Development of floral textile patterns on the base of the golden and Fibonacci geometry

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Abstract. The application of the golden and Fibonacci geometry in art, architecture and design is one of the ways for creating of aesthetic and beautiful forms. Usually with the help of the elements of the golden and Fibonacci geometry geometrical patterns are designed. The development of floral patterns for textile design on the base of the creations from the golden and Fibonacci geometry is the aim of the presented paper. The golden and Fibonacci geometry symbolism of aesthetic and beauty is applied in design of floral textile patterns, as the most used golden and Fibonacci forms are the golden spiral, Fibonacci spiral, Flower of Life, the golden circles spiral, Fibonacci circles spiral. The patterns are developed in suitable colors decisions, chosen on the base on the analogues with flowers in the nature, the symbolism and influence of the lines, forms and colors, and results of the study of the consumers opinions with correspondence analysis.

1. Introduction
The golden geometry includes geometrical elements and figures in proportions, equal to the golden section, which can be defined by taking a stick and breaking it into two portions and if the ratio between these two portions is the same as the ratio between the overall stick and the larger segment, the portions are said to be in the golden ratio. [1] Fibonacci geometry includes geometrical elements and figures in proportions, equal to Fibonacci sequence. Each number in Fibonacci sequence is the sum of the two numbers that precede it. [2] The application of the golden and Fibonacci geometry in art, architecture and design is one of the ways for creating of aesthetic and beautiful forms [3]. Usually with the help of the elements of the golden and Fibonacci geometry geometrical patterns are designed. The development of floral patterns for textile design on the base of the creations from the golden and Fibonacci geometry is the aim of the presented paper.

2. Pattern design
Pattern designs are developed on the base of geometric elements of the golden and Fibonacci geometry. For example, fifth of them are presented in Figure 1. From left to right: a variant of Flower of Life [4], one of the most popular geometrical elements, which is floral one too; a rose, result of the golden circles spiral or Fibonacci circles spiral [2]; a Venus flower, created by golden [5] or Fibonacci spirals [6]; a clover, created by golden [5] or Fibonacci spirals [6]; and a Flower of Life with approximation of circles with straight lines.
3. Floral textile patterns coloring investigation

The developed floral patterns can be colored according to the typical colors of the similar flower in the nature, like red and pink for a rose, or green for a clover. But how to choose colors if the floral pattern is in a form which is difficult to relate to a flower in the nature? In this case the connections between colors and geometric form of the element can be applied. This connection can be on the base of colors and geometric elements symbolism, or on the base of a study of consumers opinions. With the help of consumers survey connections between elements of the golden and Fibonacci geometry, which are used for floral pattern designs, and combinations between two analogous, nuanced and contrast colors is investigated. The analogous, nuanced and contrast colors are defined by the circle with four basic colors: yellow, red, blue, and green, shown in Figure 2.

![Figure 2. Color circle with four basic colors; yellow, red, blue, and green.](image)

It is seen that the more elements and their direction, which are used in floral pattern designs, can be found in the Fibonacci series tiling with regular triangles, named Fibonacci rose [7], or Fibonacci rose is used as frame of other forms creations – spirals, triangles (like directions in Flower of Life), and circles (like circles spirals). Six bi-colored geometric modules on the base of Fibonacci rose are developed – one with accent on both spirals formed by the triangles sides, one with accent on the triangles, one with both spirals drawn with curved lines, one with circles drawn in the frame of Fibonacci rose, one with combination of circles and both spirals formed by the triangles sides, and one with combination of circles and triangles. In the survey the consumers indicate their choices of combinations of modules and two analogous, nuanced and contrast colors. The consumers opinions are investigated with the statistical method of correspondence analysis, made with software STATISTICA 7.0 [8].

Table 1 presents the matching frequency between geometric modules and analogous colors. The results of correspondence analysis of connections between geometric modules and analogous colors is shown in Figure 3.
Table 1. The matching frequency between geometric modules and analogous colors.

| Geometric modules | Variant 1 | Variant 2 | Variant 3 | Variant 4 | Variant 5 | Variant 6 | Total |
|-------------------|-----------|-----------|-----------|-----------|-----------|-----------|-------|
| Colors combinations | 14-12     | 20        | 17        | 20        | 10        | 11        | 10    |
|                   | 10-12     | 9         | 12        | 14        | 7         | 7         | 10    |
|                   | 8-10      | 5         | 6         | 5         | 2         | 5         | 3     |
|                   | 6-8       | 31        | 24        | 16        | 16        | 10        | 6     |
|                   | 4-6       | 9         | 9         | 11        | 8         | 13        | 12    |
|                   | 2-4       | 20        | 28        | 26        | 16        | 12        | 18    |
|                   | 2-16      | 31        | 24        | 24        | 14        | 14        | 11    |
|                   | 16-14     | 10        | 9         | 10        | 4         | 7         | 8     |
| Total             | 135       | 129       | 126       | 77        | 79        | 78        | 624   |

Figure 3. Results of the correspondence analysis between geometric modules and analogous colors.

The graphic in Figure 3 shows that variant 1 and combination of colors 6 and 8 from the color circle in Figure 2, variant 3 and colors combinations 2-4 and 10-12, variant 4 and colors 12-14, variant 5 and colors 8-10 and 4-6 are close situated each other and therefore they are preferred by consumers.

Table 2 presents the matching frequency between the geometric modules and nuanced colors. The results of correspondence analysis of connections between the geometric modules and nuanced colors is shown in Figure 4.
Table 2. The matching frequency between geometric modules and nuanced colors.

| Color combinations | Geometric modules | Variant 1 | Variant 2 | Variant 3 | Variant 4 | Variant 5 | Variant 6 | Total |
|--------------------|-------------------|-----------|-----------|-----------|-----------|-----------|-----------|-------|
| 7-11               |                   | 21        | 15        | 19        | 15        | 12        | 13        | 95    |
| 3-7                |                   | 14        | 15        | 14        | 8         | 10        | 16        | 77    |
| 11-15              |                   | 23        | 31        | 29        | 23        | 23        | 18        | 147   |
| 15-3               |                   | 22        | 21        | 20        | 9         | 12        | 13        | 97    |
| Total              |                   | 80        | 82        | 82        | 55        | 57        | 60        | 416   |

Figure 4. Results of the correspondence analysis between geometric modules and nuanced colors.

The graphic in Figure 4 shows that variant 6 and combination of colors 3 and 7 from the color circle in Figure 2, is the most preferred. Also, variant 5 and colors combination 11-15 is strong preferred by consumers. The connections between variant 1 and colors combinations 7-11 and 15-3, and variant 3 and colors combinations 7-11 and 15-3 are enough strong.

Table 3 presents the matching frequency between the geometric modules and contrast colors. The results of correspondence analysis of connections between the geometric modules and contrast colors is shown in Figure 5.
Table 3. The matching frequency between geometric modules and contrast colors.

| Color combinations | Variant 1 | Variant 2 | Variant 3 | Variant 4 | Variant 5 | Variant 6 | Total |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|-------|
| 5-13               | 9         | 8         | 9         | 7         | 11        | 11        | 55    |
| 1-9                | 34        | 31        | 36        | 20        | 18        | 20        | 159   |
| 3-11               | 16        | 18        | 18        | 8         | 10        | 8         | 78    |
| 7-15               | 32        | 29        | 26        | 21        | 14        | 21        | 143   |
| Total              | 91        | 86        | 89        | 56        | 53        | 60        | 435   |

Figure 5. Results of the correspondence analysis between geometric modules and contrast colors.

The graphic in Figure 5 shows that variant 4 and combination of colors 7 and 15 from the color circle in Figure 2, is the most preferred. Also, variant 2 and colors combination 1-9, and variant 3 and color combination 2-11 are strong preferred by consumers.

4. Development of textile pattern and textile designs in colors
The coloring of floral textile patterns, shown in Figure 1, are realized on the base analogue with the flower colors in nature and the results of two studies. The firsts ones are results of the correspondence analysis between analogous, nuanced and contrast colors combinations from the circle with four basic
colors, shown in Figure 2, and elements of Fibonacci geometry in the frame of Fibonacci rose, which are presented in Figures 3, 4 and 5. Second ones are the results from other study about connections between colors and lines on the base their associations: symbolism and influence, presented in [9].

On the base of the colored floral textile patterns textile designs are developed with the use of bilateral and translated symmetries, which form flat rhythm made by two perpendicular linear rhythms. The coloring of the floral textile patterns and the developed on their base textile designs are presented in Figure 6.

Figure 6. The coloring of the floral textile patterns and the developed on their base textile designs with the use of bilateral and translated symmetries, which form flat rhythm made by two perpendicular linear rhythms.
5. Conclusion
The golden and Fibonacci geometry symbolism of aesthetic and beauty is applied in design of floral textile patterns, as the most used golden and Fibonacci forms are the golden spiral, Fibonacci spiral, Flower of Life, the golden circles spiral, Fibonacci circles spiral. The patterns and the developed on their base textile designs are designed in suitable colors decisions, chosen on the base on the analogues with flowers in the nature, the results of the study of the consumers opinions with correspondence analysis of connections between analogous, nuanced and contrast colors and elements from Fibonacci geometry in the frame of Fibonacci rose, and the symbolism and influence of the lines, forms and colors.

It can be concluded that the designed floral textile patterns express the aesthetic and harmonic influence of the golden and Fibonacci geometry. This influence makes the fashion sustainability of created patterns. Their fashion sustainability can be supplemented with natural and ecological coloring.

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