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GENERATIVE DESIGN WITH ARTIFICIAL INTELLIGENCE: SYSTEMATIC REVIEW OF TRENDS, TECHNIQUES, AND APPLICATIONS

Astelio Sivera-Sarmiento[1], Alejandro Valencia-Arias[2], Evaristo Navarro Manotas[3], Liliana Ramos Barrios[4], Angélica Jiménez Coronado[5]

[1]*Instituto de Investigación IDITEK, Colombia. Email: astelio@iditek.edu.co*
[2]*Investigador Independiente. Email: javalenciar@gmail.com*
[3]*Universidad de la Costa (CUC), Colombia. Email: enavarro3@cuc.edu.co*
[4]*Instituto de Investigación IDITEK, Colombia. Email: liliana@iditek.edu.co*
[5]*Corporación Unificada Nacional de Educación Superior (CUN), Colombia. Email: angelica_jimenezco@cun.edu.co*

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ABSTRACT

Generative visual design with AI transforms creative processes by autonomously generating images and structures using advanced algorithms. Its application optimizes visual production in architecture, product design and manufacturing, expanding creative possibilities. However, the lack of standards and evaluation criteria makes it difficult to adopt them in professional environments, which requires methodologies that measure the quality and coherence of the designs generated. The objective of this research is to explore AI algorithms, techniques and tools applied to generative visual design, identifying their main applications and evaluation methods. To this end, the PRISMA 2020 methodology was used, a systematic approach that guarantees the rigorous selection of relevant studies through a structured process of identification, screening, eligibility and analysis. The results show the predominance of algorithmic approaches, the diversity of tools used and the methodological and regulatory challenges in their industrial integration. Empirical validation, robust regulatory frameworks, and training strategies are required to facilitate their professional adoption. The development of generative design will depend on its integration with other disciplines and on tools that allow a more efficient interaction between AI and human creativity.

KEYWORDS: Generative Algorithms; Computational Modeling; Structural Optimization; Machine Learning; Design Evaluation.

1. INTRODUCTION

Generative visual design uses algorithms and computational models to generate images, graphics and compositions autonomously or semi-autonomously, unlike traditional design, where each element is adjusted manually, this approach allows the creation of multiple variations from predefined rules or artificial intelligence models, its application has expanded the creative possibilities and improved the efficiency in visual production (Lively, Hutson, & Melick, 2023).

The development of artificial intelligence has strengthened this field with models such as Generative Adversarial Networks (GANs), Variational Autoencoders (VAE) and Convolutional Neural Networks (CNNs), these technologies have demonstrated effectiveness in the generation of digital art, graphic design, fashion, architecture and advertising, their ability to learn and adapt allows to analyze large volumes of visual data and generate content that imitates, modifies or innovates in relation to pre-existing styles, optimizing design and production processes (Archana Balkrishna, 2024). Tools such as Midjourney and Stable Diffusion have been evaluated in different areas, including education and web design, with results that show their usefulness in improving creativity and visual literacy (Han & Cai, 2023).

The impact of artificial intelligence on generative visual design is not limited to production speed and efficiency, but also expands the creative scope, the ability to generate a large number of combinations and styles allows for the exploration of innovative approaches that push the boundaries of traditional design. However, the accelerated growth of these technologies presents significant challenges, the lack of standards to assess the quality of AI-generated design makes it difficult to adopt them in professional environments, in addition, the absence of tools that facilitate integration between generative models and conventional design platforms limits their use, resistance has also been identified in the design community, who perceive these technologies as a threat to human creativity and manual intervention in the artistic process (Dehman, 2023; Benjumea Arias et al., 2024; Silvera-Sarmiento, et al., 2018).

The future of generative visual design will depend on the development of methodologies to evaluate the quality and coherence of designs created with artificial intelligence, as well as strategies that facilitate their integration into the creative industry, the adoption of these tools will be determined not only by their technical capabilities, but also by their acceptance within the community of designers. who will be able to use them as a complement to expand their creative and expressive possibilities.

Despite the growing interest in artificial intelligence applied to generative visual design, knowledge about its fundamentals, algorithms, techniques and tools remains unstructured, the evolution of these technologies has allowed the development of generative models capable of producing images and graphics with a high level of realism and creativity, however, the lack of a clear organization of knowledge makes it difficult to understand and apply it in different areas of the world. design (Hughes, Zhu, & Bednarz, 2021).

One of the main challenges in this field is the absence of a standard to evaluate the quality of designs generated by artificial intelligence, visual and aesthetic appreciation is subjective and depends on the context, which makes it difficult to create universal metrics to measure the creativity or effectiveness of an image generated by an AI model. the lack of defined criteria generates uncertainty about the reliability and usefulness of these designs, which affects their integration into the creative industry (Lai, Chen, & Yang, 2023).

In addition, the incorporation of artificial intelligence tools into the workflows of designers and artists remains a challenge, although platforms such as RunwayML, Deep Dream Generator and Midjourney have facilitated access to these technologies, their adoption remains limited, factors such as implementation costs, technical complexity and lack of specialized training make it difficult to use them in conventional creative processes, these barriers restrict the accessibility of artificial intelligence in design and limit its use for the generation of visual content (Gerhard, Köring, & Neges, 2022).

Faced with these challenges, a greater structuring of knowledge about the algorithms, techniques, applications and tools used in generative visual design with artificial intelligence is required, a detailed analysis of these aspects would facilitate the integration of these technologies in creative processes, encourage their adoption in different design sectors and optimize their impact on visual production (Çelik, 2024).

In this sense, the objective of the research is to explore the algorithms, techniques and tools of artificial intelligence applied to generative visual design, identifying their main applications and methods of quality assessment in different creative contexts. The analysis of these technologies allows us to understand their operation, their implementation possibilities and their impact on various areas of design, such as digital illustration, architecture, fashion and advertising. In addition, the criteria used to measure the effectiveness and creativity of designs generated by artificial intelligence are examined, in order to establish evaluation frameworks that allow their integration into professional environments.

- To achieve the proposed objective, there is a series of questions that guide the research and allow a detailed analysis of the key aspects of generative visual design based on artificial intelligence.
- What are the main computational methods used in generative design?
- What AI techniques are used in the image and graphics generation process?
- What are the main application areas of generative visual design?
- What methods are used to assess the quality of generative designs?
- What are the most commonly used tools and software in generative visual design?

To this end, the article proposes a structure composed of five sections: Introduction, Methodology, Results, Discussion and Conclusions. The Introduction contextualizes generative visual design based on artificial intelligence, highlighting its evolution, applications, and challenges. The Methodology describes the approach used to analyze the algorithms, techniques and tools implemented in this field, establishing criteria for the collection and evaluation of information. In the Results section, key findings are presented that identify trends and gaps in the literature, as well as proposed criteria to assess the quality of AI-generated design. The Discussion examines the adoption and integration of these technologies in the creative industry, considering technical, economic and conceptual factors that influence their implementation. Finally, the Conclusions section synthesizes the contributions of the study and highlights the need for future research on the interaction between artificial intelligence and human creativity, promoting its optimized use in professional environments.

2. METHODOLOGY

The methodology used in this research follows the guidelines of PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), a widely recognized approach to conducting systematic reviews in various scientific disciplines (Page et al., 2021; Arenas-Peñaloza et al., 2024). This methodological framework ensures transparency and reproducibility in the selection of studies by minimizing bias and ensuring a comprehensive compilation of relevant literature on artificial intelligence applied to generative visual design.

The application of PRISMA 2020 responds to the need to structure knowledge about algorithms, techniques and tools in this field, given the rapid evolution of these technologies, a systematic review allows identifying trends, gaps in the literature and previous methodological approaches. The process follows four phases: identification, which compiles studies from indexed databases; screening, which removes duplicates and irrelevant records; eligibility, which applies inclusion and exclusion criteria, and final selection, which analyzes relevant studies to answer research questions (Page et al., 2021).

2.1. Eligibility Criteria

The study selection process was based on inclusion and exclusion criteria to guarantee the relevance and quality of the documents analyzed, specific parameters were established that allowed identifying research on artificial intelligence applied to generative visual design, considering its applicability in different creative contexts.

Studies published in indexed journals and recognized scientific conferences were selected, ensuring their methodological rigor and contribution to the academic literature, empirical research that analyzed the use of artificial intelligence in generative design was prioritized, focusing on applications, trends, techniques and implementation. The search included only documents whose title explicitly reflected their relationship to generative design, machine learning in design, or computational approaches to visual creation. Only studies published in the last ten years were considered, ensuring the updating of knowledge about artificial intelligence in this field.

The exclusion process was carried out in three phases. Initially, records with indexing errors or duplicates were eliminated, poorly indexed references, documents with incomplete information and duplicate studies in the databases were discarded, this initial purging allowed to avoid redundancies and ensure the integrity of the documentary corpus.

Then, studies without full-text access were excluded, and research that could not be accessed in its entirety was eliminated, as full review of the content was necessary for a detailed analysis of methodology and results.

Finally, a manual review of the relevance of the content was carried out, the selected studies were analyzed and those that, despite meeting the previous criteria, did not directly address the relationship between artificial intelligence and generative visual design were discarded, works that only tangentially mentioned the topic without providing empirical evidence or a substantial discussion on its applications were excluded, techniques or implementation.

This procedure ensured that the studies analysed were methodologically sound, relevant and provided key information for the research.

2.2. Sources Of Information

The search for studies was carried out in Scopus and Web of Science, two scientific databases of international reference, these platforms offer access to peer-reviewed academic literature, allowing a systematic compilation of relevant publications on artificial intelligence applied to generative visual design.

Scopus, managed by Elsevier, is one of the most comprehensive databases in interdisciplinary coverage, indexing scientific journal articles, conferences, and book chapters, providing access to up-to-date literature in technology, engineering, and applied sciences, its ability to organize studies with detailed metrics makes it easy to identify emerging trends and evaluate the impact of generative visual design research.

Web of Science, managed by Clarivate, is another source of high impact in the scientific community, its system allows tracking citations and analyzing the influence of studies over time, its focus on indexing research with high methodological rigor guarantees the inclusion of relevant and reliable literature in this review.

The selection of these databases is based on their recognition as sources of scholarly information with broad reach and strict indexing criteria, both of which offer significant coverage in artificial intelligence, machine learning, and computational creativity (Asubiaro, Onaolapo, & Mills, 2024). Its use ensures that the included studies meet high quality standards, allowing a representative analysis of scientific contributions in this field.

2.3. Search Strategy

A specific search equation was defined for each database in order to retrieve relevant studies, following the established inclusion criteria, Boolean operators and key terms were used that represent the central concepts of generative visual design based on artificial intelligence, ensuring precision and structure in the search.

Para Scopus: TITLE ("Generative Design" OR "AI-driven Design" OR "Computational Design" OR "Machine Learning in Design") AND TITLE ("Applications" OR "Trends" OR "Techniques" OR "Implementation").

Para Web of Science: TS=("Generative Design" OR "AI-driven Design" OR "Computational Design" OR "Machine Learning in Design") AND TS=("Applications" OR "Trends" OR "Techniques" OR "Implementation").

The use of Boolean operators allowed the search to be broadened without compromising the relevance of the results, the selection of key terms guaranteed the inclusion of studies aligned with the research approach, prioritizing those that analyze applications, trends, techniques and implementation of artificial intelligence in generative design.

2.4. Selection Process

The selection of studies followed a structured flow based on PRISMA 2020, ensuring systematic and reproducible filtering, first, the records were identified from the search equations in Scopus and Web of Science, then, duplicates were eliminated with specialized digital tools to maintain the integrity of the dataset.

In the screening phase, titles and abstracts were reviewed to rule out studies that did not meet the inclusion criteria, in the eligibility stage, full texts were evaluated and those that did not directly address generative visual design based on artificial intelligence were excluded, this process allowed the selection of relevant and methodologically sound research.

Figure 1 presents the flow chart recommended by the PRISMA 2020 statement, where the study selection process is visualized, in this diagram the records identified in the databases, the exclusions made in each phase of the screening and the studies finally selected for analysis are detailed.

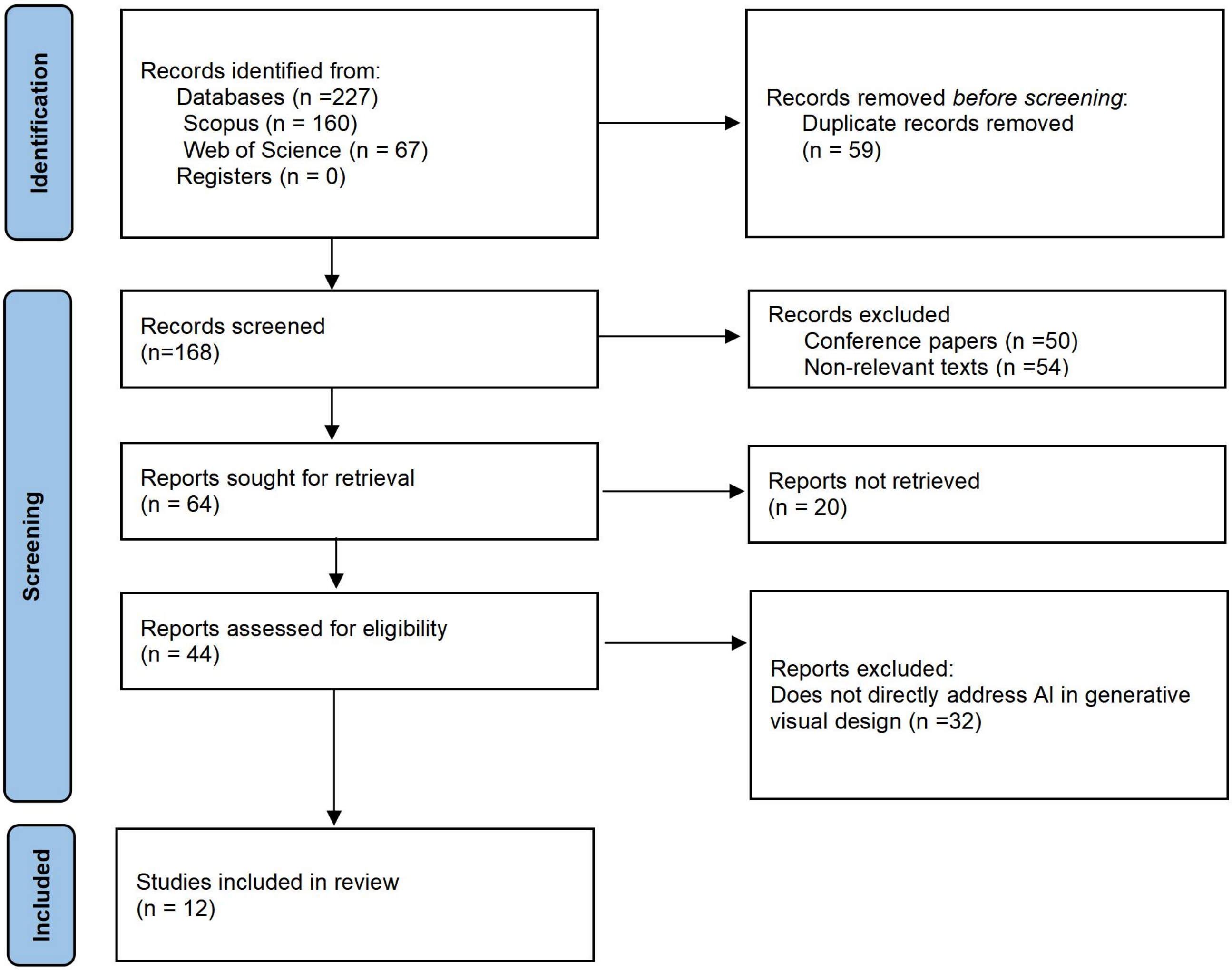

Figure 1: PRISMA Flowchart. Own Elaboration Based On Scopus And Web Of Science.

2.5. Data Processing

The data extracted from the selected studies were stored and organized in Excel, allowing their categorization and analysis, the records were structured according to author, year of publication, methodology and main findings, ensuring a clear and orderly arrangement.

To ensure the accuracy of the dataset, cleaning and verification strategies were applied, duplicate records were eliminated and errors in information extraction were corrected, filters and validation tools were used to standardize formats and maintain consistency, this process allowed for efficient classification, facilitating the analysis and identification of patterns and trends in the use of artificial intelligence for generative visual design.

2.6. Risk Of Bias

The selection of studies may be subject to biases that affect the representativeness and validity of the results, the exclusive use of Scopus and Web of Science introduces a possible database bias, since, although they offer wide coverage, they may exclude research published on other platforms.

The design of the search strategy also generates selection biases, since the terms used can limit the retrieval of studies that use different names for similar concepts, in addition, notification bias influences the results, since studies with positive or innovative findings are more likely to be published than those with negative results or replications. These limitations can impact the analysis, so their effect on the interpretation of the data was considered.

3. RESULTS

The results are organized according to the research questions to structure the analysis on the role of artificial intelligence in generative visual design, through a systematic approach, the most used algorithms, image and graph generation techniques, application areas, evaluation methods and tools used in this field are examined.

Generative visual design based on artificial intelligence has grown significantly in recent years due to advances in deep neural networks and generative models. Its implementation has automated and optimized creative processes in disciplines such as digital illustration, architecture and advertising. The development of deep learning models has made it possible to generate high-quality visual content, modifying the interaction of designers and artists with technology.

Table 1 summarizes the studies included in the analysis and provides an overview of the research underpinning this section.

Table 1: Studies Included In The Research. Own Elaboration Based On Scopus And Web Of Science.

Title	Citation (APA)
Advanced optimization of drone frame design through the application of generative design techniques and 3D printing technology	Darsin et al. (2025)
Computational design of Metal-Organic Frameworks for sustainable energy and environmental applications: Bridging theory and experiment	Ma et al. (2025)
Computational design techniques for generating specific Girih patterns: A particular focus on algorithmic design and graph theory	Razzaghmanesh & Gürer (2024)
Design and optimization of multi-MW offshore direct-drive wind turbine electrical generator structures using generative design techniques	Gonzalez-Delgado et al. (2023)
Planning Walkable Cities: Generative Design Approach towards Digital Twin Implementation	Kumalasari et al. (2023)
Simplified Methods for Generative Design That Combine Evaluation Techniques for Automated Conceptual Building Design	Lee et al. (2023)
A Generative Design Method for Cultural Heritage Applications: Design of Supporting Structures for Artefacts	Belluomo et al. (2023)
A generative design technique for exploring shape variations	Khan & Awan (2018)
Analysis of Anatolian Traditional Weaving Technique in the Context of Computational Design	Çevik et al. (2024)
Computational design of novel protein-protein interactions - An overview on methodological approaches and applications	Marchand et al. (2022)
Elementary implementation of a parameter-based generative design system considering the user environment	Ji & Jun (2014)
Parametric and and Generative Design techniques in mass-production environments as effective enablers of Industry 4.0 approaches in the Building Industry	Pasetti Monizza et al. (2018)

Figure 2 shows the distribution of computational methods in generative visual design. Generative Design is the most prevalent, with six registrations, followed by Parametric Modeling, with three. Artificial Intelligence, Machine Learning, Finite Element Analysis, Evolutionary Algorithms, and Bioinformatics Design appear twice each, indicating their importance in the field. The results show the predominant use of generative models and machine learning to optimize and develop designs.

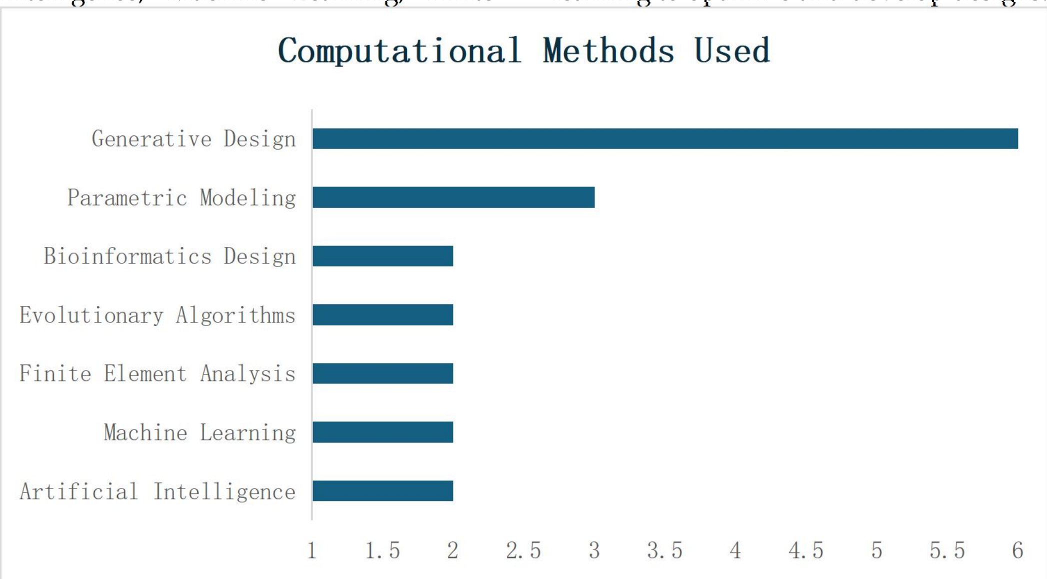

Figure 2: Distribution Of Computational Methods Used Own Elaboration Based On Scopus And Web Of Science.

Figure 3 shows the categorization of generation techniques in generative visual design with AI. Topology Optimization and Parametric Modeling are the most recurrent categories, with five records each, indicating their high presence in the field. Generative Design appears twice, while techniques such as Computational Design, Graph-Based Generation, Digital Fabrication, and Algorithmic Optimization have only one appearance. These data reflect the variety of approaches used in the discipline, highlighting the prevalence of certain methodologies.

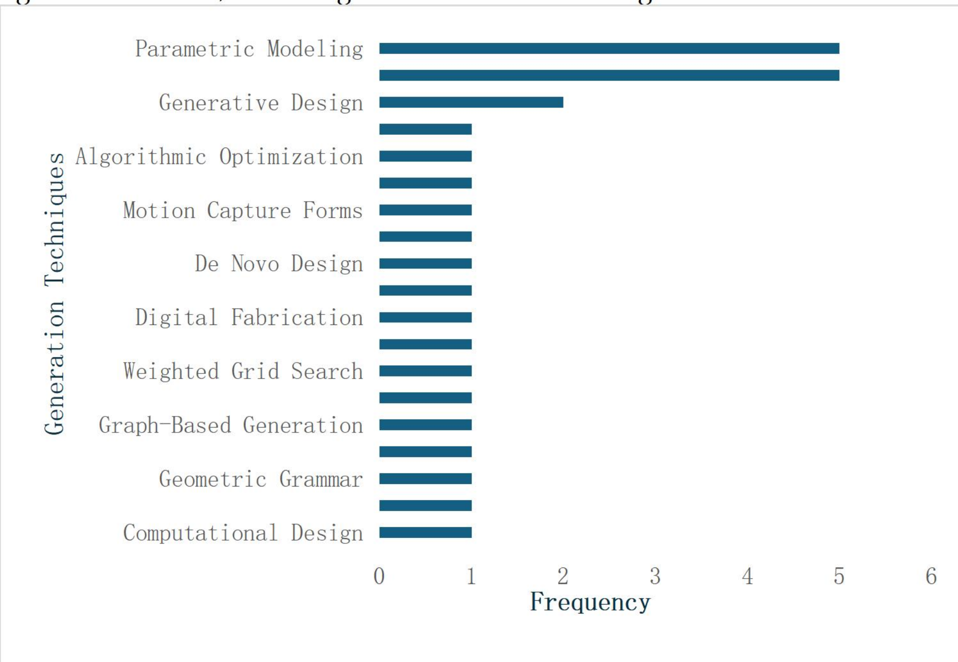

Figure 3: Distribution Of Generation Techniques. Prepared By The Author Based On Scopus And Web Of Science.

Figure 4 shows the distribution of application areas in generative visual design with AI. Architectural Ornamentation and Product Design register the highest frequency with four appearances. Construction Planning and Synthetic Biology follow with three records. Aerospace Engineering, Environmental Sustainability and Cultural Heritage appear twice. Other areas such as Renewable Energy, Digital Twin, Smart Cities and Industrial Design have only one mention. These data show the variety of applications in the field, covering both technological and creative approaches.

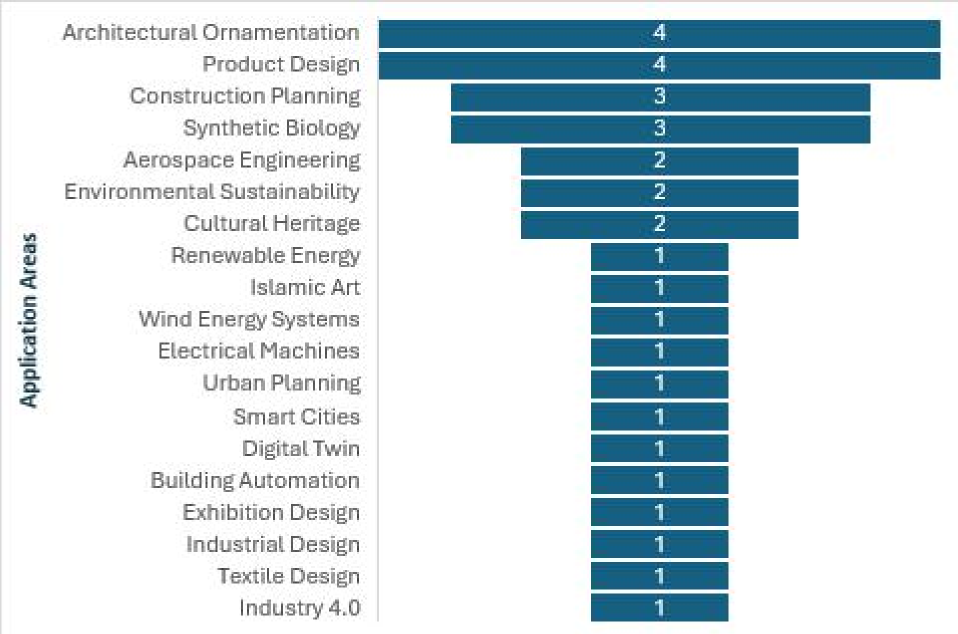

Figure 4: Distribution Of Application Areas. Prepared By The Author Based On Scopus And Web Of Science.

Figure 5 presents the distribution of evaluation methods in generative visual design with AI. Performance Metrics and Structural Integrity recorded the highest frequency with four occurrences. Simulation-Based Validation, Design Space Exploration, and Binding Affinity appear twice. Methods such as Finite Element Analysis, Impact Testing, Static Simulation, Electronic Structure Analysis, and Gas Adsorption Studies are recorded once. Approaches such as Pattern Accuracy, Algorithm Efficiency, Scenario Comparison and Environmental Analysis are also included, evidencing the diversity of techniques applied in the evaluation of generative designs.

Figure 5: Distribution Of Evaluation Methods. Prepared By The Author Based On Scopus And Web Of Science.

Figure 6 shows the distribution of tools and software in generative visual design with AI. 3D Modeling Software is the category with the largest presence, with twelve records. Parametric Design Software follows with seven mentions. Python-Based Frameworks, Bioinformatics Software, and Radiation Analysis Software appear three times. Electronic Structure Calculations, Molecular Dynamics Software, Finite Element Analysis, Geospatial Analysis Tools, Building Information Modeling, and Structural Simulation Software are registered twice, as is Custom Software Development. These data show the variety of tools used in the area.

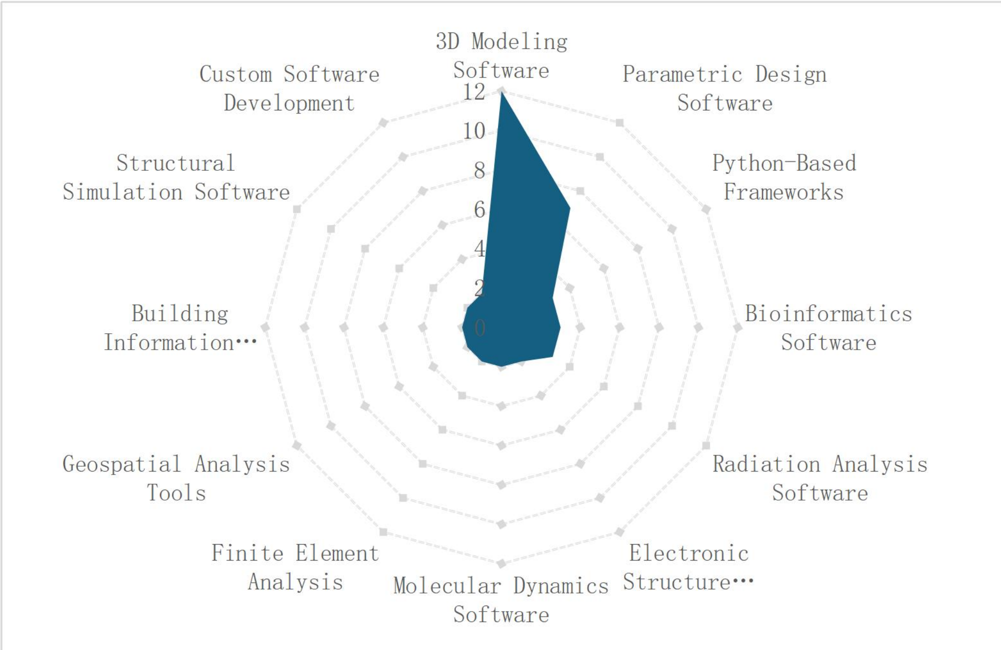

Figure 6: Distribution Of Tools And Software. Prepared By The Author Based On Scopus And Web Of Science.

The results of the research on AI in generative visual design were organized according to the main study questions. Computational methods, generation techniques, areas of application, evaluation methods and tools used were analyzed. The data shows patterns in the use of algorithmic and machine learning approaches. They also reflect the diversity of applications that integrate technological innovation and design. The evaluation of results uses different criteria, and the tools used cover a wide spectrum of specialized software. These findings offer a clear view of current trends and applications in the field.

4. DISCUSSION

The discussion is organized into sections that interpret the findings in relation to the existing literature and its impact on the field. First, the results are compared with previous studies to identify similarities and differences. Then, a conceptual framework based on the findings is presented to structure the phenomenon analyzed. Subsequently, the theoretical, political and practical implications are examined, highlighting their relevance in different contexts. The methodological limitations of the study are also analysed and, finally, future lines of research are proposed to expand knowledge in generative visual design with AI.

4.1. Analysis Of Results

The results show the predominant use of algorithmic approaches and machine learning in generative visual design. Generative Design is the most widely used methodology, in line with studies that highlight its ability to generate optimal alternatives in the design space (Khan & Awan, 2018). In addition, the application of Parametric Modeling and artificial intelligence techniques reinforces automation in the creation of shapes, aligning with proposals that integrate environmental data and simulations to optimize design (Ji & Jun, 2014). These findings confirm the transition from generative design to more adaptive and intelligent models.

The results show the variety of generation techniques applied in generative visual design with AI. Topology Optimization and Parametric Modeling are the most widely used approaches, in accordance with studies that validate their effectiveness in the structural optimization of wind turbines and drones (Gonzalez-Delgado et al., 2023; Darsin et al., 2025). The presence of Generative Design and other methodologies indicates a transition towards more flexible and efficient strategies. These findings support the adoption of advanced techniques to improve structural optimization and manufacturing processes in various applications.

The results show the diversity of applications of generative visual design with AI, integrating technological and creative approaches. The importance of Architectural Ornamentation aligns with studies that employ algorithms and graph theory to generate patterns in Islamic art with precision (Razzaghmanesh & Gürer, 2024). In

Product Design, Generative Design techniques have proven effective in optimizing models in the conceptual phase, exploring efficient structural alternatives (Khan & Awan, 2018). These findings highlight the impact of AI on the generation and improvement of complex designs (Pérez & Velásquez, 2023).

The results show the variety of methods used in the evaluation of generative designs with AI, including performance metrics, structural validations, and design space optimization. The integration of automated approaches improves efficiency in the selection of alternatives, in accordance with studies that combine generative algorithms and evaluation methodologies in architecture (Lee et al., 2023). In addition, the use of structural analysis in cultural heritage confirms the adaptability of these methods to ensure stability and aesthetics in exhibition supports (Belluomo et al., 2023).

The results show the diversity of tools applied in generative visual design with AI, including modeling software, structural simulation and computational analysis. The combination of these tools improves the generation of optimized structures, as observed in studies on the design of UAVs through additive manufacturing and finite element analysis (Darsin et al., 2025). In addition, the integration of Generative Design into urban planning demonstrates its ability to improve livability through digital models and accessibility factors (Kumalasari et al., 2023). These findings demonstrate the flexibility and scope of these technologies.

4.2. Comparison Of Results With Other Studies

The findings of this research confirm the predominant use of algorithmic approaches and machine learning in generative visual design with AI, in accordance with previous studies on the impact of generative models in various disciplines (Sengar et al., 2024; Kaswan et al., 2023). The organization of the results into computational methods, generation techniques, application areas, evaluation methods, and tools used coincides with research that analyzes the evolution of AI in design optimization (Hughes et al., 2021). However, while this study emphasizes the integration of specialized tools, other studies have focused their analysis on specific generative models such as GANs and VAEs, evaluating their performance in data synthesis and content generation (Kaswan et al., 2023).

The use of Generative Design as a central methodology reinforces research that has demonstrated its effectiveness in the creation and optimization of structures (Darsin et al., 2025; González-Delgado et al., 2023). However, studies such as that of Sengar et al. (2024) expand this perspective by highlighting applications in natural language processing, image synthesis, and drug discovery, areas not addressed in this research. This difference indicates that while Generative Design is consolidated as a key technique in visual design, its integration with other data generation approaches could expand its reach.

Another coincidence with the literature is observed in the impact of AI on design automation, modifying workflows in architecture, manufacturing, and education (Lively et al., 2023). In this sense, the results support studies that have explored the use of generative tools in collaborative environments between humans and machines (Hughes et al., 2021). However, while this research analyzes a wide spectrum of techniques and tools, other studies have pointed to limitations in the scalability of these systems and in the lack of user studies that validate their impact in real environments (Hughes et al., 2021; Lively et al., 2023).

In terms of application areas, this study highlights the use of AI in product design, architecture, and urbanism, which is consistent with research on Generative Design in urban planning and digital models for the management of the built environment (Kumalasari et al., 2023). However, recent studies have identified emerging applications, such as generative design in the food industry, exploring the relationship between food structure and consumers' sensory perception (Al-Sarayreh et al., 2023). This difference indicates that the expansion of generative design into new sectors still requires further exploration.

Finally, an important difference lies in the discussion about the principles of Responsible AI and the ethical challenges associated with automated content generation. While studies such as Kaswan et al. (2023) have addressed concerns about bias, copyright, and regulation, this aspect has not been discussed in depth in the present study. Including these considerations in future research would allow for a more comprehensive assessment of the impact of generative visual design with AI.

4.3. Conceptual Framework Proposal

Figure 7 shows the conceptual framework based on the findings on AI in generative visual design. This framework is composed of five axes: computational methods, generation techniques, application areas, evaluation methods, and tools and software. It represents the relationship between these elements and their influence on design optimization. Approaches such as Generative Design and Machine Learning are included, along with techniques such as Topology Optimization. Sectors of application and the methods used to evaluate the designs generated are also identified, evidencing the integration of AI in the creative process.

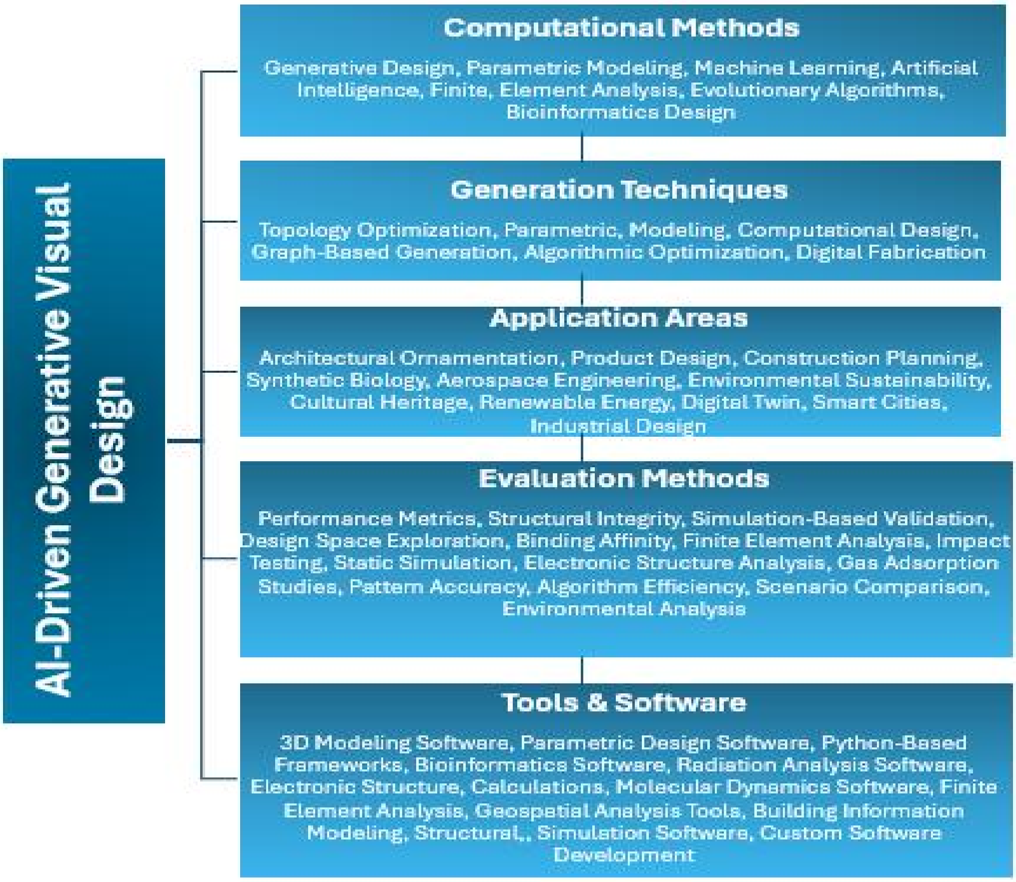

Figure 7: Conceptual Framework Of Generative Design With AI. Own Elaboration.

4.4. Implications

The use of AI in generative visual design transforms the understanding of creative processes mediated by algorithms. The findings of this research confirm that approaches such as Generative Design, Parametric Modeling and Machine Learning optimize the generation and validation of structures. From a theoretical perspective, this reinforces the role of AI as a tool for automation and exploration in design, expanding knowledge about the relationship between computational models and creativity. Identifying techniques such as Topology Optimization, Graph-Based Generation, and Algorithmic Optimization allows us to understand how algorithms improve structural and aesthetic efficiency.

In methodological terms, this study provides a structured framework to evaluate generative design, integrating computational methods, generation techniques, areas of application, evaluation and specialized tools. The relationship between these elements allows for an interdisciplinary model that links visual design with architecture, manufacturing, and biotechnology. The findings highlight the need to further explore the impact of generative algorithms on the aesthetics, functionality, and sustainability of designed products (Silvera Sarmiento 2017).

From a regulatory perspective, the adoption of AI in design poses challenges in regulation and standardization. The automation of architectural, urban and industrial design requires regulations that ensure transparency and reliability in generative models. Implementing evaluation criteria based on performance metrics, structural validations, and simulations is key to ensuring that designs meet safety and functionality standards. Regulatory frameworks should address the impact of these technologies on the labour market, establishing ethical boundaries and adaptation strategies for design professionals.

The integration of Generative AI into public policies can improve urban planning and land management. Tools such as Digital Twin and Walkability Analysis contribute to the development of more efficient and sustainable cities, optimising the distribution of spaces and mobility. These strategies can be applied in public infrastructure projects, ensuring that the designs are functional and adaptable to the needs of the population.

In industry, AI streamlines design processes, allowing for greater customization and reduced production times. Industries such as architecture, advanced manufacturing, and biotechnology are already implementing these techniques to optimize their workflows. The use of Generative Design and Parametric Modeling allows multiple configurations of the same design to be explored, facilitating the selection of cost- and performance-efficient alternatives. This impacts business competitiveness, allowing repetitive processes to be automated and to focus on tasks with greater added value.

In the practical and technological field, the integration of specialized tools and software facilitates the adoption of these approaches in professional environments. Using platforms such as Autodesk Fusion 360, Rhino, and Grasshopper allows experimenting with algorithmic models, reducing reliance on manual processes and optimizing the generation of complex shapes. The combination of structural simulations and AI-based evaluation techniques improves the accuracy and reliability of designs, validating their feasibility before production.

The implementation of these methods in professional practice requires a reformulation of training programs in design, architecture and engineering. Training in generative algorithms and computational tools should be integrated into curricula to prepare professionals in the use of these technologies. In addition, it is essential that designers develop critical criteria for interpreting AI-generated results, ensuring that creative decisions are not delegated entirely to algorithms.

4.5. Limitations

This study has methodological limitations that may influence the interpretation of the findings. The selection of sources and the categorization of techniques, applications and tools were based on a systematic review, so the results depend on the availability and quality of the studies analyzed. The exclusion of papers not indexed in recognized databases may restrict the diversity of approaches.

The validity of the results is affected by the lack of empirical studies and experimental tests that validate the effectiveness of the techniques and tools in real environments. Reliance on secondary data limits the assessment of the practical impact of generative design with AI. The rapid evolution of these technologies can make the findings obsolete in a short time.

The generalization of the results is conditioned by the interdisciplinary approach of the study. The application of AI in generative visual design varies depending on the context, and some sectors may present technical or regulatory constraints that are not considered. Future studies should integrate experimental validations and comparative analyses to improve the applicability of these findings.

4.6. Lines Of Future Research

Generative visual design with AI offers new research opportunities in different fields. This study shows the predominance of techniques such as Generative Design, Parametric Modeling and Topology Optimization, but the lack of empirical validation limits the understanding of their effectiveness in real environments. It is necessary to develop experimental studies that evaluate their impact on the optimization of designs, cost reduction and improvement in the functionality of products.

The rapid evolution of these technologies requires analysing their sustainability and adaptability in different sectors. Although architecture, manufacturing, and biotechnology have integrated generative models, their application in smart materials design or aerospace engineering remains limited. Exploring these realms could expand the scope of AI, enabling more efficient and adaptive structures.

Another key aspect is the interaction between AI and human creativity. Generative models automate processes, but their impact on creative decision-making is still unclear. It is necessary to investigate how designers interpret and modify AI-generated results, evaluating their influence on the originality and functionality of products. This would facilitate a framework for collaboration between humans and intelligent systems in visual design.

The normative and ethical implications require further study. Design automation poses challenges in intellectual property, algorithmic biases, and regulation. Future studies should develop regulatory frameworks that establish standards for the implementation of AI in generative design, ensuring its ethical and transparent use.

It is critical to integrate more robust evaluation tools to improve the accuracy of generative models. Currently, validation is based on metrics such as Performance Metrics, Structural Integrity and Simulation-Based Validation, but indicators are needed to measure the aesthetic quality, energy efficiency and production viability of the designs generated.

Finally, training in AI applied to design is a key line of research. The adoption of these technologies in industry requires professionals to acquire new competencies in computational tools and algorithmic modeling. There is a need to analyze effective educational approaches to integrate AI into design teaching and prepare professionals to use these tools critically and efficiently.

5. CONCLUSIONS

Generative visual design with AI transforms the way creative processes are conceived, optimized, and evaluated. The combination of computational models and generative techniques redefines design automation and expands its applications across disciplines. The integration of algorithms allows the development of structured, adaptive, and efficient solutions, consolidating generative design as a key tool in digital innovation.

These advances impact sectors such as architecture, manufacturing, and biotechnology, where AI facilitates the exploration of optimal configurations. However, its implementation faces methodological and regulatory challenges. The lack of empirical validation limits the understanding of its effectiveness in real environments. It is necessary to develop experimental studies to demonstrate its feasibility and to evaluate its sustainability, adaptability and scalability in different contexts.

Generative design with AI raises questions about the relationship between automation and human creativity. Algorithmic optimization generates efficient models, but its impact on creative decision-making remains unclear. It is essential to investigate the interaction between designers and intelligent systems to establish a balance between algorithmic autonomy and human intervention.

The ethical and regulatory implications require further analysis. Design automation poses challenges in intellectual property, copyright, and algorithmic biases. Regulatory frameworks are needed to ensure transparency and reliability in these systems. The lack of standards can make it difficult to adopt, so it is essential to establish clear criteria for their application in industry and academia.

From a practical perspective, generative design requires accurate assessment tools. The metrics must consider not only functionality and structural stability, but also aesthetic quality, energy efficiency and production feasibility. The optimization of these models must integrate multidimensional factors that allow the design to be validated before its implementation.

The adoption of AI in generative visual design requires changes in professional education and training. The integration of computational tools and algorithmic methodologies into curricula is essential to prepare the designers of the future. Training in generative techniques will strengthen the interpretation of results and foster effective collaboration between humans and AI systems, ensuring their critical and strategic use in professional practice.

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