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SEMI-AUTOMATED MODELING OF COMBINED STAINED GLASSES

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***Abstract.** The possibility of forming an algorithm that allows creating computer projects of stained glass paintings by a semi-automated tool is being investigated.*

***The purpose.** To form an algorithm of actions based on classical stained glass technology using specialized modeling tools to create a project for a combined stained glass canvas.*

***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.** The basic tools and algorithm of their use necessary for creation of the professional project of a stained-glass cloth are developed.*

***The scientific novelty.** It consists in creating a concept of new computer tools and an algorithm for their use, aimed at improving the quality of stained glass projects and speeding up the workflow.*

***Practical significance.** This algorithm and the tools mentioned in the article can be useful in creating computer software designed for the design of stained glass.*

***Keywords:** stained glass, design, computer technology, semi-automatic, algorithm.*

INTRODUCTION

Based on his own many years of experience in creating stained glass compositions and practical work with various computer systems, the author aims to develop a theoretical basis for the development and implementation of a professional automated system for designing stained glass windows. Before you start designing tools and algorithms, you need to understand the requirements for new computer technology.

The first and most important requirement for a computer technology tool is to enable the designer to obtain a professional stained glass project, even if the designer is unfamiliar with the technical details of stained glass. This is a definite novelty, as no existing computer system at the moment provides such an opportunity. Such computer technologies will be aimed at designers in the field of design and art, who will develop similar projects. The author of this study offers a number of basic tasks that, in his opinion, should be solved by a professional computer system for stained glass design. Anyone who is even a little familiar with stained glass will agree that stained glass design is very harmonious to create by computer. If we do not take into account the artistic drawing itself, then all other operations are purely geometric tasks.

ANALYSIS OF RECENT RESEARCHES

It is difficult to imagine that in today's oversaturated with competing software products, there is no one dedicated to the design of stained glass windows. After a long search on the World Wide Web, a single system was found — Glass eye. There are two other small additions: Rapid resizer and Pattern Wizard, but it is impossible to call them systems, as the main function is to proportionally enlarge the image and distribute it on standard sheets of paper. It is, more, help for people with hobbies. The fact that they were not easy to find shows that they are not very popular and famous. Despite the quality of the software product itself, the professional field itself is not very wide nowadays. Stained glass is an exclusive product, not for mass consumption, especially in our time. Since, from a commercial point of view, it is profitable to consider products of mass consumption, it is logical that in companies are in no hurry to make investments in this direction. However, there is one computer program.

But unfortunately, after studying the possibilities of this package, it turned out that from the point of view of a professional stained glass window, the program does not solve almost any

problem of design at the professional level. It is more or less possible to create a project with this product, but it will take almost as much time as to perform a traditional tool. In addition, with the same success, it is possible to use two-dimensional graphics packages, such as Adobe Illustrator, Corel, or even AutoCAD, which, incidentally, still have an advantage in the accuracy and number of graphics tools and output formats for export.

The main professional differences of Glass Eye are the library of glass brands from world manufacturers, the calculator of the plane of material and cost. Automatic part marking, import and export of graphic vector formats and the function of optimal arrangement of parts for cutting are useful. In contrast to the above, the library of templates, in general, is purely commercial and almost uninteresting to professionals. A template library is required in such a software product, but must be structured quite differently to be useful.

The latest version of Glass eye has included the function of scanning and tracing lines. The direction of work is correct, but tracing an existing line drawing makes almost no sense, as any existing vector editor will do. Therefore, it is necessary to indicate important, but not included in the system functions:

1. The program does not have the ability to parametrically configure a complex window opening.
2. There is no library and parametric adjustment of the calculated samples of the connecting geometric grid (ornamental fillings) relative to the proportions of the hole.
3. It is not possible to automatically embed figurative elements in a geometric connecting grid.
4. There is no tool for automatic creation of inter-element space of a given value between the parts of stained glass.
5. Lack of specialized vectorization of the scanned image and automatic creation of the scheme of the connecting grid on its basis.
6. Limited color and graphic editor tools.
7. Impossibility to create or import a complex asymmetric three-dimensional object and create a curvilinear geometric grid of whips.
8. There is no possibility of creating a curvilinear scan.
9. Lack of export of the created model of a cloth in three-dimensional editors.

This is about the functional side. It is possible to note, on the other hand, the graphic interface very weak for the commercial program, both from the ergonomic point of view, and from graphic. It is based on a standard template of

Windows interface elements with almost no significant changes. In general, studying the materials of the site of Dragonfly, it seems that the purpose of this project is to advertise the products of glass companies, rather than a functional component of the system itself. Based on the above, it is logical to recognize the need for professional computer technology in this area, which will improve the quality and significantly reduce the design and execution of stained glass, thereby reducing their cost and making them more accessible to a wide range of users.

PURPOSE

Given all the above and based on his many years of experience in creating stained glass compositions and practical work with various computer systems, the author aims to develop a theoretical basis for the development and implementation of a professional automated system for designing stained glass windows. First, before you start designing tools and algorithms, you need to understand the requirements for new computer technology. In general, the first and most important requirement for a computer technology tool is to enable the designer to obtain a professional stained glass project, even if the author is unfamiliar with the technical intricacies of stained glass. This is a definite novelty, as no existing computer system at the moment provides such an opportunity. As already mentioned, it is possible to create a stained glass project in AutoCAD or Rhinoceros, for example, but to do this, the designer must be a stained glass specialist and also have computer systems at a professional level, which is rarely combined. Most of these computer technologies will be aimed at designers in the

field of design and art, who will develop similar projects.

The author of this study offers a number of basic tasks that, in his opinion, should be solved by a professional computer system for stained glass design. Consider the two-dimensional functions required in the computer technology of stained glass. Anyone who is even a little familiar with stained glass will agree that stained glass design is very harmonious to create by computer. If we do not take into account the artistic drawing itself, then all other operations are purely geometric tasks.

MAIN

To create combined stained glass paintings, a combination of the image of ornamental filling with the image of free art form is used. This operation is very important, because the combined stained glass compositions are very popular around the world and there are many examples.

In the heraldry of Europe and America, combined stained glass windows are created as follows. The main ornamental filling is made mainly of transparent glass, and the figurative heraldic center is made of colored glass. The filling has a regular, and the figurative center has a free-form connecting grid. The task is to combine these completely different geometric structures into one. To do this, it is necessary to determine the sequence of operations:

1. Search for the appropriate filling in the specialized library. Samples must be pre-loaded in vector format. When transferring the selected model of ornamental filling to the working field, it automatically changes to the size of the canvas according to the geometric algorithms described in section (Fig. 1 a,b).

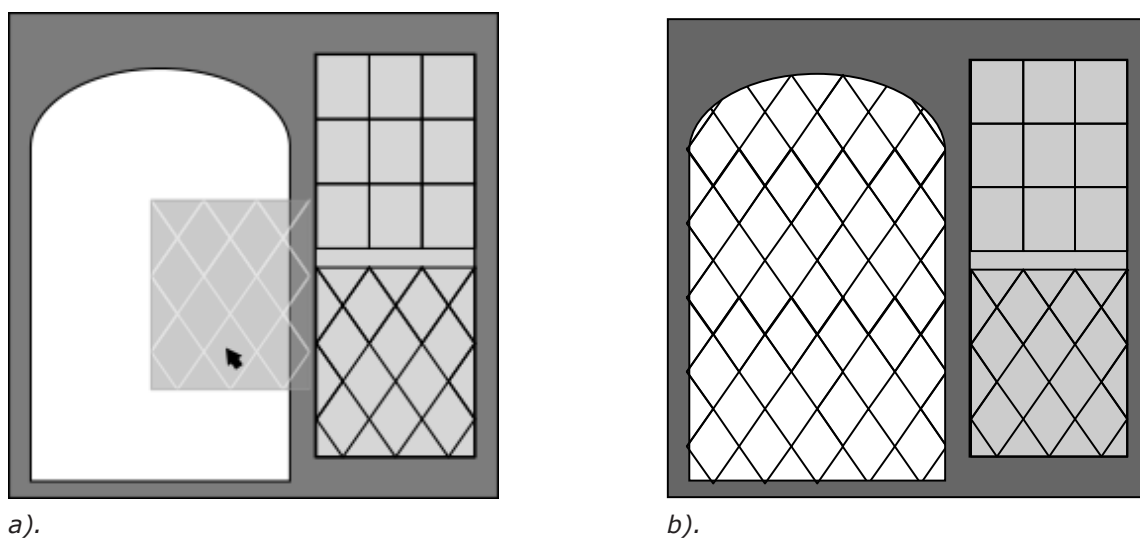


Figure 1. Creating an ornamental filling using the sample library

2. Moving a figurative element in an ornamental geometric grid. He is selected by the designer from a pre-prepared library, the window of which opens on the screen (Fig. 2, a).

3. Transformation of the selected figurative element — increase or decrease it, if necessary, also, return to a certain angle and fix it in the user's chosen place (Fig. 2, b). In most cases, a frame is added. In the future, it will be made of colored or clear glass (Fig. 2, a). The formation of the frame should be performed parametrically in a special window, where you can choose the style of the frame. It is envisaged to use a library in which to store self-created or imported images. Once selected, it is transferred to the workspace, where it can be moved, rotated and scaled. Next, the exact location and size of the image is determined, after which it is fixed in place. The connecting grid scheme consists of segments of straight, closed and open curves. To facilitate the process of forming the scheme, an appropriate algorithm for forming lines is proposed.

4. Formation of an integral connecting grid, using two-dimensional Boolean operations. Namely, the contour of the silhouette of the figurative element is subtracted from the plane of the ornament and replaced by its image. Then

the figurative element is combined with an ornamental grid.

5. To form a constructive scheme of stained glass, the image of the figurative element is replaced by its constructive scheme (Fig. 2, b).

6. The bend of the connecting line is limited by their possible maximum curvature, because the minimum bending radius for each material of the connecting profile is related to its rigidity.

7. The endpoint curve is drawn to any intermediate point of the adjacent curve. Thus, each of the open curves with its ends adjacent to the other curve. The set of these geometric elements always form closed contours. From the midline of the created scheme equidistant in both directions, at a distance of 1.2 mm, closed contours are created (Fig. 3).

They will be the contours of the patterns of glass elements. Directly for cutting paper patterns in a more traditional version or in the modern one you need an algorithm for the optimal location of patterns — cutting cards, for direct access to the CNC machine. In both cases, it will be necessary, as mentioned above, to mark the glass elements to be able to assemble the canvas in the future.

Similar techniques have already been developed and it would be logical to use one of them.

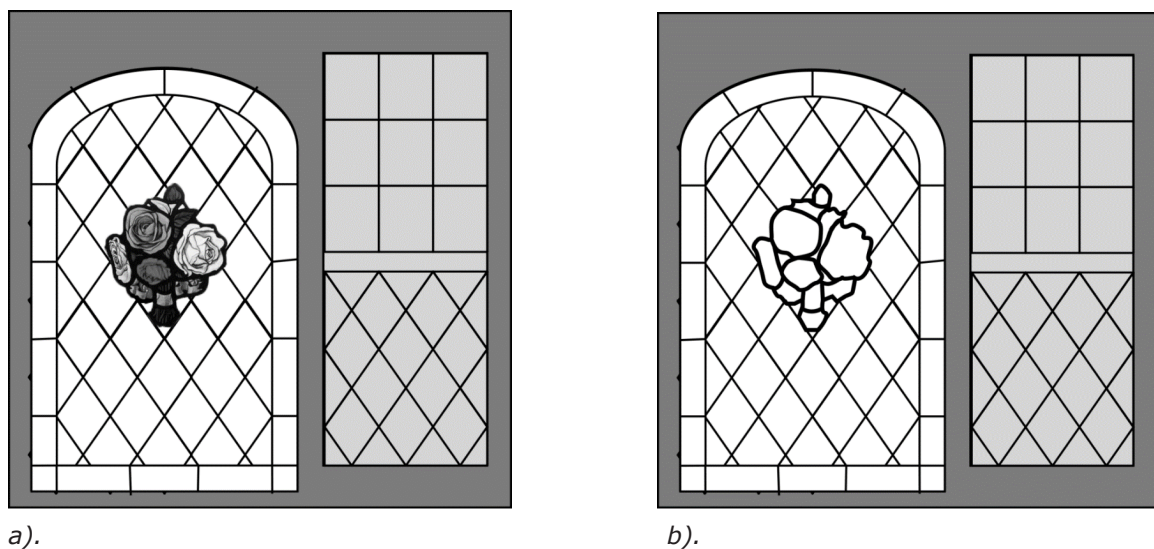


Figure 2. Creating a compositional figurative center using the sample library

Thus, the space necessary for the use of the connecting profile and the real profile of each of the glass elements are formed (Fig. 2). At the same time, another problem needs to be solved in the division of the future connecting profile into its component parts. This distribution must be performed under certain conditions for each

model of connecting grid according to technical and geometric constraints. Next, according to the scheme of the obtained connecting grid, by extruding the profile contour model in the direction of each of the lines, we create a three-dimensional model of the connecting structure (Fig. 4). To delimit the parts of the connecting profile,

it will be advisable to use a logical Boolean operation of subtraction (difference) (Fig. 2). This operation is irrelevant in the case of designing a lead canvas. The lead connection profile is very soft and flexible and easy to cut in place. The second thing is brass or other hard metal. Here you can't do without pre-cut fasteners. Thus, several goals are achieved simultaneously.

First, the distribution according to the technological requirements of the connecting grid on the connecting elements. This means that it is possible to obtain a model of the connecting profile segments for each canvas, which is extremely important for the rigidity of the future canvas. The fact is that the stained glass canvas is created on the principle of braiding, ie one line of the connecting profile should not pass completely through the canvas. The material of the connecting profile is also taken into account. For example, the means of joining lead (a) differs significantly from brass (b) profiles (Fig. 4).

Secondly, the joints of the connecting elements are formed. We will also automatically obtain the actual lengths of the fasteners. But you need to print this information digitally. This will be especially useful in the case of bronze stained glass. The result will be a complete three-dimensional model of the connecting grid. If we need to export the model for visualization in a third-party three-dimensional system, we will need the texture coordinates and the textures of the surfaces.

The necessary tool is a line splitter at a certain distance from the average. Analogues in other systems have a name in English — «offset», for example, in Autocad. But in our case, the tool must perform a slightly different function. The operation will be performed for one object and for a whole group of objects at the same time, as well as bifurcation in both directions from the centerline, which will be removed (Fig. 66). In the case of computer-aided design of stained glass, this operation is very important because it creates a space between the glass elements of stained glass for the connecting profile. The space between the newly created lines must be regulated parametrically, both in free user mode and by specified standard sizes. Conventional classic navigation and symmetry tools should be available. They will be needed when you need to mirror, rotate, or scale or copy items. Then the extra inner lines of the figurative element are automatically removed. If necessary, the user creates connecting grid lines instead. By the way, by figurative element, we mean the image. This image can be complex and divided into parts or be one part (Fig. 3)

with a painting. When creating a fully figurative artistic stained glass with graphic means, you will need a basis from the scanned image of the composition. Then the lines of the image are drawn, the necessary scheme of the connecting grid is formed. But this approach has certain disadvantages, such as longer execution time and complexity. The second method is parametric. That is, we use pre-prepared libraries of vectorized, ornamental fillings and existing figurative elements in the database. Fillings can be used both on their own and together with figurative elements, depending on the task.

In this case, we significantly speed up the project execution time, but we have certain limitations due to the content of the library of elements. Therefore, it is important to be able to use graphical tools to adjust the connecting grid in the parametric version. Thus, the creative potential of the designer is significantly expanded.

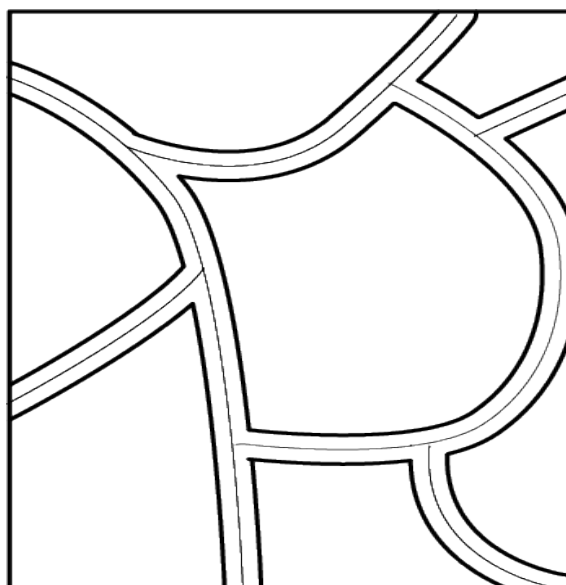


Figure 3. The scheme of creating an inter-element space and obtaining patterns of parts of the canvas

RESULTS AND DISCUSSIONS

Anyone who is even a little familiar with stained glass will agree that stained glass design is very harmonious to create by computer. If we do not take into account the artistic drawing itself, then all other operations are purely geometric tasks.

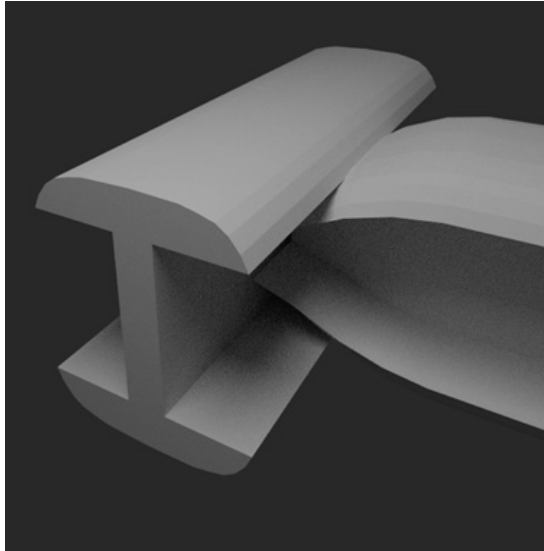
Creating an ornamental filling tool and a database of filling schemes (pattern gallery).

Classical stained glass often uses a figurative image in the center of the canvas, such as coats of arms, vignettes, etc., which is

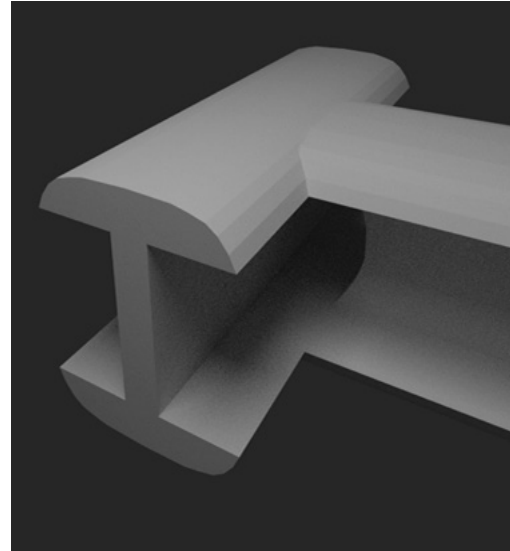
also done on paper. The figurative center was drawn into the general grid by hand. The task is to create such a figurative center separately or take it from the library and embed it in the canvas grid. The technology must have the tools to create and embed a figurative image automatically with the freedom to move and

transform within the canvas.

Creating an element tool and a library (art element gallery). One of the most important tasks is to obtain a digitized image of the sketch and its vectorization. Next, we create a check for geometric constraints and author's correction related to artistic requirements.



a).



b).

Figure 4 Scheme of joints of lead and brass profiles

CONCLUSIONS

1. The proposed geometric algorithms will create procedural schemes of the connecting grid of the main types of ornamental stained glass fillings for given holes, which avoids the violation of the proportionality of the relationship of parts, and significantly speed up the design process.

2. The developed methods of modeling the connecting grid of combined stained glass

canvases combine ornamental fillings, figurative elements with vector graphic modeling, which will create complex combined compositions. The use of template libraries will greatly facilitate the design process [64].

3. Proposed technology that will enable a wider range of professionals to use computer-aided design of stained glass, improve the quality of projects and reduce the process of designing figurative compositions.

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АНОТАЦІЯ

Петрушевський А. О. Напівавтоматичне моделювання комбінованих вітражів.

Досліджується можливість формування алгоритму, що дозволяє створювати комп'ютерні прєкти вітражних полотен напівавтоматизованим засобом.

Мета. Сформувати алгоритм дій на основі класичної вітражної технології спеціалізованими засобами комп'ютерного моделювання для створення проекту комбінованого вітражного полотна.

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 ІТ-технології в культурно-мистецьку практику;

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

Результати. Розроблено основні інструменти та алгоритм їх використання, необхідні для створення професійного проекту комбінованого вітражного полотна.

Наукова новизна. Полягає у створенні концепції нових комп'ютерних інструментів та алгоритму їх використання, спрямованого на покращення якості створення проектів вітражних проектів та прискорення робочого процесу.

Практична значущість. Цей алгоритм та зазначений в статті інструментарій може бути корисним при створенні комп'ютерного програмного забезпечення, призначеного для проектування вітражних полотен.

Ключові слова: вітражне полотно, проектування, комп'ютерні технології, напівавтоматичний, алгоритм.

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