History of Artificial Intelligence and Its Potential to Revolutionizing the Interior Design Industry

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ABSTRACT

With its constant development and refinement, artificial intelligence (AI) has incorporated itself in many practical fields, including design. Interior design, as part of the design discipline, has also begun to incorporate AI into its industry, from the design process to the production process. Due to its constant evolution, the current studies of AI's influence in the interior design industry are often limited to singular focus areas, creating an incomplete assessment of the correlation and impact of AI on the interior design industry. This research studies the impact of AI on the interior design industry, from the historical development of AI and its implementation in interior design in general, its integration into the design process, its application to the workflow and production process, to its current challenges and limitations in the interior design industry. The research uses a literature study, which chooses scientific writings and research that this research considered significant in the study of AI's influence and potential in the interior design industry. This research provides insights for interior design and artificial intelligence professionals, researchers, and stakeholders. It highlights the importance of interdisciplinary collaboration to maximize the potential of artificial intelligence in the interior design industry.

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1. INTRODUCTION

Artificial Intelligence (AI) has become an increasingly noticeable topic in various fields, including the interior design industry [1]. In 2018, researchers tried to use AI to assemble the Kamprad chair from IKEA, and AI took much longer than humans [2]. Although this research shows the limitations and barriers of AI in carrying out simple labour work at that time, in recent years, AI has developed much more in the design field. Several factors, such as machine learning, pattern recognition, algorithms, and natural language processing, including the development of the supporting hardware, pushes AI's rapid advancement. It opens up new opportunities to revolutionize how interior designers work and create innovative spaces [3][4]. AI has the potential to automate time-consuming tasks, optimise the design process, and assist designers in coming up with more efficient and functional solutions [5][6]. However, AI has not been a priority in the development of the interior design industry. In a survey conducted by Cervený et al. of 144 furniture companies studied,

only 3.4% of companies have integrated AI in their business [7]. This paper aims to comprehensively review scientific writings and literature that discuss the history of AI and the potential and obstacles to AI integration in the interior design industry. The paper will help to understand the development of artificial intelligence over time and explore its application in interior design, from the stages of idea formulation design development to design applications to the production process. The paper also provides a solid foundation for further discussion about the future of the interior design industry, which is increasingly applying AI [8]. This review also aims to identify future research opportunities, challenges, and directions in integrating AI into interior design [9].

2. RESEARCH METHODS

This research analyses scientific writings and literature that can demonstrate the interconnectivity between AI and interior design to understand the extent of AI's potential in the interior design industry. Due to the extensive literature present in the field, the research limits the topic of study to the history of AI's application in the design world, its integration into the design process, its application to the workflow and production process, and its current challenges and limitations in the interior design industry. The study limits the choice of scientific writings and literature based on its publication date due to the rapid development and changes of AI and scientific writings and literature that studies the direct application of AI into the industry's workflow and production line. These criteria are applied to obtain results and discussions that follow the state of the interior design industry and artificial intelligence capabilities at the time of research. The selected literature and writings are then analysed to identify key findings, trends, research gaps, and practical implications. The literature search is conducted through the available academic databases [10].

Based on this methodology, this research uses the study of Turing [11], McCarthy, et al. [12], and Rusel andNorvig [13] to analyse the historical development of AI; the study of Leach [14], Chaillou [15], and Bier and Knight [16] to explore the opportunities and challenges AI faces in the field of interior design; the study of Wolniak [17] and Verganti [18] to study the influence of AI in the design process; the study of Brisco, et al. [19], Krish [20], Van Daele, et al. [21], Bolek, et al. [22], Huang and Zheng [23], Hou et al. [24], Milne et al. [25], Paterson [26], Mehmood et al. [27], Farzaneh et al. [28], Seseni and Mbohwa [29], and Halle et al. [30], to study the implementation of AI into the interior design industry, both in the design and production phases. These scientific writings and literature are chosen due to the focus of their study and the research topic they represent. This research is significant in studying AI's influence and potential in the interior design industry. It can be used to assess the connection between AI and the interior design industry.

This research also uses the study of Zhang et al. [31], Strauß [32]Bartneck et al. [33], and Sepúlveda [34] to represent the scientific writings and literature that display the challenges and difficulties of AI's implementation in the interior design industry. Additionally, the research studies the European Commission's ethical and practical guidelines regarding the use of AI [35] to view the research from the perspective of legislature published by a governing body. The selected scientific writings and literature are then analysed in depth using both academic and practical perspectives to gain a balanced understanding of AI's influence and integration into the interior design industry. The research also uses the existing AI-based interior design products to analyse the research topic further. The result of the study can then provide insights for interior design and artificial intelligence professionals, researchers, and stakeholders.

3. RESULTS AND DISCUSSION

3.1. History of The Development of Artificial Intelligence and Its Integration into The World of Design

AI has undergone a significant evolution since its emergence in the mid-20th century. Alan Turing made a statement that captures the potential of machine intelligence to be developed based on human habits that use thinking as a basis for problem-solving and decision-making and use this logic to test the intelligence of developed machines [11]. The foundation was also developed by Allen Newell, Cliff Shaw, and Herbert Simon through the concept of thinking 'logic theorist,' a program created to imitate the human way of solving problems [12]. From the journal of Turing and McCharty et al., we can see that the phenomenon of AI that has begun to enter all aspects of human life and activities today is a technology developed since the mid-20th century. Although it started with simple programming, the development of AI was initially based on human

efforts to produce machine processes that mimic human thinking abilities, including the design thinking process. The growing ability of computers to analyse data and algorithms indirectly also increases AI capabilities. The development of algorithms, increased computing power, and abundant data availability have driven AI to advance in various fields, especially in AI's ability to make logical analyses in problem-solving in specific subjects [13]. From Russell and Norvig's explanation, we can see that AI not only automates activities but also automates learning, which is at the core of innovation. AI's ability to solve problems without time or volume limits is a potential that humans do not have. This aspect can potentially cut costs and work time [18].

With the increasing capabilities of AI, the potential to integrate AI in the real world is also getting bigger, including in the design world. One path of AI integration into the design world is through the ability to generate images automatically. One of the earliest examples of AI-generating images is 'Memories of Passersby I' (see Figure 1). The painting results from machine learning conducted by Mario Klingemann from thousands of face paintings from the 17th century to the 19th century. This painting is important because it is one of the first paintings produced by AI that is not a combination of dataset images like previous AI applications. The development of 2D images, such as paintings and drawings, into 3D products and building designs is the final step in the potential of AI to be integrated into actual practice. Current technology does not support AI to be used by people who do not have special skills [14]. Based on research from Leach, we can see that AI development in the field of design still requires expertise and knowledge from the human side to produce the proper and efficient products. Human input in terms of information and command will affect the level and capability of AI.

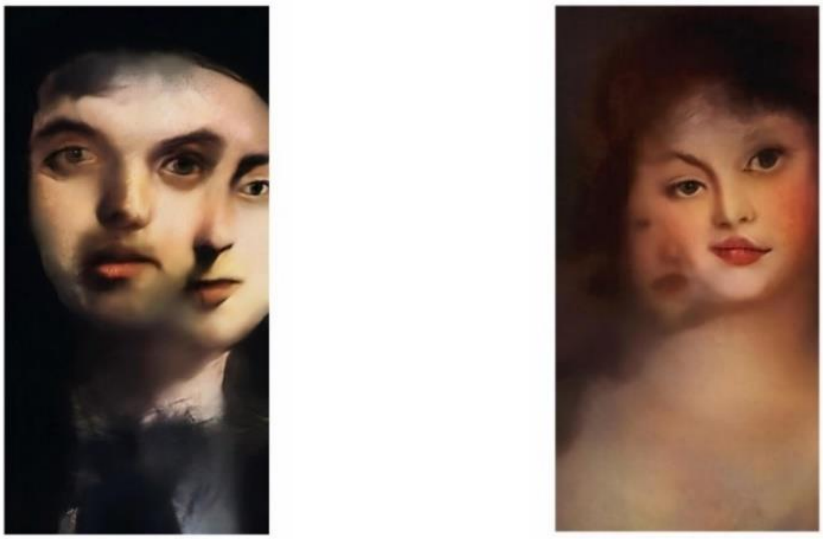

Figure 1. Memories of Passersby I.
Source: Mario Klingemann, 2019 (taken from https://www.sothebys.com/en/articles/artificial-intelligence-and-the-art-of-mario-klingemann)

Chaillou's research shows the potential of AI in architecture, such as the development of floor plans, facades, perspectives, structures, and building simulations, to the urban scale [15]. Although AI has not been effectively integrated into building design, appropriate AI can help the design work process in segments. Some of the world's architectural studios, such as Morphosis, Coop Himmelb(l)au, and Zaha Hadid Architects, have applied AI to develop design options and also help simulate building user behaviour [14]. These examples show that the level of AI utilisation in the design field will depend on the designer's expertise as an AI user and the designer's ability to integrate AI information and products segmented into one complete design. The segmentation of AI capability also helps designers who do not want or do not need full AI capabilities to produce design work throughout their design process. Integrating digital technology into the design process also encourages designers to change the view of their work from static to dynamic [16]. Bier and Knight saw the potential of developing architecture into a more kinetic, adaptive, responsive, intelligent, interactive, and so on. AI's ability to make predictions and simulations quickly and in large volumes will make

the transition process smoother. In the explanations delivered by Leach, Challiou, Bier, and Knight, we can see the potential and application of AI in the design world. AI still cannot move automatically and autonomously. The capabilities and effectiveness of AI in the design world depend on the designers' ability and knowledge to input data and analyse the results of the product developed by AI, creating a unique and close symbiosis of workflow between them.

3.2. Integration of Artificial Intelligence in The Design Stages in The Interior Design Industry

The rising application of artificial intelligence also pushes the industrial world to adopt this potential into work and production processes, including interior design. Interior design has been studied separately since the early 19th century when a new pedagogy regarding interiors gave rise to the profession of interior designer, separate from the architect or designer [36]. In its development, the science of interior has two different focuses: furniture and spatial exploration of space limited by walls, doors, windows, openings, and other barriers [37]. The ability of AI to study and analyse patterns and schematics to produce optimal designs can demonstrate their potential in every step of the design process. These capabilities demonstrate the potential of artificial intelligence when integrated into the design process, including in the design thinking process.

'Design thinking' is a creative strategy used in the design process, including problem-solving and formulation of design results [38]. There are five steps in the design thinking process: empathise, define, ideate, prototype, and test [17]. Although this design flow is closely related to the ability and essence of humans to process problems [39], with its current development, artificial intelligence is adaptable towards the process. As an industry, interior design is faced with practical issues, products that must stand out or attract consumers' attention, and production costs [39]. From the explanation delivered by Wolniak about the stages of design thinking [17], we can see in Table 1 that AI has the potential when integrated into design thinking processes in interior design. Ai's current abilities still require input and supervision from humans. Table 1 shows that the highest potential of artificial intelligence in the design thought process is at the ideate stage. This stage uses most of the designer's energy, time, experience, and capital resources. The potential of artificial intelligence that can quickly generate design idea options in the form of realistic images and with a large volume of work will help designers create a foundation of ideas that can produce design solutions quickly and precisely, cutting both the cost and time for an optimum result.

Table 1. Integration of artificial intelligence in the stages of design thinking.

Design Thinking Stages	Explanation [17]	Artificial Intelligence Integration	Examples of Artificial Intelligence Tools and Applications
Empathise	This stage is focused on knowing the characteristics of product targets and objectives. This stage will use processes such as observation, interviews, or surveys. For furniture design, this stage is essential to know the extent of the product market and the community's needs. For interior spatial design, this stage is necessary to get an idea of the client, the background, and the situation they face to be the basis for understanding the next design stage.	Although it cannot observe and communicate directly with respondents and consumers, artificial intelligence can help the survey process, data analysis, prediction of result models, and survey data validation. It cuts the cost and time designers need to know the needs of consumers and marketing targets in general.	Some examples of artificial intelligence applications in this stage are QuestionPro (questionnaire automation), Zamplia (respondent identification), Yabble (prediction of survey results), and info tool (problem correction from surveys) [40].
Define	This stage is focused on determining the needs of users or consumers. This stage is essential to decide on the result of the design product following the wishes of consumers. For furniture design, this stage is carried out to determine the typology and development focus of the product. This stage is carried out for interior spatial design to determine clients' needs, their	Artificial intelligence can make predictions to determine consumer needs. However, human involvement is still needed to improve the effectiveness of artificial intelligence in the subsequent design step, mainly due to the personal nature of this phase. The more detailed the definition of design, the more focused artificial intelligence will be in determining	The limitations of current levels of artificial intelligence require human data input to enrich their algorithms. Which indirectly encourages the dependence of artificial intelligence on humans. Shumailov et al. Explaining the phenomenon of 'model collapse' where, without training input from humans, artificial intelligence systems will sooner or

	problems, and possible design options to meet their needs.	design algorithms, regulations, and limitations.	later encounter problems/or be destroyed [41].
Ideate	This stage is the design development stage based on the definition of user or consumer needs carried out in the previous stage. This stage is the most crucial because it produces furniture and interior spatial design options. The main objective of this stage is the development of creativity, innovation, and ideas in developing design solutions.	Artificial intelligence has great potential in this stage, with the ability to generate ideas that are done quickly. Processes that are usually time-consuming in data collection and idea development that require the cooperation of experts from various fields can be completed with the help of artificial intelligence algorithm processes trained in studying inputs related to design needs. Although the results of the AI drawings today are not up to the technical level, they can be used to develop design ideas for the next stage. The primary key to using artificial intelligence in this stage is supervised learning, where AI is used to learn algorithms on the correct data under the context of the problem from the previous stages [18].	Some examples of applications of idea formulation through artificial intelligence are design development through text input, such as Midjourney and Dall-e. Design software such as Adobe and Canva have also integrated artificial intelligence that can be utilised as an additional tool in the design process (although it also has controversies, as it is considered not appreciative for human artisans that use their software).
Prototype	This stage includes developing and creating prototypes to present solutions to design problems in the previous stage. Prototypes can help visualise in real time for the design team and clients or users regarding the design concept. In furniture design, this stage will produce a prototype showing the materials, shapes, dimensions, and possible production costs. This stage produces design drawings for interior spatial design that illustrate scaled design solutions.	The prototype stage entails a technical scheme that translates design ideas into the form of engineering drawings. Artificial intelligence is still limited in design optimisation and topology in industries that have integrated CAD into the design process. Artificial intelligence can help make designs lighter, stronger, and more economical. It will help in producing more optimal products for the market.	Some examples of CAD applications that have integrated artificial intelligence are Fusion 360 from Autodesk and Solidworks. The design team can provide input on the constraints of materials, size, weight, strength, manufacturing method, and cost to produce an optimal product prototype. Hunde and Woldeyohannes, in their research, stated that the integration of artificial intelligence in CAD provides a more accessible design process, stores knowledge, makes changes without human intervention, and reduces design time and ergonomic engineering delivery. However, significant effort is still required to gain recognition from academia and industry [42].
Test	In this stage, the results of product prototypes from the previous stage will undergo a simulation process. In furniture design, this stage will determine the strength and feasibility of the product. In interior spatial design, this stage will determine the accuracy of the design solution's results in meeting the client's needs. This stage will produce input and comments from the market/client that can be used for design improvements that will be used as evaluation (and encourage the design team to repeat the design thinking process) or determine that the design thought process has achieved satisfactory results.	Artificial intelligence can help speed up the simulation process to obtain data relating to the functionality of the final design result to market and client needs. Artificial intelligence simulations can improve the quality and efficiency of testing, organise data results efficiently, and help provide input in making final decisions in product testing. The predictive capabilities of artificial intelligence can also provide additional perspective by giving further information from an event or scenario that was not observed in the original data.	Some examples of simulation applications that can be used in the simulation process with artificial intelligence are Artificial Neural Network (ANN), which is used to predict energy use, and Crayon, which can provide data about competitors through competitor websites, review sites, and publications. The ability of AI to make predictions quickly and precisely is one of the main advantages of AI at this design stage.

The potential for AI to generate idea options at high speed and large volumes starts from the difference in idea processing flows compared to traditional human-centred flows. Verganti et al. describe the difference between the two in a comparison between linear systems (humans) and loop systems (AI), wherein in a loop system, the data that AI receives from one user will be combined with other data and processed

automatically in algorithms in a fast fashion to find the best solution for that user (see Figure 2). AI then stores and integrates the new data to enhance their learning [18]. Thus, the more accurate data AI learns in the design process, the more design options and completions AI offers designers. The ability of artificial intelligence to analyse large amounts of data and produce designs from training results through datasets of images and text also reduces the need for a workforce, especially experts from related fields. Artificial intelligence can accelerate and enrich every stage of design thinking and provide opportunities for designers to develop their designs further. The large number of artificial intelligence services on the market also offers an opportunity for the industrial world to choose the most appropriate application according to needs, without any service monopoly that can harm the design industry.

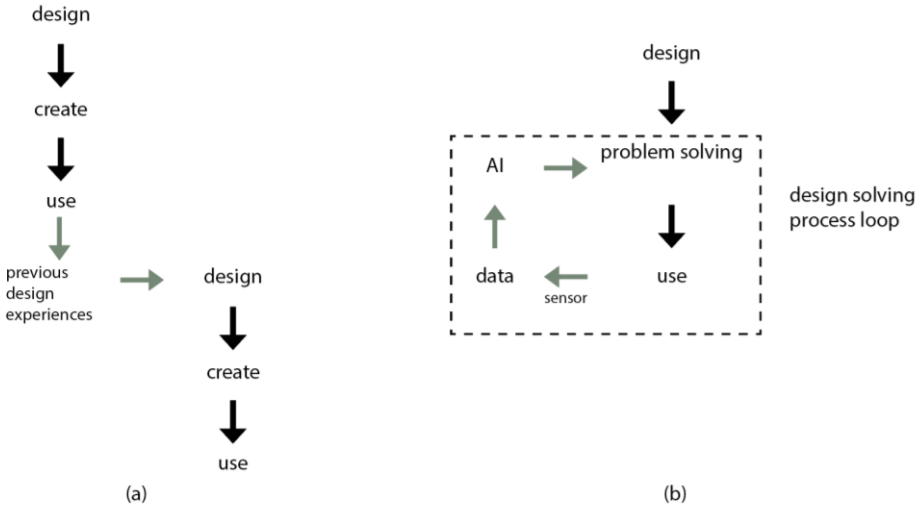

Figure 2. The author's interpretation of the traditional human-based design process that is linear (a) and the design process based on AI that is loop (b).
Source: Diagram based on the research by Verganti, Vendraminelli, and Lansiti [18]

3.3. Applications of Artificial Intelligence in the Interior Design Industry

AI has options to assist in the design process of both interior space design and furniture design. In the interior space design process, several factors will affect the quality of the space, such as the composition and harmonisation of the function of the space on the scale, proportion, colour, material, acoustics, and lighting [43]. Some of the potential applications of artificial intelligence in the interior design industry identified through a literature review in this study include:

3.3.1. Design idea generation

The generative design process is a design process that helps find unknown or unclear alternatives to a design with the help of mathematical and logical methods [44]. As mentioned in the previous chapter, one application of AI design idea generation can be done through text-to-image prompt capabilities provided by several commercial applications such as Midjourney and Dall-E. Some big companies like Google and Microsoft are also starting to develop AI in this field. The ability to translate abstract ideas into images can give designers a starting base in the process of determining their design ideas. Research conducted by Brisco, Hay, and Dhami concluded that AI helps find the final concept through clear images (detailed) that are realistic and three-dimensional [19]. In Figure 3, we can see one example of developing design ideas from a bathroom using the Midjourney application version 6, where the results of the picture can show the arrangement of space, types of furniture, different material applications, and the placement of lighting in the room. Designers can also develop the concept into a more detailed design. The result of image generation carried out by Midjourney is much more thorough, realistic, and user-friendly compared to 'Memories of Passerby I', made only five years earlier.

Figure 3. The result of generating design concepts through text-to-image applications with the prompt 'photo of hotel bathroom with freestanding bathtub behind glass wall.'
Source: Midjourney, 2024

In addition to drawings, idea generation can also be done in CAD. Krish presented several examples of design idea generation on coffee tables and MP3 musical instruments using the Generative Design Method (GDM) and Genetic Algorithm Designer (GADES) processes [20]. Although these two techniques cannot yet be incorporated into the realm of AI, they are the initial bases that show the potential of AI in producing design options that can be made in the industrial world. Krish's research also explains that GDM techniques can provide the ability to organise design information in a generic format that can provide new and better ways of differentiating designs, resulting in a better understanding of creativity for interior designers.

3.3.2. Automation of the technical drawing analysis process

Artificial intelligence can help automate the process of analysing technical drawings used in interior design, especially in building renovation projects, in buildings where their technical data is in the form of archives of technical drawings that are still manual (not in the form of CAD). AI can also help analyse technical drawings of furniture that might be used in the project. Werk24 has developed AI for the analysis process, and it can cut the analysis and archive process for interior designers, especially small-scale design companies. In research conducted by Van Daele et al., AI was used to analyse technical drawings, and it was able to cut at least 15 minutes of conventional work time [21]. Such time savings are vital in interior design, as that time can be allocated to other activities. Research conducted by Van Daele et al. also demonstrated the ability of AI to be a structured assistant for interior designers.

3.3.3. Space layout generation

This potential is a more specific development than image generation because, in this field, AI is required to understand more deeply the context and elements of a space, size, openings, furniture, and connectivity with other rooms. In the research conducted by Bolek, Altin, and Özbaşaran, the generation of spatial layout was done by applying Metaheuristic algorithms assisted by AI. Metaheuristics are algorithms that can optimise the resolution of complex problems that cannot be achieved through manual solving through evolutionary methodologies, swarms, physics, and human behaviour [22]. This research shows AI's ability to arrange furniture in a room optimally. Although still in prototype form, if the system works on a large scale, it can be an essential application for designers who need to arrange complex buildings with many restrictions or with much deep space. AI can provide optimal design completion or additional perspectives for interior designers to design according to user needs and existing regulations. The research conducted by Huang and Zheng also explained the ability of AI to recognise spatial functions and develop space layouts through the Generative Adversarial Networks (GAN) approach [23]. The study also found AI's tendency to study abstract concepts to see concrete results and infer accurate standards from notions that are not deep,

like human thought processes. This similarity in mindset is supported by AI's ability to process data and algorithms much faster and in larger volumes, making AI more efficient than designers' thinking abilities. Although the result of creating an AI room layout is still not perfect, the resulting design options will help interior designers see the design from a broader perspective.

3.3.4. Generation of colour and material options

Colour and material determine the user's perception of a room. Research conducted by Hou et al. regarding the prototype of AI applications that provide colour scheme options for interior spaces can produce colour choices that balance creativity and problem consideration [24]. It is a significant development because previous experiments have resulted in colour schemes that are chaotic, not specific, or unique. With the potential of AI in managing the selection of colour schemes, interior designers can produce space design options with space perception that can meet client needs quickly. The potential of AI in colour can also be extended to selecting materials influenced by visual and touch senses.

3.3.5. Lighting and acoustics simulation

Artificial intelligence can simulate indoor lighting and acoustic conditions, allowing designers to optimise visual and auditory comfort. In research conducted by Milne, Davison, and Ausiello, early experiments to apply AI to determine reverberation time resulted in a level of precision that exceeded that of humans [25]. The research can be a foundation for seeing the great potential of AI in interior space acoustic simulation. Conventional simulations assisted by computer applications still take a long time to produce accurate simulation data. AI can think in loops and produce simulations quickly due to their precise acoustic data learning. AI can also analyse an interior space's proper lighting placement, type, and colour. Paterson said AI applications in lighting include indoor lighting design, lighting optimisation, construction, and operational systems [26].

3.3.6. Energy optimisation and efficiency

The energy use of a building is determined by the arrangement of interior space that houses the activities of users of the building. It puts interior design in a crucial position to produce an environmentally friendly design. As discussed earlier, the potential of AI in making effective and efficient use of space can be deepened by using AI to regulate energy consumption in space. Research conducted by Mehmood et al. shows that AI will play a role in designing and operating energy-efficient buildings with comfortable indoor living environments through consistent and precise data input [27]. Research conducted by Farzaneh et al. shows that AI can be applied in monitoring, gathering information, controlling, evaluating, and managing energy consumption in buildings [28]. It differs from automation and management systems without AI because AI can estimate energy consumption by constantly monitoring and studying user’s behaviours.

From the review of the scientific writings and literature above, we can see the ability of AI to help the development of the interior design of a space. The effectiveness and capability of AI in analysing data and inputs quickly and in large volumes will allow the design process, especially for interior designers who work individually or in small teams. The ability of AI to accumulate data can also help design understanding and provide new perspectives for interior designers to get a design idea that is right, effective, and able to answer the problems given by potential users of the space.

AI can also be applied to the furniture design field. The main difference between these two fields is that furniture design is more personal for designers. However, it still pays attention to the needs of furniture users so that the product results have a market and consumers. AI has been applied directly in furniture design, especially in the design process and the effective use of materials. Within the design process, AI's potential in processing and developing designs through loop learning systems provides new perspectives for designers to deepen their work. One early example of AI integration into furniture design was the Elbo Chair by Arthur Harsuvanakit and Brittany Presten, which used Autodesk's generative design lab. AI was asked to design a chair based on a chair design from Denmark in a modern style [45]. Although it is a prototype in terms of design stages, the Elbo Chair shows the potential of AI in furniture design.

According to research conducted by Seseni and Mbohwa in 2018, AI still cannot be applied to the small to medium-scale furniture industry due to limited funds, employee education levels, and employee reluctance to adapt to new technologies [29]. However, with the development of AI learning capabilities, AI integration in the furniture industry is becoming more accessible for designers to accept. An example of such

ease of application is the 'A.I.' collection, developed by Phillipe Starck for Kartell (see Figure 4). The collection was made by the AI generation that was asked to produce chairs that could withstand the human body's weight with the least material and energy without regard to memory considerations and outside influences. This collection example is a further step in integrating AI into furniture design, as Starck's 'A.I.' collection uses AI algorithm thinking. The 'A.I.' collection breaks the conclusions of Seseni and Mbohwa because, unlike Harsuvanakit and Preston, Starck does not have an extensive background in information technology, and the design process he went through still runs effectively. Integrating AI into the interior design industry will go side by side with the growing availability of digital design tools that are more accessible to designers due to more user-friendly digital programs and the increasing ability of computer learning and analysis. [46].

These AI furniture products also show the effectiveness of material use through a topology optimisation (TO) approach. The 'A.I.' collection is designed around this approach. TO is one of the main elements in furniture design, especially related to the volume and type of material. These two things significantly influence the shape of furniture, furniture weight, and material surplus during production, and they will affect the selling price in the market. Research conducted by Haley, Campanile, and Hasse on the ability of AI to analyse TO made in one type of material shows that AI can calculate designs much faster than conventional methods with the same design results [30]. This research is in line with the results of the design of 'A.I.' and Elbo furniture, where the materials used are limited to vital structural applications without the presence of additional elements that only serve aesthetics. Advances in CNC engineering, 3D printing, and material processing also enable AI designs to effectively apply in real-time.

Figure 4. A.I. Lounge, A.I. Chair and A.I. Console, Kartell's collection, designed by Phillipe Starck with AI. Source: Starck, 2020 (taken from https://www.starck.com/)

3.4. Challenges and Problems of Artificial Intelligence in the Interior Design Industry

Although artificial intelligence offers a wide range of potential in the interior design industry, its application also faces challenges. One of the main challenges is the need for skilled human resources to develop and apply AI in the design and production process. Seseni and Mbohwa state that human resources' ability will determine AI's effectiveness [29]. Research conducted by Zhang et al. on several design teams also shows differences in utilising the potential of AI in the design process [31]. AI helps the design process for low-performing teams but hinders high-performing teams. The study also found that AI tends to degrade high-performing team performance, and the results of teamwork with AI encourage team members to perceive their work as better than teams that perform well but are not supported by AI, even though, in reality, their work results are worse. Both studies illustrate that the relationship between AI and the design team dramatically influences the effectiveness of AI in the design process. With the rudimentary nature of AI today (where AI still requires constant input from humans), the results of AI's contribution to the design process will be primarily determined by the ability of humans who use it. The example of Starck's 'A.I.' collection also shows that with its current development, designers' experience in their science field has more positive influence on AI work than designers' knowledge of information technology and algorithms.

Human input to AI also determines AI performance. Research conducted by Strauß explains the phenomenon of Deep Automation Bias (DAB), which results in the tendency of AI work to be biased in the social context [32]. The research highlights AI development's lack of fairness, accountability, and transparency. This bias can also occur in the world of design. This problem was faced by Google Gemini when

asked to create images in the initial version of its launch so that Gemini produces biased and incorrect images in social context and history. [47].

AI learning input sources also need to be an essential note in the ethics of using AI. Bartneck et al. touched on the importance of privacy in AI ethics and how the retrieval of private data, in this case also concerning works of art, can harm the original data owner if misused [33]. The rejection of artists, especially digital artists, by AI database retrieval systems has also been a concern. Some image generation services such as Midjourney, AI Lenses, and Stable Diffusion use internet databases to perform machine learning, and they often do not use permission and respect the privacy of their creators [49][50][51]. While AI can support the design process, if the data and algorithms used to train AI violate ethics, designers should not have the right to use AI input and work in their design process. This problem will also become a legal problem if the results of AI integration use data in their learning loop without permission. In addition to the legality of AI works, integrating AI in design also raises problems in recognising AI works. Sepúlveda, in his writing, conveyed considerations about the magnitude of human intervention in integrating AI design so that the design results can be identified as an original work [34]. This stage of recognition is also related to the copyright registration process, which is essential, especially in the furniture industry. Not all countries also recognise AI as a standalone entity with the right to obtain copyright [52][53]. Starck's sample of the "A.I." collection can be listed as original work by Kartell because Starck is the lead designer. However, if the data input basis uses data that has its copyright, then the recognition process becomes more complicated [54]. Without copyright protection, furniture designs can be taken by other individuals or companies.

An ethical and practical guide is needed to overshadow the integration of AI in the interior design industry. The EU has been trying to get trustworthy AI through *Ethics Guidelines for Trustworthy AI (Ethics Guidelines)*, where AI needs to have three components, which must be met throughout its life cycle: (1) it must be legally compliant, comply with all applicable laws and regulations (2) it must be ethical, ensure adherence to ethical principles and values, and (3) it must be robust, both from a technical and social point of view because, despite its good intentions, AI systems can cause unintentional harm [35]. These three components can be the basis for answering the problem of AI legality to be integrated into the design and production process of the interior design industry. Data input and the level of cooperation between AI and humans are the key to successfully using the full potential of AI in the interior design industry. The ability of humans to harness the advantages of AI and sort the results of AI work processes into design stages will determine whether AI will become an integral part of interior design or will only be an additional tool for interior designers.

4. CONCLUSION

A review of 25 scientific journals shows that artificial intelligence has great potential to revolutionise the interior design industry, where AI capabilities can be integrated into every design stage. AI can also automate design ideas, colour choices, and materials to optimise energy use. AI has also been harnessed in furniture design, from idea generation to material use optimisation. AI's ability to process large volumes of data quickly can help designers and companies perform their work processes [55]. Some companies and designers have also marketed AI products. AI capabilities have evolved much more rapidly than people thought when the Kamprad test was conducted. However, this paper also finds challenges and problems when AI is integrated into work processes in the interior design industry. In addition to ethical issues, AI has limitations in recognising legality and recognising AI as an independent entity that can create a design. This problem prevents AI from becoming integral to the interior design industry [56]. Companies tend not to take advantage of AI's potential in the interior design industry practices, even though CAD has been integrated into the work process [7].

The research also found that in the current stages of AI, AI cannot be seen as a threat to the viability of the interior design profession. AI is still in the stage where interior designers are still the dominant element in the design, both in terms of data input, data processing, legality, and copyright recognition. Although AI can help the design process, the ability and experience of human designers are still the determining point of AI's effectiveness. Further research is needed to explore innovative solutions and overcome barriers to applying artificial intelligence in interior design. Some promising research directions include the development of more intuitive interfaces between designers and artificial intelligence systems, the refinement of algorithms to produce more creative and functional designs, as well as the investigation of the long-term impact of the use of artificial intelligence in the interior design industry [57]. Interdisciplinary collaborations

between interior designers, artificial intelligence experts, researchers, and other stakeholders will be essential in shaping the industry's future [58]. With a coordinated and visionary approach, the potential of artificial intelligence in interior design can be maximised, resulting in more innovative, efficient, and user-centric spaces.

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