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TEXTILE PATTERNS FOR INTERIOR DESIGN WITH THREE-DIMENSIONAL SPIRALS

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Abstract: *Three-dimensional (3D) spirals are fascinating geometric shapes that are used in a variety of applications, such as textile fabric pattern and texture design, architecture, art, and engineering. In this paper, design of patterns using three-dimensional spirals are explored. The work began by discussing the mathematical properties of spirals and their applications. Then, several techniques for designing textile patterns are presented, including the use computer algorithms. Finally, examples of patterns that have been designed using spirals are presented. A comparative analysis was made with available literary sources. Guidelines for applying the obtained results in practice and guidelines for continuing this development are proposed.*

Keywords: *Pattern making, Interior design, Spiral, Data analysis, Color properties, Contemporary design*

1. INTRODUCTION

The rapid change in fashion styles and trends, diverse models and modern consumer demands, innovative materials, expect manufacturers to react quickly and present on the market up-to-date, beautiful and attractive fashion products. As for the variety of products, when creating new models in the interior, the designer must take into account the style and diverse preferences of consumers. The individuality of the furniture in the home is the main emphasis on which the user bases his decision, and in other cases, after he likes a given shape, the color is one of the main elements in forming his decision.

Using modern information and communication technologies (ICT), designers can promote their products and services worldwide [1]. ICT is also successfully used in the design of textile patterns itself. Computer-generated forms are distinguished by the fact that they can be obtained through easy-to-understand and use algorithms [2]. Software tools facilitate the process of creating geometric shapes and combining them with a variety of colors. In the majority of available publications in this field, these geometric shapes are presented through their mathematical descriptions [3], [4]. A major disadvantage of published software tools is that they offer the generation of a limited set of shapes.

Spirals are shapes that are ubiquitous in nature and have long fascinated humans. From the spiral patterns found in seashells to the spiral galaxies in the universe, spirals are figures of beautiful and mesmerizing shapes. In recent years, designers and artists have been exploring the use of 3D spirals in their work [5]. 3D spirals are more complex than their 2D counterparts and offer a greater range of possibilities for designing textile patterns.

A 3D spiral is a curve that starts at a point and moves away from it while rotating around an axis. The shape of a helix is determined by its pitch, which is the distance the helix moves away from the point of revolution, and its radius, which is the distance from the center to a point on the helix curve [6]. 3D spirals are widely used in various fields. In architecture, 3D spirals have been used to create unique and visually stunning buildings [7]. In art, 3D spirals are used to create sculptures and installations that evoke the viewer's sense of space and movement. In engineering, 3D spirals are used to design complex structures, such as bridges and towers, that can withstand extreme forces [8].

There are various techniques for designing patterns for 3D spiral patterns. One approach is to use mathematical formulas to generate a spiral shape and then manipulate the shape [9], [10]. Another approach is to use computer algorithms to generate the spiral shape and then apply various transformations, such as scaling and rotation [11]. Last but not least, physical models can also be used to experiment with different spiral shapes and patterns [12].

There are a number of examples of models that have been designed using 3D spirals [13]. In jewelry, 3D spirals are used to create intricate and delicate designs that are both beautiful and functional. In textiles, 3D spirals are used to create fabrics with unique textures and patterns. In sculpture, 3D spirals are used to create large-scale installations that interact with the surrounding environment.

There are known sources in the literature [14] that cover the technical aspects of creating broken and continuous spirals using the Blender 3D software. Step-by-step instructions are provided on how to create a basic shape spiral for a cylindrical object and how its radius, object density and repeating pattern size can be changed.

In his book, Rosen [15], discusses the technical aspects of developing precise professional garments. The author presents the tools, concepts, procedures and principles of professional creation of planar models using base curves.

The book by Browning et al. [16], covers the benefits and principles of biophilic design and presents the connections between nature, human biology and interior design. The book provides insight into the role of nature in design and may inspire new ideas for incorporating organic shapes and patterns into fashion and interior design.

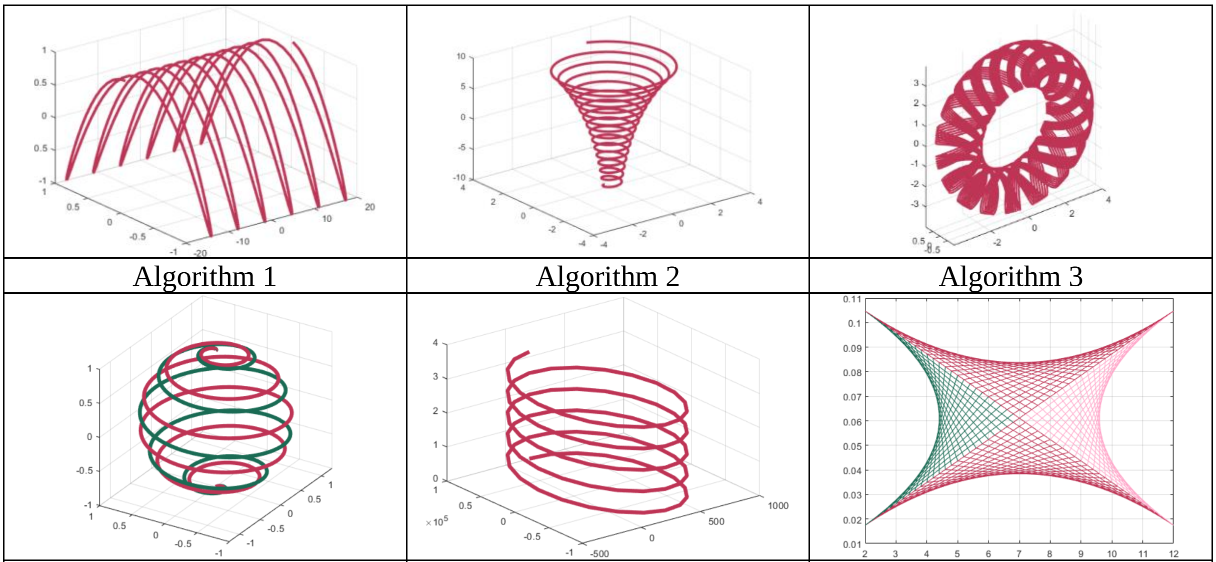
A major drawback that can be pointed out in the available literature is that solutions with specialized software products are offered for the creation of three-dimensional helices. This type of software is complex and requires considerable time to learn and master. This can slow down the textile pattern design process to some extent.It is necessary to make a deeper analysis of the known methods and approaches used so far to create tridimensional spirals, which will lead to improvement and facilitation of the process of creating modern textile patterns, with the aim of implementation in automated systems to help to the designers.

The purpose of this article is to explore the design of textile patterns using 3D spirals and demonstrate examples of their use.

2. MATERIAL AND METHODS

Algorithms and procedures for creating trimeric helices presented in the available literature sources were used [7], [12], [17]. These algorithms are presented in Appendix A. The algorithms are implemented in the Matlab 2017b software system (The Mathworks Inc., Natick, MA, USA.).

Figure 1 shows in general view six different three-dimensional spirals that are realized. The spiral obtained by Algorithm 1 is alternating semicircles. The second spiral has an increasing radius along the horizontal axis and increasing in height. The third spiral is a "doughnut" type. The fourth is two spirals wound around a sphere. The fifth spiral has the same radius for all turns and increases in height. The sixth helix imitates a ship's sail under the pressure of the wind.



Algorithm 1 | Algorithm 2 | Algorithm 3

Algorithm 4 | Algorithm 5 | Algorithm 6

Fig. 1. 3D spirals generated with algorithms

The palettes, presented by Nisha [2022] were used. These are related to combining the Pantone color of 2023 with other suitable colors. The colors used are presented in Table 1. The values of the color components from the RGB and Lab color models are indicated. The first color is Pantone's for 2023 – Viva magenta, followed by light pink and green. Purple and yellow follow. Finally, they are beige, brown and pink.

Table 1. Colors used in this study

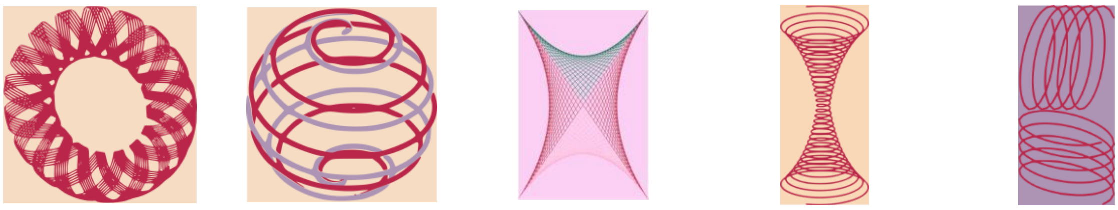
Color component / Color number	R	G	B	L	a	b
C1	186	38	73	41,70	58,96	17,46
C2	255	167	202	77,97	37,08	-4,34
C3	26	107	84	40,20	-29,89	6,08
C4	173	147	180	64,20	15,76	-13,58
C5	234	224	51	87,51	-14,42	78,43
C6	206	194	174	78,90	0,88	11,58
C7	105	64	38	31,37	15,02	23,17
C8	173	147	180	64,20	15,76	-13,59

Examples of application of the developed patterns in the field of interior design are offered. For this purpose, the online applications “Bags of Love” (https://www.bagsoflove.co.uk accessed 4 April 2023) and “Digital Fabrics” (https://www.digitalfabrics.com.au accessed 4 April 2023) were used.

3. RESULTS AND DISCUSSION

3.1. Results

Figure 2 shows the realized motifs with 3D spirals. Motif M1 is obtained by Algorithm 3, it combines color C1 and C6. Motif M2 obtained by Algorithm 4 combines three colors C1, C4 and C6. Model M3 uses a spiral generated with Algorithm 6. It combines the colors C1, C2 and C3. Model M4 is created as a mirror copy of the spiral generated with Algorithm 2. Thus, a figure was obtained, representing an increase in the diameter of the spirals from the center of the motif up and from the center down. Two colors C1 and C6 are combined. Motif M5 is realized, with the spiral obtained with Algorithm 5 presented in a vertical winding direction and below it, rotated by 90 degrees. The colors C1 and C8 are combined.



M1 M2 M3 M4 M5

Fig. 2. Motifs (M) with 3D spirals

Figure 3 shows an example of the application of a three-dimensional spiral of the "doughnut" type, obtained by Algorithm 3, in the cladding of chairs, stools and a folding table. When implementing the fabric design, the element is rotated in arbitrary directions. The interior of the room includes a cozy sitting area with two comfortable chairs, modern stools and an elegant table. The chairs have a classic design, without armrests and a high back. The stools are a unique piece with a contemporary design, featuring a sculptural, geometric shape and a seat upholstered in the same fabric design that provides a stunning complement to the chairs. The folding table is a minimalist piece with a rectangular shape with a polished wooden frame and a top lined with the proposed fabric design, which adds a touch of sophistication to the room. The table is suitable for placing books, magazines or drinks and is at a comfortable height for both chairs and stools. The overall effect of these elements in the room is a harmonious balance of comfort, style and functionality. The seating area invites you to relax and rest, while the table provides a functional surface for everyday use.

Fig. 3. Interior design with 3D spiral obtained from Algorithm 3

Figure 4 shows an example of the application of three-dimensional spirals of the type described around a sphere, obtained by Algorithm 4, in the upholstery of a sofa. The proposed sofa model is a modern, L-shaped piece of furniture with an elegant, minimalist design. It comfortably accommodates up to 3-4 people. The sofa is upholstered with a luxurious beige damask, decorated with the motifs of the proposed spiral, which gives a touch of sophistication to the room. The seat back has firm and supportive sides, providing a comfortable sitting experience. The sofa has square shaped armrests that provide a comfortable place to rest your hands or a cup of coffee. The legs are made of sturdy metal and finished in a matte gold color, adding a contemporary look to the sofa. Overall, the design of the living room sofa is stylish, comfortable and suitable for entertaining guests or relaxing with the family.

Fig. 4. Interior design with 3D spirals obtained from Algorithm 4

Figure 5 shows an example of an application of three-dimensional sphere-type spirals obtained by Algorithms 2, 5, and 6. The pillows have an attractive design that includes spiral motifs, each with a unique repeat. The first pillow has a spiral motif that mimics a ship's sail, with a bold, curved shape that evokes the feeling of a sea adventure. The second pillow has a rising spiral motif obtained by repeat of type half drop, which creates a sense of depth and movement. The third cushion includes two non-intersecting spirals at 90 degrees to each other. They create a mesmerizing geometric pattern. Each pillow has a soft texture and is covered in a neutral-toned fabric that complements the intricate design. Cushions are suitable for adding visual impact and texture to sofas and chairs, and spiral patterns create a sense of energy and dynamism in the room. The cushions on offer are a beautiful and unique addition to any home decor.

Fig. 5. Interior design with 3D spirals obtained from Algorithms 2, 5 and 6

3.2. Discussion

Designing 3D spiral models is an interesting and complex process that requires a thorough understanding of mathematical principles and design techniques. Spirals have fascinated mathematicians and artists alike for centuries, and their application in design is prevalent in fields as diverse as architecture, engineering, and art [7], [8].

Spirals are characterized by their mathematical properties, such as the constant distance between each turn of the spiral, the angle of the spiral, and the shape of the curve itself. These properties are critical when designing spiral patterns, and designers should have a clear understanding of them before creating any patterns. Through the presented algorithms for creating spirals and their implementation in a programming environment, this work complements the results of Browning et al. [16] who point out that through spirals a connection can be made between nature, human biology and interior design.

Designers can use mathematical formulas and the computer algorithms proposed in this development to create complex spiral patterns. These techniques can be used to build complex patterns of patterns that would be difficult to realize by hand [15]. The computer algorithms proposed here can be used to generate patterns based on predefined parameters or to randomly generate patterns of elements from which to make patterns for interior design.

Designing 3D spiral patterns requires skill and creativity. The presented comparative analysis with available literature sources can help designers learn from past designs and incorporate new ideas into their work. Guidelines for applying the results obtained in practice can also help designers to create models that are both beautiful and functional.

4. CONCLUSION

In this paper, a study is made on the design of textile pattern patterns using 3D spirals. The mathematical properties of spirals, their applications, and several techniques for designing textile patterns with them are discussed. Also shown are examples of pattern patterns that are designed using 3D spirals. The use of spirals in textile pattern design offers a wide range of possibilities and is a fascinating area of research for designers and artists alike.

Designing 3D spiral models is a fascinating and challenging process that requires an understanding of mathematical and algorithmic design principles and techniques. By using mathematical formulas, computer algorithms to create three-dimensional spirals, designers can create complex patterns of textile patterns that are both beautiful and functional. Guidelines for applying these results in practice and continuing developments in this area can help designers improve their skills and create even more complex and unique models.

Appendix A. Algorithms for 3D spirals

x = -6*pi:0.1: 6*pi;
y = sin(x);
z = cos(2*x);
plot3(x, y, z,'g','linewidth',3);
	t = linspace(-10,10,1000);
	xt = exp(-t./10).*sin(5*t);
	yt = exp(-t./10).*cos(5*t);
	plot3(xt,yt,-t,'linewidth',3);
		t = 0:pi/500:40*pi;
		xt = (3 + cos(sqrt(32)*t)).*cos(t);
		yt = sin(sqrt(32) * t);
		zt = (3 + cos(sqrt(32)*t)).*sin(t);
		plot3(xt,-yt,-zt,'linewidth',2)

Algorithm 1	Algorithm 2	Algorithm 3

t = 0:pi/500:pi;
xt1 = sin(t).*cos(10*t);
yt1 = sin(t).*sin(10*t);
	a=200; b=200; r=50
	t = 0:pi/10:10*pi;
	st = a+r*sin(t);
		angle=0.5; lower = 2;
		upper = 12;
		stepvalue = 0.2;

<table>
<tr>
<td><pre>zt1 = cos(t);
xt2 = sin(t).*cos(12*t);
yt2 = sin(t).*sin(12*t);
zt2 = cos(t);
plot3(xt1,yt1,zt1,xt2,yt2,zt2,'linewidth',6)</pre></td>
<td><pre>ct = b*r*cos(t);
plot3(st,ct,t/10,'g','linewidth',6)</pre></td>
<td><pre>lastindex = (upper-lower) * (1/stepvalue) + 1;
mid = ceil(lastindex/2);
x = [lower:stepvalue:upper];
line1 = tand(angle)*x;
line2 = tand(180-angle)*x + line1(lastindex)+line1(1);
plot(x,line1,x,line2);
for i = 1:(mid-1)
    hold all
    plot([x(i),x(mid+i)],[line1(i),line2(mid+i)]);
    hold all
    plot([x(i),x(mid-i)],[line1(i),line2(mid-i)]);
    hold all
    plot([x((mid*2)-i),x(mid+i)],[line1((mid*2)-i),line2(mid+i)]);
    hold all
    plot([x((mid*2)-i),x(mid-i)],[line1((mid*2)-i),line2(mid-i)]);
end</pre></td>
</tr>
<tr>
<td>Algorithm 4</td>
<td>Algorithm 5</td>
<td>Algorithm 6</td>
</tr>
</table>

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