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DEVELOPMENT OF AI AND VR TECHNOLOGY IN ARCHITECTURAL FIRMS

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ABSTRACT

In the 4.0 era, many industries combine technology such as the world of design where AI and VR are widely used for reasoning, exploration, visualization, and design innovation. The use of AI and VR in the field of architecture is not something new, previously the theory of AI was discovered in 1956 by Mccarthy and was created to produce intermediate information parameters by imitating the statistical distribution of the information presented as a result of changing options, this concept is the core paradigm from AI and VR theory. Many architecture firms struggle to combine enterprise architecture and technology creation for business strategy. AI and VR can reduce design and development time by as much as 10% and 7%, also minimizes errors that occur in projects by 90%. The research aims to prove that AI and VR help make decisions in the planning and design stages through mixed methods, namely qualitative as a literature study to analyze the use of AI and VR in architecture and quantitative with surveys to analyze interest and feasibility. Based on validated literature, it's evident that AI and VR advancements are poised to significantly benefit architectural firms by aiding in decision-making, minimizing risks and costs through visualization and calculations, as supported by a survey of 40 architects across 4 bureaus, indicating their crucial role in both current and future architectural practices, with potential to garner substantial market interest, revolutionizing design innovation and efficiency.

Keywords: *AI, Architecture Firm, Enterprise Business, Digital Entreprenuership, VR.*

ABSTRAK

Di era 4.0, banyak industri menggabungkan teknologi seperti dunia desain di mana kecerdasan buatan (AI) dan realitas virtual (VR) secara luas digunakan untuk penalaran, eksplorasi, visualisasi, dan inovasi desain. Penggunaan AI dan VR dalam bidang arsitektur bukanlah hal baru, sebelumnya teori AI ditemukan pada tahun 1956 oleh McCarthy dan diciptakan untuk menghasilkan parameter informasi intermediate dengan meniru distribusi statistik dari informasi yang disajikan sebagai hasil dari perubahan opsi, konsep ini adalah paradigma inti dari teori AI dan VR. Banyak perusahaan arsitektur berjuang untuk menggabungkan arsitektur dan teknologi sebagai bentuk strategi bisnis. Penggunaan AI dan VR dapat mengurangi durasi waktu perancangan desain sebanyak 10% bahkan 7%, pemanfaatan AI dan VR juga mampu mengurangi kesalahan dalam proyek hingga 90%. Penelitian ini bertujuan untuk membuktikan bahwa AI dan VR dapat membantu dalam pengambilan keputusan saat tahap perencanaan dan desain melalui metode campuran, yaitu kualitatif sebagai studi literatur untuk menganalisis penggunaan AI dan VR dalam arsitektur dan kuantitatif dengan survei untuk menganalisis minat dan kelayakan. Berdasarkan literatur yang divalidasi, jelas bahwa kemajuan AI dan VR berpotensi memberikan manfaat signifikan bagi perusahaan arsitektur dengan membantu dalam pengambilan keputusan, meminimalkan risiko dan biaya melalui visualisasi dan perhitungan, sebagaimana didukung oleh survei 40 arsitek dari 4 biro, yang menunjukkan peran penting mereka dalam praktik arsitektur saat ini dan masa depan, dengan potensi untuk menarik minat pasar yang substansial, merevolusi inovasi desain dan efisiensi.

Kata Kunci: AI, Bisnis Perusahaan, Firma Arsitektur, Kewirausahaan Digital, VR

INTRODUCTION

In the era of the industrial revolution 4.0, research and development investors are currently increasingly developing technology, the innovations carried out make it possible to encourage more innovative and efficient production activities (RCC Harvard, 2024). Even though it is not something new, technology such as Artificial Intelligence (AI) and Virtual Reality (VR) is one of the technologies that continues to be developed today.

This is done to meet human needs through better performance. AI has the ability to analyze, respond and create through the data provided, while VR becomes an immersive interaction simulator tool in the virtual world. These two technologies are able to work together to become a link between humans and the digital world (Cureton, 2023).

According to Akmal (2017), Ir. Ciputra explained 3 points that have been difficult for architects so far. In corporate projects, architects face several challenges that need to be overcome to ensure project success and meet owner expectations. First, they must understand and support the owner's objectives that focus on corporate goals, which involve aspects such as profits, company growth, expanding market share, and increasing productivity.

Architects need to realize that their designs must not only consider the ideal architectural concept, but must also contribute significantly to achieving the owner's business goals. In addition, architects often face difficulties in conveying design concepts that are well understood by owners. Project owners have their own views, desires and philosophies regarding their company, which is important for architects to understand.

Therefore, architects must be able to communicate effectively with owners, understand their way of thinking, and present design concepts as simple solutions that can solve problems faced in the field (Wibowo et al., 2020). Finally, project oversight is an important element in ensuring the quality of the final product. Architects are often less active in monitoring the quality of their services during project implementation. This inactivity can cause a decrease in building quality from the expected standards (Akmal, 2017).

Nowadays, the problems often experienced by architectural firms can be made easier through the use of AI and VR. The use of technologies such as Virtual Reality (VR) and Artificial Intelligence (AI) brings significant changes in the way architects overcome challenges that arise in projects. First, VR allows architects to create more immersive and realistic visual experiences related to architectural design.

With VR, project owners can interact with 3D models, feel the space, and understand design concepts better, overcoming obstacles in concept communication (Rahman & Hasrun, 2023). In addition, AI is also useful in monitoring

and optimizing design efficiency, calculating parameters such as energy use and sustainability (Gravirtarsi, 2023). Finally, AI can also be used in project monitoring, providing real-time data analysis regarding project progress, including evaluation of work quality and construction efficiency (Febriani et al., 2017).

This allows architects and project owners to more effectively monitor the quality of the final result and ensure that enterprise goals are achieved (Sachan, 2022). Thus, VR and AI not only facilitate better communication and visualization in design, but also improve understanding and monitoring in projects (Effendi & Purwanto, 2021).

METHODS

This research adopts a mixed approach using qualitative literature study methods and quantitative feasibility survey methods. This research was carried out in three stages. The first stage explores in depth the use of AI and VR in architecture from various book, article and journal sources to see the advantages, disadvantages, and impacts that can influence the world of architecture and its design process. The second stage was a survey of interest and feasibility in using AI and VR technology in Indonesian architectural firms.

This stage involved 40 architects from 4 architectural and interior firms, including female and male architects, age range between 22 and 40 years, and all participants had completed a Bachelor's degree. Participant periods of service in the architecture industry ranged between 1 and 20 years. The third stage is to analyze and examine the feasibility of AI and VR technology opportunities to help architectural firms.

1. Stage one: literature study
2. The search for literature studies at this stage uses a systematic review by Hart (2000) which states that a literature review involves searching and evaluating relevant sources, as well as organizing and presenting the information found. There are 3 important processes in literature studies which include editing, organizing, and finding. The first editing process involves collecting data regarding the development of AI and VR technology, the use and benefits of AI and VR in the world of architecture, the advantages and features that can be provided in AI and VR, as well as the impact and solutions that AI and VR provide to architectural firms.

   The data taken in this process is then checked again in terms of completeness, clarity of meaning and harmony of meaning between one another. The second process is organizing, namely organizing the data obtained with the necessary framework, in this case the data will be processed into tables which are divided into 2 large types, namely AI and VR, with 5 categories including advantages, disadvantages, features, impacts and solutions to problems

Table 1: Data Framework Template

TYPE	CATEGORY				
	Advantages	Disadvantages	Feature	Impact to Architecture	Solution to Problem
Artificial Intelligence	AI optimizes designs, predicts performance, and streamlines workflows, enhancing sustainability and innovation.	Challenges include skill requirements and potential biases in algorithms.	Machine learning enables continuous improvement and data-driven design decisions.	AI automates tasks, analyzes data, and improves decision-making, revolutionizing architectural processes.	Invest in AI for smarter, more efficient designs, and provide training for staff to ensure responsible integration.
Virtual Reality	VR offers immersive design experiences, improving communication and collaboration with clients and stakeholders.	Initial costs and expertise needed, with some users experiencing discomfort.	Lifelike virtual environments enable interactive design presentations and realistic walkthroughs.	VR transforms design presentations, enabling interactive walkthroughs for better project understanding.	Embrace VR for enhanced client engagement and streamline design reviews, investing in training and user-friendly platforms for integration.

Source : Author Analysis, 2024

The third process is finding where the results of organizing the data will be matched with the basic theory that has been searched for and then it will be concluded what benefits, features and opportunities AI and VR technology can provide to architectural firms.

3. Stage two: interest and feasibility survey
   The exploration in stage one was then validated through a survey to see the high interest and feasibility of using AI and VR technology in architectural firms. The survey will be distributed using quota random sampling to four firms, with 1 firm focusing on property architecture, 1 firm focusing on villas and resorts, 1 firm focusing on interior architecture, and 1 firm focusing on cultural architecture.

   The results of the organized framework in stage one will be used to plan and modify AI and VR technology advancement items in architectural firms. These items were compiled into a quantitative survey instrument design which was measured using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) (Joshi et al., 2015).
   The reliability test in this research used Cronbach Alpha and McDonald's omega as an alternative

measure of reliability with the help of the JASP (Jeffreys's Amazing Statistics Program) version 18.1. These reliability measures were employed to ensure the consistency and stability of the survey responses collected from 40 architects across 4 bureaus. Cronbach's alpha evaluates the internal consistency of a set of items within the survey, with values closer to 1 indicating higher reliability. Similarly, McDonald's omega offers an alternative measure of reliability, capturing the proportion of variance in the observed total scores attributable to the underlying construct.

Cronbach Alpha is a benchmark used to describe the correlation or relationship between the scale created and all existing variable scales (Bonett, 2014). The instrument used in this variable is said to be reliable if it has a Cronbach Alpha of more than 0.60. Meanwhile, McDonald's omega (ω) is an alternative measure of reliability, which provides an estimate of the proportion of variance in the total scores that is attributable to the underlying construct being measured.

Cronbach Alpha Coefficient Formula:

$$\alpha_u = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum {S_I}^2}{{S_I}^2}\right)$$

k = Number of questionnaire items

□ = Reliability coefficient of questionnaire items

∑□² = The amount of valid item score variance

□² = Total variance of item scores

4. *Stage three: opportunity analysis*

The results of stage one literature study and the results of stage two survey will then be analyzed to see how big an opportunity AI and VR technology can help architectural firms and how this technology can have an impact on architectural firms. Items that have been stated in the results of the literature study will be validated with Cronbach Alpha values. AI and VR technology are stated to be able to help architectural firms and are declared to have high interest in architectural firms' futures if the item-rest correlation value reaches more than 0.300 for each survey result item.

RESULTS AND DISCUSSION

Stage one involves conducting a literature study, which provides various pieces of information. This study reveals that AI and VR hold immense promise for architecture, enabling the exploration of new ideas and the creation of innovative spaces, while also enhancing analytical data, including insights from site analysis and the identification of business value in enterprise architecture. Naturally, as machine learning, AI and VR do have other objectives that are needed to provide a certain output according to the liking of the architect. These certain outputs mean a big data input. To understand how these gray areas can be adopted in architecture, five categories to break down informational gap is presented based on previous research on architecture firms that have used AI nor VR in their everyday process:

1. Advantages

   AI offers a wide range of benefits from decision making, analyzing the risk factor, and even gives out solutive ideas even so in the architecture enterprise, it is able to identify their business value to organizations. According to Taguimdje et al. (2020), study done by Université Côte d'Azur in France tested 500 architecture firms that use AI where results show that using AI minimizes human intervention in processes by 31.20% and also capable of becoming personal and virtual assistants to automate their production processes by 18.60%. Overall, the advances of AI application in architecture have birthed various well-known subfields of AI including: (a) machine learning (b) computer vision (c) natural language processing (e) knowledge-based systems (f) optimization (g) robotics (h) automated planning and scheduling. The advanced AI application has also been acknowledged as part of the bigger design scope for example, the UK Government has mandated that all public projects must be built by the help of AI softwares to minimize the risk and cost (Abioye et al., 2021).

   On the other hand, VR helps to reflect the complete world with interactive mode to help architects and other related fields to understand the environment, utilities, and so much more (Aryani et al., 2023). Using VR to architectural designers will allow them to understand the spatial qualities of their designs instantly which led to employee satisfaction increased due to the practical use and cost efficiency. With structures difficult to understand, VR helped to load effects, load paths, and the deformed shape of simple structures to improve the quality of structural construction (Abioye et al., 2021).

2. Disadvantages

   Even though AI is considered an intelligent component in order to help the architecture world, it needs several things to complete itself which makes it pretty difficult sometimes for architecture firms to provide, thus making their AI seem pointless and often unused. AI's capacity and intelligence are based on data given from AI staff to the AI itself. However, the lack of AI engineers to help generate makes it hard for architecture firms to outsource. The lack of data or information also gives AI a lack of ideas to generate and thus making it hard to help count the value and cost. Another part why AI is pretty hard to maintain is that most intelligent machines follow a black-box approach, which means that they do not explain the reasons for reaching conclusions which means that there needs to be a trust building foundation between human and machine. Internet connectivity is also essential in maintaining the AI to keep running, some architecture firms are built in places that may have unstable connections. Other than that, most countries have not developed or supported the use of AI which makes it difficult

to obtain one and even if it is obtainable, it is unsure that the law abides to the use of AI (Abioye et al., 2021).

The use of VR in architecture is a great deal of help, however, it does show some difficulties regarding the existence of VR in architecture. For starters, the interface is not sufficiently user-friendly which means there needs to be a special engineer to understand the use of VR and architecture and the supply is not high enough to complete the demand. A sense of isolation is also felt by the users since VR imitates the real world, it sometimes isolates the way architects think and design. All this led to VR being unable to be shared through simple learning but it must be through an intensive course in order to operate the machine. Other difficulties VR faced are registration inaccuracies, inconsistent and unrealistic luminance of virtual objects, drifting errors, unreliable location and motion tracking, and overlaying virtual objects at large distances from the user is problematic (Abioye et al., 2021).

3. Feature

   AI itself has different features depending on the usage and what kind of needs are needed. In architecture, AI's ability to simultaneously perform thousands of operations features the ability to analyze, calculate, and give out options for decision making. Automated planning and scheduling are also part of the feature whereby intelligent systems select and sequencing actions based on their expected outcomes which involves the selection of plans and allocation of time and resources necessary to achieve the desired goals based on the total available resources. NLP or Natural Processing Language is creating computational models that mimic the linguistic capabilities of human beings which helps in text processing and summarization, user interfaces, multilingual and cross language information retrieval, and speech recognition. Last, the Knowledge Based System and Optimization helps to determine the past cases or experiences or other relevant sources and provides the best outcomes given a set of constraints (Abioye et al., 2021).

   VR has its own features that can enhance the world of architecture. Such as virtual visualizations, virtual walkthroughs, multi user & device presentations. This helped architects to design and understand the surroundings of the project whether it is demolition, renovation, newly designed, and even additional design. This feature also helped architects to present a better experience to clients which led to innovation and exploration of design (Abioye et al., 2021).

4. Impact to Architecture

   Nowadays, AI is mainly used in architecture in order to provide a solution or ideas to provide additional innovation and exploration for design ideas. However, the current situation

with AI being used without understanding each region's regulation is also a setback. For example, according to Xavier de Kestelier, residential buildings in Asia, where there are specific rules to be respected, which AI as a result have not been equipped with such knowledge. On the other hand, architecture is considered a diverse and complex practice that deals with numerous constraint possibilities which have the potential to make it or break it. AI however follows the black box pattern where they give solutions without having any description as to why they provide this solution (Gallo et al., 2020).

With technology growing overtime, so is VR as a machine that helps to give a new meaning in design. VR has several impacts such as exploration and expressing the imagination, presenting a 3d modeling in a full scale, being able to create a multiverse platform that enables several parties, improving communication to the client and stakeholders, and enhancing building performance. This is because VR is equipped with the ability to VR and discrete event simulations for supporting complex manufacturing and assembly tasks which simulate complex construction operations in advance will reduce the risks and potential delays (Abioye et al., 2021).

5. Solution to Problem

   The world of architecture will forever continue to grow and digitalize. The use of AI in architectural firms help to help outsource their team. By using the automated planning and scheduling system, AI helps to generate which team members are suitable for certain projects and provide estimated time duration. In Souteyrat (2023), Zaha Hadid's Analytics and Insight use AI to produce up to 40 pieces of drawings, with 10,000 ideas generated previously in just 27 hours. AI's ability to provide tracks for positioning the building's core, pipes, and even ventilation is also a great deal of help (Lukito & Rahadiyanti, 2022). With today's working environment, they are also able to use AI to track people's needs and environmental conditions to easily understand the risk in building a new building, relocating, or renovating (Moreschini et al., 2023).

To tackle problems in the architecture world, VR is able to navigate objects and gestures through system recognition, real time modification, and real time integration with internet of things (IoT) devices. VR offers architecture and construction practitioners the ability to personally experience the built environment in an immersive manner through interactive mode where the environment tested displays stereoscopic images, listens to 3-D sounds, and inside a 3-D world are free to explore and interact (Sirror et al., 2021).

Through the literature analysis above, summary points regarding advantages, disadvantages, features, impact on architecture and solutions to problems, are summarized as follows:

Table 2: Summarized Literature Analysis

Contexts	Main Findings	Sources
Advantages	1. Using AI minimizes human intervention in processes by 31.20%. 2. The capability of AI as a personal and virtual assistant automates production processes by 18.60%. 3. Using AI softwares to minimize the risk and cost. 4. VR help architects and others to understand the environment and utilities. 5. VR help to understand spatial ability, which leads to increased satisfaction and cost efficiency. 6. VR has helped to improve the quality of structural construction.	(Taguimdje et al., 2020; Abioye et al., 2021; Aryani et al., 2023)
Disadvantages	1. Lack of data or information provided by AI developers. 2. Accebilities of Internet connectivity to access AI. 3. The VR interface is not sufficiently user-friendly. 4. VR exhibits registration inaccuracies, inconsistent and unrealistic luminance of virtual objects, drifting errors, unreliable location and motion tracking, and overlaying virtual objects at large distances from the user is problematic.	(Abioye et al., 2021)
Features	1. AI's ability to analyze, calculate, and provide data for decision-making. 2. Automated planning and scheduling by AI. 3. AI's capabilities of human activity, such as assisting in text processing and summarization, user interfaces, multilingual and cross-language information retrieval, and speech recognition. 4. VR helps with visualizations, virtual walkthroughs, multi user & device presentations.	(Abioye et al., 2021)
Impact to Architecture	1. Using AI to give solution or ideas to provide additional innovation and exploration for design ideas. 2. VR has several impacts, such as exploration and expressing imagination, presenting 3d modeling in a full scale, creating a multiverse platform that involves several parties, improving communication with clients and stakeholders, and enhancing building performance. 3. VR helps simulate complex construction operations to reduce risks and potential delays.	(Gallo et al., 2020; Abioye et al., 2021)

Table 2: Summarized Literature Analysis (lanjutan)

Contexts	Main Findings	Sources
Solution to Problem	1. AI in architectural firm helps to create planning and scheduling system automatically. 2. AI's ability to provide tracking for building construction such as positioning the core, pipes, and even ventilation. 3. AI understand new building risk, relocating and renovating. 4. VR is able to navigate objects and gestures through system recognition, real time modification, and real time integration with internet of things (IoT) devices. 5. VR offers ability to experience the built environment in an immersive manner through interactive mode where the environment tested displays stereoscopic images, listens to 3-D sounds, and within a 3-D world.	(Souteyrat, 2023; Lukito & Rahadiyanti, 2022; Moreschini et al., 2023; Sirror et al., 2021)

Source : Author Analysis, 2024

The summarized literatures were transformed into survey items using the methods and respondents mentioned previously. There are 16 survey items which include the following:

Table 3: Survey Items

Item	Statement	Type	Scale
AI 1	AI can help architectural firms in decision making	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
AI 2	AI can minimize risk and cost through visualization and calculations	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
AI 3	AI provides innovative and explora-tive design ideas	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
AI 4	AI efficiently reduces the duration of design planning time	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
AI 5	AI makes design more accurate through its ability to provide various data of environmental condition and client's need	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
VR 1	VR widen exploration process and expresses the imagination of the design	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)

Source : Author Analysis, 2024

Table 3: Survey Items

Item	Statement	Type	Scale
VR 2	VR helps architects on improving communication to clients and stakeholders	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
VR 3	VR provide better visualization through its building performance trial	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
VR 4	VR provide better visualization through its lighting simulation	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
VR 5	VR provide better calculation through its structure analysis information	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
ALL 1	In the next few years, i see the use of AI in architectural firms	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
ALL 2	In the next few years, i see the use of VR in architectural firms	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
ALL 3	I will use AI for my future project	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
ALL 4	I will use VR for my future project	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
ALL 5	AI in architecture will be in demand in the future	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)
ALL 6	VR in architecture will be in demand in the future	Ordinal	5-point Likert scale (1 = strongly disagree, 5 = strongly agree)

Source : Author Analysis, 2024

All of these items were then validated through a survey of 40 architects where 26 respondents were men and 14 women. As many as 80% of respondents have obtained a Bachelor's degree and 15% of them have received a Master's degree. More than half of the total new respondents had a period of service as an architect for 1 to 5 years. Through AI and VR, architecture has changed into a digitalized design innovation and exploration where architects are able to push themselves

out of their comfort. However, with the advanced changes of technology, there are some ground rules to understand further about the foundation of using AI and VR in architecture and how to obtain the best output from the architectural process from concept to execution, decision making, analyzing the risk factors of cost, time efficiency, and even the impacts that will bring architecture into a collaborative and solutive environment.

By dividing into five categories, getting a better understanding about the pros and cons of AI and VR in architecture is important to highlight the needs to be provided by architects. These categories are based on architecture firms that have used AI and VR through their process.

Table 4: Data Framework Results

TYPE	CATEGORY				
	Advantages	Disadvantages	Feature	Impact to Architecture	Solution to Problem
Artificial Intelligence	Decision making Minimize risk and cost through visualization and calculations Analyzing risk factor Identify business value	Internet connectivity Lack of data means lack productivity Lack of AI engineers High initial cost	Decision and analyzing Automated planning and scheduling NLP KBS and Optimization	Innovative and explorative design ideas Ability to perform thousands of operations and analyzes options Helps to outsource resources for firms Minimize risk and cost	Generate team members and project Duration Provide big data about environmental condition and people's needs Time efficiency Building coordination exterior and interior
Virtual Reality	Compatible with popular 3d and BIM format Real time visualized	Inconsistent and unrealistic luminance Drifting errors Unreliable location Motion tracking errors Overlaying virtual objects at large distance from the user Sense of isolation	Virtual visualizations Virtual walkthroughs Multi user & device presented	Exploration and express the imagination Presented a 3d modeling (full scale) Multiverse platform that enabled several	Object and gesture recognition Real time modification Real time integration with internet of things (IoT)

Source : Author Analysis, 2024

From the results of the table above, the data was summarized into survey items which were then validated using JASP and Cronbach Alpha assessment. The validity test results show the following results:

The Cronbach Alpha point estimate with 95% correctness is 0.877, which means it has exceeded the standard point of 0.6, so this test is considered valid. The overall Cronbach Alpha value is between a minimum of 0.808 and a maximum of 0.925.

Table 5: Frequentist Scale Reliability Statistics

Estimate	McDonald's ωt	Cronbach's α	Average interitem correlation	Mean	sd
Point estimate	0.874	0.877	0.310	59.750	8.524
95% CI lower bound	0.817	0.808	0.134	57.109	6.982
95% CI upper bound	0.931	0.925	0.469	62.391	10.945

Source : Author Analysis, 2024

For individual assessment, each statement item has a standard item-rest correlation value of more than 0.300 to be valid. It can be seen from the table above which shows that overall, each item is valid.

Table 6: Frequentist Individual Item Reliability Statistics

TYPE	CATEGORY		Item-rest correlation
	McDonald's ωt	Cronbach's α	
AI 1	0.870	0.872	0.492
AI 2	0.862	0.870	0.532
AI 3	0.869	0.873	0.457
AI 4	0.868	0.872	0.466
AI 5	0.867	0.866	0.617
VR 1	0.862	0.867	0.594
VR 2	0.873	0.875	0.382
VR 3	0.870	0.873	0.446
VR 4	0.871	0.875	0.397
VR 5	0.858	0.866	0.615
ALL 1	0.869	0.865	0.631
ALL 2	0.869	0.873	0.454
ALL 3	0.860	0.867	0.594
ALL 4	0.874	0.874	0.416
ALL 5	0.867	0.863	0.662
ALL 6	0.865	0.868	0.569

Source : Author Analysis, 2024

Table 7: Item Reliability Results

Item	Statement	Cronbach's	Item-rest correlation	Reliability
AI 1	AI can help architectural firms in decision making	0.872	0.492	Valid
AI 2	AI can minimize risk and cost through visualization and calculations	0.870	0.532	Valid
AI 3	AI provides innovative and explorative design ideas	0.873	0.457	Valid
AI 4	AI efficiently reduces the duration of design planning time	0.872	0.466	Valid
AI 5	AI makes design more accurate through its ability to provide various data of environmental condition and client's need	0.866	0.617	Valid
VR 1	VR widen exploration process and expresses the imagination of the design	0.867	0.594	Valid
VR 2	VR helps architects on improving communication to clients and stakeholders	0.875	0.382	Valid
VR 3	VR provide better visualization through its building performance trial	0.873	0.446	Valid
VR 4	VR provide better visualization through its lighting simulation	0.875	0.397	Valid
VR 5	VR provide better calculation through its structure analysis information	0.866	0.615	Valid
ALL 1	In the next few years, i see the use of AI in architectural firms	0.865	0.631	Valid
ALL 2	In the next few years, i see the use of VR in architectural firms	0.873	0.454	Valid
ALL 3	I will use AI for my future project	0.867	0.594	Valid
ALL 4	I will use VR for my future project	0.874	0.416	Valid
ALL 5	AI in architecture will be in demand in the future	0.863	0.662	Valid
ALL 6	VR in architecture will be in demand in the future	0.868	0.569	Valid

Source : Author Analysis, 2024

CONCLUSION

Architects in corporate projects often face challenges aligning designs with owner objectives, effectively communicating concepts, and maintaining project quality. To address these, integrating AI and VR technologies offers solutions. The aim is to streamline project management, enhance design creativity, and improve communication. AI automates tasks and generates design options, while VR provides immersive experiences. A survey among four architectural firms will assess feasibility and interest, guiding implementation. Additionally, a literature survey will provide insights into best practices and potential challenges in adopting AI and VR in architectural practice.

The integration of AI and VR technologies in architecture firms stands out as a transformative approach, as evidenced by comparisons with other studies. While past research has explored individual aspects of AI or VR adoption, such as AI's impact on firm performance or VR's role in design visualization, few have comprehensively examined their combined effect on architectural practice. For instance, Taguimdje et al.'s (2020) study demonstrates AI's ability to enhance firm performance through improved efficiency and productivity. Similarly, Aryani et al. (2023) highlight VR's immersive visualization capabilities for architectural understanding. However, the integration of both technologies offers a synergistic approach, streamlining project management, enhancing design communication, and improving stakeholder engagement. By synthesizing insights from various studies and exploring real-world applications in architectural firms, this research aims to contribute valuable insights into the holistic impact of AI and VR technologies on architectural practice, driving innovation and efficiency in the industry.

Based on the results of validated literature, it can be concluded that the development of AI and VR can help architectural firms in the future. AI can help architectural firms in decision making. Apart from that, AI can minimize risk and costs through visualization and calculations, which is proven by a survey of 40 architects in 4 bureaus showing results that exceed standards for each statement, which means that it is proven that AI and VR plays an important role in the continuity of architecture firms now and in the future. With better development, this technology also has the potential to have great market interest in the world of architecture.

The ability of AI and VR to design, plan and visualize projects can change the direction of design to be more innovative and exploratory. This conclusion shows that the role of AI and VR in the future of architecture will be increasingly important and play a central role in innovation and efficiency in this industry.

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