DEVELOPMENT OF EXPERT SYSTEM BASED ON KANSEI ENGINEERING TO SUPPORT CLOTHING DESIGN PROCESS

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Abstract: *The article presents the development of the concept of operation of the expert system prototype for the selection of clothes according to the consumer's wishes on the basis of the methodology of Kansei engineering in the shell 'Rapana', which ensures the dialogue in the form of successive questions of the system and the user's responses to express consumer's impressions about the design elements of the garment.*

Keywords: *Kansei Engineering, expert system, emotional design, semantic differential, fashion dresses*

1 INTRODUCTION

Within the concept of a current policy in the field of quality products and services the need to improve the competitiveness of products is highlighted. This is impossible without further study of customers' specific, especially their system of clothing perception. Development of design efficiency is based on the study of impressions of garments which provide high aesthetic garments' quality and increase their attractiveness to consumers.

Time requirements include the mobile edition of various fashionable products [1], fast update range and availability of products that are in demand among the population, that is, now the concept of product development is the unity of functionality and emotion in the best possible design to meet the needs and desires of consumers.

High saturation of information environment and the risk of making wrong decisions increase the relevance of information technology as a means to support decision making. One way to address the informal or weakly formalized problems is the use of artificial intelligence methods and the creation of expert systems (ES).

2 ANALYSIS OF PUBLISHED DATA AND STATING THE PROBLEM

Today, scientists in the world successfully implement elements of artificial intelligence and the ES at various stages of designing clothes: for selection of clothes style according to the constitution features of consumers [2], for the choice of clothes to form a harmonious image of individual consumers [3], to assess the quality of design clothes drawings [4], for the formation of industrial clothing range [5], for the production of flexible reorientation of women's outerwear [6] and other purposes.

However, at this stage the ES operate mainly with digital information that provides performance of the product's main function: to fit the human body. Some researchers work with problems of achieving the psychological comfort of clothing [7]. While today's main role of defining the functional characteristics of the product is the art of creating and selling impressions, emotions and fun. The paper [8] defines the problem of considering impression for the purposes of product design, demand study for garments [9], assessing the quality of product design [10]. This has led to the emergence of a popular current theory of emotional design.

Research of recent decades indicates active learning in the field of impressions from clothes for problems of models' design. They show that the percentage of impressions among other factors when choosing clothes is equal to 33%. This significant proportion causes the intensity of the evaluation study on impression of shapes, colours and materials [11] and [12].

Emotional design is extremely versatile trend that originated in Japan just three decades ago. In the 1970s the concept of Kansei Engineering appeared. This derivation used to transmit quality satisfaction from using some object or subject. So, there are objects in which much Kansei, and there are those who have it smaller or even not at all.

Kansei Engineering (KE) as a term, eventually transformed into “emotional design”. KE develops methods of implementation of perceptual and emotional qualities into product design. The emotions which are caused by outfits play an important role in enhancing the aesthetic quality of clothing.

Steps of image analysis based on KE are investigated in detail in [13]. This method may be used for any product design, including clothing.

The research results [10] are aimed at the analysis of new products that incorporate specific elements (functions, form, and colour) to implement pre-planned impression.

Mathematical description of nonlinear characteristics of garment design attributes allows to formalize the consumer’s impression and present emotional design process as the rules of ES functioning.

Development and implementation of interactive systems based on KE to select ready-made clothes via the Internet are shown in [14]. Authors consider the type of a product and its purpose to be the main criterion for selection. They do not pay detailed attention to the relationship between artistic and compositional features of a model and the desired impression from it.

Introduction of KE to develop an ES for the design of special and corporate clothes is presented in [15]. Interactive system based on KE to support the design of clothing is presented on the example of the classic men's range of clothing (jackets) and is described in [16]. The authors emphasize the difficulty of identification of visual images of clothes and emotions of the consumer, and thus justify the limited capacity of the system and the use of KE when designing clothes.

However, the most active and capricious fashion and clothing customers are the women. Moreover, the women's clothing range is much wider and more complex than the male one. Accordingly, the process of designing clothes to create a certain image that corresponds to premeditated impression is more important when dealing with women's range.

For the operation of the ES on the basis of KE in the design of women's clothing models we should have an apparatus of quantitative and qualitative assessment of the consumer’s impression from clothing, garment models’ base and the productive model of the ES, reflecting the relationship between consumer’s experiences and models’ appearance of women's clothing.

3 THE PURPOSE AND OBJECTIVES OF THE STUDY

The aim of this study is to develop a prototype of the ES of the choice of clothes models based on the assessment of consumers’ emotional impressions using the methodology of KE. To achieve this goal it is necessary to solve the following tasks:

- to establish a database of typical emotional key words, that is Kansei words (KW) regarding fashion;
- to form the catalogue of photo materials of models working for famous Fashion Houses;
- to build a semantic differential (SD) scale to describe the artistic and design solutions of clothes;
- to perform identification of visual images of clothes and KW;
- to build a productive model of the ES;
- to form the knowledge base of the ES.

4 MATERIALS AND METHODS OF KANSEI ENGINEERING PROCESS STUDY

4.1 The choice of method for assessing the consumers’ emotional state

There are eight types of KE [17], which are to be improved at any time and they implement typical sequence of actions. In [18] a new paradigm of design concepts, mental images and consumer preferences are connected. According to the researchers [17, 18] there are three aspects of Kansei, which the authors of this work present in a diagram of relationship triad in Fig. 1.

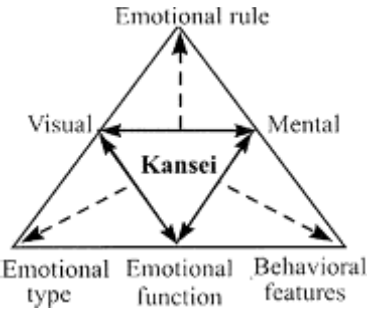

Figure 1 The parts of Kansei system caption

The means of Kansei: all sensation (sight, hearing, taste, smell, touch, balance, recognition); to which “internal factors” (such as personality, temperament, character, mood, experience, etc.) are added to form the emotional type of consumer, his emotional and behavioural characteristics.

The process of Kansei: visual perception and mental types (associated with emotions, feelings, experience and intuition, as well as interactions between them) are expressed through emotional function.

The result of Kansei: emotional response is the only perception of the product. Accordingly, motivation of Kansei-design is a rapprochement between the individual (consumer) and its environment (whether

physical or social) through a new design of products and systems.

The technique of Kansei-design forms the system of KE, which the authors presented in a summarized version in Fig. 2.

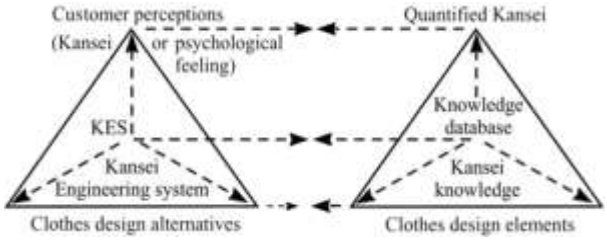

Figure 2 Generalized system of Kansei Engineering

The system is to identify emotional impressions in individual consumers and implement these emotions into future design of specific objects.

This paper has selected KE of Type 2, which is a computerized expert system to transfer the feelings of consumer from a product. Methodology of emotional engineering of type 2 is aimed at translating feelings and emotions into their corresponding colour, shape and material.

Typical ES have the following structure: database, knowledge base (KB), the mechanism of withdrawal (solver), subsystem of explanations, user interface [19]. The proposed computer system architecture has three databases (words, images, design and colour), knowledge base, inference engine and consumer's interface. Database of KW is formed of adjectives that describe the consumer's feelings from garments. Image Database is a set of photos of clothes. Database of design and colour consists of design attributes and colours that correlate with KW. Knowledge base consists of rules needed to determine the high correlation between product attributes and KW. The main part in the expert system is inference engine – a software mechanism that searches the knowledge base rules for rational logic solutions. The task of consumer's interface is the exchange of information between the consumer and the machine output.

A key phenomenon upon which the concept of expert systems is built we call synaesthesia. There are many types of synaesthesia: for example, the feeling of tactile forms during wearing clothes, associating shapes, colours and temperament [20]. The project is based on the association of colours perception, textures, and shapes while considering clothes and emotions that arise. Visual impressions and associations, the first feeling, psychological perception of colour in general and the major symbolic significance of these colours, symbolic and communicative sense of form and colour are converted into visual data – hue, brightness, saturation, heat and coldness [21].

The basic method of image analysis in KE is the method of semantic differential in the classification of Kansei attributes [17]. SD is the method of psycholinguistics, which is a combination of scaling procedures and method of controlled associations [20].

This method allows to model semantic space that shows the relationship between the samples of products and meanings of words – adjectives that describe the impression from the products. The ratio between the content and meaning of the image can be represented with the help of a scheme (Fig. 3), which is called "logical-semantic triangle" or semantic triad.

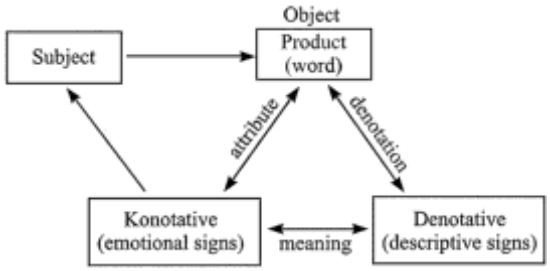

Figure 3 Structure of semantic triad

Semantic triad is a schematic representation for the notion that every word (in this case the product) has at least 2 types of meanings (denotative and connotative), that is lexical (descriptive) and emotional.

4.2 Investigated materials and equipment used in the experiment

For the study the material of fashion mega-portal "first VIEW" [22] was used which makes it possible to work with digitized photographs from the whole show collection.

The object of the study is the women's fashion dresses in spring-summer 2016 season. Leading selection criteria of photographic material chosen for the study are:

- homogeneity of the material;
- respect to the author's chronological sequence of models demonstration on the catwalk;
- technical quality of photos.

The size of samples is 12 most frequently appearing outfits over the investigated period in press releases of designers and Fashion Houses namely Alexander McQueen (UK), Elie Saab (Lebanon), Oscar de la Renta (USA), Roberto Cavalli (Italy), Valentino (Italy), Emanuel Ungaro (France), Jason Wu (USA). The names should match the selection criteria:

- the history of the House should have at least 10 years;
- House should have been known worldwide and considered a "trendsetter".

As the object of study is women's dresses, from the collection of hits models by these houses in the period of spring-summer 2016 all models of women's dresses were picked up. Thus, a general collection was formed which amounted to 66 photos of fashion dresses for subsequent questionnaire.

4.3 Stages of Semantic Differential formation of the emotional development of Kansei words

By analogy with [13], the basic process of emotional component research is advisable to present by three stages of formation of SD emotional development of KW for clothes, as shown in Fig. 4, in the scheme, developed by the authors.

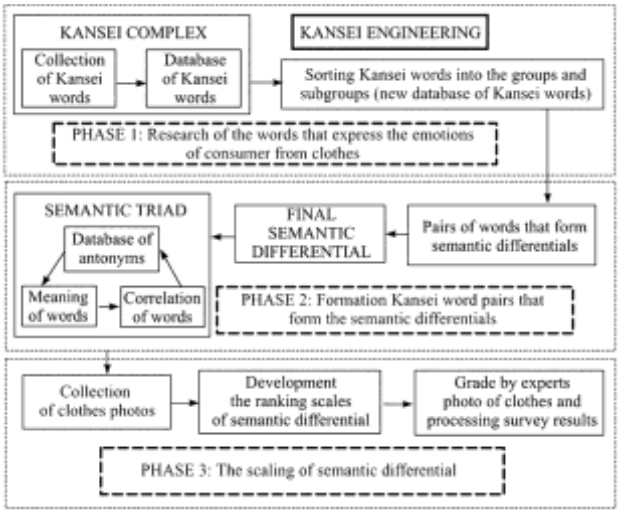

Figure 4 Semantic differential of the emotional development of Kansei words

Step 1: Research of words that express the emotions of consumers from clothing

(1.1) Collection of KW – typical emotional keywords that reflect physiological impression from any models of clothes – database of KW (Table. 1).

Table 1 Database of typical emotional Kansei key words

No	KW	No	KW
1	Active	51	Intriguing
2	Aesthetic	52	Laconic
3	Agreeable	53	Light
4	Alive	54	Luxurious
5	Alluring	55	Magnificent
6	Authoritarian	56	Majestic
7	Authoritative	57	Manly
8	Balanced	58	Mature
9	Benevolent	59	Modern
10	Blinding	60	Mysterious
11	Bold	61	Natural
12	Breakneck	62	Nice
13	Bright	63	Noble
14	Brilliant	64	Notable
15	Calm	65	Official
16	Carefree	66	Open
17	Charming	67	Organic
18	Cheerful	68	Passive
19	Chic	69	Pleasant
20	Clean	70	Practical
21	Clear	71	Pretty
22	Cold	72	Proportional
23	Comfortable	73	Provocative
24	Conservative	74	Purple
25	Costly	75	Rational
26	Cozy	76	Regal
27	Creative	77	Reliable
28	Decisive	78	Resilient
29	Decorative	79	Respectable
30	Deep	80	Restrained
31	Delicate	81	Rich
32	Dreamy	82	Romantic
33	Dynamic	83	Rough
34	Elegant	84	Seductive
35	Emotional	85	Serious
36	Energetic	86	Severe
37	Ethnic	87	Sexual
38	Excitable	88	Simple
39	Exclusive	89	Smart
40	Exquisite	90	Soft
41	Fairy	91	Solemn
42	Fashionable	92	Sophisticated
43	Female	93	Spectacular
44	Festive	94	Sports
45	Formal	95	Strong
46	Fresh	96	Sturdy
47	Functional	97	Stylish
48	Harmonious	98	Tender
49	Innovative	99	Tonic
50	Inspiring	100	Traditional

(1.2) Sorting out typical keywords into groups and subgroups (Table. 2) – new database of KW.

Table 2 Grouping of Kansei words (KW)

Clothing style	KW (database 1)	The base colour	KW (database 2)
Classic	Respectable, Practical, Elegant	Red	Ruling, Bold, Luxurious
		Orange	Bohemian, Exquisite, Natural
		Yellow	Gullible, Calm, Attractive
		Green	Creative, Elegant, Emancipated
		Blue	Energetic, Businesslike, Luxurious
		Violet	Classic Chic, Spectacular, Luxurious
		Achromatic	Restrained, Intellectual, Cold
Romantic	Female, Fine, Exquisite	…	…
Sports	Practical, Functional, Comfortable	…	…
Folk	Ethnic, Natural, Ecological	…	…
Avant-garde	Outrageous, Creative, Unusual	…	…

Step 2: Formation of word pairs that form the semantic differential

(2.1) This process includes the selection of words from a common database of KW with the opposite meaning and interpretation. Each pair of KW is the SD poles for a particular attribute of an investigated

fashion model: style, shape, colour, material and so on.

(2.2) Coding of KW pairs. The common practice of coding uses the first letters of words with opposite meaning.

(2.3) Search for positive correlation between each word from the SD (column 2 and 3 of Table 3) with words that express the emotions of consumers from clothing (column 6 and 7 of Table 3).

Table 3 Consolidated results for semantic differential of impressions from clothes

Pair code	KW		Meaning		Positively correlated to	
	KW 1	*KW 2*	*KW 1*	*KW 2*	*KW 1*	*KW 2*
CS	Casual	Smart	practical	for special events	Comfy Rational	Exquisite Charming
RS	Romantic	Sports	feminine image	everyday sportswear	Elegant Exquisite	Functional Dynamic
CA	Classic	Avant-garde	typical forms	unusual fashion	Austere Elegant	Epatage Creative
FM	Folk	Modern	national attire	modern styles	Ethnic Natural	Voguish Modern
RO	Rectangle	Oval	geometric symbols	geometric symbols	Practical Persistent	Female Calm
TdTu	Trapezoid (long base down)	Trapezoid (long base up)	geometric symbols	geometric symbols	Creative Impulsive	Pragmatic Decisive
MP	Mono colour	Poly colours	simple colour palettes	elaborate colour palettes	Unvaried Stable	Complex Fantasy
BS	Bright	Soft	pure colours	gray hues	Solemn	Matte
LD	Light	Deep	white hues	black hues	Light	Heavy
WC	Warm	Cool	golden hues	blue hues	Cheerful	Fresh
MtPt	Mono texture	Poly texture	one texture	many textures	Classic Elegant	Luxurious Avant-garde
MS	Matte texture	Shiny texture	absorb light	reflect light	Moderate Simple	Smooth Bright
TN	Gauzy	Opaque	freely pass light	do not pass light	Light Delicate	Sturdy Thin
SA	Symmetry	Asymmetry	equal parts of garment	unequal parts of garment	Static Balanced	Expressive Dynamic

Step 3: Scaling of semantic differential

(3.1) Collection of photographic material (in this case – models of clothes).

(3.2) Development of assessment of SD scales on each of Kansei attributes.

Bipolar adjectival pairs – simple, economical tools that make it possible to get some data based on a subjective understanding of connotative meanings of words by people. These tools include a few scales put horizontally on a form (questionnaire). Each scale has seven gradations that are expressed numerically (-3, -2, -1, 0, +1, +2, +3) or verbally (hard, medium, low, can, low, medium, hard) (Fig. 5).

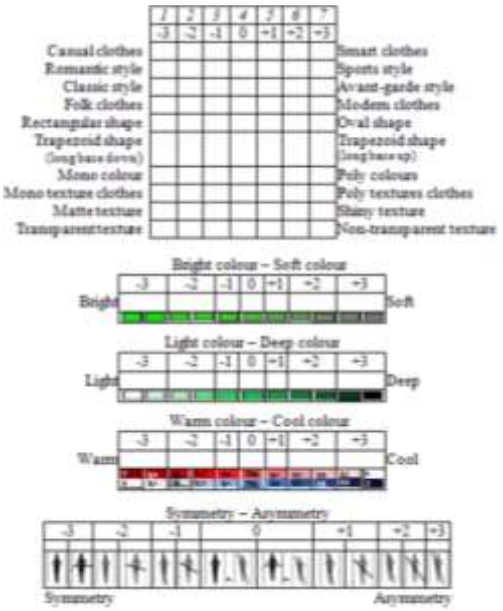

Figure 5 Example of scales of Kansei words of semantic differential for the questionnaire

(3.3) Evaluation of photo material by experts using semantic differential scales and processing of survey results.

The expert group consisted of 10 experts and 16 consumers. In a survey photos of clothes were valued using evaluation factors in bipolar scales defined by verbal antonyms of KW from each end of the scale (Fig. 5).

Since these evaluations are subjective, as a result of the survey psychographic profile of one dress pattern was constructed (Fig. 6). This profile reflects the average amount of evaluation coefficients for each pair of KW.

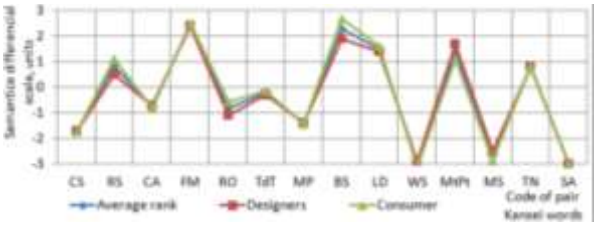

Figure 6 Example of psychographic profile of an outfit 1

As shown in Fig. 6 psychographic profile of an outfit visually practically does not differ for different groups of experts.

4.4 The method of forming a database of expert system of clothes' choice based on the assessment of emotional impressions of consumers

Analysis of the emotional component of the garment on the basis of SD can be achieved through cluster analysis. Such an approach will identify models of clothes based on perception and emotional needs of the consumer.

Cluster analysis is a process of multidimensional grouping of objects. In this case it is grouping of clothes depending on the impressions that they cause in consumer.

Using cluster analysis involves the constant action sequences, regardless of the subject of research. Accordingly the sequence in this case is as follows:

- sampling selection for cluster – set of female models of light dresses;
- determining the set of variables, which will be evaluated in the sample objects – a pair of KW of SD;
- calculation of the degree of similarity between the objects;
- using cluster analysis method for grouping similar objects;
- results validation of cluster solutions.

Cluster analysis can be used only when the following requirements are observed: performance should not correlate with each other, they should be dimensionless, their distribution should be close to normal, they must meet the requirement of 'stability', by which we mean no effect on their value random factors; in addition, the samples must be homogeneous and do not contain 'emissions'.

In order to implement these conditions it is necessary to conduct a preliminary factor analysis. These requirements are automatically met by the procedure of a factorial design. Initial data for factor analysis are the profiles of each of the fashion models, presented as a series of average figures (for all groups of experts) of evaluation ratios.

5 THE RESEARCH RESULTS OF CONSUMER'S EMOTIONAL WORDS

The consistency degree of photo evaluation results by experts using SD scales is confirmed by concordance coefficients and Pearson criteria. Table 4 presents the consolidated results of the evaluation level coordination of expert opinions of the first five models.

Table 4 The consolidated results of the evaluation degree of coordination of expert opinions (fragment)

Number of an outfit	ω for the expert group		χ^2_p for the expert group	
	consumers (16 people)	*professionals (10 people)*	*consumers*	*professionals*
1	0.898	0.734	186.74	95.42
2	0.896	0.600	186.42	77.37
3	0.953	0.884	198.18	114.92
4	0.892	0.653	185.60	84.92
5	0.922	0.828	179.78	107.65

Tabular value of Pearson criterion for 5 percent of the weight level and the corresponding number of freedom degrees (χ^2_{tabl} = 22.36) is less than the estimated value criterion. Therefore it is possible to state with 95-percent probability that the frequency of evaluation ratios of KW pairs in different experts is coordinated in accordance with the calculated rate of concordance. Thus, each clothes model can be described with the help of 14 rating pairs of KW.

Factor analysis is conducted using the package PASW Statistics. The analysis results by the method of principal components and using the method of rotation (Varimax rotation with Kaiser normalization) are presented in Table 6 as a matrix of returned components. The choice of such methods of analysis is explained by the fact that only these methods are mathematically justified and can be implemented in software environment.

Factor loadings, presented in the matrix (tab. 5), should be understood as correlation coefficients between the variables and factors. In the table factors that indicate a high degree of correlation with the variable component (factor) are highlighted. Software environment PASW Statistics generates a specified value factors used in solving the problem of hierarchical clustering.

Table 5 Matrix of the returned components of Kansei words of semantic differential

Code	Component					
	1	*2*	*3*	*4*	*5*	*6*
SA	0,801	–	–	–	–	–
CA	0,742	–	–	–	–	–
BS	–	0,890	–	–	–	–
LD	–	0,878	–	–	–	–
WC	–	0,420	–	–	–	–
CS	–	–	0,771	–	–	–
MS	–	–	0,673	–	–	–
RS	–	–	-0,661	–	–	–
TN	–	–	–	-0,832	–	–
MtPt	–	–	–	0,751	–	–
FM	–	–	–	–	0,798	–
MP	–	–	–	–	-0,692	–
TdTu	–	–	–	–	–	0,842
RO	–	–	–	–	–	-0,653

Thus, as the results of the factor analysis, six factors (components) are highlighted, which can combine all pairs of words of SD that reflect consumer's impressions from clothes. To facilitate communication between the man and the ES, which concept is being developed, for the design of system dialogues names of factors are presented by the most important components of each consistent according to table 6, namely *SA*, *BS*, *CS*, *TN*, *FM*, *TdTu.*

In solving the problem of clustering the original set of clothes' models is divided into subsets that do not overlap, so that each cluster consisting of fashion models, that is, as close to the metric ρ (Euclidean distance) and clothes' models from different clusters should differ significantly.

The method of intergroup relations was used for clustering. As a result we obtained a dendrogram (Fig. 7), at the hierarchical levels the outfits are

located in such a way as to emphasize their mutual relationship considering some analyzed features. In the dendrogram each model is represented by its serial number in the source directory of the photographic images.

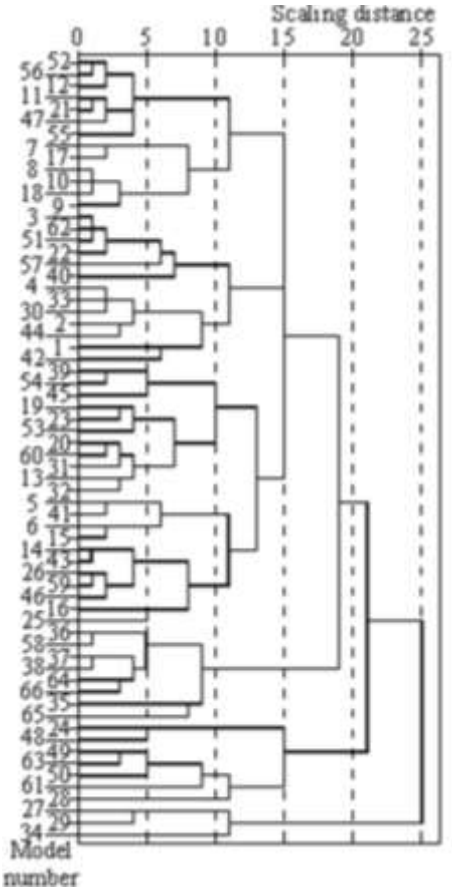

Figure 7 Dendrogram with using the method of intergroup relations between models of ready-to-wear women's clothing

As a result of the cluster analysis 25 conventional groups were selected (tab. 6). Groups are formed of models with closest bonds that differ less than 20% (as it is evidenced by the mark 5 on the scale of scalable distance in the dendrogram).

Table 6 Belonging of clothes' models to clusters (Cl)

Cl	Colour									
	Red	*Orange*	*Yellow*	*Green*	*Blue*	*Violet*	*White*	*Gray*	*Black*	*Poly*
1	1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	65
3	-	-	-	-	-	-	-	-	51, 57	-
4	-	-	-	-	-	-	-	-	40, 62	-
5	-	-	5	-	-	-	41	-	-	-
6	-	-	-	-	-	-	-	-	-	36, 58
7	-	-	-	-	-	-	-	-	-	35
8	-	-	-	43	-	-	-	-	-	14, 26, 46, 59
9	-	-	-	-	-	-	-	50	-	-
10	-	-	-	18	-	-	-	-	8, 9, 10	52, 56
11	-	-	-	-	-	-	-	-	-	27, 29
12	-	-	-	-	-	3	-	22	-	33, 42
13	-	-	-	-	-	-	-	-	-	61
14	31, 13	-	-	-	-	-	60	-	-	32
15	-	60	53	-	-	-	15	-	-	-
16	-	-	-	-	-	-	-	-	-	37, 38, 16, 66
17	-	-	-	-	-	-	7	17	-	-
18	-	-	-	-	-	-	-	-	-	28
19	-	23	-	-	-	-	19	-	-	-
20	-	-	-	-	-	-	-	-	-	34
21	-	-	-	-	-	-	-	-	-	11, 12, 21, 47, 55
22	-	-	-	-	-	-	-	-	-	49, 63
23	4, 39	54	-	-	-	-	-	-	-	30, 45
24	-	-	-	-	-	-	-	-	-	24, 48
25	-	-	-	-	-	-	-	-	-	2, 25, 44

As shown in Table 6 in each cluster there are models of different colours that are in separate cells. This approach allows to detail the search for the desired models in a common database of images.

6 DISCUSSION OF RESEARCH RESUTS AND THE PROSPECTS OF KANSEI ENGINEERING

According to the results of factorial and cluster analysis we may form a productive ES models for choosing clothes considering the wishes (opinions) of a consumer. ES model of production presupposes knowledge of the relationship between the concepts. The relationship between the concepts is presented in the form of ordered sequences $Cl_i = (f_{1i}, f_{2i}, f_{3i}, f_{4i}, f_{5i}, f_{6i})$ and $M = (Cl_i$, colour), where i is a model number.

In order to determine the factors that have a high degree of influence in clusters, cluster analysis is performed with k-mediums, the results of which are presented in table 7, where the final cluster centres are sorted according to the figure of the first factor.

Table 7 Interpretation of clusters

Cluster	*Factor*					
	f_1	f_2	f_3	f_4	f_5	f_6
8	-1	-1	0	0	-1	1
15	-1	-1	0	-1	1	1
19	-1	-1	1	0	1	0
20	-1	0	0	-1	-3	-1
25	-1	0	0	-1	-1	1
10	-1	1	0	1	0	1
5	0	-1	-1	-1	1	0
14	0	-1	0	1	1	-1
13	0	-1	2	-1	1	1
1	0	0	-2	1	0	1
17	0	0	1	1	1	1
21	0	0	1	1	0	-1
18	0	0	2	-2	-1	1
11	0	1	1	0	-3	1
12	0	1	-1	-1	0	0
3	0	2	0	-1	1	-1
4	0	2	1	-1	1	0
24	1	-1	1	0	-1	-1
6	1	0	-2	1	0	-1
23	1	0	0	-1	0	-1

Cluster	Factor					
	f_1	f_2	f_3	f_4	f_5	f_6
7	2	-1	-2	-1	0	0
16	2	0	-1	0	0	0
22	2	0	2	-1	0	2
9	2	1	2	0	0	1
2	3	-1	0	0	1	0

Fig. 8 presents quantitative relations between clusters that are already available in a database of ES which is being developed. An analysis of Table 7 revealed that in the database following important factors are not available: f_1 = -3; -2, f_2 = -3; -2; 3, f_3 = -3; 3, f_4 = -3; 2; 3, f_5 = -2, 2, 3, f_6 = -3; -2; 3. Therefore, the rules of the ES should consider the above mentioned fact as the answer to lack of response in the system of clothes' models that match specific emotions. However, the database is open, and thus can be updated during the usage.

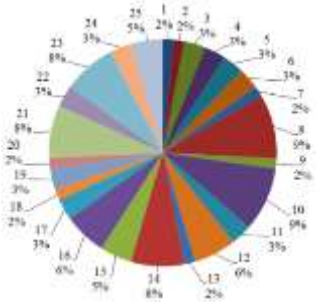

Figure 8 Coordination of observations in clusters

The easiest way of the ES development is to use "empty" shell, which corresponds by its purpose and structure to the conceptual model (or other model) of objective environment which is the subject to review. To develop a prototype of ES for subtasks of choosing ready-made garments based on the methodology of KE, which in appearance corresponds to the wishes of the consumer, in this paper we selected "empty" shell of ES called "Rapana", which is distributed free of charge via the web-site [24] and is able to solve the problem of different industries.

Complex "Rapana" includes two components: "Cognitograph" (software for the developers of knowledge base of the ES) and "Expert" (application for users). Using "Expert" does not require special training, because dialogue is conducted by natural language. According to the above outlined research results, seven entities must be entered in shell. The figures for these entities must be determined by the consumer in the form of answers to the questions of the system: *SA*, *BS*, *CS*, *TN*, *FM*, *TdTu* and 1*c* (colour). For making a decision two entities are necessary, their figures are determined immediately by ES regulations: *Cl* (cluster) and *M* (model). Example of dialogues of the developed ES, which represent consumer's answers to the system's questions and explanations of dialogue results are shown in Fig. 9.

Figure 9 Dialogues of ES prototype of subtask of readymade garments' selection based on the methodology of KE: *a* – the choice of the symmetry model of designed clothing; *b* – choice of outfit's colour characteristics; *c* - result is an option of the proposed clothes' model; *d* - explanation of the dialogue result

The way of decision-making (for example, as shown in Fig. 9) can be viewed as a subprogram called “Cognitograph” (Fig. 10). In Fig. 10 letter marks mean the codes of entities included in the regulations; digital designations are the numbers of rules used by the ES to get answers to user’s questions.

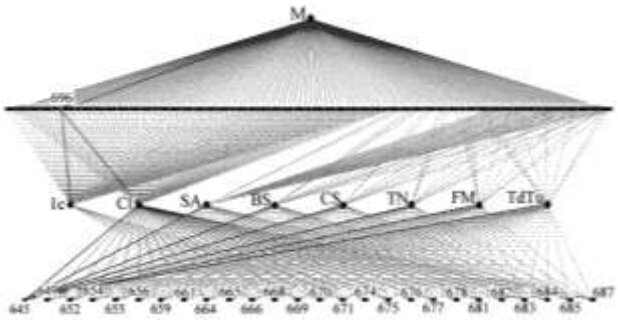

Figure 10 The result of the dialogue (the way of the decision-making)

Decision making (Fig. 10) provides for the implementation of rules 645 and 696, which are involved in entities: *M* – model, *1c* – colour, *Cl* – cluster, *SA* – symmetry-asymmetry clothes, *BS* – colour characteristics, *CS* – casual, elegant clothes, *TN* – tissue characteristics, *FM* – folk, modern clothes, *TdTu* – dress. The way how the decision is made is marked with a thick line.

Prototype of ES of a subtask of models’ selection based on the methodology of KE in the shell “Rapana” provides a dialogue with the user as a series of questions and answers of system’s user. Thus, the necessary conditions for the further development of artificial intelligence techniques in the design of clothing were created.

7 CONCLUSIONS

As a result of research Database of typical KW that reflect possible emotions and impressions of consumers from clothes was generated. The base contains 100 words – adjectives that can describe any sort of fashion model, regardless of the type of product, manufacturer, etc., and they are set out in alphabetical order.

Analysis of photographs from clothes’ collection shows by 12 famous Fashion Houses was conducted and photographic images of women's dresses were selected. The selected material was sampled for the next general assessment of impressions that are caused by outfits. In addition, the catalogue of photos forms the basis of women's dresses images for the database of ES which is under development.

With the help of the developed bipolar scales of SD the description of artistic and design solutions of clothes in the form of psychographic profiles was made. Each profile is a list of the average meanings of the estimated coefficients of SD.

Identification of visual images of clothes models by the impressions that they produce was made by cluster analysis. As a result, each of the 25 received clusters is presented by clothes’ models that have roughly the same psychographic profiles.

The final cluster centres together with the information on the colour solutions of models allowed to build the productive model of ES for the choice of clothing that meets pre-defined customer’s impressions.

The ES knowledge base for solving the subtasks of choosing the models of readymade garments based on KE methodology in the shell “Rapana” has been developed. The knowledge base provides dialogue as a series of questions by the system and answers by the user. This system can be used for the selection of readymade garments (eg. in the shops, including online stores) and to select a prototype to develop new model of clothing that meets the wishes of the consumer.

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