Impact of artificial intelligence (AI) on industrial design for architect design purposes

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Abstract. The paper analyzes the impact of artificial intelligence (AI) on industrial design. It discusses how AI has revolutionized the creation and production processes by automating many steps such as virtual simulation, shape and material optimization and product personalization. It also explores how AI can improve efficiency and reduce costs, as well as contribute to the creation of innovative products and the exploration of new technologies and materials. The research also presents personal examples of the integration of AI in the development of design concepts in teaching activities. At the same time, it discusses the challenges and risks associated with using AI in industrial design, such as the issue of transparency and control over decisions made by algorithms and the loss of jobs in the human sector. The paper concludes with a plea for a responsible and ethical approach to using AI in industrial design, which should leverage its advantages without negatively affecting people or the environment.

1 Introduction

AI (Artificial Intelligence) works by mimicking human cognitive processes, such as learning, thinking and problem solving. An AI model can be achieved through several techniques, including machine learning, which allows AI systems to learn from data and make predictions or recommendations without being explicitly programmed to do so. An AI can also be realised through explicit AI techniques, such as search algorithms, which use pre-defined rules to find solutions to problems. In general, AI works by receiving input data, processing it and producing results or actions. This process can be supported by technologies such as artificial neural networks or machine learning algorithms, which allow the AI system to learn and adapt to new data and situations.

2 The significance of artificial intelligence (AI) in industrial design

Artificial intelligence (AI) is starting to be considered an important factor in industrial design because of its ability to optimise and customise the design process. AI can help predict consumer preferences based on collected and processed data or existing market research, which can lead to more efficient and personalised products. AI can also be used in identifying and solving problems with a particular product or service design, allowing designers to work

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faster and explore more possibilities. In addition, augmented reality and virtual reality technologies have become important tools in today's design, giving designers the opportunity to experiment and test concepts and prototypes in virtual environments before they are put into practice.

Therefore, AI will allow the field of design to evolve more efficiently, effectively and customised. It is important to mention that although it will make an important contribution in the years to come, AI must be used responsibly and with attention to ethical and privacy issues so that it can provide a positive impact in the industry.

3 Purpose of the paper

This paper on *artificial intelligence in industrial design*, as a whole, may be important for several reasons. The paper can help to understand how AI can be used to optimise and customise industrial design and could provide insight into the evolution of AI in the design industry by assessing its potential in the future. AI technology may have ethical and privacy implications and the paper explores these issues for the responsible use of AI in the future. The topic of the paper can start a debate about the importance and responsible use of AI in industrial design, which can lead to a more conscious evolution of this industry and a pragmatic approach to future technologies. Therefore, this paper about the use of AI in design and beyond can be a tool for the understanding and evolution of this continuously developing and challenging industry.

4 The role of AI in optimizing design processes

Artificial intelligence (AI) can play an important role in optimising industrial design by predicting consumer preferences. Thus an AI can analyse consumer demographics and behavioural data to assess in the future what products will be popular and what needs they might address. This can help create more relevant and attractive products for consumers. As a series of data and algorithms, AI can automate certain steps in the design process, such as generating shapes and patterns, thus reducing design time and eliminating human error. Thus the regenerative design process and the search for suitable forms for the required functions, a process that can currently take weeks or months, could be done faster and easier. Having access to databases, detailed analysis about products or their performance, an AI can use machine learning algorithms to evaluate product performance and identify areas for improvement much faster than the human factor, which can help make the best decisions about conceiving and finalizing a design product. With faster access to up-to-date information on materials, prices, production costs, such an AI system could help identify the best materials and optimise costs by evaluating options in an ever-evolving market and increase the efficiency of the products produced.

Today we see more and more market research targeted at a specific user group. Large social platforms have already been using algorithms for several years that predict the behaviour of users who use those platforms and insert ads tailored to each target group or users who have a specific digital behaviour. This way an AI can use consumer information more quickly to personalize the process of making a particular product and could offer unique solutions for individual consumer needs.

Therefore, AI can optimise industrial design by predicting consumer preferences and can automate the design process. It can perform product performance analysis and choose the best and most efficient materials with optimal production costs. It could also help integrate a higher degree of design customisation.

Having this data collected responsibly, advertising campaigns can also be done faster with a better targeted audience, which would benefit from services or products more adapted to

market requirements [1]. This personalization of products according to customer needs and preferences, with the help of AI could lead to a more satisfying experience for future consumers. To perform these consumer analyses an AI could use a few options such as:

1. data analytics - where demographic (age, occupation, education) or behavioural data of consumers can be collected and analysed to understand their preferences.
2. An assessment of future development directions in which it can use machine learning models to predict market trends and identify products that will be popular in the future taking into account the evolution and consumer acceptance of products already on the market.
3. An optimisation or automation of marketing campaigns: AI can optimise marketing campaigns much faster by identifying target groups and customising marketing messages according to user preferences.

5 The impact of AR/VR technologies in industrial design

The impact of these AI and VR (virtual reality) technologies in future design products can have many benefits in the future. A designer using AI could automate many of the design processes, such as creating 3D models or generating design variants, which can save time and resources. Virtual reality environments can give designers and customers the opportunity to experience products in a virtual environment before they are made in reality, which can improve the design and decision-making process. If AI is used to analyse customer trends and preferences, this could influence future industrial design to be more sustainable and efficient in all aspects.

Considering that nowadays user experience (UX) is a very important factor in choosing a product or service, the design of new products or services will have to take these aspects into account. VR can be used to create immersive experiences for customers, which can improve product appeal and increase future customer satisfaction. Already these innovative technologies, even if they are just at the beginning, are becoming attractive to new generations of designers and are starting to be used more and more in all branches of design. And the combination of these technologies, together with 3D printing, can produce products that would otherwise have been almost impossible to produce using traditional production methods. Leading architecture firms, game companies, and designers are already starting to use AI technology in their products [2].

Leading aerospace agencies (such as NASA) are integrating artificial intelligence into certain design processes, making structures much more resilient for use in space [3]. These technologies are also increasingly being studied in the field of experimental medicine, having a growing impact on the evolution of treatments for various serious health problems [4]. Combining engineering knowledge with AI capabilities will lead to a possible technological leap much faster than previously expected.

As Tom Dixon and Phillipe Stark recently stated for the Dezeen platform, the use of AI will become commonplace in design management and production [5]. Although seen as a threat, AI is becoming an opportunity for designers to find new innovative solutions in the creative process.

6 Future evolution in AI and VR technology

The future evolution of AI and VR technologies could be characterised by a number of trends that at least at this point are intuitive. AI software will gradually start to develop using deep learning models, which can improve the ability of AI systems to make complex decisions and perform more advanced tasks. The integration of AI technology into many industries, such as healthcare, retail, financial services or the military, will become increasingly

advanced. Already, universities around the world like University of Southern California (https://ict.usc.edu/) have set up research departments in the area of AI and virtual reality to develop innovative treatments or for post-traumatic medical recovery [6]. This integration will lead to the development of AI technologies and applications that can assist people with disabilities or improve people's lives.

At the same time, the development of these systems, which will be integrated into more and diverse domains, will also require the increased importance of AI ethics and regulation to address important issues such as privacy and legal liability for companies developing AI systems.

The development of VR technology can already provide more immersive and realistic experiences for users and its use in many industries such as entertainment, education or healthcare is changing the way we approach emerging issues. It will be possible to design or build new advanced courses for medical or engineering universities that prepare future professionals, using virtual reality in teaching examples.

If 10 years ago the cost of virtual reality equipment was exorbitant, as technology has advanced, it has become much more affordable, leading to the transformation of advanced degree programmes in major universities.

Overall, AI and VR technologies are expected to continue to evolve and diversify in the future, with a focus on increasing their performance and accessibility, as well as addressing important ethical and social issues.

7 The integration of AI and human creativity

The emergence of AI models such as *MidJourney, Dall-e or ChatGPT* and their use by an larger number of people, including in fields considered creative, has generated a number of questions and concerns about their influence on human creativity. Creative professions (visual artists, painters, sculptors, photographers, graphic designers, etc.), considered almost impossible to copy or automate a few years ago, have seen themselves in a new paradigm. Works of art, photography, music, literature have become a global database for artificial intelligence which has started to learn styles and generate increasingly complex images, melodies, sounds. This is seen as a threat to whole categories of crafts and specific creative skills.

However, if used responsibly and with a desire to generate new opportunities and ideas, the integration of AI technology into human creativity can have much better long-term effects. AI can automate certain creative processes, such as creating sketches or generating design variants much faster, which can free up time for more complex creative activities. AI can suggest new ideas and creative directions, based on analysis of data about audience trends and preferences. AI technologies can be used to generate music, poetry and other art forms, which can expand the boundaries of human creativity but without infringing intellectual property rights. AI can be used to create experiences that are more personalised and more in line with individual audience preferences, which can improve the creativity and appeal of new products.

Thus, integrating AI technology into human creativity the creative processes can be improved and open up new possibilities for artistic expression. However, it is important to avoid replacing human creativity with AI technology and to value the human role in the creative process. The greatest danger could be the abandonment of creativity, which is an important characteristic of human beings and future evolution.

In the images below (Fig. 1-3) we have some examples of integrating AI and VR technologies in a creative process of looking for automotive design concepts. These images are part of a didactic experiment integrating new technologies. The use of AI generated a number of working variants, from which a proposal was chosen by the human factor and

further worked on in 3D Virtual Reality programs (Gravity Sketch). The VR environment allowed a much better realization and observation of shapes at 1:1 scale, having the possibility of immersion inside and outside the 3D shapes made.

Fig. 1. Concepts made with the help of AI models. Personal archive

Fig. 2. Final selection of the concept to be realized in 3D format, in VR space. Personal archive

Fig. 3. Making the final shape in GravitySketch in VR for possible 3D printing. Personal archive

8 The role of AI in sustainable design

Energy efficiency and sustainable design is already a benchmark and a prerequisite today in any field of activity that involves making a product or service. With the help of new technologies artificial intelligence can play an important role in sustainable design. AI can analyse huge amounts of data about the environmental impact of products and suggest more sustainable and energy-efficient solutions. It can optimise production processes and reduce energy and resource consumption, thus improving the sustainability of products. In design,

AI can use machine learning models to create sustainable and energy-efficient product ranges based on criteria such as product lifetime, materials used and energy efficiency. AI algorithms can quickly generate and evaluate a large number of design options based on specified criteria, allowing designers to explore more possibilities and find optimal solutions. Indeed, all this information is taken from existing databases, but the access and speed of AI analysis will considerably decrease the time required to execute the final product. AI can be used to simulate and predict how a product will perform under different conditions, helping designers to optimise its performance and reliability. Digitally linking the final product to the AI models with which it has been made could enable monitoring and evaluation of product performance over time, so that issues affecting product sustainability can be identified and addressed [7].

Hence, AI can provide powerful support in sustainable design through data analysis, optimisation, design and monitoring, and can help create sustainable and energy efficient products. However, it is important to approach the use of AI technology with caution to avoid creating new problems or exacerbating existing ones.

9 Challenges and Limitations

Artificial intelligence can offer many advantages in the evolution of design, but there are also a number of challenges and limitations to consider. Thus we should not forget that the evolution of AI designs depends on the databases and the information that is contained in them. If some information is inconsistent or has limited access, then the projections and variants rendered by AI may also be flawed in their ability to find innovative solutions to a given problem. Issues of fairness and some possible gaps or constraints in the datasets may negatively influence the design of future products or services [8]. Another important issue is the lack of empathy which could sometimes lead to an incorrect or inadequate appreciation of customers' needs or wishes. AI does not have the ability to feel empathy or understand the cultural and social context, which can lead to potentially flawed product design.

It should not be forgotten that AI technology and its implementation currently has a number of high costs for companies or simple users. These costs can be a barrier for some start-up companies or industries. Being a technology based heavily on programming software, databases and huge computing power, it has a level of complexity well above average and its use involves a whole team of specialists in the field to make it work. Funding is therefore extremely important when it comes to using AI software in the production process. The implementation of an AI system can vary greatly depending on the scope and complexity of the project and the resources available to the company. Costs can include investment in hardware and software, training and skills development in the development team, as well as maintenance and upgrade costs. According to a report published by McKinsey in 2020, companies that have successfully implemented AI technologies report a positive impact on revenue, profitability and productivity. In addition, implementation costs have been significantly reduced in recent years [9].

Overall, AI can be a powerful tool in the evolution of product design, but it is important to consider these challenges and limitations to avoid problems and get the best results. The role of designers and other professionals in the product design industry is essential in using AI technology responsibly and wisely in this field.

10 Ethical and privacy concerns

Energy efficiency and sustainable design is already a benchmark and a prerequisite today in any field of activity that involves making a product or service. With the help of new technologies, AI can play an important role in sustainable design. It can analyse huge

amounts of data about the environmental impact of products and suggest more sustainable and energy-efficient solutions. It can optimise production processes and reduce energy and resource consumption, thus improving the sustainability of products. In design, AI can use machine learning models to create sustainable and energy-efficient product ranges based on criteria such as product lifetime, materials used and energy efficiency. AI algorithms can quickly generate and evaluate a large number of design options based on specified criteria, allowing designers to explore more possibilities and find optimal solutions. Indeed all this information is taken from existing databases, but the access and speed of AI analysis will considerably decrease the time required to execute the final product. AI can be used to simulate and predict how a product will perform under different conditions, helping designers to optimise its performance and reliability. Digitally linking the final product to the AI models with which it has been made could enable monitoring and evaluation of product performance over time, so that issues affecting product sustainability can be identified and addressed. Depending on the complexity of the project and the firm's available resources, total costs can vary greatly. According to a report published by Deloitte in 2020, the average cost of implementing an AI system can range from $1 million to $100 million [10].

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11 The need for human oversight in industrial design

Human vision and coordination are essential in the design process because human vision is essential to generate creative and innovative ideas. Human designers add value through their ability to think outside the box and create unique and beautiful products. Designers are able to understand the needs and desires of customers and create products that meet those needs. They have the ability to empathize with their users, which can lead to the creation of products that are better optimized for them. Designers and specialists have a deep understanding of the cultural context in which products are created and used, which allows them to create products that are appropriate for those cultures in which they develop a particular product. They are also responsible for creating products that meet ethical and moral standards and do not harm society or the environment. They have the ability to make responsible decisions and address social and environmental issues. Human vision and coordination are essential to ensure control and direction of the project. Designers, architects or engineers can make important decisions about the direction of the project, the necessary adjustments and the resolution of problems that arise in the design process. However, in order to collaborate with A.I. they will need to permanently update the information and always be in touch with the latest technologies emerging on the market. It will probably be necessary to learn new skills to collaborate effectively with AI models [11]. (Fig. 4)

Fig. 4. AI-generated architectural structures. Personal archive

In conclusion, human vision and coordination are critical to creating quality design and ensuring that products are well optimised for users, socially and ethically responsible and appropriate for the cultural and social context.

12 Conclusion

The findings of studies that lead to the implementation and use of AI in design processes are varied and evolving, and the use of neural networks shows that AI technologies can improve the efficiency of design processes by automating repetitive tasks or by conducting a multitude of demographic and impact studies on the end customers who will use future products.

Although a question mark has been raised over human creativity with regard to the variants generated by AI models we can already see that the use of AI technologies can be used to improve design processes and generate new and innovative ideas, but they cannot replace human vision or the creative skills of designers. It will be up to the designers in which direction they go further with the development of the final products. AIs will be able to propose new ideas, but their finality will be decided by the human factor who will choose or transform the proposed concepts. With faster access to information on new materials and technologies, the sustainability factor will become an important pillar in the development of future design products. Studies show that AI technologies can be used to optimise design processes and support the development of more environmentally friendly or energy efficient products. There are and will be increasing future challenges and limitations in the use of AI in design processes, such as ethical and privacy issues, and the need for a balance between technology and human skills. This balance will depend on the human factor who will have to develop new skills to use these innovative technologies. Having a high complexity, designers will be required to work with engineers and specialists in the AI fields to address all the issues outlined above.

In conclusion, AI technologies can offer significant advantages in industrial design processes, but it is important to take the ethical and technical issues related to implementation into account with the utmost responsibility.

Finding a balance between the use of AI technologies and human skills in the design process will be the main challenge in order to achieve the best results.

References

1. European Parliament, State of the art and future of artificial intelligence, [Online]. Available at:
   https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/631051/IPOL_BRI(2019) 631051_EN.pdf.
2. Dezeen.com [Online]. Available at: https://www.dezeen.com/2023/04/26/zaha-hadid-architects-patrik-schumacher-ai-dalle-midjourney/.

3. Nasa.gov [Online]. Available at: https://www.nasa.gov/feature/goddard/2023/nasa-turns-to-ai-to-design-mission-hardware

4. Kadirvelu, B., Gavriel, C., Nageshwaran, S. et al. *A wearable motion capture suit and machine learning predict disease progression in Friedreich's ataxia*. Nat Med **29**, 86–94 (2023). https://doi.org/10.1038/s41591-022-02159-6.

5. Dezeen.com [Online]. Available at: https://www.dezeen.com/2023/01/12/design-trends-2023-artificial-intelligence-circular-economy - British designer Tom Dixon and French designer Starck told Dezeen that using artifical intelligence (AI) in the product-creation process will become more commonplace in 2023. "AI will dominate the aesthetics and the conversation around design – knocking aside the more important and pressing subject of sustainability," said Dixon. " AI is the biggest threat and opportunity that the profession faces this year.".

6. ICR.usc.edu [Online]. Available at: https://ict.usc.edu/research/projects/strive/.

7. N. Nozaki, E. Konno, M. Sato M. Sakairi, T. Shibuya, Y. Kanazawa, Serban Georgescu (2017) *Application of artificial intelligence technology in product design*. (2017) Fujitsu Scientific & Technical Journal [Online]. Available at: https://www.researchgate.net/publication/318860126_Application_of_artificial_intelligence_technology_in_product_design.

8. Choung, H., David, P., & Ross, A. (2022). *Trust in AI and its role in the acceptance of AI technologies. International Journal of Human–Computer Interaction*, **1–13**. https://doi.org/10.1080/10447318.2022.2050543.

9. McKinsey Analytics, *Global AI Survey: AI proves its worth, but few scale impact* (2020).

10. Deloitte, *Thriving in the era of pervasive AI*, 2020.

11. R. Verganti, L. Vendraminelli, and M. Iansiti. *Design in the Age of Artificial Intelligence*. (2020) Harvard Bussines School. Bussines School. https://www.hbs.edu/ris/Publication%20Files/20-091_3889aa72-1853-42f8-8b17-5760c86f863e.pdf.