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The use of Artificial Intelligence Techniques to Enhance Creativity in Industrial Design

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Abstract

Artificial intelligence (AI) introduces a fresh perspective to industrial design with its logic and precision, The techniques used in AI programs involve analyzing and processing input data to create designs or visual products. These products help boost growth rates and revenues, ultimately attracting more customers. The research problem lies in: What is the possibility of creating modern designs for industrial products through AI programs? The importance of the research lies in the following points: contributing to finding new design ideas for industrial products, and highlighting the applications and uses of artificial intelligence in the field of industrial design. The research objectives are: to create designs for industrial products using AI programs, reduce time, effort, and cost, obtain a large number of designs with the possibility of modification before starting execution. The following research hypothesis is proposed: AI programs can be used to create numerous designs for industrial products. The research follows a descriptive approach using the analytical method to describe and analyze AI program techniques and the extent to which they can be used in industrial product design. The research also follows an experimental approach, which involves conducting a series of experiments to prove the hypothesis. AI programs were used to create ten designs for an industrial product (a small car), and the designs were evaluated through a questionnaire presented to ten reviewers, including faculty members and a number of designers. The results showed a strong positive correlation between the four sections of the questionnaire. The research hypothesis was proven to be true. The researcher recommends the need to adopt the use of AI programs and consider them as a tool in the hands of the designer to generate new and innovative design ideas.

Keywords

Artificial Intelligence, Industrial Products, Industrial Design

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Introduction:

Artificial Intelligence (AI) is an integral part of the digital technology communication system, where the digital transformation of the fashion industry enhances its ability to produce and utilize data that was previously technically or financially unattainable. AI has become part of how we manage businesses across various industries, with communities increasingly adopting these technological advancements to maximize benefits and achieve sustainable and inclusive growth. (Mohamed, Shaimaa Mostafa, 2024). One of the main features of AI is its ability to analyze and process the data and information input into it, transforming them into designs or visual products that help increase growth rates and revenues for the company, thereby attracting more customers. It can also predict fashion trends. (Banerjee, S., et al., 2022). After more than 60 years of development, AI has bridged the gap between learning and innovation, creating a closed loop of human creativity in a unique, effective, accurate, and stable manner. The innovative work of AI initially flourished in the field of artistic creativity, and is now rapidly expanding into various practical fields. AI and innovative design represent science and art, respectively. They continually merge with each other. In the context of integrating art and science, creators in various fields can significantly improve the efficiency and quality of design through AI.

(Yonghui Lin, 2020)

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Research Problem:

The research problem can be formulated through the following question:

- What is the potential of creating modern designs for industrial products using AI programs?

Research Significance:

The significance of the research can be summarized in the following points:

- Contributing to the development of new design ideas for industrial products.
- Highlighting the applications of AI and its uses in industrial design.

Research Objectives:

The research aims to achieve the following:

- Develop designs for industrial products using AI programs.
- Reduce time, effort, and cost.
- Generate a large number of designs with the ability to modify them before implementation.

Research Hypotheses:

This research will verify the following hypothesis:
AI programs can be used to create multiple designs for industrial products.

Research Methodology:

The research follows a descriptive approach using an analytical method to describe and analyze the techniques of AI programs and their potential for use in designing industrial products. The research also adopts an experimental approach based on conducting experiments to validate the hypothesis.

Previous Studies:

The Study of: (Tahamid Ahanaf , et al., 2023), Titled" AI Technology Underpinning the Design and Production of Mechanical Automation Equipment"

The aim of this study was to assess the impact of AI technology on mechanical manufacturing. To do this, 30 mechanical engineering students were divided into two groups. Group A used traditional design and manufacturing methods, while Group B incorporated AI to enhance their processes. The results showed a significant difference in resource utilization: at a production level of 30%, Group A had a waste rate of 0.4%, while Group B reduced it to 0.2%, saving 0.2%. At production stages of 50% and 70%, Group B saved 0.3% more resources due to 1% less waste compared to Group A. These findings suggest that AI can significantly improve manufacturing efficiency and reduce resource wastage, accelerating the advancement of mechanical manufacturing.

The Study of: (Hassanin, Magdolin El-Sayed, 2020), Titled " The Industrial Design Process in Light of Artificial Intelligence "

The research aims to regulate the role of artificial intelligence in reshaping and practicing the stages of the industrial design process. It has become clear that AI can play an effective role in practicing most stages of the industrial design process. The research followed an inductive approach, where a proposed concept for an artificial intelligence system was developed, considered as an assistant to the industrial designer in performing their work. This system primarily relies on applying various AI patterns according to their objectives and capabilities in practicing the stages of the industrial design process.

Theoretical Framework

Artificial Intelligence

It is one of the subfields of computer science that focuses on creating software and hardware components capable of simulating human behavior. Computers have the ability to simulate certain cognitive abilities of the human mind, such as performing mathematical operations and making simple decisions, in addition to their superior capacity for storing and retrieving information. The field of Artificial Intelligence (AI) aims to simulate certain processes of perception and logical reasoning that humans excel at, in an automated manner and at high speed.

(Youssef, Gehan Fahmy Mustafa, 2023)

Artificial Intelligence (AI) has become one of the biggest disruptors in the consumer market. It has been widely adapted across various services and products without being recognized by consumers. Companies are increasingly interested in using generative AI to produce creative outputs that were traditionally considered unique to humans. The generative AI technology models data distribution, and it has been proven that AI successfully performs creative tasks once thought to be exclusive to humans. AI addresses consumers' aesthetic and functional needs, offering novelty and speed. (Sohn, K., et al., 2021)

AI relies on machines' ability to process data and inputs at exceptional speeds, allowing them to perform cognitive human functions such as perception, learning, thinking, and problem-solving. The primary goal of AI applications is to train machines to think and make decisions using advanced human-like thinking processes, achieved through the creation of intelligent software systems that simulate the way the human brain solves problems and makes decisions.

(Hagag, Mohamed Abdelhamid, 2023)

The use of AI in design and the creative process will require precise standards to maintain brand identity and protect intellectual property.

(Oxford Analytica, 2024)

The logic and precision of AI provide a new perspective on industrial product design. AI technology is shaping the future of industrial product design. New products with unique visual effects and a distinctive user experience can be created, enhancing the aesthetic value of products while increasing their practicality and functionality. AI technologies meet basic user needs in industrial products, while offering a unique experience using 3D representations of two-dimensional designs. (Yongmin Wang, Nuo Pang, 2024)

Humans combine creativity and thought through design, especially in modern engineering, where computer technology influences all aspects of design, development, construction, marketing, and after-sales services. Traditional planning methods no longer meet the needs of modern society, leading to the growing interest in AI systems in engineering. AI technology is transforming mechanical design, overcoming human expertise limitations, and improving productivity and product quality. AI enables automatic control in the design process, reduces external interference, and enhances production efficiency and work quality. It also adapts to diverse product needs and optimizes manufacturing, contributing to reduced resource waste. The application of AI in industrial design and automation is essential for continuous advancement, offering improvements over traditional methods.

(Tianrong Han, Yeqin Xu, 2021)

With the gradual expansion of AI applications, human exploration of the unknown world and its ultimate limits deepens, drastically changing people's lives and production methods. In the era of AI, art will undoubtedly be significantly influenced. However, more importantly, we must observe the new changes that technological development in the AI age has brought to art. This article describes the development state of smart technology and artistic product design, discussing examples of AI technology applications in art. Based on the concept of AI's boundaries, innovative methods in artistic product design are explored in-depth.

(Yonghui Lin, 2020)

Predictive industrial maintenance is a vital tool for improving efficiency and reducing costs. It relies on machine learning and deep learning algorithms to build AI (XAI) to analyze data and determine the condition of equipment. These techniques help reduce failures and improve equipment reliability by predicting future problems. Digital twins are also used to create digital replicas of systems and products to enhance factory performance. By analyzing real-time data using sensors, maintenance strategies can be optimized, reducing downtime and emergency repairs. These applications are part of the shift toward digital industries, providing greater sustainability and efficiency.

(Chitranjanjit Kaur, Anurag Sharma, 2025)

Design integrates knowledge from multiple fields. It encompasses not only aesthetic expression but also logical thinking in philosophy. Therefore, it is not only the creative process of artists but also a logical thinking process. With the rise of the new era, AI and art design have found a point of convergence, and a series of ideas and applications have emerged that merge AI and artistic design. As shown in the following figure, the process of artistic design has been greatly simplified after integrating AI. Cognitive science and AI provide a conceptual library to describe and design graphs, which can then be automatically generated based on the calculation model. This can help designers eliminate tedious steps in certain aspects of design. In an AI environment, whether it's engineering design to solve complex problems or artistic design in drawing, AI and design show good coordination. The following figure (1) demonstrates this.

(Yonghui Lin, 2020)

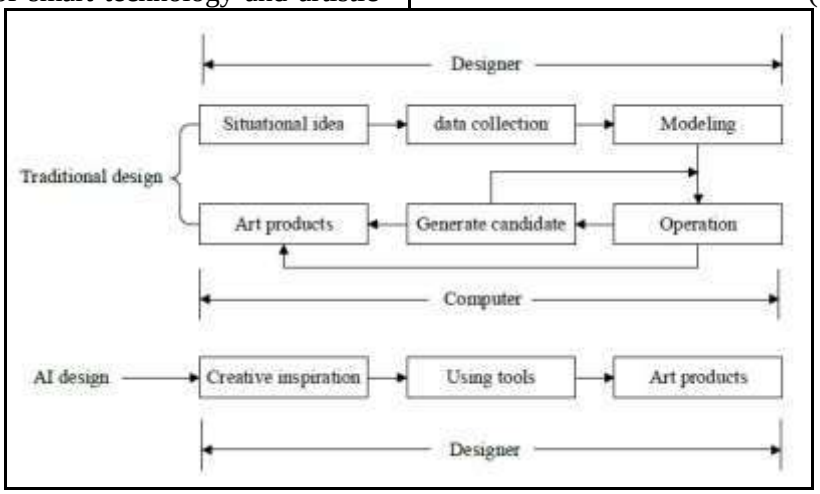

Figure (1) Comparison of two design methods (Yonghui Lin, 2020)

The integration of Artificial Intelligence (AI) systems within Industrial Automation (IA) and AI awareness is a key area in modern industrial applications. Beyond custom arrangements, visual organization plays a significant role in highlighting the innovation in industrial product design, validating its effectiveness, and supporting its development strategy. As AI applications continue to expand, human exploration into uncharted territories and the boundaries of this field are advancing rapidly. Both human life and production methods have experienced profound transformations. In the age of AI logic, designing embedded systems for industrial products will undoubtedly have a major influence. More importantly, the study of the changes brought about by technological progress in AI awareness is crucial for enhancing embedded system designs. This technological advancement and product planning showcase the evolution of industrial product design and highlight examples of AI awareness applications within embedded systems. Consequently, research methodologies now focus on designing embedded systems both internally and externally, with AI logic as the foundation. AI logic technology has been successfully incorporated into industrial product plans, providing electronic support to businesses in creating products based on human experience. These emerging technologies are increasingly recognized as vital in the creative applications of artificial intelligence.

(Kiran Nair, et al., 2021)

Efficiency is another important aspect when considering big data. Efficiency issues under the influence of big data mainly arise in rapid data updates and short update periods. Although traditional design performs well and provides detailed accuracy, some "quick needs" take a long time to meet their requirements, and energy consumption does not align with demand. The following figure (2) demonstrates this.

(Yonghui Lin, 2020)

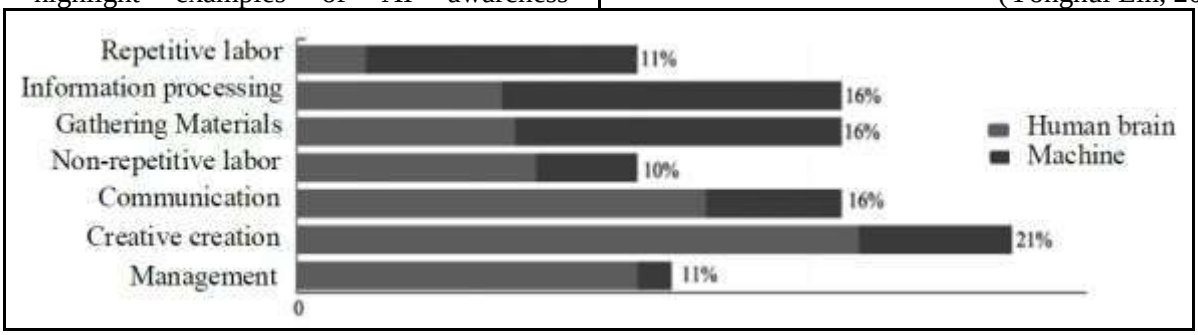

Figure (2) Designer's daily time allocation

The advancement of design, manufacturing, and automation boosts the GDP, raises the standard of living, and establishes the production base for sustainable development. The progress of artificial intelligence can enhance the level of automation. Therefore, the use of AI technology can improve the operational efficiency of machinery manufacturers while simultaneously reducing resource waste, significantly impacting the rapid advancement of mechanical manufacturing.

(Tahamid Ahanaf , et al., 2023)

Users' needs are met through the interaction between users and the designed products, that is, the users' self-behavior. Traditional design tends to focus more on the visual characteristics, design concept, and interaction style of products, while modern design is not only a creative process but also incorporates many scalable elements. In order to make the designed products more specific and practical, designers, decision-makers, and manufacturers need to collect users' behavior and other information more effectively, to improve the "temperature" of the designed products and show their concern for the users. (Yonghui Lin, 2020)

Artificial Intelligence Patterns:

There are seven patterns of artificial intelligence that recur in different combinations across all of its systems. Some cases use a single pattern for their application, while others combine a few of them together. By understanding these patterns, we can achieve the desired final goals for AI systems. The following figure (3) demonstrates this.

(Hassanin, Magdolin El-Sayed, 2020)

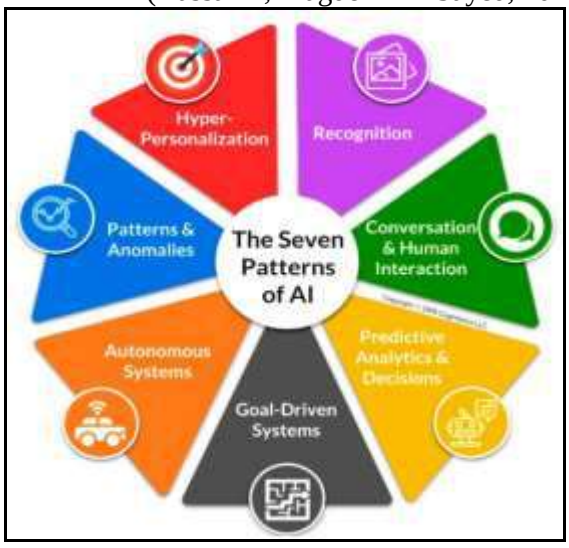

Figure (3) Artificial Intelligence Patterns

Experimental Work:

First: The Procedural Experiment:

Artificial intelligence in industrial product design is characterized by saving time and effort, increasing efficiency, and offering a variety of results, which enrich the design process and assist industrial designers in innovation, creativity, and generating multiple ideas. This provides greater opportunities for selection and reaching the best designs. This is evident through the practical aspect of the research, which is an experiment to use artificial intelligence in industrial design. This experiment involves designing a small electric car for use in cities, where AI can contribute to the development of sustainable design solutions through optimal resource usage and waste reduction.

AI programs were used in the industrial design software during the product design phase through the following steps:

1- Initial Design Stage: A freehand sketch of the design idea was drawn with a pencil on plain paper. Then, a scan was made to convert it into a file that can be processed by a computer.

2- Improving Freehand Designs Stage: The scanned file was uploaded to Freepik to create multiple, more advanced designs.

3- Developing Freehand Drawings into 3D Designs Stage: This step involved the following points:

- Uploading the files of the freehand drawings from the previous step to the promeai website, along with a request to experiment with the design idea for the car, specifying the design requirements for the product. This resulted in a 3D design resembling a realistic image.
- Similar experiments were conducted on another site called vizcom.ai, producing other results with different additions.

4- Evaluation Stage: The evaluation stage involved selecting the best results from the ideas generated on the previous sites.

5- Assessment Stage: This stage involved re-uploading the image of the selected product after evaluation, specifying the display methods, output, and the level of image quality.

6- Printing Stage: The final design was printed using the required display and output methods.

The following presents the designs created using artificial intelligence programs, where a description with all the details was entered along with an illustrative sketch. This is evident in the following figures (4 to10)

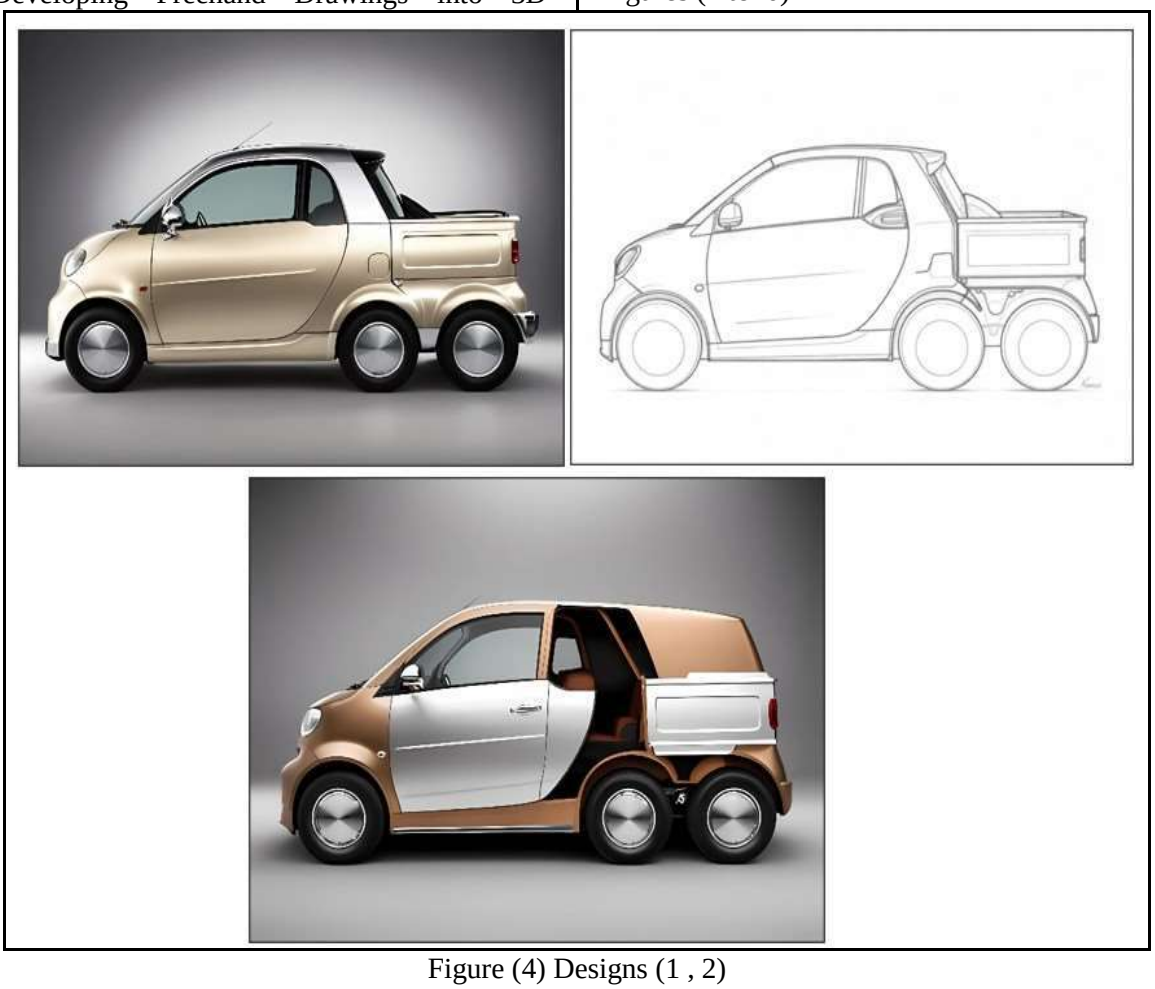

Figure (4) Designs (1 , 2)

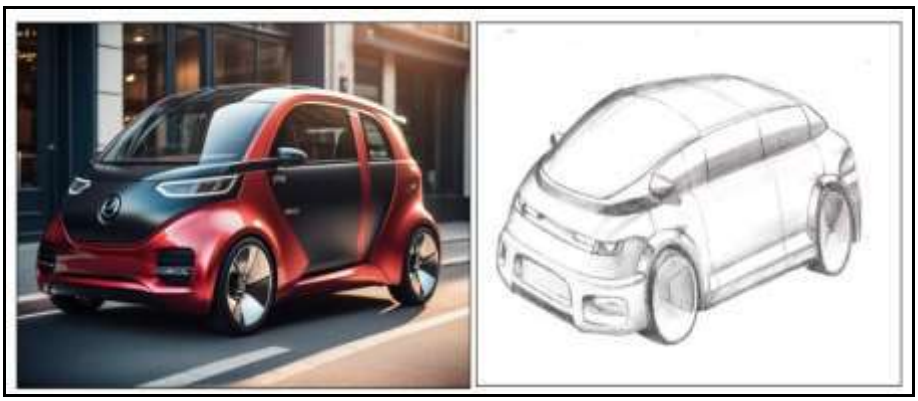

Figure (5) Design 3

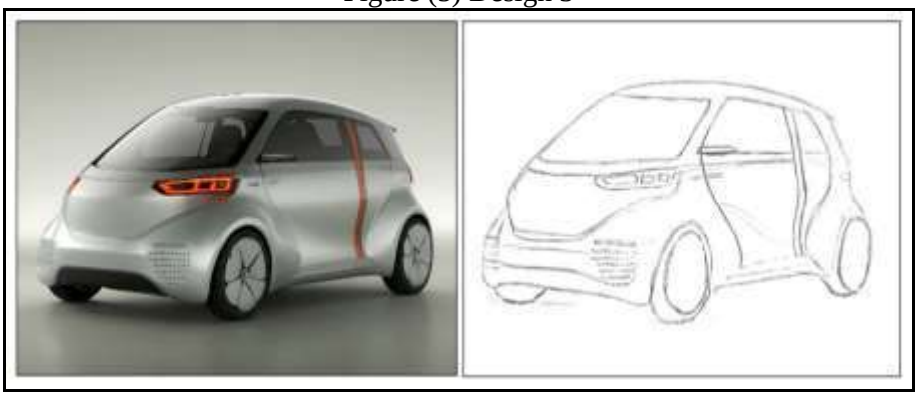

Figure (6) Design 4

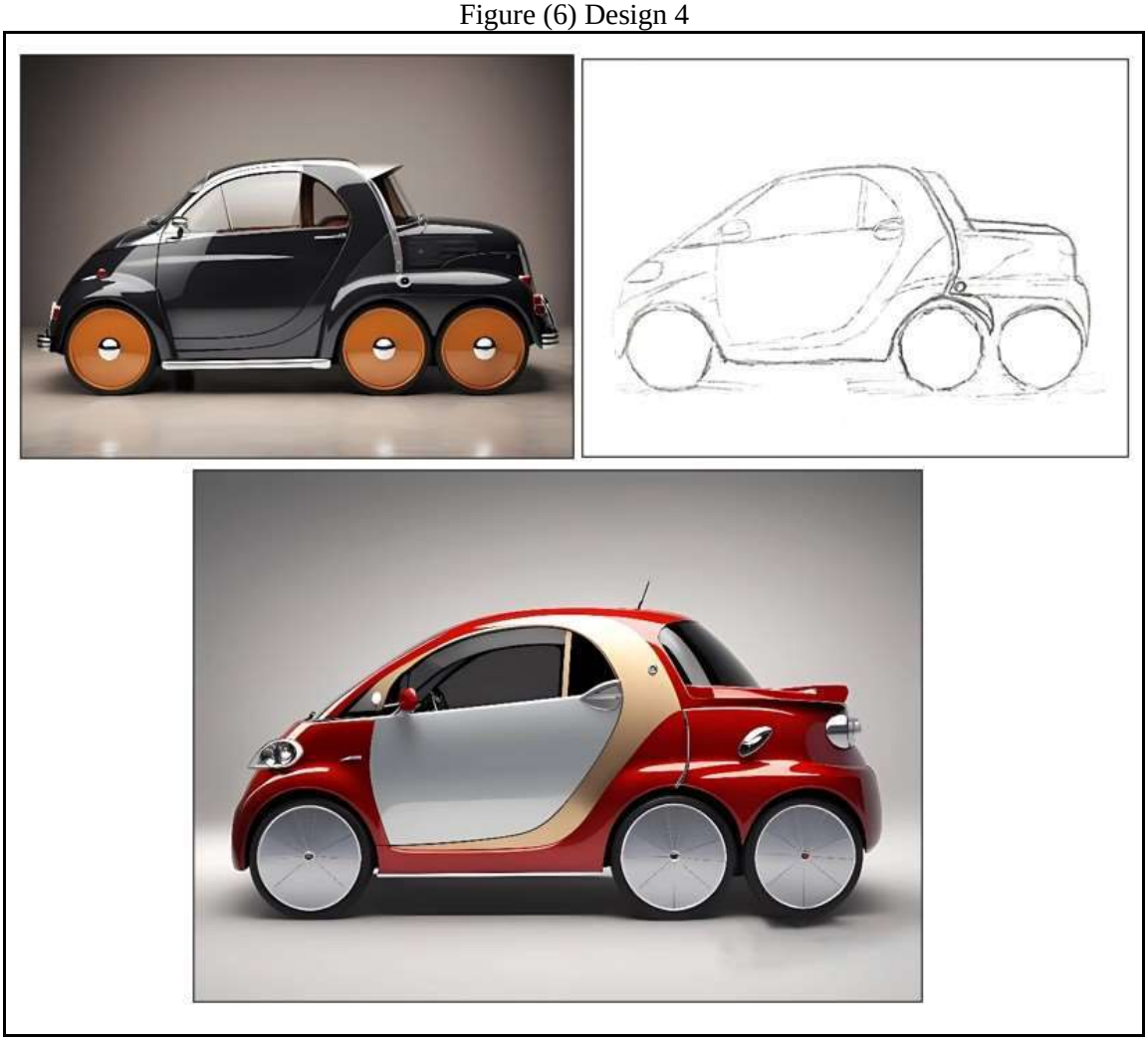

Figure (7) Design (5, 6)

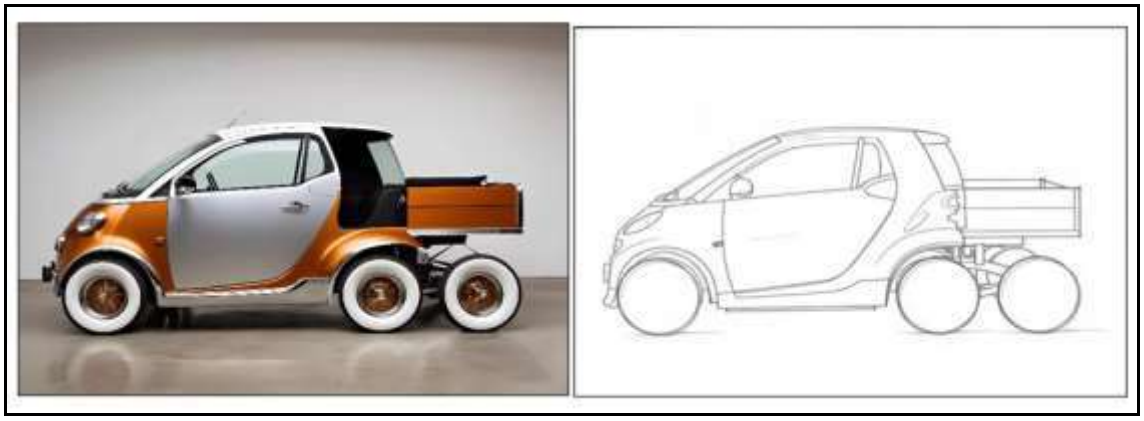

Figure (8) Design 7

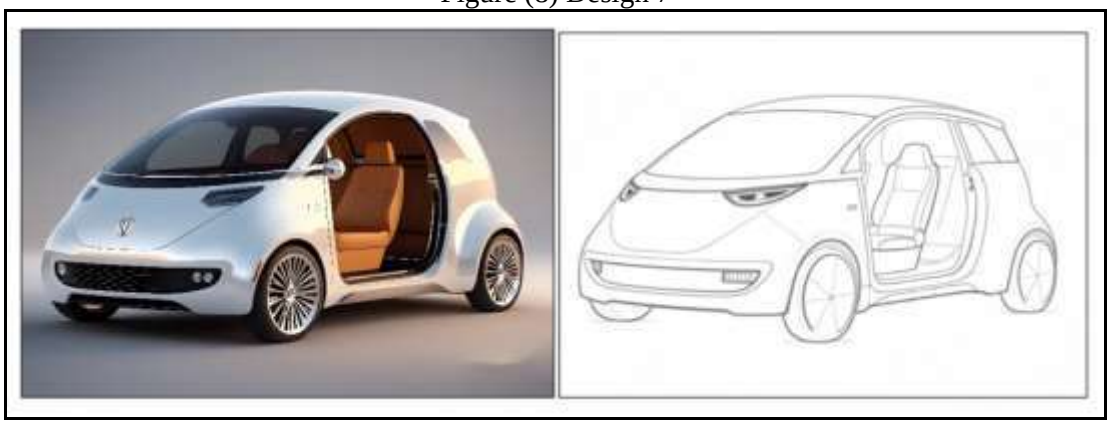

Figure (9) Design 8

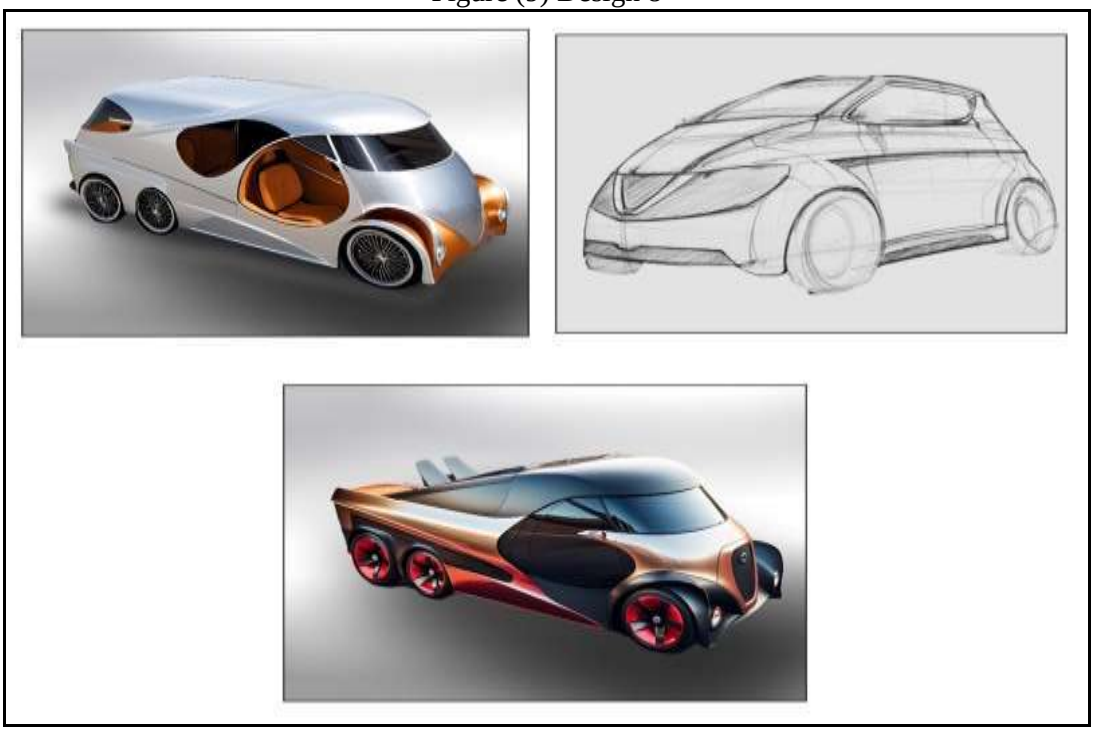

Figure (10) Designs (9,10)

Second: Survey Design:

The questionnaire was designed using a five-point Likert scale to evaluate the ten proposed designs. The questionnaire was presented to 10 evaluators, including faculty members and specialists. It included four main sections: (innovative aspect, application of AI programs, achieving sustainability in design, and functional aspect).

Section 1: Innovative Aspect This section included the following questions:

Does the design's lines align with the shape of the product?, Does the design achieve the correct proportions and ratios?, Does the design maintain balance in its components appropriately?, Does the proposed design achieve creativity and originality in industrial product design?

Section 2: Application of Artificial Intelligence in Industrial Design This section included the following questions:
Is it easy to use AI programs to create multiple designs with diverse ideas?, Has the AI program successfully simulated the designer's ideas accurately?, Does using AI programs contribute to saving time and effort?, Is it possible to modify designs with precision and skill?
Section 3: Achieving Sustainability in Design This section included the following questions:
Does the design contribute to environmental conservation by using electricity instead of fuel?, Does the design take environmental sustainability standards into account?, Does the design use sustainable or recyclable raw materials?
Section 4: Functional Aspect This section included the following questions:
Does the current design meet the needs of the targeted market?, Is the design easy to use and operate by the end-user?, Does the product design incorporate all the required functions effectively?

Results & Discussion

The relative weights of the evaluation results for the axes and survey items were calculated. In Table (1), the results of the evaluators are presented, with each axis represented graphically separately to illustrate the impact of each axis's characteristics on the proposed designs. Finally, the overall evaluation of the designs was presented by showing the combined averages of the axes to identify the most successful designs in achieving the research objectives.

Table (1): Relative weights of design evaluations based on the survey items assessed by the evaluators

Design	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Average Score
Design 1	89.80	91.20	92.40	94.50	91.98
Design 2	89.70	92.00	94.67	97.07	93.36
Design 3	84.40	86.40	91.47	93.60	88.97
Design 4	92.80	95.80	95.47	97.33	95.35
Design 5	89.80	93.20	94.93	96.00	93.48
Design 6	93.50	92.10	92.80	94.40	93.20
Design 7	86.40	86.40	90.13	92.53	88.87
Design 8	91.60	91.00	91.47	92.27	91.58
Design 9	93.30	92.70	94.40	95.73	94.03
Design 10	90.90	92.30	93.60	94.93	92.93
Average	89.90	90.94	93.34	94.95	92.28

The evaluators' assessment of the innovation aspect for all designs is illustrated in Figure (11).

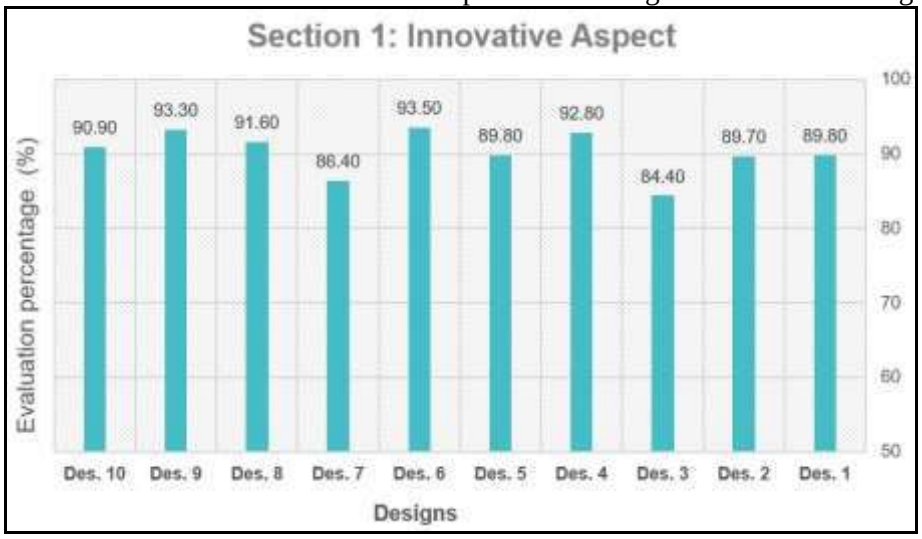

Figure (11) The evaluators' assessment of the Innovation Aspect

The evaluators' assessment of the Application of Artificial Intelligence in Industrial Design for all designs is illustrated in Figure (12).

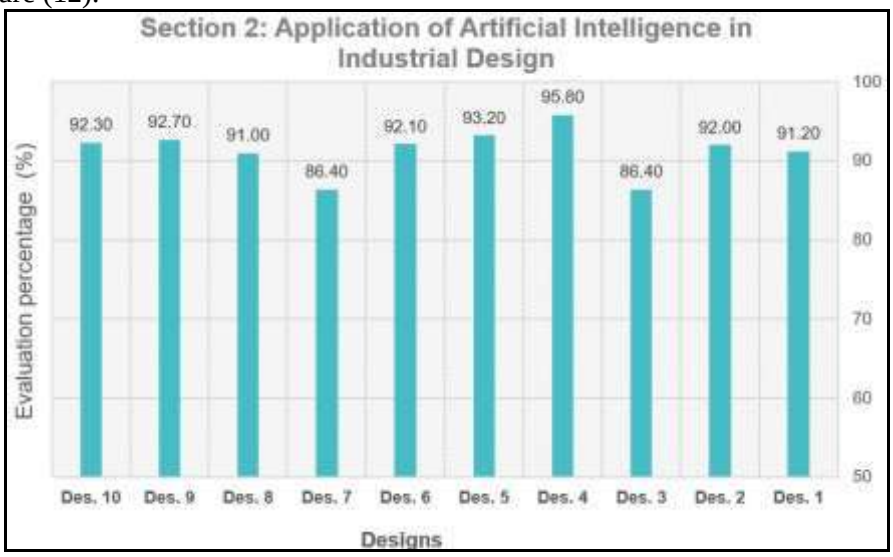

Figure (12) The evaluators' assessment of the Application of Artificial Intelligence in Industrial Design

The evaluators' assessment of the Achieving Sustainability in Design for all designs is illustrated in Figure (13).

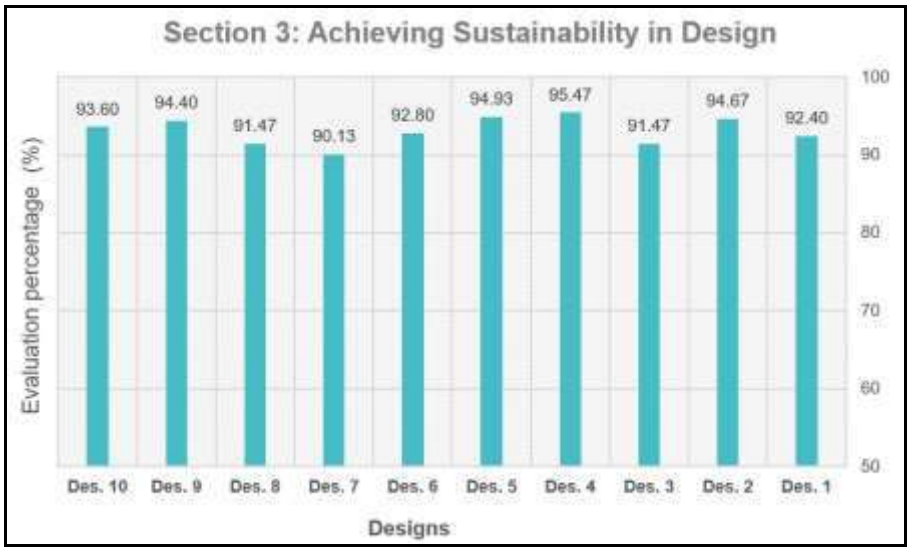

Figure (13) The evaluators' assessment of the Achieving Sustainability in Design

The evaluators' assessment of Functional Aspect for all designs is illustrated in Figure (14).

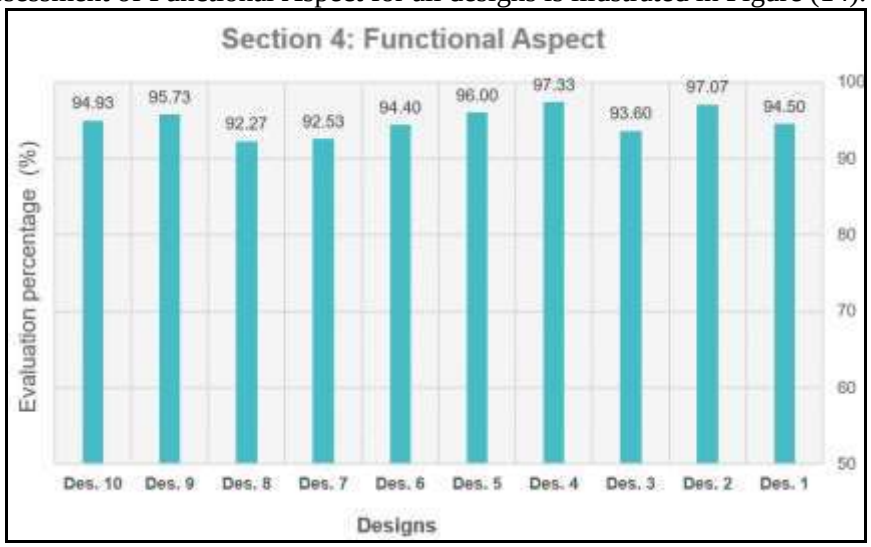

Figure (14) The evaluators' assessment of the Functional Aspect in Design

Overall Evaluation of the Proposed Designs is illustrated in Figure (15).

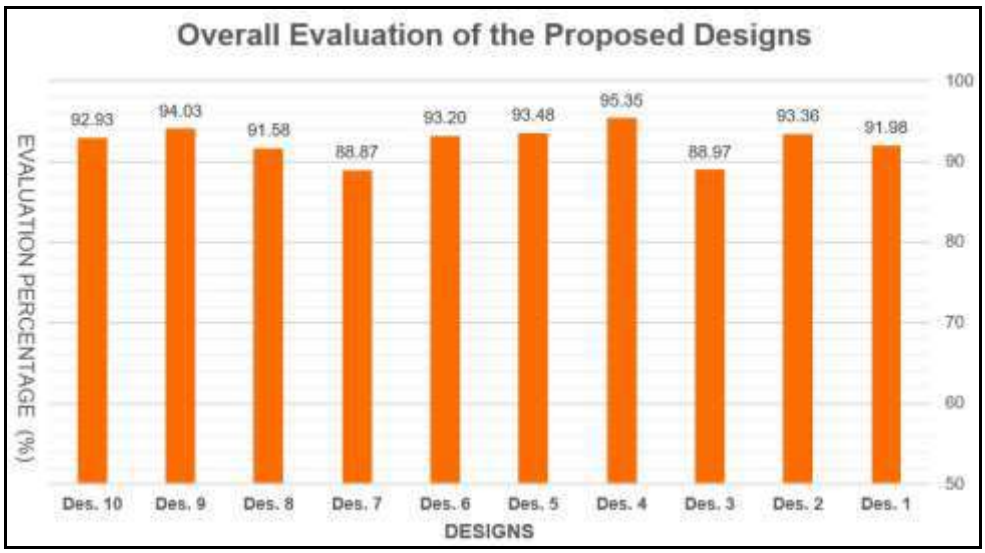

Figure (15) Overall Evaluation of the Proposed Designs

Analysis and Discussion of Results:

Highest Average:

Design 4 has the highest average score of 95.35, indicating it performed the best overall. This design achieved high scores across all criteria, with particularly outstanding performance in the third and fourth criteria (95.47 and 97.33, respectively). This makes Design 4 the most well-rounded and successful design overall.

Lowest Average:

Design 7 has the lowest average score of 88.87, with particularly weak scores in the first and second criteria (both scored 86.40). Despite performing slightly better in the third and fourth criteria, it still lags behind other designs in these crucial areas.

Criterion-wise Analysis:

- **Criterion 1:** The average score for this criterion is 89.90, with most designs scoring in a similar range, but Design 4 stands out with 92.80. Design 3 performed the weakest with 84.40, highlighting an area of improvement for this design.
- **Criterion 2:** The average for this criterion is 90.94, and Design 4 again leads with 95.80, followed closely by Design 5 with 93.20. Design 7 scored the lowest with 86.40, showing its weakness in this criterion.
- **Criterion 3**: This criterion had a higher average score of 93.34, with Design 2 leading at 94.67, followed by Design 5 with 94.93. Design 7 again scored the lowest in this area at 90.13.
- **Criterion 4**: The highest average for this criterion was 94.95, with Design 4 achieving the top score of 97.33, followed by Design 2 at 97.07. Design 7 again scored the lowest with 92.53.

Trends:

- Design 4 consistently performed the best across all criteria, making it the overall winner. Its performance was especially strong in the third and fourth criteria, where it had the highest scores.
- Design 7 is the weakest performer overall, struggling significantly in the first and second criteria. Even though it performed somewhat better in the third and fourth criteria, its overall scores are still far below the other designs.
- Design 2 is a strong competitor, with solid performances in all criteria, particularly excelling in the fourth criterion. Its average score of 93.36 places it second, just behind Design 4.

Conclusions:

Top Performer:

Design 4 is the best overall design. It excels across all criteria, with especially high scores in Criterion 3 and Criterion 4. It could serve as a model for other designs to improve their performance.

Figure (16) Top Performer

Weakest Performer:

Design 7 is the lowest-performing design. It struggles in the first and second criteria, which heavily impacts its overall score. Significant improvements in these criteria could elevate its performance to a competitive level.

Figure (17) Weakest Performer

Improvement Opportunities:

- Design 3 and Design 7 should focus on enhancing their scores in the first and second criteria, as these are key areas of weakness.
- Design 2 could improve its performance in Criterion 1 and Criterion 2 to close the gap with Design 4.

Overall Trend:

- Most designs performed well in Criterion 3 and Criterion 4, which seem to be the stronger areas for all the designs. Designs should focus on improving their performances in the first two criteria, as they show more variation across different designs.
- By focusing on these areas, the lower-performing designs could improve their overall average and compete better with the higher-ranked designs.

Research Recommendations:

- Adopt artificial intelligence programs in industrial design.
- Enhance the use of artificial intelligence to increase efficiency and innovation in design.
- Focus on developing artificial intelligence tools for industrial design.
- Strengthen the role of artificial intelligence in product design.
- Increase the emphasis on using artificial intelligence to achieve sustainability.

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