EXPERT SYSTEMS TO SOLVE INFORMATIONAL ISSUES IN APPAREL DESIGN

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Abstract: This research is devoted to developing of the expert systems for rapid change in production of clothing. The main objective of the study was achieved through the formation of rules of decision-making that intent to solve subtasks of rapid change in production of women's outerwear, including selection of fashion fabric and parameters of the pattern blocks for the specific garments types, and choosing the models of readymade garments. Multifractal analysis was used to evaluate roughness of fabrics. Knowledge base was developed in the shell "Rapana".

Keywords: rapid change; garment type; fabric; multifractal analysis; expert system.

1. INTRODUCTION

High saturation of information environment and the risk of making wrong decisions in existing conditions increase the relevance of information technology as a means to support decision-making [1]. The clothing industry is quickly becoming a high-tech industry due to rapid advances in technology. Rapid change in the production usually means huge changes in design and style of the garments, which are under development, as well as in their fashion fabrics and sewing techniques, which must be applied almost instantaneously. One way to address the informal or weakly formalized problems is the use of artificial intelligence methods and the creation of expert systems (ES).

Nowadays, scientists in the world successfully implement elements of artificial intelligence and the expert systems at various stages of designing clothes. Among them are expert systems 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].

The aim of this study is to develop several interrelated subsystems of the expert system for the rapid change in the production of the women's outerwear based on the previously developed prototype [6].

2. METHODS

Knowledge base of ES consists of known facts and rules, which are constructed by developer. The known facts are extracted from the literature review and previously conducted researches [1, 2, 7, 8, 9]. In the given situation, unknown facts are to be obtained from the information about some of the fabrics properties, constructive parameters of the pattern blocks and emotional impression of the different styles of garments. Typological analysis of the set of garment structure elements [9] is a basis of the knowledge base that is needed to make a well-grounded decision to select a garment prototype.

The principle of universality was formulated as a basic principle of heuristic clothes design [8].

It was discovered that the set of universal parameters might and must be obtained for every one of the objects of unification. The main ones of them are the following parts of a garment: a front, a back, a sleeve, and a collar. The parameters of them depend on the characteristics of the chosen fashion fabric. The lists of fabric characteristics, which are needed to be investigated in order to select a fashion fabric for garments of the given transformation chain, were formed in [10]. The method of determination the fabric roughness characteristics and scripts, which allow doing it by using Rhinoceros, was developed [7].

In order to perform garment style selection Kansei Engineering methodology is to be applied. Analysis of photographs from clothes' collection shows by 12 famous Fashion Houses was conducted and photographic images of women's dresses were selected [1]. 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 bipolar scales of semantic differential the description of artistic and design solutions of clothes in the form of psychographic profiles was made [11]. Each profile is a list of the average meanings of the estimated coefficients of semantic differential. Identification of visual images of clothes models by the impressions that they produce was made by cluster analysis. As a result, clothes' models that have roughly the same psychographic profiles present each of the 25 received clusters. Combination of characteristics, which define each of clusters, are to be used in forming the productive model of ES under development.

3. DISCUSSING IDEAS

When rapid change in production of clothing occurs, it is necessary to determine the direction of the changes. Thus, the sequence of garment transformation into another type of one must be chosen from the infinite number of presumably even possibilities. The basic hypothesis of this study is the following statement: the direction of the changes might be described by transformation chain, which consists of different garment types and must be chosen out of the previously formed in [12] list.

Recommended ranges of fashion fabrics properties (or garments of the transformational chain that is used when the rapid change is occurred [6, 12]) are to be obtained as intersections of the uncountable sets, which determine the value ranges of specific parameters of the main fabric properties of the different end uses. The same goes to constructive parameters of the pattern blocks for specific garments.

According to the preliminary conducted researches, one of the most important properties of fabric, which is to be used for garments of the transformation chain in rapid production of the women's outerwear, is its smoothness. Such a property is usually evaluated by the friction coefficient. However, due to the results of the recent researches [7, 13], roughness is a preferable parameter to evaluate the smoothness of the fashion fabric in comparison with the coefficient of friction. For that reason, prerequisite of the productive model of ES is adequate assessment of fabric roughness characteristics.

4. EXPERIMENTAL

According to the method [7], two parameters (R_a , R_{max}) are used to reflect fabric roughness: R_a – arithmetical mean deviation of the profile, μm ; R_{max} – maximum height of the profile, μm . The script and scanned images of tissue samples were used in 3D computer graphics software (Rhinoceros) to evaluate the fabrics' roughness [7].

If we consider a fabric fragment to be a self-similar object and a section profile – a multifractal and regard the series of values of coordinates on the profile as a multifractal set, MFFA can be applied. Recently, we developed a method of MFFA, giving a description of the time series within the framework of a simple numerical procedure [14]. Subsequent optimization of

method of multifractal analysis (MFFA) allowed one to carry out the multidimensional analysis of multifractal multiplicities [15-20].

The method of MFFA was applied to several types of fashion fabrics, which are suggested to use for the collection of transformable garments that is currently under development. The garments types are coats and jackets, which have interchangeable parts. Therefore, tissues of fashion fabrics were selected out of coat fabrics. They must be examined on the subject of usability for the mentioned garments types. Thus, six tissues of coat fabrics were used for the current research.

The images of fabrics were taken with the digital microscope Sigeta Forward LCD (10-500x). The bitmap image of the fabric profile was scaled to real size and construction lines were applied as it shown in Figure 1.

Figure 1. Section profile of the fashion fabric (tissue number 2)

We represent in the Figure 2 for the value $q = 4$ the dependence $F_q(s)$ of the tissues studied. You can notice a pronounced linear dependence for different values of q . If you pay attention to Figure 2, you can observe significant differences in the dispersion at the same value of $q = 4$, which clearly indicates a difference in the roughness of the material. Negative values of q were not taken into account because at $q < 0$ the use of such a multifractal analysis method is inapplicable since negative values of q result in inadequate estimates of small details of image. The issue may be due to hardware errors. To obtain statistically reliable data, one should change the value s from $s_{\min} \approx 6$ to $s_{\max} \approx \min(M, N)/4$. For self-similar sets, it leads to the scaling ratio:

$$F_q(s) \sim s^{h(q)} \quad (1)$$

where $h(q)$ is a generic index of Hearst.

Figure 2. Dependence of the dispersion on the scale s for all types of fabrics

The mass index can be found from the determined dependency $h(q)$:

$$\tau(q) = qh(q) - D, \quad (2)$$

D is the topological dimension of the space containing the investigation object (for the surface $D = 2$).

In Figure 3, let us represent the mass indices of the samples under study. Linear dependence indicates that the method error is minimal, that is, a change in the magnification scale has little effect on the magnitude of the mass index. This indicates the existence of a self-similar structure of the material. Figure 3 shows the mass indices for the three types of tissues considered: 1, 2, and 5. The difference in the values of the mass index at the same values of q indicates different indicators of the roughness.

Figure 3. Dependence of the mass index for various fabric

Results of the above-mentioned assessment are to be used for the formation of productions of the expert system that is under development.

5. DEVELOPMENT OF THE EXPERT SYSTEM

In order to develop a prototype of ES, we selected 'empty' shell of ES called 'Rapana', which is distributed free of charge via the web site (<http://esrapana.narod.ru/>). Using 'Rapana' does not require special training, because dialogue is conducted by natural language. The developed expert systems for several different but related subtasks are considered as parts of the bigger one, which is aimed for the rapid change in apparel design at the specific enterprise.

ER-model (entity-relationship model) of subject environment of the expert system of rapid change in clothing design process was formed (Figure 4). It allowed forming the structure of the expert system database.

Figure 4. ER-model of the subject environment

As it can be seen in the Figure 4, there are several main entities, attributes of which must be defined almost instantly if the rapid change in the production of the clothing occurs. The list of entities is as follows: a fabric, a garment style, a transformation chain, a basic design. Others depend on the above-mentioned ones.

For that reason, the expert system includes subsystems for the fabric selection, choosing the model of readymade garment with predefined impression as well as choosing constructive parameters of the pattern blocks and optimal garment type that is to be designed.

Productive models of the subsystems were formed based on the previously conducted researches [1, 2, 8, 9], abovementioned study of the fabrics roughness, and information, which was extracted from the literature review [21, 22]. As a result of investigation of amounts of eases on the main constructive levels it was discovered that there is no any universal basic garment design, which can be used for the transformation chain, which consists of more than three garment types. However, the universal basic garment designs were found for several different combinations of garment types. The matrix of combinations of eases, which are recommended for the different sleeves, was formed. The recommendations, which are needed in order to construct the universal basic garment design that is taking into account the fabric properties, were developed. The universal designs of the collars were developed as well [8].

Productive model of the developed ES is a set of tables. In each table, the seeking results are at the intersection of few antecedents. An example of productive model of ES "Functional part" is displayed in the Table 1.

Table 1. A Fragment of Productive Model of ES

Garment types	Parameter of collar, a, cm		
	Straight collar	Mandarin collar	Straight collar with wings
Suit jacket	4.1÷4.8	3.6÷4.6	3.4÷5.8
Jacket	4.8÷5.6	3.3÷5.5	4.1÷8.9
Coat	4.1÷5.2	4.0÷5.8	4.6÷8.4
Suit jacket, jacket	4.8	3.6÷4.6	4.1÷5.8
Jacket, coat	4.8÷5.2	4.0÷5.5	4.6÷8.4
Coat, suit jacket	4.1÷4.8	3.6÷4.6	4.6÷5.8
Suit jacket, jacket, coat	4.8	4.0÷4.6	4.6÷5.8

An example of productive model of ES "Fabric selection" is displayed in the Figure 5.

Suit, coat and linings	X ₃ =1		X ₃ =0	
	X ₅ =1	X ₅ =0	X ₅ =1	X ₅ =0
X ₁₄ =1	1.000	0.651	0.768	0.419
X ₁₄ =0	0.581	0.232	0.349	0

Figure 5. A fragment of the production model of ES for solving the subtask of fabrics selection (X₁₄ – roughness characteristic)

Thus, the prototype of ES, which is under development, consists of the following subsystems: "Transformation chain", "Basic design", "Fabric selection" (Figure 6), "Garment style" (Figure 7), and "Functional part" (Figure 8). Figures 6 and 7 display the dialogues with system's user.

Figure 6. Subsystem of ES for solving the subtask of fabrics selection

Figure 7. Subsystem ES for the choice of clothing

The way of decision-making can be viewed as a subprogram called “Cognitograph” (Figure 7). 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. Decision making (Figure 8) provides for the implementation of rule 891, which is involved in entities: B – garment type, TK – collar type, BBT – type of the transformable garment. The way how the decision is made is marked with a thick red line.

Figure 8. The result of the dialogue (the way of the decision-making) for the subtask of collar parameters selection

The subsystems might be used together as a united system and each one of them might be used as a separate system to solve the specific tasks at the specific enterprise.

6. CONCLUSIONS

The main objective of the study was achieved through the formation of rules of decision-making that intent to solve subtasks of rapid change in production of women's outerwear, including selection of fashion fabric and parameters of the pattern blocks for the specific garments types, and choosing the models of readymade garments.

Verification of the experimental results was conducted by assessment of the fitting quality of garments, which were designed based on the work of the expert system. It was confirmed that system decisions are adequate to the given design circumstances. Complex indexes of fitting quality of garments samples are about $4.407 \div 4.889$ (out of 5.000). It confirms the possible application of developed system into garment design and manufacturing. Thus, the necessary conditions for the further development of artificial intelligence techniques in the design of clothing were created.

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8. REFERENCES

- [1] Kuleshova S. G., Zakharkevich O. V., Koshevko J. V. & Ditkovska O. A. (2017). Development of expert system based on Kansei Engineering to support clothing design process. *Vlakna a Textil*, Vol. 4, (2017), pp. 30-41.
- [2] Nada Y.A. & Meshref H. (2014). Analysis, design, and implementation of intelligent expert system for clothes style selection. *International Journal of Computer Applications*, Vol. 105, (2014), pp. 15-20.
- [3] Akimochkina I.M., Krivoborodova E.U. & Petushkova G.I. (2007). Expert system for choosing preferred clothing to form harmonious appearance of individual consumers. *Sewing industry*, Vol. 2, (2007), p. 55.
- [4] Gnidenko A.V., Yudin L.P. & Kuzmichev V.E. (2007). Architecting of expert system of quality assessment of clothes' designs. *Sewing Industry*, Vol. 5, (2007), pp. 52-54.
- [5] Nigmatova F.W. & Alimov H.A. (2009). Formation of industrial range of garments based on expert system. *Sewing Industry*, Vol. 2, (2009), pp. 27-28.
- [6] Zakharkevich O.V. & Pochuprin A.V. (2014). Development of prototype of expert system for rapid change in production of women's outerwear. *Easter-European Journal of Enterprise Technologies*, Vol. 2/2 (68), (2014), pp. 50-55.
- [7] Zakharkevich, O. V. (2015). Method of determination fabrics roughness characteristics. *Herald of Khmelnytskyi national university. Technical science*, No.2, (2015), pp. 85–90.
- [8] Zakharkevich O.V., Kuleshova S. G. & Shvets G. S. (2015). Recommended ranges of collars' parameters for transformable garments. *Magazine textile and clothing*, No. 9, (2015), pp. 210-220.
- [9] Zakharkevich O.V. (2010). Development of typological range of womens outerwear. *Herald of Khmelnytskyi national university*, No.5, (2010), pp. 15-18.
- [10] Zakharkevich O.V., Kuleshova S.G. & Shvets G.S. (2015). Determination of fabrics properties for reversible garments. *TEXTTEH VII International Conference Proceedings*, Vol. 7, (2015), pp. 78-88.
- [11] Kurochka S., Sviruk L., Kuleshova S. & Zakharkevich O. (2017). Method of analyzing images of clothes based on Kansei Engineering. *International Conference on Technics*, ARTTE Vol. 6, No. 3, 2018 ISSN 1314-8788 (print), ISSN 1314-8796 (online), doi: 10.15547/artte.2018.03.005

- Technologies and Education ICTTE 2017, Yambol, Bulgaria, October 19-20st, (2017), pp. 92-99.
- [12] Zakharkevich O.V. (2012). Developing of rational transformations chains of the women's shoulder clothing. Herald of Khmelnytskyi national university, No. 2, (2012), pp. 73-76.
 - [13] Nazanin E., Mohammad A.T., Masoud L. & M. Khosro. (2017). Modelling of surface roughness based on geometrical parameters of woven fabrics. Indian Journal of Fibre & Textile Research, Vol. 42, (2017), pp. 43-50.
 - [14] Kantellhardt J.W., Zschiegner S.A., Kosciely-Bunde E., Havlin S., Bunde A. & Stanley H.E. (2002). Multifractal detrended fluctuation analysis of nonstationary time series. Physica A, Vol. 316, (2002), pp. 87-114.
 - [15] Feder J. (1998). Fractals: Plenum press, New-York and London, (1998).
 - [16] Halsey T.C., Jensen M.H., Kadanoff L.P., Procaccia Itamar & Sraiman B.I. (1986). On Fractal measures and their singularities: the characterization of strange sets. Phys. Rev. A., Vol. 33, (1986), pp. 1141-1151.
 - [17] Chhabra A.B. & Sreenivasan K.R. (1991). Negative dimensions: Theory, computation, and experiment. Phys. Rev. A, Vol. 43, (1991), pp. 1114-1117.
 - [18] Gao-Feng Gu & Wei-Xing Zhou. (2006). Detrended fluctuation analysis for fractals and multifractals in higher dimensions. Phys. Rev. E, Vol. 74, (2006), pp. 061104(8).
 - [19] Olemskoy A.I., Borisjuk V.N. & Shuda I.A. (2008). Multifraktalnyy analiz vremennykh ryadov. Vestnik Sumskogo universiteta, Vol. 2, (2008), pp. 70-81.
 - [20] Olemskoy A.I., Perekrestov V.I., Shuda I.A., Borisjuk V.N. & Mokrenko A.A. (2009). Issledovanie multifraktalnykh poverhnostey kondensatov, poluchennykh metodom magnetronnogo raspyleniya. Metallofiz. Noveishie Tekhnol, Vol. 31, No.11, (2009), pp. 1505-1518.
 - [21] Selezneva A.V. & Slavinskaya A.L. (2014). Designing effect of woman's figure, created corset, consider psikhofiziologic comfort. Proceedings of higher education institutions. Textile industry Technology, Vol. 2 (350), (2014), pp. 102-106.
 - [22] Yakymchuk D., Yakymchuk O., Chepeliuk O., Myrhorodska N., Koshevko J. & Orlenko O. (2017). Study of cutting presses in designing a women's costume for hospitality industry. Eastern European Journal of Enterprise Technologies, Vol. 5, No. 1 (89), (2017), pp. 26-36.