THE PROGNOSTIC MODEL IN APPAREL DESIGN

Svetlana Kuleshova[1], Oksana Zakharkevich[2], Alla Slavinskaya[3]
Department of Technology and Design of Sewing Garments,
Khmelnitsky national university
Institutskaya street, 11, Khmelnitsky, Ukraine, 29016
[1]kuleshova_lana@ukr.net, [2]zbir_vukladach@ukr.net, [3]tksv@khnu.km.ua

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Abstract. *Ability to predict the morphological features of costumes' forms is one of the main purposes of the prospective design because it provides the consumers demand in a certain period.*

We used the qualitative and quantitative analysis of the photographic material of the female costume collections of European fashion houses for a certain period for the verification of the theoretical prognostic model. Analysis of the experimental curves confirms the cyclical nature of the basic and derivative shapes' development. Herewith, periods of the incipience, development and recession of the basic and derivative shapes are mirrored.

Geometric symbols of basic and derivative shapes of the costume were proposed as the input data for the first stage of the apparel design.

Design of the X-shaped dress was described as the example of usage the proposed prognostic model. It includes few stages: determination of the dominant basic and derivative shapes; representation of the geometric symbols of these shapes on the female figure; measuring of the projection shape parameters; calculation of the scale factors and amount of eases in order to recreate the volume-spatial garment form; and obtaining the garment blocks by using the tools of the 3D-design.

Results of the study could be use in researches of the relationships between geometric symbols of the shapes and the corresponded eases.

Introduction

Successful apparel design might be achieved as a result of the prediction the costume's shape. As we know from the researches [1-6], a structure of the costume's shape is the dominant factor in the factors system of the suit's perception as general object.

Morphogenesis of women's costume is widely studied by many authors [1-11]. According to their researches [1-6, 8, 9] composition parameters of the shape are taken as primary, predefined input data for further studies of the apparel design.

In previously published works [10, 11] we have demonstrated that the process of structural formation is a part of the rationalization of the future apparel shape. It means that a topical issue at present is to develop a methodology for determining, analyzing and forecasting morphological structure of the costume's shape.

The dominant feature of the morphological structure of the costume's shape is a volume-spatial form, which we can represent as a geometric symbol.

The main purpose of this research is to develop practical recommendations for the verification of the prediction costumes shapes on the base of geometrical symbols' frequency of modern European women's costume, and recreating women's garment forms according to the dominate geometrical symbol of the shape (basic or derivative).

In order to obtain patterns in women's costumes' structure we have to solve few tasks:

- obtain graphics data and calculation data of the theoretical models of predictions the costume's shape;
- compile the catalog of collections models' photoimages in some chronological period;
- represent costumes' shapes in the chronological period as the geometric symbols;
- make quantitative analyzis of the fashion materials in the chronological period.

Shapes classification

According to the works [1-9], we can assume that costume shape could be represented at the plane as one of the simple figures – rectangle, trapezium, or ellipse. These three shapes are the basic shapes (BSh) of the clothing: rectangle BSh1, trapezium BSh2, and ellipse BSh3.

It means, that basic shapes use simple structural geometrical symbol (GS) as a base.

Then derivative shapes DSh12, DSh21, DSh13, DSh31, DSh23, DSh32 [7] arise as combinations' result of the geometrical symbols of the basic forms (figure 1). The first number in the name of the shape means the number of the basic shape, which is at the top of the combination. For example, name "DSh12" means that it consists from two basic shapes (rectangle BSh1, and trapezium BSh2), and rectangle is located at the top of the combination.

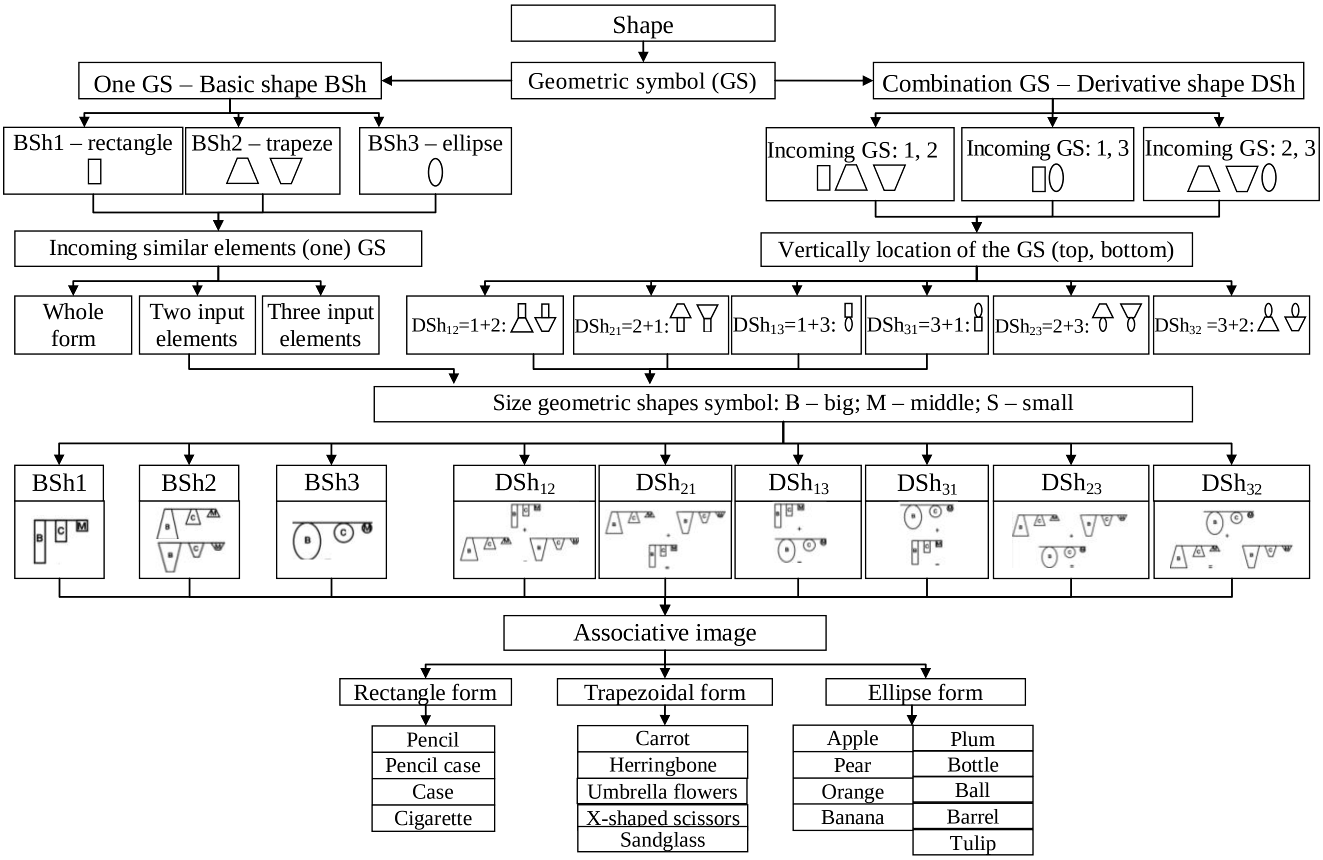


Fig. 1 – Shapes classification

The prognostic model's verification

Structure of the costume's shape is an object, which has the cyclical nature of the development in time for a number of its parameters. These parameters are called endogenous variables of the prediction object [5].

Endogenous variable can be regarded as an object which is completely provided with qualitative and quantitative information in the form of statistical and structural models of clothes for a certain study period.

It could be considered, that this information is sufficient for the prediction and for the construction of the generalized graphical models for different (shot and long) time periods.

Forecast verification determines the predictive power of prognostic model forecasts. Because of the complexity of these models, forecast verification goes a good deal beyond simple measures of statistical association or mean error calculations.

Forecast verification of morphological features of the costume's shape is a stage of the designe, when new information about fashion must be systematized.

Kozlova in her work [3] has established that the whole cycle of shape structure development covers period in 24 years. Extremal point of the curve characterizes a halfcycle – 13 years. Halfcycle includes two periods, which represent development of the derivative shapes. It means that all basic and derivative shapes exist at the same time. Then cycle will be repeated again, but the quantative characteristic of the morphological parameters could be different [7].

Mathematical interpretation of the cycle's changes includes following formulas, which represent dispersion of shapes in a theoretical fashion [3]:

$$P_1(t) = \frac{100}{3{,}24}\left[1{,}08 + \sin\frac{2\pi(t-1955)}{13}\right], \quad (1)$$

$$P_2(t) = \frac{100}{3{,}24}\left[1{,}08 + \sin\frac{2\pi(t-1955)}{13} - \frac{2\pi}{3}\right], \quad (2)$$

$$P_3(t) = \frac{100}{3{,}24}\left[1{,}08 + \sin\frac{2\pi(t-1955)}{13} - \frac{4\pi}{3}\right], \quad (3)$$

$$P_1(t) + P_2(t) + P_3(t) = 100 \quad (4)$$

were $P_1(t)$, $P_2(t)$, $P_3(t)$ – dispersion of ellipse shape, rectangle shape, trapezium shape in a theoretical fashion, %;

t – year;

1955 – year of the counting for 10 % significance level;

13 – value of period of the fashion changes.

Existing graphic of the cycle's changes of the geometrical structure of costume was extended (figure 2). It includes prediction of changes in development of the basic shapes. This model represents theoretical development model of the costumes' shapes.

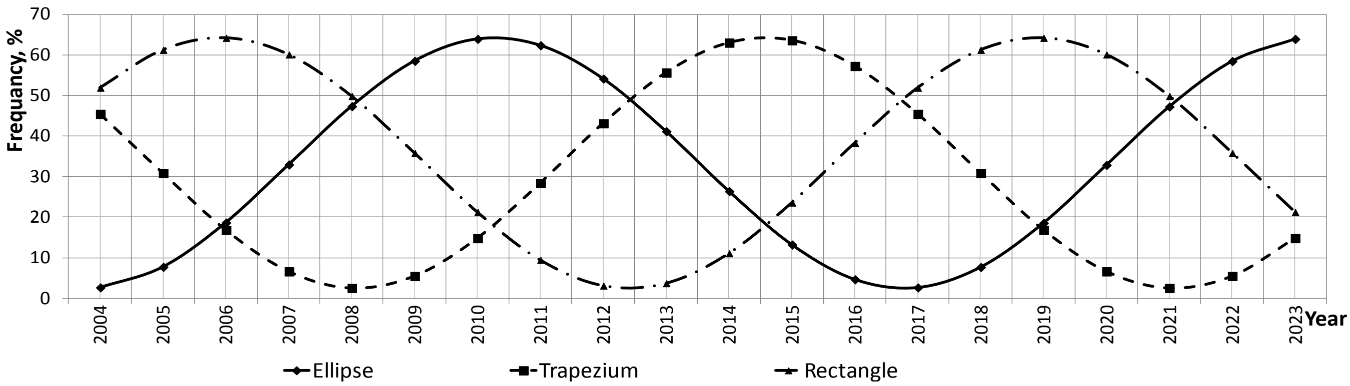


Fig. 2 - Evolution of geometric structures of modern European women's costume of the XXI century (value of period of the fashion changes – 13 years)

Kozlova in her works has assumed that the value of period of the fashion changes would decrease [3].

Besides that, any prognostic model needs some correction to account the effect of exogenous variables. These variables include socio-economic, scientific, technological, demographic, environmental, cultural, and climatic factors, which define the design situation of their time [5].

We suppose that in XXI century the value of period of the fashion changes is less than it was before, and probably it could be equal to 6 years. That is why formulas (1-3) were changed correspondingly and dispersions of the costumes' shapes in theoretical development model were recalculated (figure 3). For analysis we have allocated a 6-year period (2009-2014) on the graph.

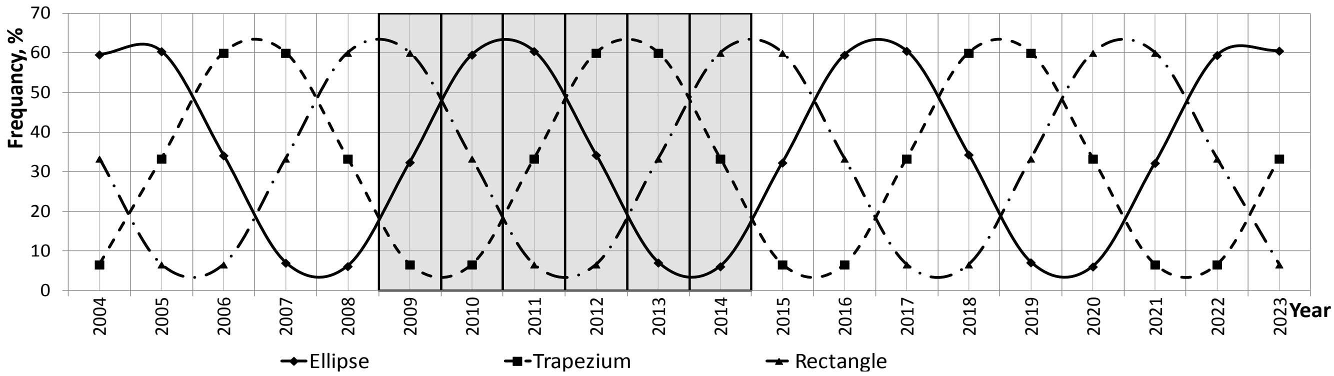


Fig. 3 – Evolution of geometric structures of modern European women's costume of the XXI century (value of period of the fashion changes – 6 years)

The program of statistical research of the shape of fashionable costume was compiled for the verification of prediction the morphological features of costume’s shape from 2009 to 2014 (table 1).

Table 1 – The program of statistical research of the fashionable costume’s shape

№	Operation	Purpose
1	Gathering of the information about fashionable costume's shape	Knowledge systematization, and forming the statistical totality of the morphological structure of the costumes shape
2	Determination of the significance of the shapes structure changes	Forming the thesaurus of the geometrical symbols of the shapes
3	Matching of the main changes with the geometrical symbols of the basic and derivative shapes	Formalization of the actual knowledge about previously identified geometrical symbols
4	Mathematical and statistical data analysis	Obtaining of the graphic models of the statistical dispersion of the parameters
5	Evaluation of the obtained data	Objectification of the statistical dispersions

Fashion mega portal «first VIEW» [13] was used to carry out this study. This portal allows us to work with digital photos of the collection shows.

Modern European women's costume (seasons “autumn-winter” and “spring-summer” during 2009 – 2014) was selected as object for the study.

We have selected seven fashion houses for our research: Alexander McQueen, Chanel, Dior, Valentino, Gucci, Iris van Herpen, Slava Zaitsev. These fashion houses meet the following criterias:

– the history of the house has over ten years;
– the fashion house is famous, and it could be claimed as fashion lawmaker.

At the first stage of this research, over 4000 images (about 50 models in each collection) were analyzed and presented graphically as the geometric symbols (GS).

Models were located in a united modular grid in full growth. We have taken into account the symmetry of the human figure, but we have ignored a number of characteristics of costume shape (color, sewing lines, decorative details, fabrics properties, etc.). These actions allow us to trace the process of forming a women's costume's shape by allocating the main feature of the costume (figure 4).

Fig.4 - Examples of a graphical analysis of the visual projections' structure of the costume

Quantitative analysis of the theoretical development model of the costume' shapes means that we have to determine the percentage of each tendency in collections of the current year or season. Quantitative analysis is represented in the tables 2 and 3. The data in tables confirm the development of the specific fashion forms.

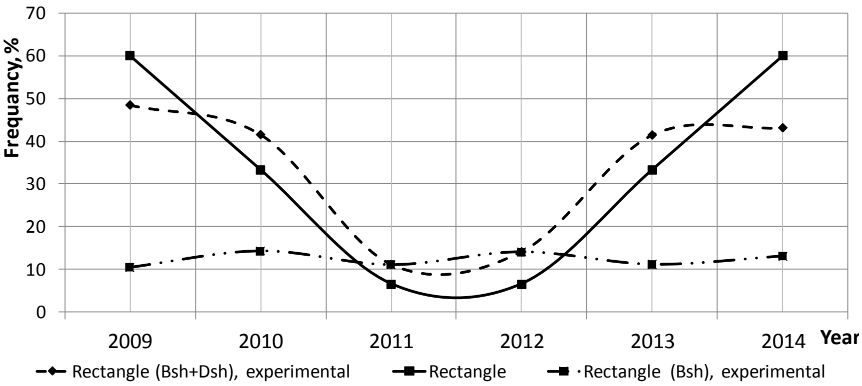
Table 2 – Statistical analysis model of the geometric symbols of the modern European women's costumes shape (2009 – 2014)

№	Fashion house	Number of garments	Percentage of garments with the												
			basic shape, %				derivative shape, %								
			BSh1	BSh2		BSh3	DSh_{12}, DSh_{21}		DSh_{13}, DSh_{31}			DSh_{23}, DSh_{32}			
1	Alexander McQueen	600	8.0	15.0	15.6	21.0	1.8	1.6	5.0	2.0	–	20.0	2.4	7.6	–
2	Chanel	613	21.1	11.3	18.1	14.8	4.9	2.1	6.8	2.9	2.7	6.4	3.5	5.3	–
3	Dior	600	6.8	11.0	26.0	19.0	2.2	–	2.2	1.6	0.4	20.8	4.6	5.2	0.2
4	Valentino	600	15.2	22.6	20.2	18.0	2.6	2.0	2.0	2.4	1.0	11.0	1.4	1.6	–
5	Gucci	600	12.0	8.6	9.4	23.8	1.8	2.0	3.4	9.0	2.6	18.0	4.0	4.8	0.6
6	Iris van Herpen	300	11.0	10.5	8.5	33.0	1.0	3.5	5.0	1.5	–	14.0	0.5	4.0	7.5
7	Slava Zaitsev	602	14.9	17.3	12.7	20.7	2.2	7.6	3.6	3.4	–	13.1	0.4	3.6	0.4

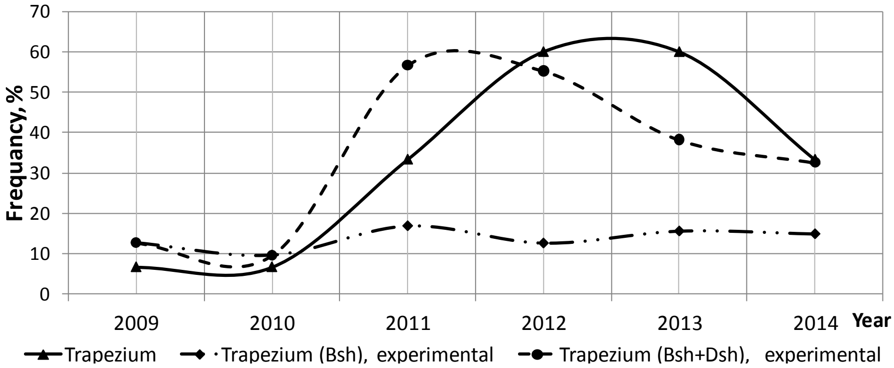
Table 3 - Quantities analysis of the theoretical development model of the costume' shapes

Year	Percentage of garment styles with the											
	basic shape, %				derivative shape, %							
	BSh1	BSh2	BSh3	**Total**	DSh_{12}	DSh_{21}	DSh_{13}	DSh_{31}	DSh_{23}	DSh_{32}	**Total** DSh_{23} $+DSh_{32}$	**Total for derivative shapes**
2009	10.5	35.6	19.2	**65.3**	1.11	2.38	3.8	7.6	16	4.5	**20.5**	**34.7**
2010	14.3	25.9	22.4	**62.5**	1.9	2.8	6.1	3.3	18.8	4.1	**22.9**	**37.5**
2011	11.1	34.3	20.9	**66.3**	0	1.6	3.7	2.6	20.8	4.1	**24.9**	**33.7**
2012	14.1	26.4	17.6	**58.3**	1.2	2.6	3.8	7.6	17.6	7.5	**25.1**	**41.7**
2013	11.2	36.7	17.2	**65.1**	3.7	2.5	1.9	0.9	16.8	5.9	**22.7**	**34.9**
2014	13.1	29.6	24.3	**67.0**	5.4	3.9	1.7	4.2	12.4	5.3	**17.7**	**33.0**

As a result of analysis, we can say that at period 2009-2014 in fashion collections there are all of described shapes (basic and derivative) (figure 5).



a



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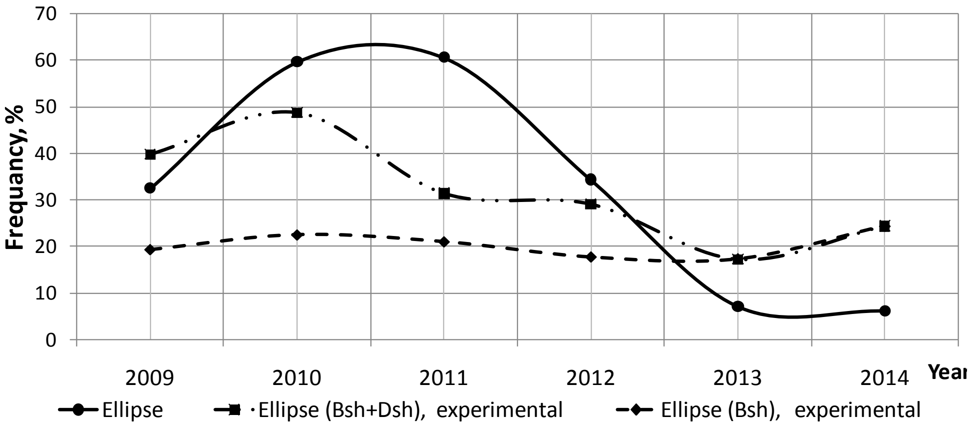


c

Fig. 5 – Theoretical and experimental development models of the shapes: a – BSh1; b – BSh2; c – BSh3

As we know from the work [7], development of the each basic shape passes through the three periods: incipience, development, and recession. According to the prediction (figure 2) period from 2009 to 2014 is a period of the trapezium shape development with the extremum point in 2012. At the same time it is recession period for the ellipse shape, and incipience period for the rectangle.

Through analysis of the prediction by the theoretical development model of the costume' shapes (figure 2) and experimental data (figure 3) for the same period we can assume that dispersion value in calculation model is higher than experimental. Quantitative analysis showed that the frequency difference is about 10.0-50.0 %.

This is because each of the base shapes forms its derivative shapes [7], and all of these shapes exist in a fashion simultaneously. Thus, theoretical model (figure 2, 3) displays the total number of basic and derivative shapes.

That is why we used total number of each basic shape and its derivative shapes for the verification of the theoretical model of the fashion.

Through the Fisher test we have confirmed that theoretical model could be used to predict dispersion of the basic shapes (table 4). Besides that we can make a conclusion that the value of period of the fashion changes in formulas (1-3) is equal to 6.

Table 4 – Fisher test

Parameter	Rectangle	Ellipse	Trapezium
D	34.658	22.143	19.177
D_a	24.520	15.741	13.487
F	1.414	1.407	1.422
F_{table}	4.500		

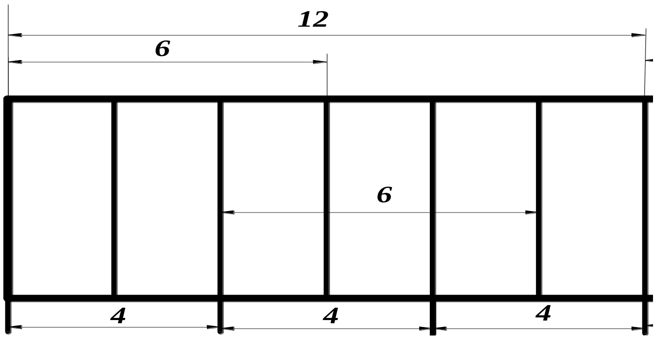
The derivative shapes' development

As we can see at the figure 5 there is certain regularity in the fashion cycles: experimental number of the shapes goes to theoretical number in four years and graphic makes a loop. Thus, each cycle has hysteresis.

Hysteresis is the time-based dependence of a system's output on present and past inputs. Phenomenon of "saturation" is a characteristic of the hysteresis [12].

Over time, the numbers of derivative shapes of dominate basic shape increase, until the process gets closer to saturation, when the number again decreases. At the same time, another basic shape begins to dominate and number of its derivative shapes is going to increase.

According to the study [7], in general, a temporary structure of the shape development can be represented by the following scheme of the diffusion range of its development cycle (figure 6).



12 years – general trend of shape structure,

6 years – geometric characteristics of the basic shape - pulsing of the geometric symbol;

4 years – development of derivative shapes, geometric symbols of form elements are grouped vertically and horizontally;

2 years – mobile characteristics of the derivative shape's width;

2 years – mobile characteristics of the derivative shape's length

Fig. 6 – Scheme of diffusion interval of the development cycle of the shapes' structure

In order to study the statistical significance of derivative shapes we have modeled their chronological dispersion (figure 7).

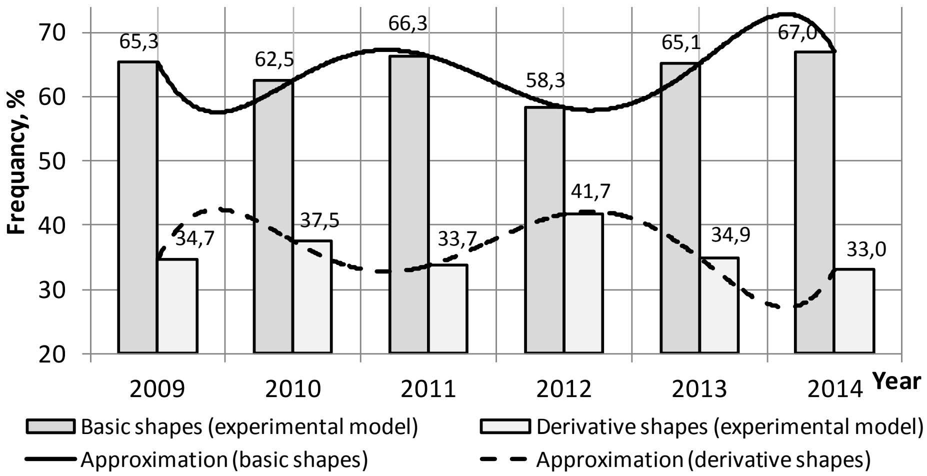


Fig. 7 – Percentage of the basic and derivative shapes in European women's costume (2009–2014)

Analysis of the experimental curves confirms the cyclical nature of the basic and derivative shapes' development. Moreover, periods of the incipience, development and recession of the basic and derivative shapes are mirrored.

Data in the table 3 and on the figure 8 are showing the active existence and development of the derivative shapes in period 2009-2014.

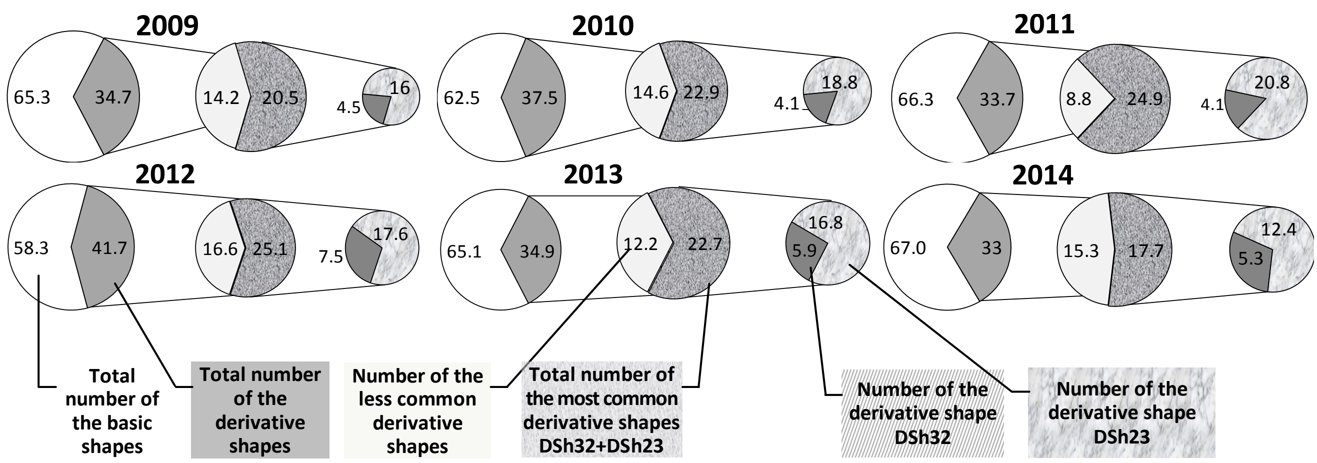


Fig. 8 - Derivative shapes' number in total number of garments (2009-2014)

Derivative shapes DSh23, DSh32 appear in collections when basic shapes BSh2 and BSh3 dominate (figure 9, 10). Derivative shapes DSh13, DSh31 appear more common when rectangular basic shape is in its incipience period.

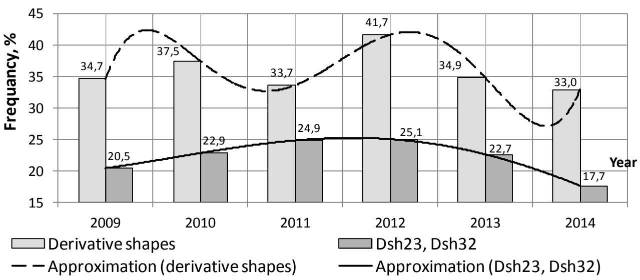


Fig. 9 – Persentage of the derivative shapes DSh_{23}, DSh_{32} in the European women's costume (2009-2014)

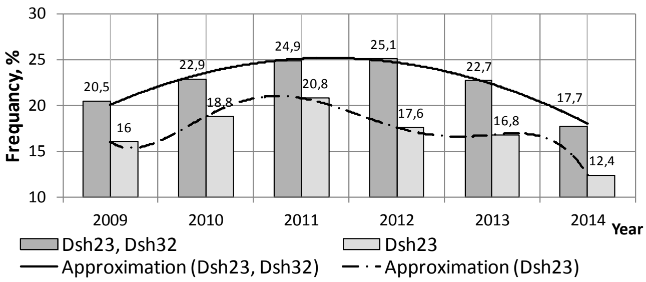


Fig. 10 – Persentage of the derivative shapes DSh_{23} in total DSh_{23}, DSh_{32} (2009-2014)

Example of the prognostic model's usage

We suppose that the described prediction method could be used as a first stage in the apparel design. Thus, if we use the prognostic model on the first stage of the apparel design we have only geometrical symbol of the garment's shape, which dominates in the period. Geometrical images of the garments shapes must be represented on the female figure.

For example, according to the prognostic model the main basic shape in the period is trapezium BSh2 (P_2(2013) = 60 %). This shape is presented on the female figure (figure 11) as a complex model, which includes contours of the garments of the certain type with the correspondent shape.

Separate garment must be presented as it shown on the figure 12: front view, right (left) view, and back view of the garment. That is how we can measure projections parameters of the shape (figure 12).

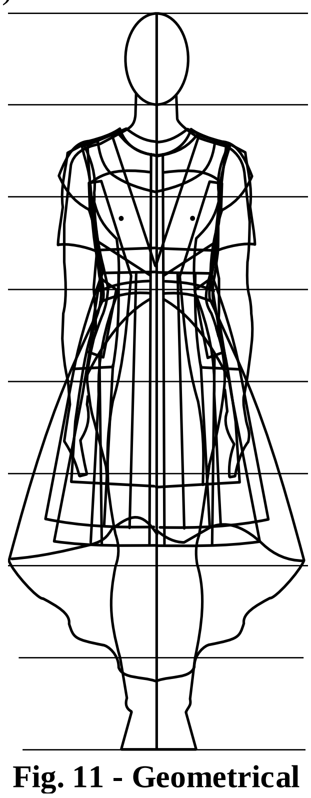


Fig. 11 - Geometrical images of the dominant shapes (2009-2014)

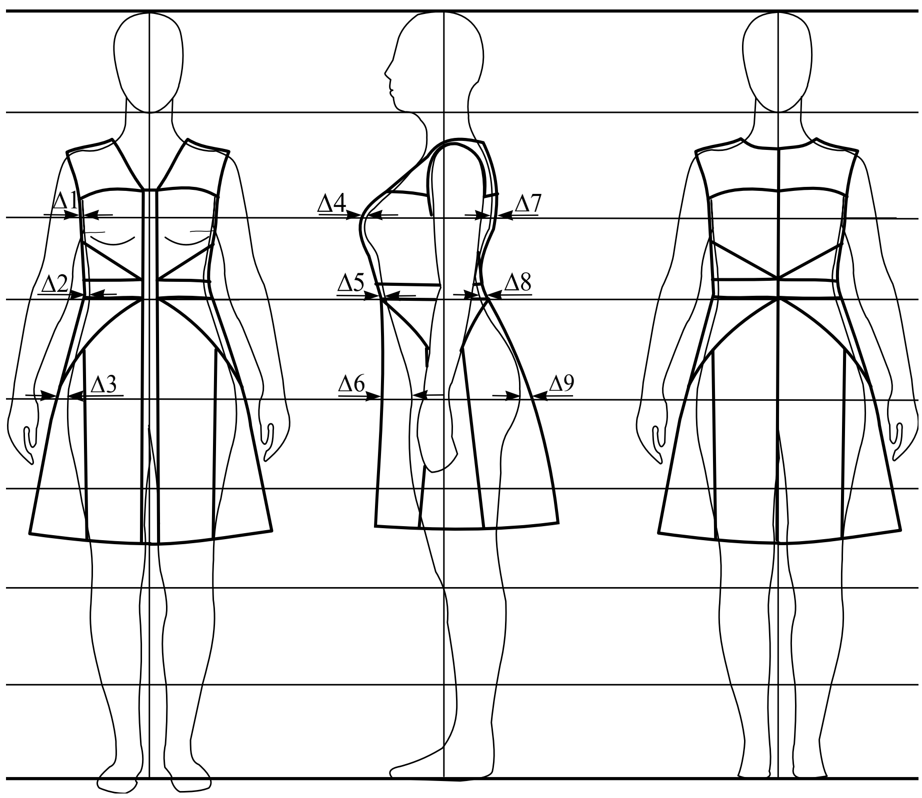


Fig. 12 - Projections parameters of the X-shaped dress (female figure: height 169 cm, bust 92 cm, hips 101 cm)

For recreating garments' volume-spatial form we need information about relationship between projections parameters and amount of ease for these shapes. Strunevich has proposed to calculate amount of ease by formulas [14], which we have transformed according to our purpose and have described them in previously published work [15].

The values of the projections parameters for the dress (on the figure 12) are presented in the table 5.

Table 5 – Input data for the recreating virtual garment's form (X-shaped dress)

Body measurements	Value, cm	Projections parameter	Value, mm	Projections parameter	Value, mm	Projections parameter	Value, mm
Bust	92	Δ_1	5	Δ_4	10	Δ_7	10
Waist	68	Δ_2	12	Δ_5	10	Δ_8	10
Hips	101	Δ_3	15	Δ_6	58	Δ_9	25

In study of garments shape's features and its transformation with time we used computer program "Scale factor" [15].

Thus, we can calculate the scale factors (table 6) by use values of amount of ease, which were obtained with formulas (described in [15]) and measured projection parameters (figure 12, table 5). We used this information to recreate derivative forms of garment (X-shaped dress on the figure 13).

Table 6 – Calculation results

Scale factor on the	Value			Ammount of eases, cm
	Kx		Ky	
	front	back		
bustline	1.21	1.18	1.01	9.7
waistline	1.08	1.07	1.00	3.5
hipsline	1.13	1.16	1.00	6.9
above the waist	1.15	1.12	1.01	-
below the waist	1.11	1.12	1.00	-

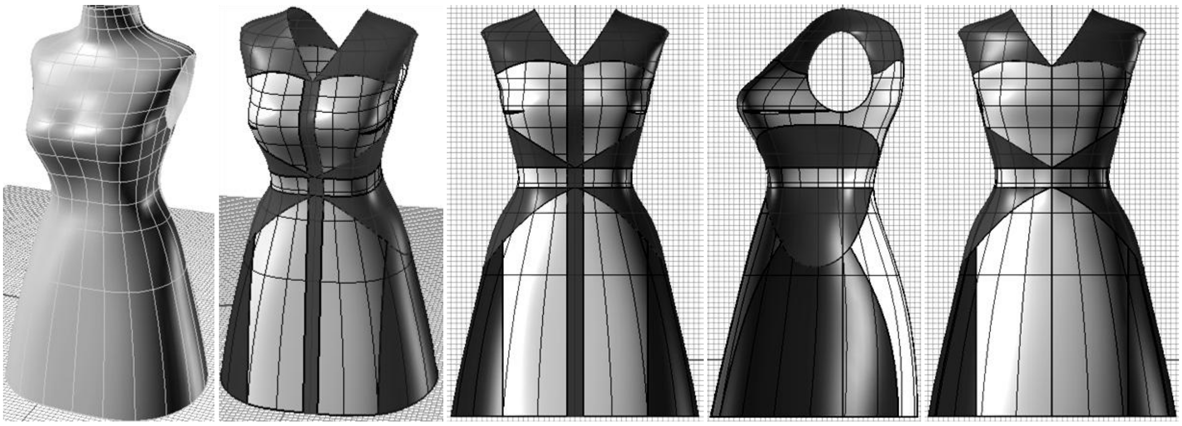


Fig. 13 – Virtual garment form (X-shaped dress)

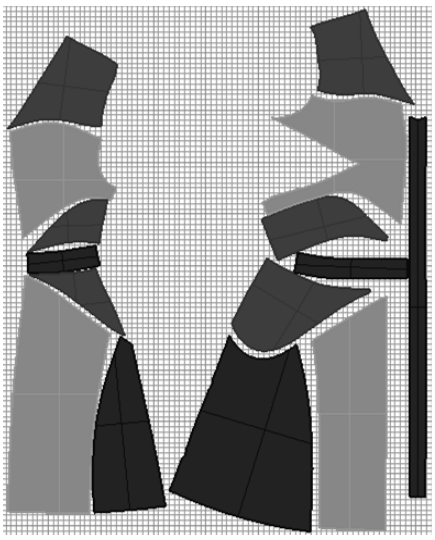


Fig. 14 – Blocks of the X-shaped dress

Conclussion

As a result of this work we can conclude that verification model has confirmed the theoretical prognostical model of the morphological shape's structure of the costume for a certain period of time. Herewith, the value of period of the fashion changes in XXI century in prognostic model is equal to 6.

Analysis of the experimental curves confirms the cyclical nature of the basic and derivative shapes' development. Herewith, each cycle has hysteresis, and periods of the incipience, development and recession of the basic and derivative shapes are mirrored.

Temporary structure of the shape development was represented by the scheme of the diffusion range of its development cycle.

Geometric symbols of basic and derivative shapes of the costume could be used as the input data for the first stage of the apparel design.

Design of the X-shaped dress was described as the example of usage the proposed prognostic model. It includes few stages: determination of the dominant basic and derivative shapes; representation of the geometric symbols of these shapes on the female figure; measuring of the projection shape parameters; calculation of the scale factors and amount of eases in order to recreate the volume-spatial garment form; and obtaining the garment blocks by using the tools of the 3D-design.

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