsitekno*, *3*, 10–23. https://repository.unimal.ac.id/1020/3/B ARSITEKNO VOL 3.pdf

Chaillou, S. (2019). AI + Architecture Towards a New Approach. In *AI & Architecture*. Harvard GSD.

DeepMind. (n.d.). *AlphaGo*.

DeWeerdt, S. (2019). Deep connections Efforts. *Nature*, *571*(7766), S6–S8.

Finch. (n.d.). *THE NEW ERA IS ADAPTIVE*.

Franco, J. T. (2019). *Can a Machine Perform the Work of an Architect? A Chat with Jesper Wallgren, Founder of Finch 3D*.

Fridman, L., & Stevens, M. (2019). *Michael Stevens: Vsauce | Lex Fridman Podcast #58*.

Glover, G. H. (2011). Overview of functional magnetic resonance imaging. *Neurosurgery Clinics of North America*, *22*(2), 133–139. https://doi.org/10.1016/j.nec.2010.11.001

Haryanti, R. (2018). *Bagaimana "Artificial Intelligence" Mengubah Dunia Konstruksi?* Kompas.Com. https://properti.kompas.com/read/2018/07/13/143903221/bagaimana-artificial-intelligence-mengubah-dunia-konstruksi?page=all

Hayworth, K. J. (2012). Electron imaging technology for whole brain neural circuit mapping. *International Journal of Machine Consciousness*, *4*(1), 87–108. https://doi.org/10.1142/S1793843012400057

Ichi.Pro. (2020). *Tur AI dalam Arsitektur*. Ichi.Pro. https://ichi.pro/id/tur-ai-dalam-arsitektur-263377795628968#:~:text=Artificial Intelligence (AI) pada dasarnya,baru desain arsitektur yang radikal.

ISO 19650. (n.d.). *BIM - Building Information Modelling - ISO 19650*.

Mark, E. (2003). Preeliminary Stages of CAAD Education. *Science Direct Journal*, *12*(6), 661–670. https://doi.org/10.1016

McCarthy, Minsky, Rochester, & Shannon. (1955). *A PROPOSAL FOR THE DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE*. 1–13.

Myeers, K. (2020). *How artificial intelligence is improving the efficiency of BIM*.

Novianti Indah Putri. (2019). Mekanisme Umum Untuk Sistem Kecerdasan Buatan. *Jurnal Informatika Computing*, *06*(02), 58–75.

Nur Fitri Lathifa. (2017). Automatictecture : Otomatis Penuh Dalam Arsitektur Masa Depan. *Jurnal Arsitektur NALARs*, *16*(1), 43–60.

Plowright, P. D. (2014). Revealing Architectural Design. In *Revealing Architectural Design*. https://doi.org/10.4324/9781315852454

Prakoso Bhairawa Putera. (2011). *E-Book dan Pasar Perbukuan Kini*. Indonesian Scientific Index. http://www.buku-e.lipi.go.id/utama.cgi?artikel&1321295564&&1

Prijotomo, J. (2015). *Sumbangan Arsitektur Bagi Dunia*. Kebudayaan Kemdikbud. https://kebudayaan.kemdikbud.go.id/ditwdb/sumbangan-arsitektur-nusantara-bagi-dunia-josef-prijotomo/

Rizal, I. F. (2018). Rancang Bangun Digital Home Assistant dengan Perintah Suara Menggunakan Raspberry Pi dan Smartphone. *Jurnal Unram*, *2*(2).

Russell, S. J., & Notvig, P. (1995). *Artificial Intelligence: A Modern Approach (AIMA)* (1st ed.). Prentice Hall.

Sangadji, S. (2019). Pengaplikasian Building Information Modeling (BIM) Dalam Desain Bangunan Gedung. *Jurnal Matriks Sipil*, *07*(04). https://jurnal.uns.ac.id/matriks/article/view/38475/25492

Schumacher, P. (2010). The Parametricist Epoch. *Architects Journal*, *231*. https://www.patrikschumacher.com/Texts/The Parametricist Epoch_Lets the Style Wars Begin.htm

Setyoadi, Y. (2015). Integrasi Software CAD-CAM Dalam Sistem Operasi Mesin Bubut CNC. *Jurnal Informatika Upgris*, *1*(2). http://journal.upgris.ac.id/index.php/JIU/article/view/873

Slattery, A. (2018). *AI and Machine Learning – What are the Most Important Data Storage Requirements?*

Team Cleo. (n.d.). *On Premise vs. Cloud: Key Differences, Benefits and Risks*.

ThinkAutomation. (n.d.). *What is the AI effect, and is it set to happen again?*

UCL Space Syntax © 2021. (n.d.). *Space Syntax*. 2021.