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Scale factors calculating for recreating women's garments' form

In this article authors described the possibility of using the non-uniform scaling to scale separate horizontal sections of the virtual mannequin (3D CAD system) or to scale patterns (2D CAD system).

Regressions between body measurements, amount of ease (on the bustline, waistline, hipline) and scale factors were used to determine connection between features of the garments forms and eases. In the cases, when we have no concrete value of amount of ease on the bustline, waistline and hipline, we proposed to calculate the scale factors by use values of eases, which were obtained with described formulas and measured projection parameters. And it would be possible to recreate and study any form of garment even if we have only its geometrical symbol.

Several simple algorithms of calculating the scale factors in different processes of design and study virtual garments form were the basis for the computer program "Scale factor". Algorithms could be called from the main window by clicking on the appropriate button.

There are two parts on the main window: "Shape scale", which must be used in 3D design process of creation the virtual garment form, and "Pattern scale", which must be used in 2D design process to construct the bodice blocks. Each part includes two panels. Buttons on the left panel ("with amount of ease") represent algorithms of calculating the scale factors by using amount of ease on the bustline, waistline, and hipline. Buttons on the right panel ("with geometric symbol") represent algorithms of calculating the scale factors in the cases, when eases are unknown. Computer program "Scale factor" can be used in study of garments shape's features and its transformation with time. Besides that it would be possible to research relationship between the body measurements and proportional characteristics of the form to achieve its aesthetic quality.

Key words: *non-uniform scaling, virtual model, scale factor, amount of ease.*

Introduction

Pattern-making is the process of transforming three-dimensional designs into their dimensional constituent pattern pieces. So, three-dimensional computer-aided design has become one of the most indispensable elements in modern industries.

There are two major basic pattern generation methods in conventional garment design. One is the flat pattern process, where patterns are designed two-dimensionally and the other is the 3D draping method, where a flat fabric is directly formed into a garment on a mannequin.

Scaling is one of many methods to obtain the 3D form of virtual garment. Uniform scaling is

a linear transformation that enlarges or shrinks objects by a scale factor that is the same in all directions. The result of uniform scaling is similar to the original.

Group of authors with team leader Natalia Syryi ("3D-fashion", 2015) propose to use uniform scaling to scale separate horizontal sections of the virtual mannequin.

But the garment's form is not the same as the human's body form. In the most of instructions for constructing the foundation pattern the width of the bodice block is equal to the chest measurement with some ease plus back width measurement with another ease and plus armscye width with its ease. And the values of eases are not equal to each other.

The ratio of values of eases in scaling garment's form must be the same as in construction, which was obtained by classic instructions. Probably it could be done by scaling with a separate scale factor for each axis direction. Non-uniform scaling is obtained when at least one of the scale factors is different from the others. Non-uniform scaling changes the shape of the object. It includes the case that one or more scale factors are equal to zero.

Zaharkevich & Hrechana (2011) proposed to use non-uniform scaling to scale separate horizontal sections of the virtual mannequin. The scaling process is the same as Natalia Syryi ("3D-fashion", 2015) proposed, but the scale factors are different for each axis direction. And in this case one scale factor is equal to zero (for z axis direction).

There is enough information at present about scaling process in garment industry. But we still need some detailed information about determining the scale factor for each axis direction in concrete case of 2D or 3D garment's design. The main aspect of the problem is the connection between features of the human body, features of the garment and scale factors.

The main purpose of this work is to develop a computer program of calculating the scale factors, which could be used in different processes of design and study garments' forms.

Scaling 3D forms of garments

Theoretical scale factors were obtained by mathematical model of calculating scale factors. The model was described by Zaharkevich & Hrechana (2011). So, previous theoretical and experimental researches were used as a basis for the regression relationships between body measurements, amount of ease (on the bust line, waistline, and hipline) and scale factors. The regressions for the bustline and the waistline are presented in the table 1 (the regressions for the hipline were obtained too, but not presented). These regressions ensure that the ratio of different parts of the amount of ease in virtual garment form will be the same as in standard form of real garment. So they can be used to calculate scale factors for creating virtual women's garment form.

Table 1

Regressions between body measurements, amount of ease, and scale factors (fragment)

Scale factor	Formula (bustline)	R^2	Formula (waistline)	R^2
kxb	0,022·Pg – 0,001·Og +1,093	0,968	0,019 Pt – 0,00098 Ot + 1,087	0,75

kxf	0,0188 Pg – 0,00068 Og + 1,062	0,981	0,0164 Pt – 0,00151 Ot + 1,118	0,85
ky	0,00216 Pg – 0,00016 Og + 1,01	0,90	0,0014 Pt – 0,00029 Ot + 1,02	0,92

In the table 1 *kxb*, *kxf*, *ky* - scale factors; Pg (Pt) – amount of ease on bustline (waistline), cm; Og (Ot) – body measurements on bustline (waistline), cm.

On the figure 1 we can see that theoretical and experimental data are almost the same. The similar diagrams were obtained for all of scale factors on the bustline, waistline and hipline. So we can use the scale factors, which were obtained by regressions, in scaling process (figure 2).

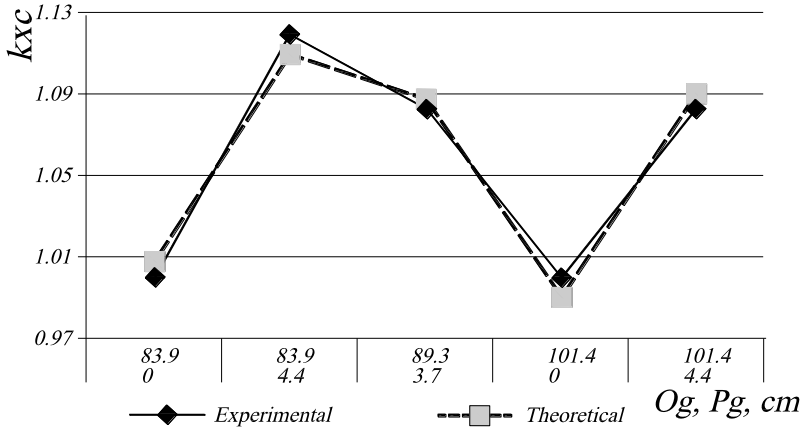
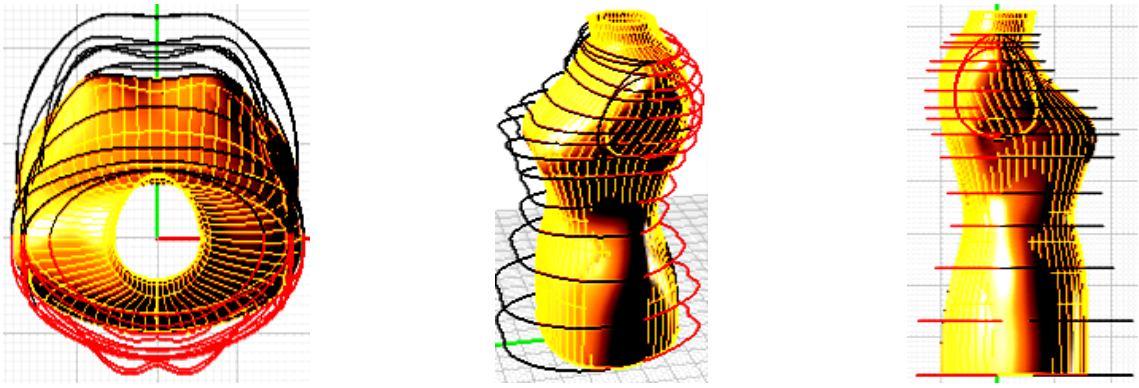


Fig. 1. Theoretical and experimental scale factors (kxc) on the bust line for the different values of bust and amount of ease



a b c

Fig. 2. Scaling process: a) top; b) perspective; c) right

The formulas from the table 1 must be applied in that case when garment form is obtained by scaling the horizontal sections of virtual human body form.

In that case when there is no virtual human body form but there is a garment form, scale factors could be obtained as ratio of two scale factors: the first one is using in scaling process from body form to form of garment, that is designed, and the second scale factor is using in scaling process from body to actual garment.

Coefficient k_1 must be obtained by one of the formulas from table 1. Coefficient k_2 must be obtained by the same formula but with other value of independent variable (eases).

Scaling patterns

At present, the garment industry uses 2D and 3D CAD tools. Designers use the instructions for the basic blocks, for example by Aldrich (2008). Instructions are given for a wide range of basic

garments. And the instructions must be used every time to obtain the garment's block but with different values of the eases.

Slavinska (2007) proposed the method of the silhouette transformation of the garment's parts. The transformation values of larger or lesser free fitting addition are laid in the directions of coordinates from the construction points of the original construction. The values are mentioned on the cross-section of the perpendiculars dropped from the points. This method is similar to the grading process.

Grading of garment design by scaling method was advanced by Masalova, Melikov, & Shil'dt (2005). Method involves grading garment design by moving constructive points relative to axes of grading, with value by which said movement of constructive points is performed being proportional to single scaling factors, which is calculated as ratio of desirable construction's size to basic construction's size.

Then the silhouette transformation of the garment's parts could be accomplished by pattern's scaling. It demands further research in this area to obtain regression relationships between body measurements, eases (on the bustline, waistline, and hipline) and scale factors.

Theoretical scale factors in process of pattern's scaling we obtained by mathematical model of calculating scale factors. Each scale factor is an average value of the results of division the length between two points of the garment's block by the length between the same points of the basic block. The lengths were obtained with using the instructions which have been proposed by few different authors. The lengths are depending of body measurements and eases.

So this information was used as a basis to obtain the regression relationships between body measurements, amount of ease and scale factors for the pattern's scaling.

Scaling without information about eases

All of described calculations could be used as a basis for the scaling just in case when we have concrete value of eases. But in some cases we have no this information. For example, we have only a sketch or geometrical image of the garment's shape. The shapes of different garments were analyzed by Kyleshova (2013). Geometrical images of the garments shapes were represented on the female figure (figure 3 presents three of them). As we see it is possible to measure only projections parameters of the shapes (figure 4).

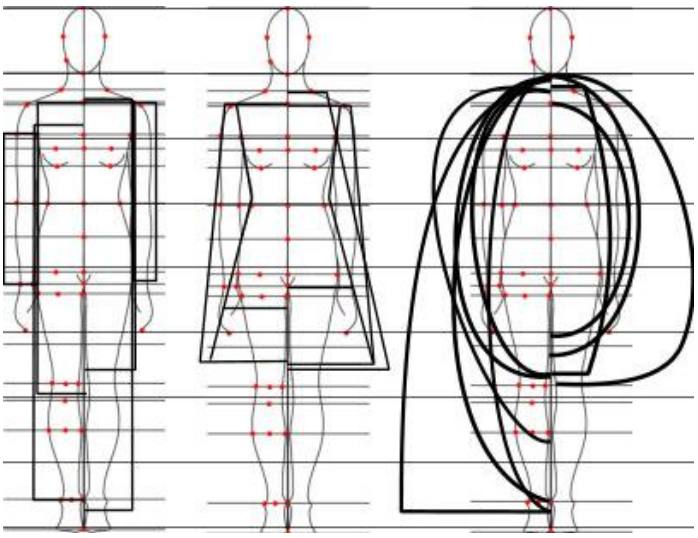


Fig. 3. Geometrical images of the garments shapes

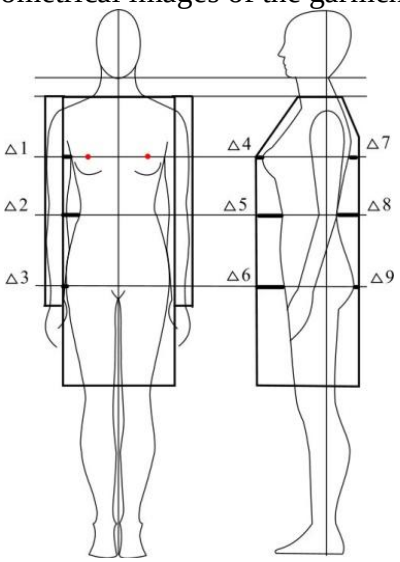


Fig. 4. Projections parameters of the garment's shape

If we need to study features of the derivative forms of garments, which are represented by their geometrical images, we must have information about relationship between projections parameters and amount of ease for these shapes.

Strunevich (2008) propose to calculate amount of ease by formulas, which we transformed according to our purpose:

$$Pg = -1.004+0.976\cdot\ 4+0.214\cdot\ 1-0.008\cdot\ 7; \quad (1)$$

$$Pt = -4.14 -0.1\cdot\ 5+0.82\cdot\ 2-0.12\cdot\ 8; \quad (2)$$

$$Pst = 10.84 +0.06\cdot\ 6-0.66\cdot\ 3 +0.1\cdot\ 9, \quad (3)$$

Pg (Pt, Pst) – amount of ease on bustline (waistline, hipline), cm;

1, 2… 9 – projection parameters of the silhouette of the garment, mm.

Projection parameters of the silhouette of the garment must be measured as it shown on the figure 4. Thus, we can calculate the scale factors by use values of amount of ease, which were obtained with formulas (1-3) and measured projection parameters. And in that case it would be possible to recreate and study derivative forms of garment even if we have only its image.

Computer program "Scale factor"

Computer program "Scale factor" includes several simple algorithms (figure 5). Each of them could be called from the main window by clicking on the appropriate button (figure 6).

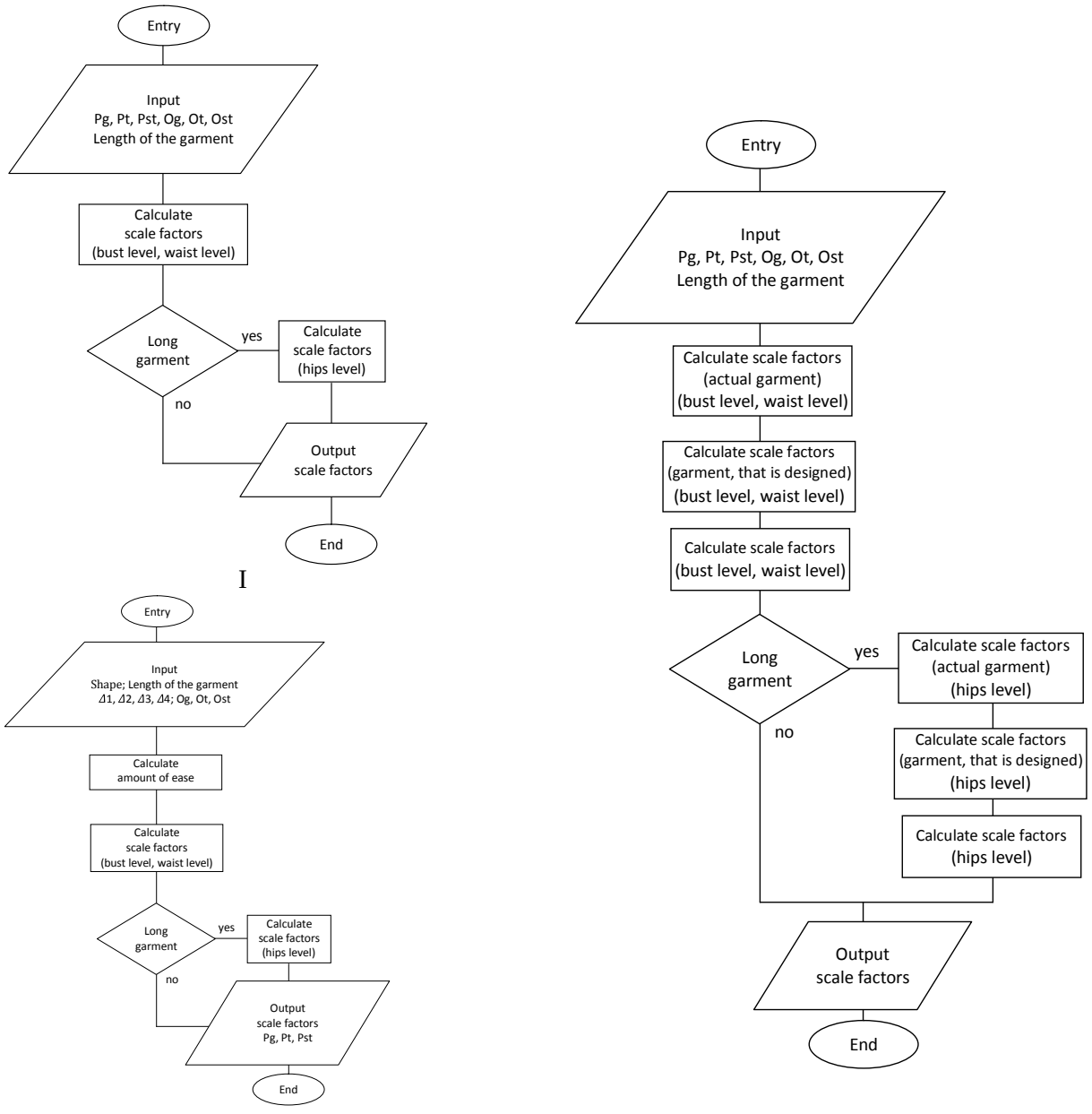
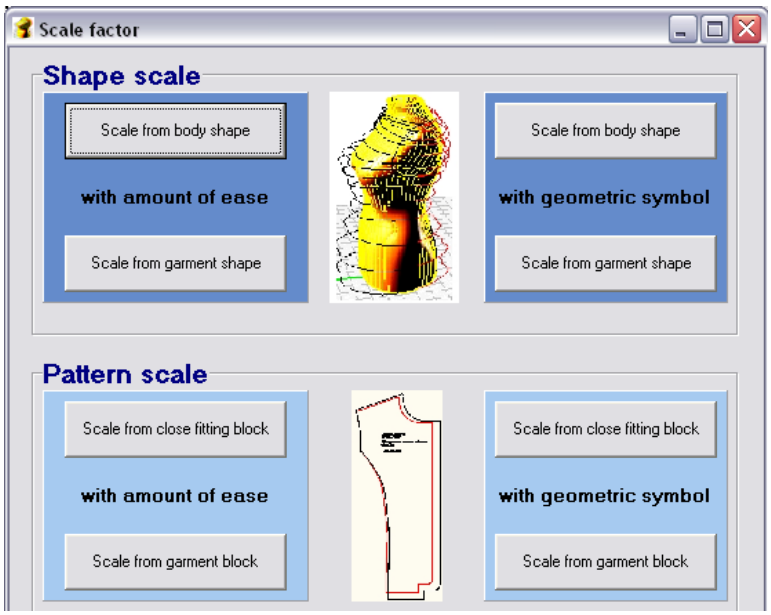
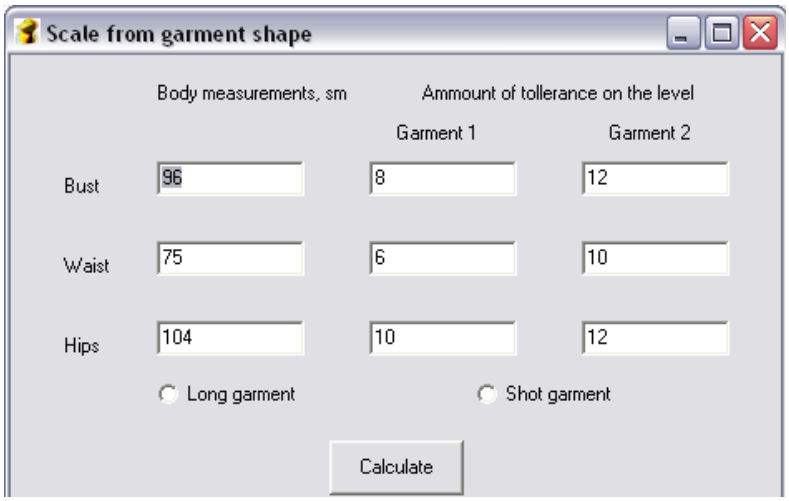


Fig. 5. Algorithms of the scale factors calculating



a



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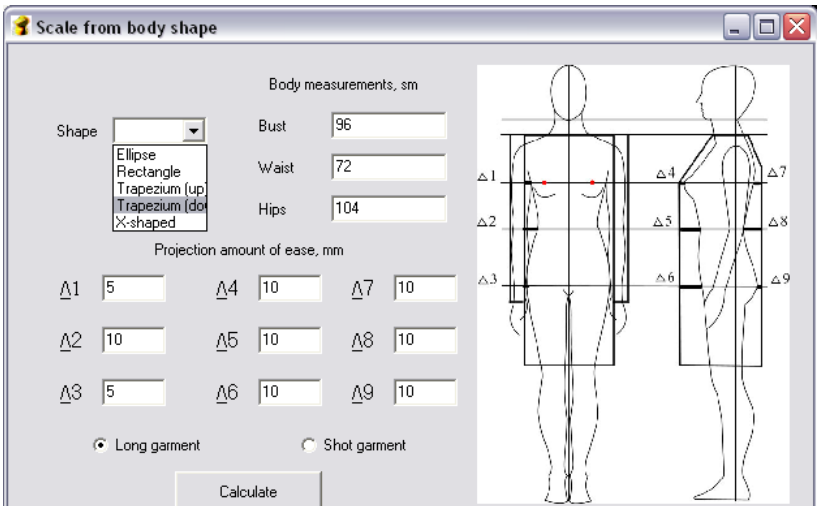

c

Fig. 6. Windows of the program “Scale factor”: a – main window;
b – “Scale from garment shape”; c – “Scale from body shape” (with geometric symbol)

As we see at the figure 5 there are two different parts on the main window: “Shape scale”, which must be used in 3D design process of creation the virtual garment shape, and “Pattern scale”, which must be used in 2D design process to construct the bodice blocks. And each part includes two

panels. Buttons on the left panel ("with amount of ease") represents algorithms of calculating the scale factors by using variables Pg, Pt, Pst in formulas. Buttons on the right panel ("with geometric symbol") represents algorithms of calculating the scale factors in the cases, when variables Pg, Pt, Pst are unknown. Click on each button calls the next window. Name of the window is the button name. As we can see at the figure 5 (b) window "Scale from garment shape" includes two labels: "Garment 1" means actual garment; and "Garment 2" means garment, which is designed.

Message boxes with results of calculation are presented on the figure 7.

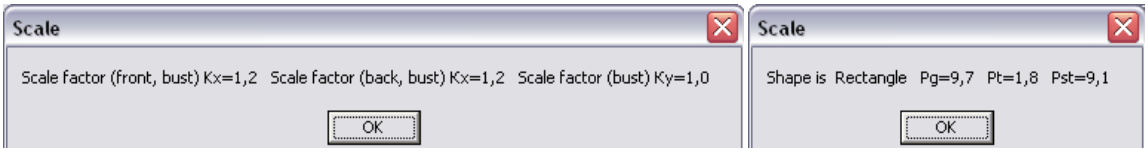

Fig. 7. Message boxes of the program "Scale factor"

Conclusion

The information we have obtained can be used in processes of design and study of women's garments' form. Computer program "Scale factor" can be used in study of garments shape's features and its transformation with time. Besides that it would be possible to research relationship between the body measurements and proportional characteristics of the form to achieve the aesthetic quality of the garment.

References

3Dfashion – 3D technology in the design of clothing. Retrieved from: http://www.3dfashion.biz

Aldrich, W. (2008). *Metric pattern cutting for women's wear (5th ed.)* Wiley-Blackwell

Kuleshova, S. G. (2013). Розробка баз даних графічних образів моди XX–XXI ст. [Database design of graphic fashion images in XX-XXI centuries]. *Herald of Khmelnytskyi national university. Technical science*, 3, 148-153. Retrieved from: http://lib.khnu.km.ua/pdf/visnyk_tup/2013/(201)2013-3-t.pdf

Masalova, V. A., Melikov, E. Kh., & Shil'dt, E. V. (2005). *RU Patent No. 2264145* Russian Federation: Russian Patent and Trademark Office. Retrieved from: http://www.freepatent.ru/images/patents/205/2264145/patent-2264145.pdf

Slavinska, A. L. (2007). *Основи модульного проектування одягу: Монографія.* [Basis of a modular clothes design: Monography]. Khmelnitsky: XNU.

Strunevich, E. Yu. (2008). *Разработка метода преобразования творческого эскиза в модельную конструкцию при автоматизированном проектировании женской одежды* [Developing of the method of transformation the sketch to construction in the process of automated designing women's clothing] (Unpublished doctoral dissertation). Moscow state university of design and technology, Moscow.

Zakharkevich, O. V., & Hrechana, M. V. (2011). Метод побудови віртуальної форми жіночого плечового виробу шляхом масштабування [Method of constructing a virtual model of the woman's garments by scaling]. *Interuniversity collection "Scientific notes"*, 34, 95-100.