An investigation of application of the golden ratio and Fibonacci sequence in fashion design and pattern making

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Abstract. The Golden ratio and Fibonacci sequence are used as proportions in design as symbols of beauty and harmony. That symbolism is a result of the strong connections in their mathematical nature. The Golden section is a number, introduced with Greek letter φ, which is found by dividing a line into two parts as the longer part divided by the smaller part is equal as the whole length of longer and smaller parts divided by the longer part. Fibonacci sequence is a series of numbers where every number is equal to the two numbers before it. An investigation of application of proportions based on the Golden ratio and Fibonacci sequence in the fashion design and pattern making of ladies’ clothing is the main aim of the paper. Based on the study it may be concluded that in fashion design and pattern making the Golden ratio and Fibonacci sequence can be used in creation of beautiful and harmonic forms directly or with the help of geometrical figures as: In directly use the Golden and Fibonacci numbers proportions can be in one and the same or different directions. In the application with the help of geometrical shapes the Golden and Fibonacci figures combine proportioning and form creation. The Golden and Fibonacci shapes can be used directly as forms or as frames of forms creation of elements and pieces. Its application can be in different directions and location according the bodice. The Golden section and Fibonacci sequence can combine proportions with other principles of design as symmetry, rhythm, etc.

1. Introduction
The proportions are one of the most important design principles. The Golden ratio and Fibonacci sequence are used as proportions in design as symbols of beauty and harmony. That symbolism is a result of the strong connections in their mathematical nature. The Golden section is a number, introduced with Greek letter φ, which is found by dividing a line into two parts as the longer part divided by the smaller part is equal as the whole length of longer and smaller parts divided by the longer part, or a/b = (a+b)/a = 1.61803398874989484… [1] Sometimes the Golden ratio is presented in a turned way in which the number is equal to the division of the smaller by the longer part equal to the division of the longer part by the whole length of the line, or b/a = a/(a+b) = 0.61803398874989484… Fibonacci sequence is a series of numbers where every number is equal to the two numbers before it, or xₙ = xₙ₋₁ + xₙ₋₂. The sequence starts with 0 and 1 and goes 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, etc. [2]

An investigation of application of proportions based on the Golden ratio and Fibonacci sequence in the fashion design and pattern making of ladies’ clothing is the main aim of the paper.
2. Application of the Golden ratio and Fibonacci sequence in fashion design and pattern making

The Golden ratio and Fibonacci sequence are used in proportion of design and pattern making of elements and pieces in ladies’ dresses and jackets directly or with the help of geometrical figures in Golden or Fibonacci numbers proportions: the Golden triangle [3], an isosceles triangle with the ratio of the base to the leg which is equal to the Golden section; the Golden rectangle [4], an rectangle with sides which division is equal to the Golden ratio; triangles and rectangles with sides in proportions of Fibonacci sequence; and etc.

The design and pattern making of elements, which are created with applied directly or by geometrical figures the Golden ratio and Fibonacci numbers proportions, are: different types of seams in the bodice and sleeves; contours like necklines and armholes; 3D elements [5, 6]; and etc. The Golden and Fibonacci geometrical figures are used for creations of pieces and elements directly or as frames.

A design and pattern making of a lady’s dress with application of the Golden triangle is presented in Figure 1. The yoke by the neckline is designed in a form of a Golden triangle. Another Golden triangle is used as a frame for design of the princess seams (seams which transform the darts and create a form-fitting shape) between bust area and arm holes. The proportion between both triangles are to the Golden ratio: φ.a and a. The smaller Golden triangle, this one which is situated under the neckline, can be used as a base of applications and in this case the application is in form of a spiral shape designed by Golden triangles.

Another design and pattern making of a lady's dress with application of the Golden triangle is shown in Figure 2. The Golden triangle is used as a frame of design of the neckline form. The four concave curves, which form the neck opening, are connected in the point of intersection between the bisectors of the Golden triangle. The princess seams are the same like the ones in the previous dress. The line under the neck opening is connected with the princess seam under an angle which is close to the angle between legs of the Golden triangle or 32 degrees.

A design and pattern making of a lady's dress with application of the Golden rectangle is presented in Figure 3. Two Golden rectangles form the neck opening and the yoke under the neckline. That piece is connected with the front by a frame of one-sided plates. Like the outside roll lines the inside roll lines of the plates are formed by a Golden rectangle too. The outside roll lines of the vertical plates divide the shoulders into Golden ratio. The Golden one is the proportion between the width of the vertical plates and the shoulders.

Another design and pattern making of a lady's dress with application of the Golden rectangle is shown in Figure 4. The neck opening and the both yokes by the neckline are formed in the frames of three Golden rectangles. The three Golden rectangles are arranged by a linear rhythm on symmetry of translation and divide the shoulders in Golden proportions. The distance between the end points of shoulders and the biggest Golden rectangle and the shortest distance between armholes and the biggest Golden rectangle are in Golden ratio proportion too. Golden ones are the proportions between the vertical sides and the roundness radii in the three Golden rectangles.

Figure 5 presents a design and pattern making of a lady’s dress with application of proportions on the base of Fibonacci sequence. The three bi-sided tucks are the basic design idea and form the center of the composition. A Fibonacci proportion is used in their creation and distance between tucks and their volume are connected in ratio 3:5, two contiguous Fibonacci numbers. The tucks which transform the bust and waist darts are formed in the frames of isosceles triangles with division between the base and legs, which is equal to 3:5 too.

Figure 6 shows another design and pattern making of a lady’s dress with application of proportions on the base of Fibonacci sequence. The high neckline is the main design idea and it is created with the use of Fibonacci proportions. The high neck opening is drawn on the base of the neckline of the constructional base with the use of proportions between three contiguous Fibonacci numbers 1, 2, and 3. The high neck opening divides the neckline of the constructional base in vertical direction in ratio
2:3. The triangle in the neck opening contour is an isosceles one with division between the base and legs, which is equal to 1:2.

**Figure 1.** Design and pattern making with the use of Golden triangles, presented with green tick lines, directly and as a frame.

**Figure 2.** Design and pattern making with the use of Golden triangles, which are shown with green tick lines, as frames.

**Figure 3.** Design and pattern making with the direct use of Golden rectangles, shown with green.

**Figure 4.** Design and pattern making with the use of Golden rectangles, presented in green tick.
Figure 5. Design and pattern making with the use of Fibonacci proportions. 

Figure 6. Design and pattern making with the use of Fibonacci proportions.

Figure 7 presents a design and pattern making of a lady’s jacket with application of the Golden ellipse [7], in which the ratio between the major and minor axes is Golden. The neckline and the three yokes under it are formed with the help of arcs of four Golden ellipses. The four ellipses are drawn in a radial rhythm with one and the same center and their axes are in Golden proportions. The smallest ellipse forms the neckline. The biggest ellipse is limited by the shoulders width. The three pieces, formed by Golden ellipses, connect each other by one-sided plates. The width of the plates is in Golden proportion with the width of the smaller yoke by the shoulders. The border line, the princess seam and the seam of connection between front and sleeves divide the arc of the biggest Golden ellipse in Golden ratio too: b, φ.b, and φ².b (or φ.b,b).

Figures 3 and 7 present application of the Golden ratio in design and pattern making of 3D elements which are made by connection of pieces by seams. Figure 5 shows a design and pattern making of 3D elements in one piece with the help of proportions based of the ratio between two contiguous Fibonacci numbers. Figures 8, 9 and 10 present application of the Golden proportion in design and pattern making of 3D elements which are situated in one piece.

Figure 8 shows a design and pattern making of a lady’s jacket with free draperies, which are fixed in the design seams of semi raglan forms [8], as the draperies are designed with the help of the Golden proportion. The semi raglan front and back forms of the sleeve are divided in parts and draperies are a result of arrangement of the parts on the base of translated symmetry and linear rhythm as their width and the width of the tucks are in the Golden section proportion; φ.c and c.

Figure 9 presents a design and pattern making of a lady’s jacket with gathers, which are fixed in the design seams of raglan forms [8], as the tucks are created with the use of Golden triangles. The raglan forms are divided and parts are arranged around Golden triangles. In the model in Figure 10 [8], the gathers from Figure 9 are transformed in bi-sided tucks, formed in the frames of the Golden triangles, which design the tucks as the legs of isosceles triangles mark the outside roll lines of the tucks.
In Figure 11. The Golden and Fibonacci proportions can be used in design and pattern making of combined 3D elements, like the bi-sided tucks, fixed in ruffles, presented in [9], which divide the neckline of a dress in the Golden ratio: \(d, \phi.d, \text{ and } \phi^2.d\) (or \(\phi.\phi.d\)).

**Figure 7.** Design and pattern making with direct use of Golden ellipses, presented in green tick curves, and Golden proportions.

**Figure 8.** Design and pattern making of 3D element with the use of Golden proportions.

**Figure 9.** Design and pattern making of 3D elements with the use of Golden triangles, presented in green tick lines.

**Figure 10.** Design and pattern making of 3D elements with the use of Golden triangles.
3. Conclusion
In fashion design and pattern making the Golden ratio and Fibonacci sequence can be used in creation of beautiful and harmonic forms directly or with the help of geometrical figures as: In directly use the Golden and Fibonacci numbers proportions can be in one and the same or different directions. In the application with the help of geometrical shapes the Golden and Fibonacci figures combine proportioning and form creation. The Golden and Fibonacci shapes can be used directly as forms or as frames of forms creation of elements and pieces. Its application can be in different directions and location according the bodice. The Golden section and Fibonacci sequence can combine proportions with other principles of design as symmetry, rhythm, etc.

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