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ALGORITHMS TO ASSESS BY CRITERIA THE HARMONY OF THE TYPOLOGICAL RANGES OF CUTTING LINES IN CLOTHES

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Abstract

The main objective of the study is to develop the algorithms to assess by criteria the harmony of the typological ranges of cutting lines in clothes. In order to develop the algorithms models of the analytical description of the restrictions in the modification process of the designing object were described. The developed algorithms are as follows: algorithm to specify the anthropometric information in the system of projection dimensions of harmonious female body; algorithm to classify the typical bodies by the indices of deviation in the net of harmonious cutting lines; algorithm to transform the general sketch of harmonious female body into the given body type; algorithm to design the universal construction for the transformation chain of typological range of designing object; algorithm to modify the horizontal projection cutting lines into curve lines of the garment; algorithm to define the designing object; algorithm to form the production model of the knowledge base of expert system.

Keywords: algorithm, harmonious, clothes, typological range.

INTRODUCTION

The axiom of artistic clothing design is the statement that proportion is a classic means of compositional construction of any object.

Semantical sense of information regarding visual reflection takes its grounding on the general nature principle, which appears in the similar changes, and, in particular, in the principle of proportions. The proportionality and similarity of an object are expressed in relative sizes based on comparison of two or more measurements of the object itself. An essential element of coding images by vision is the proportionality, which forms the algorithm of associative perception of dimensional and spatial structure by features of geometric similarity.

Dimensional and spatial structure of clothing has double characteristic of perception. Subjective and emotional characteristic appears when the algorithm of the dimensional structure of clothing is identified as an algorithm of dimensional structure of specific images, which are stored in the personal or genetic memory.

Objective and functional characteristic appears due to the algorithm of integrity of general assessment criteria of the object's aesthetic form.

According to the Hamilton's principle [1], integrated brain activity, if codes of the coder and decoder are similar, leads the organism into the state of the positive emotional excitement. Emotional reaction is unconscious aesthetic assess of the harmonious reflection of an object.

Thus, proportion is the objective characteristic of the clothing harmony.

EXPOSITION

The base that is needed to form input data to design the system "Clothing" is the modern concept of semantic nets in form of the typological ranges modules. The series of works [2] on conceptual modelling of the subject area of the expert system is devoted to application of the particular elements of the fundamental mathematical apparatus of Petri nets [3].

The concept of typological ranges is used in areas of literature, architecture, philology, archeology, anthropology, and many others [4]. Oscar Montelius gave the description of the typological range as follows: the series is typological if its objects are functionally definite things, which are the things of the same category. The range shows gradual changes of the form during the time going [5].

It is advisable to arrange the figure types in the form of the typological range that is designed on extension principle of typical graphs based on the rubricating of the development level of body anatomic belts. This range highlights differences between the separate body types as well as interrelationships between them.

While typological analysis is conducted the complex objects (in the given circumstances women figures) are to be presented with samples of typical figures. Thus, description of a body type is the typical figure that is characterized with typical set of morphologic features. As morphologic features to recreate the figure's outline, projection body measurements on the front and side images of the figure are used more and more often [6-9].

Conditions those describe the ability to inherit the morphologic parameters might be described by the multicriterial analysis of the object set. It is based on the calculation of the Euclidean distance that is considered as a measure of the objects similarity [10]. A measure of aesthetic, which is a universal characteristic of the clothing harmony, is considered from the point of view of information theory as "an order in complexness" in form of the integral assess of the order [11].

Algorithms of inheritance of morphologic features of typical figure are recreated in the last version of the pattern design system "Grazia" (module "Individual and corporate orders") [12]. However, in the module the criteria of harmonious figures are not taken into account.

MODELS OF ANALYTICAL DESCRIPTION OF RESTRICTIONS IN THE MODIFICATION PROCESS OF DESIGNING OBJECT

Results of the harmonization technique, which is used to harmonize design and composition decisions of garments, might be assessed by experts, who assess quality indexes, as well as with help of some abstract criteria.

Eysenck's concept formula of aesthetic measure [13] is as follows:

$$M=C\cdot O, \quad (1)$$

where C – complexity;

O – orderliness.

Measure of the proportion system is a measure of the dimensional orderliness of the clothing dimension structure.

Informational properties of the proportion's relations are described by formula:

$$p^s = \frac{r^i}{r^j}. \quad (2)$$

where p – a base of the proportion series; s=1, 2, 3… – indicators of the degree that characterizes the relative position of its members.

A key measure in information theory is the amount of uncertainty that is called "entropy". It is calculated as follows [14]:

$$H = -\sum_{I}^{n} p_i log_2 p_i. \quad (3)$$

where p_i – probability of presence in the system of i^{th} element of its alphabet.

It is advisable to include into the alphabet of the typological range's harmony follows elements:

a) elements that form the main properties of the game field of designing system "body-clothing";

b) elements that form complexes, which are the functional and structural features of body type;

c) elements that change a length of transformational chain if they are not universal;

d) elements that determine aesthetic expression of clothing;

e) elements of the clothing design.

The algorithm to assess the harmonization parameters of the system "Clothing" by criteria includes four blocks of data provided for the given typological range. Based on the information model of integrated database of designing process of harmonious clothing it was proposed to use a system of assessment, which takes into account parallel ways of forming the local databases. Among them are features of the morphological structure, fabric properties, cutting lines of a form, and a construction.

Concept modelling of the information support of harmonization process of clothing demands technical description that is based on a semantic network. Nods of the semantic net are blocks those realize interactive or calculative actions, and edges are the results of the blocks functioning.

A view of determined semantic net, which displays solving processes of tasks system to form the typological series, is shown on the example of harmonized objects (fig. 1). The nods of net B_i (i=1,..) are related to modules those perform action blocks of the following purposes:

1. specify the anthropometric information in the system of projection dimensions of harmonious female body;
2. classify the typical bodies by the indices of deviation in the net of harmonious cutting lines;
3. define the designing object;
4. transform the general sketch of harmonious female body into the given body type;
5. form the production model of the knowledge base of expert system;
6. design the universal construction for the transformation chain of typological range of designing object.

Modelling the expert knowledge about harmonization processes of the objects, which belong to the system "Clothing", demands that the processes to be presented in unambiguous and optimal form of datasets, algorithms, and software programs.

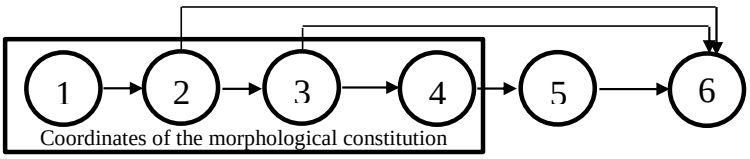

***Fig. 1**. Semantic net, which displays solving processes of tasks system to form the typological series of design objects*

ALGORITHM TO SPECIFY THE ANTHROPOMETRIC INFORMATION IN THE SYSTEM OF PROJECTION DIMENSIONS OF HARMONIOUS FEMALE BODY

A module to determine analytical criteria to assess the results of modifications in subsystem «figure» includes a set of modules, general structure of which is of the same type. The modules are as follows: a module of technical sketch of conditional harmonious figure; a module of harmonized figure types and their parameters; a module of identification of the typical figures, which are similar to harmonious. The principle basis of the proposed assessments are the selection methods in the study of the morphological constitution of the body and its basic coordinates such as bones, muscles and fat. The coordinates objectively reflect geometry of a body surface and they might be compared by using the specific scale with projection dimensions of body in order to construct a graph model of harmonious typical figure.

Not all of the typical women figures, body measurements of which are mentioned in regulatory documents, are harmonious [15-17]. If their measurements differ from the harmonious ones more than limit of visual

perception tolerates, then their forms must be corrected. Group of harmonious figures includes the figures, which meet the canon proportions of women bodies. In order to represent the measurements of the harmonious figure, which is built on the rule of "golden ratio" and chosen as an etalon, the system of conditional units was developed based on numbers of the Fibonacci series [18] (fig. 2).

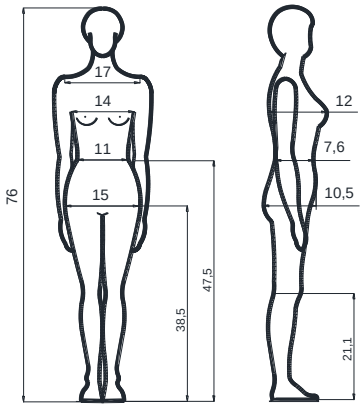

Fig.2. *Module of the technical sketch of the nominal harmonious figure of a woman*

In order to select out the typical figures, which match to harmonious proportions, according to the equation 2 the factor of proportion was proposed. It must be calculated as follows:

$$K_{pr} = P/76 \qquad (4)$$

where K_{pr} – proportionality constant between heights of typical figure and nominal harmonious figure;

P – height of a typical harmonious figure, cm;

76 – height of the nominal harmonious figure.

Typical figures match harmonious figures' proportions if they have projection body measurements, which differ no more than 3% from the measurements of etalon harmonious figure (table 1).

Table 1. Anthropometric characteristic of the harmonious typical women figures

Height, cm	Body measurement, cm						Typical figure that is considered harmonious
	Chest width		Difference, %	Hips width		Difference, %	
	Typical figure	Harmonious figure		Typical figure	Harmonious figure		
152	24.8	24.8	0	30.8	30.8	0	152-80-88
158	26.2	25.8	1.6	31.7	32.0	-1.0	158-84-88
164	27.4	26.8	2.2	33.6	33.3	0.9	164-88-92
170	28.6	27.8	2.9	34.5	34.5	0	170-92-96
176	28.6	28.8	-1.0	36.4	35.7	1.9	176-96-100

A set of 257 typical figures, which are presented in [19, 20] was examined using the coefficient of deviation. Among them are 97 figures with height 152 cm, 98 figures with height 164 cm, and 62 figures with height 176 cm. The coefficient of deviation was calculated by following formula:

$$k = \frac{(\frac{T}{K_{pr}} - T_h)}{T_h} \cdot d_h \qquad (5)$$

where k – coefficient of deviation;

T – body measurement of typical figure, cm;

T_h – body measurement of harmonious figure, conditional units.

Main horizontal projection measurements of a body were selected out to calculate the differences (fig. 3, table 2).

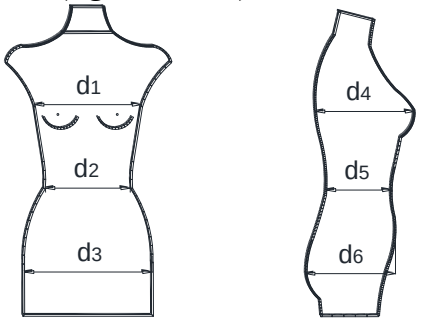

Fig.3. *The system of projection measurements of a body: a) front view; b) side view*

Table 2. Parameters of projection measurements of the etalon of harmonious figure

Figure projection parameters	Height, cm	d_1	d_2	d_3
Relative parameters of harmonious figures, conditional units	76,0	13.7	10.5	14.7
		d_4	d_5	d_6
		12.1	7.6	10.5

Using the calculated coefficients of deviation intervals between sizes were calculated for the body shapes with chest circumference 80…132 cm (bust) and body shapes groups defined by Hip-Chest circumferences. Shapes codes by Hip-Chest circumferences are as follows: -III, -II, -I, 0, I, II, III, IV, V, VI, VII.

Different body development degrees on bust, waist, and hips level in two projections are determined taking into account obtained ranges of deviations (table 3). Degrees of development of morphological feature are characterized by following indexes Small – S, Medium – M, Large – L, Extra Large – XL, Extra-Extra Large – 2XL, Extra-Extra-Extra Large – 3XL.

Table 3. Characteristic of deviations of projection measurements of women figures (fragment)

Development degree of anatomic part of a body	Height, cm	Projection measurements (front), conditional units						Projection measurements (profile), conditional units					
		d_1		d_2		d_3		d_4		d_5		d_6	
S	152	-2.055	-0.274	-1.47	-0.105	-1.764	-0.441	-3.993	-2.42	-2.052	-0.304	-3.15	-0.63
	164	-3.155	-1.235	-1.785	-0.42	-1.911	-0.588	-4.84	-2.783	-2.964	-0.912	-3.15	-0.945
	176	-2.055	-0.411	-1.575	-0.315	-1.47	-0.147	-3.993	-2.299	-1.444	0.228	-1.89	0.315
M	152	-0.274	1.507	-0.105	1.26	-0.441	0.882	-2.42	-0.847	-0.304	1.444	-0.63	1.89
	164	-1.235	0.685	-0.42	0.945	-0.588	0.735	-2.783	-0.726	-0.912	1.14	-0.945	1.26
	176	-0.411	1.233	-0.315	0.945	-0.147	1.176	-2.299	-0.605	0.228	1.90	0.315	2.52
L	152	1.507	3.288	1.260	2.625	0.882	2.205	-0.847	0.726	1.444	3.192	1.890	4.410
	164	0.685	2.603	0.945	2.310	0.735	2.058	-0.726	1.331	1.140	3.192	1.260	3.465
	176	1.233	2.877	0.945	2.205	1.176	2.499	-0.605	1.089	1.900	3.572	2.520	4.725
XL	152	3.288	5.069	2.625	4.095	2.205	3.675	0.726	2.299	3.192	5.092	4.410	7.035
	164	2.603	4.521	2.310	3.675	2.058	3.234	1.331	3.267	3.192	5.168	3.465	5.670
	176	2.877	3.836	2.205	2.835	2.499	3.087	1.089	1.815	3.572	4.408	4.725	5.880
2XL	152	5.069	7.809	4.095	6.195	3.675	5.586	2.299	4.598	5.092	7.828	7.035	10.815
	164	4.521	7.535	3.675	5.775	3.234	5.145	3.267	6.292	5.168	8.132	5.670	8.925
	176	3.836	4.247	2.835	3.150	3.087	3.381	1.815	2.299	4.408	5.092	5.880	6.405
3XL	152	7.809	8.220	6.195	6.615	5.586	6.027	4.598	4.961	7.828	8.284	10.815	11.441
	164	7.535	7.946	5.775	6.195	5.145	5.439	6.292	6.776	8.132	8.588	8.925	9.555

Characteristic of deviations of projection measurements allows realizing an algorithm to classify the typical bodies by the indices of deviation in the net of harmonious cutting lines. It is performed by combination of degrees of development of morphological features.

Such combination specifies forming front and profile body type. Analysis of the variants of development of morphological features along with their combination principle allowed developing the classification that includes 26 types (table 4).

A body type is marked as follows: the first letter marks a degree of body development on the bust level; the second – on the waistline; and the third one – on the hips level.

The set of considered figures is divided into the five groups based on the principle of the visual similarity (table 4).

Table 4. Characteristic of the groups of typical female body shapes

Proportion type of a body	Body shape group				
	Top hourglass	Inverted triangle	Rectangle	Spoon	Bottom hourglass
Skinny	–	–	S–S–S	S–S–M	S–M–M, S–M–L
Normal	M–S–S	M–M–S	M–M–M	M–M–L, M–L–M	M–L–L, M–L–XL
Wide	XL–L–L	XL–XL–L	XL–XL–XL	XL–XL–2XL	XL–2XL–2XL
Large	2XL–XL–XL, 2XL–XL–L	2XL–2XL–XL, 2XL–XL–2XL	2XL–2XL–2XL	2XL–2XL–3XL, 2XL–3XL–2XL	2XL–3XL–3XL
Massive	3XL–2XL–2XL, 3XL–2XL–XL	3XL–3XL–2XL	3XL-3XL-3XL	–	–

The optimal combination of the fraction of chaos and orderliness of the typological series describes the relative entropy of the golden section rule. The relative entropy is 0,382. Then the fraction of orderliness is about 0.618 if the typological range is harmonious.

A special case of Hamilton's principle is a principle of minimax, which is based on Euclidean distance calculation [10] between the new type and types of the typological range.

A set X of figures types is presented as follows:

$$X = (F_1, F_2, F_3, F_4, F_5, F_6), \quad (6)$$

where F_1, F_2, F_3, – front projection measurements, conditional units; F_4, F_5, F_6 – profiles projection measurements, conditional units.

A measure of the objects similarity is the Euclidean distance $\rho(Xp, Xq)$ that is calculated as follows:

$$\rho(Xp,Xq) = \sqrt{\Delta d_1{}^2 + \Delta d_2{}^2 + \Delta d_3{}^2 + \Delta d_4{}^2 + \Delta d_5{}^2 + \Delta d_6{}^2}, \quad (7)$$

where Xp – typical figure; Xq – harmonious figure; Δd_1, Δd_2, Δd_3, Δd_4, Δd_5, Δd_6 – absolute deviations of projection body measurements, conditional units (see table 4).

ALGORITHM TO TRANSFORM THE GENERAL SKETCH OF HARMONIOUS FEMALE BODY INTO THE GIVEN BODY TYPE

Eleven steps form a transformation technique that is used to transform a technical sketch of the harmonious figure into the technical sketch of the typical one (fig. 4):

Step 1. Applicate the boundaries of anthropomorphic belts to the frontal and profile projections and draw the axis of symmetry on the frontal projection (fig. 4, a).

Step 2. Copy the left part of a figure and left hand on the frontal projection.

Step 3. Copy the whole figure and right hand on the profile projection.

Step 4. Increase or decrease the width of the figure's sections and the segments of the upper limbs in a horizontal direction (fig. 4, b).

Step 5. Increase or decrease the length of the figure's sections and the segments of the upper limbs in a vertical direction.

Step 6. Construct auxiliary mesh to correct the body shape on the profile projection (fig. 4, c).

Step 7. Correct the mutual location of the anthropometric parts of a figure and the segments of limbs on the profile projection (fig. 4, d).

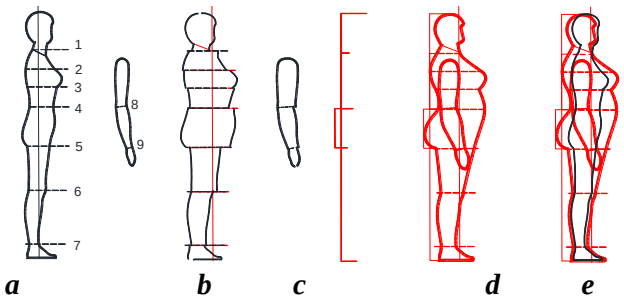

Fig. 4. *Module of transformation of technical sketch of a harmonious figure into a typical one*

Step 8. Correct the figure's contours by constructing smooth lines in the places of anthropomorphic belts' transition.

Step 9. Joint the upper limb with the figure on the profile projection and the left hand with the left half of the figure on the frontal projection.

Step 10. Mirror reflection of the right side of a figure on the front projection.

Step 11. Correct the body form on the levels of shoulder blades, buttocks and chest (profile projection of a figure) [21].

It is advisable to use AutoCAD in order to apply the algorithm of transformation.

ALGORITHM TO FORM THE PRODUCTION MODEL OF THE KNOWLEDGE BASE OF EXPERT SYSTEM

Complex "Rapana" includes two components: "Cognitograph" (software for the developers of knowledge base of the expert system) and "Expert" (application for users). Using "Expert" does not require special training, because dialogue is conducted by natural language.

Seven entities are entered into the shell. The figures for these entities are determined by the consumer in the form of answers to the questions of the system: SA, BS, CS, TN, FM, TdTu and 1c (colour). For making a decision two entities are necessary, their figures are determined immediately by expert system regulations: Cl (cluster) and M (model). Example of dialogues of the developed expert system, which represent consumer's answers to the system's questions and explanations of dialogue results are shown in [22]. Letter marks mean the codes of entities included in the regulations; digital designations are the numbers of rules used by the expert system to get answers to user's questions.

ALGORITHM TO DESIGN THE UNIVERSAL CONSTRUCTION FOR THE TRANSFORMATION CHAIN OF TYPOLOGICAL RANGE OF DESIGNING OBJECT

Main features of the game space are the basis of the algorithm to design the typological range of objects, which belong to the system «body→clothing» and are designed by module technique. The main features are as follows: limitation, structurality, ceaselessness, uniformity, achirality.

Limitation is achieved by operational apparatus of affine transformation those are defined by intervals of deviations (table 3).

Structurality is presented by functional block of alterations in the transformational net of typological range (fig. 4).

Ceaselessness is based on calculation of Euclidian distance between typical and harmonious figures of the typological range (formula 7).

Ability to combine is limited by rules of proportion types to determine psychological comfort of a person.

Uniformity of the game space is described with help of algorithm of universality of the consumer's "Self concept" that is related with the system "Costume" using triad of transformation described by [23] (fig. 4).

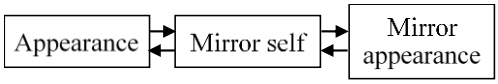

Fig. 4. *Self-concept components*

Achirality of the psychology of objects perception is proved by unequal uniformity of mirror alterations perception (fig. 5) [24]:

Ideal self – harmonious figure;

Mirror self – harmonious typical figure;

Mirror appearance – ideal costume.

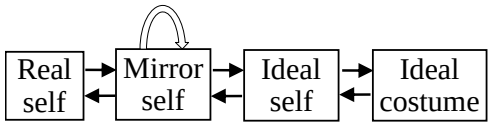

Fig. 5. *One's self-perception*

Results of alterations, which are performed using the proposed algorithm, are clothing models those are aesthetic and harmonious. Alterations number is limited by criteria of psychological comfort, which ought to be about $0{,}62 < r_S \leq 0{,}79$.

CONCLUSION

Analytical models of the criterial assessment of harmonization parameters of the system "Clothing" were proposed. Concept modelling of information support of harmonization process grounds on the alphabet of elements, which describe harmony of the typological range of aesthetic measure of design solutions of clothing.

The algorithm to determine a harmonious figure type was developed based on Euclidian distance calculation. The deviations of projection body measurements were input data to calculate the Euclidean distance.

The algorithm of the game space to design the typological range of the system "body-clothing" was described with taking into account psychological perception of consumers.

Expert system that was developed in the empty shell "Rapana" allows reflecting the consumer's perception of his "Mirror self" while garment is designed.

Described technique might be used in design processes such as clothing design, where aesthetic criteria are greatly concerned.

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