# POSSIBILITIES OF ARTIFICIAL INTELLIGENCE IN COMPUTER-AIDED DESIGN OF STAINED GLASS ART

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*Abstract. The article discusses the possibilities of artificial intelligence (AI) in the computer design of stained glass windows. Stained glass art has a long history, dating back to Ancient Rome. In the Middle Ages, stained glass became an integral part of Gothic architecture, and during the Renaissance it gained wide popularity in secular interiors. Nowadays, stained glass is used in various fields: from architecture to fashion. Modern technologies make it possible to create stained glass using various methods, including classic stained glass, Tiffany, fusing, sandblasting and others. However, the process of creating stained glass remains labor-intensive and requires highly qualified craftsmen. AI can help automate routine tasks and open up new avenues for creative expression. The article identifies tasks that are difficult for humans to perform and that can be successfully assigned to specially trained neural networks. The conditions for creating a professional system for designing stained glass canvases based on artificial intelligence have been clarified.*

***The purpose.*** *The aim of the article is to explore and uncover the possibilities of applying artificial intelligence in stained glass computer design. The article aims to identify the potential advantages of intelligent systems in creating and optimizing stained glass designs, particularly in analyzing and processing large volumes of data, automating the design process, enhancing accuracy and speed of development, as well as improving the functionality and aesthetic appearance of the final product. Additionally, the article seeks to highlight potential challenges and limitations in the application of artificial intelligence in this field and to point out directions for further research and technology development.*

***Methodology***. *The following methods were used in the study:*

*1) analytical method by which the literature was analyzed;*

*2) theoretical and conceptual method, which allowed to determine the conditions necessary for the introduction of IT technology in cultural and artistic practice;*

*The study used methods of computer modeling and analysis, which increased the accuracy of the results.*

***Results***. *It has been determined that the application of artificial intelligence in stained glass computer design can significantly streamline and enhance the process of developing stained glass panels.*

***The scientificance novelty*** *The analysis of artificial intelligence capabilities in the form of automated algorithms for the development and optimization of stained glass design is a new research direction.*

***Practical significance***. *With machine learning algorithms, artificial intelligence can generate unique and creative stained glass designs, taking into account contemporary trends and individual preferences of clients.*
<u>*Key words:*</u> *stained glass, design, computer technology, artificial intelligence.*

## INTRODUCTION

Stained glass art is a complex and intricate form of artistic expression that requires a deep understanding of design, color, and composition. And also, knowledge of production technology. Computer-aided design (CAD) tools have not previously been used to assist stained glass artists in their work, and the potential of artificial intelligence in this area is even less explored. The purpose of this article is to explore the potential of artificial intelligence in stained glass CAD and discuss its current applications, challenges, and future directions.

Current applications of artificial intelligence in CAD have already made significant contributions to various fields, including medical image informatics. In modern computer technology, today there is only one specialized computer system dedicated to stained glass design – Glass Eye. For more than ten years, the world and domestic specialized literature has raised the question of the need to modernize production technologies and design of modern stained glass windows. Unfortunately, essentially nothing has changed since then. As before, in the vast majority of cases, stained glass windows are decorated using traditional methods. This is due to the fact that existing computer technologies do not provide significant advantages in time and convenience of the stained glass design process. The creation of a professional automated computer system for stained glass design will significantly reduce their implementation time, make the process convenient and accessible to a wider user audience through parameterization of the graphics creation process, the use of template libraries and other technologies. To create such a system, specialized technology is required that takes into account all professional requirements and the development of appropriate geometric algorithms. Throughout the entire historical period of the existence of stained glass technologies, craftsmen tried to improve the process of both design and production. It is known that the form of the production process gradually changed under the influence of inventions in the field of glassmaking and metallurgy. The same applies to the design technology itself. The greatest changes and innovations in technology occurred during the Renaissance, when great attention was paid to art. Computer technology

in this area began to be used very late, only in 2000. Unfortunately, the only existing GlassEye system is more aimed at amateurs in the field of stained glass and advertising of glass manufacturers and, in our opinion, does not meet professional requirements. Additionally, it was released in 2000 and has not been updated since then. Which doesn't mean it's popular. The problem can be solved by creating a specialized design system based on artificial intelligence.

## LITERATURE REVIEW

Despite recent advances in the field of artificial intelligence (AI) and its applications in various fields, there is a lack of information in modern scientific publications on the topic of introducing AI into computer-aided design (CAD) systems for stained glass windows. A thorough literature search revealed virtually no studies exploring the potential of AI in stained glass design. Thus, the article, Ploennigs J. and Berger M., 2023, [19] explores the issue of using AI in architecture and construction engineering. There is no mention of designing stained glass panels. Petrushevsky A., 2022, [15] considers the features of using new, specialized software tools in the design of combined stained glass windows without the use of AI. In the dissertation, Whipple K., 1984, [17] due to its age, we are talking only about the use of today's standard tools (CAD). This suggests that research into the use of artificial intelligence in stained glass design is still in its early stages. There are several possible explanations for the lack of research in this area. One possibility is that the field of stained glass design is relatively small and niche. As a result, there may be fewer researchers interested in developing such technologies.

1. Another possibility is that the field of AI is still relatively young and rapidly evolving. This can make it difficult for researchers to keep up with the latest advances in artificial intelligence and apply them to new areas such as stained glass design.

2. Despite the lack of research, AI has clear potential in the field of stained glass design. AI can be used to automate many time-consuming and tedious tasks associated with stained glass design, such as checking and calculating geometric constraints in stained glass windows. AI can also be used to create

new and innovative solutions that would be difficult to create manually.

3. In the future, it is likely that we will see more research into the use of artificial intelligence in stained glass design. As AI technology continues to evolve, it is likely to become more accessible and convenient for artists and designers. This will lead to the creation of specialized software based on neural networks in the field of stained glass design.

**MAIN PART**

In this article we will look at the main tasks posed by CAD design of stained glass panels and in solving which specially trained neural networks can help.

Artificial intelligence (AI) can be used to automate stained glass design tasks. These tasks include:

*Scanning and image recognition.*

AI can be used to automatically scan images quickly and accurately. In addition, selective image scanning becomes possible. Neural networks can be told to scan selected parts of an image and automatically add dividing lines to the resulting image, taking into account geometric constraints. It is necessary to add vectorization of the scanned material

here. Similar functionality is already available in most neural networks. This information can then be used to create digital representations of stained glass designs and element libraries. This digital representation can be used for a variety of purposes, such as creating sketches, calculating the number and size of parts, and modeling the appearance of stained glass.

*Creation of new projects.*

AI can be used to create stained glass designs based on an original image or description, broken down into pieces that take into account the geometric constraints of the glass. This may be useful for designers who have no experience working with stained glass. AI can create designs that take into account all technical and compositional features, shape and color. AI can also help create new stained glass designs. By understanding design principles and analyzing existing stained glass designs, AI can create sketches and suggest color palettes based on the artist's initial concept or description. This can be especially useful for designers who are new to stained glass technology, or for those looking for inspiration for their work.

*Calculation of the number and shape of parts taking into account geometric restrictions.*

AI can be used to calculate the number, shape and size of stained glass parts. You can use this information to make sure your canvas has the right number of pieces and the right size. These data correlate with the physical properties of the materials used in production. A suitable task for AI would be to calculate the optimal pattern placement of glass pieces when cutting glass. This will help prevent errors and optimize material consumption in the production process. By automating tasks, AI can make the process more efficient and accurate. This could lead to higher quality stained glass that would be more affordable to produce for a wider range of artists.

*Check existing designs for geometric constraints.*

The creation of sketches of stained glass paintings can already be successfully entrusted to almost any existing generative neural network right now. The result of such an experiment will be presented below. However, such a project cannot be immediately accepted for execution due to the lack of control over the size and shape of the resulting parts. If we train specialized AI on the best examples of stained glass art and add a system for checking for geometric constraints, we will get a specialized verification system for designing stained glass canvases.

*Creating templates for cutting glass.*

AI can be used to create glass cutting patterns, which can save time and effort for designers and manufacturers. AI can be used to optimally place glass pieces, taking into account factors such as size and shape, glass colors and the desired design.

*Creation of patterns and three-dimensional models for volumetric stained glass.*

Additionally, artificial intelligence can simplify the technical aspects of stained glass design. AI can minimize errors and ensure efficient use of materials. This can save time and resources, especially for large-scale projects.

The integration of artificial intelligence into stained glass design is not intended to replace the artistry and craftsmanship of traditional methods. Instead, AI serves as a powerful tool that enhances the creative process by freeing artists from tedious tasks and allowing them to focus on artistic expression. By automating routine tasks and providing intelligent assistance, AI can allow stained glass designers to push the boundaries of their craft, creating even more complex and impressive works of art. To create a professional design system, you need a library of images of stained glass motifs. This data set should be as diverse as possible, including compositions from different cultures, time periods, and artistic styles. In this paper, the experiment was carried out using a standard publicly available neural network. But even he demonstrated an interesting result. The problem with standard

popular neural networks is that machine learning, which is indiscriminate from a professional point of view, is based on freely available material. But such material is not always of the required quality for professional design.

## EXPERIMENT

To conduct an experiment on generating an image of a sketch of a stained glass canvas project, the Adobe Firefly neural network was chosen. The reasons are quite obvious. Well-known, reputable manufacturer and free access for the user. The task will be to create a simple stained glass design with a rectangular pattern (Figure 1). The first text prompt was as follows: "Generate a linear project for only rectangle stained glass window". With two different settings, the following result was obtained.



*Fig. 1. First generated image*

The prompt was further refined to the following text: "Make a project for a classic stained glass canvas with a pattern of identical rectangles". The following images were obtained as a result (Figure 2).



*Fig. 2. Corrected image*

## CONCLUSIONS

Based on the experiment and as a result of the analysis, the following conclusions can be drawn.

1. Artificial intelligence has great prospects for use in solving a number of problems in combination with classical software tools in the computer design of stained glass panels. Even in its present form, it is possible to use neural networks to generate sketches for stained glass projects.

2. For the professional use of such technologies in the computer design of stained glass panels, it is necessary to create a specialized neural network in combination with a package of innovative specialized classical software tools. The capabilities of neural networks at the moment for designing stained glass windows are completely insufficient.

a. During the image generation process, current models absolutely do not take into account the physical properties of the materials used and the associated geometric design constraints.

b. At this stage, it is very difficult to get a specific, regular result using a text query.

c. Existing models often contain errors and artifacts.

3. When machine learning a specialized model, it is necessary to use verified and selected professional samples of stained glass art with maximum coverage of styles and periods. In our experiment, when the combination "classic rectangular pattern" was added to the prompt, the general-purpose model did not react in any way, from which we can conclude that it does not have classified information about the styles of stained glass art. The neural network is configured for maximum "creativity" based on popular images, which greatly limits the possibilities of professional use even for sketches.

4. To generate and configure simple and regular patterns, it seems more appropriate to use classical software tools. For example, vector procedural librarie.

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## АНОТАЦІЯ

***Петрушевський А., Антонович Є. Можливості штучного інтелекту в комп'ютерному проектуванні вітражів.***

*Досліджується можливості штучного інтелекту (ШІ) в комп'ютерному проектуванні вітражів.*

***Мета**. Мета статті полягає в дослідженні та розкритті можливостей застосування штучного інтелекту в комп'ютерному проектуванні вітражів. Стаття спрямована на виявлення потенційних переваг інтелектуальних систем у створенні та оптимізації дизайну вітражів, зокрема, в аналізі та обробці великого обсягу даних, автоматизації процесу проектування, підвищенні точності та швидкості розробки, а також покращенні функціональності та естетичного вигляду готового виробу. Крім того, стаття має на меті висвітлити потенційні виклики та обмеження в застосуванні штучного інтелекту у цій галузі та вказати на напрями подальших досліджень та розвитку технологій.*

***Методологія**. У дослідженні використано наступні методи:*

*1) аналітичний метод, за допомогою якого була проаналізована література;*

*2) теоретико-концептуальний метод, який дав змогу визначити умови, необхідні для впровадження IT-технології в культурно-мистецьку практику;*

*У дослідженні використовувались методи комп'ютерного моделювання та аналізу, що дозволило підвищити точність результатів.*

***Результати**. Визначено що застосування штучного інтелекту в комп'ютерному проєктуванні вітражів може значно полегшити та покращити процес розробк вітражних полотен.*

**Наукова новизна.** *Аналіз можливостей штучного інтелекту у вигляді автоматизованих алгоритмів для розробки та оптимізації дизайну вітражів є новим напрямком досліджень.*

**Практична значущість**. *За допомогою алгоритмів машинного навчання, штучний інтелект може генерувати унікальні та креативні дизайни вітражів, враховуючи сучасні тенденції та індивідуальні побажання замовників.*

<u>Ключові слова:</u> *вітражне полотно, проєктування, комп'ютерні технології, штучний інтелект.*

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