IMPROVEMENT OF THE EXPERT SYSTEM FOR RAPID CHANGE IN PRODUCTION OF WOMEN'S OUTERWEAR

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Today, fashion industry is facing a huge challenge towards sustainability because fast fashion is dominating the mass market. Fast fashion and consumers' purchasing format are closely linked to each other.

At the same time [1], the word 'designer' is a broad description covering many different functions. The area a designer may cover today can range from the prediction or generation of the next season's range to pattern cutting and responsibility for the finished sample. This has to be checked in all sizes with cost lay plans, costings and manufacturing specifications. A designer in a large company may specialise in a particular area and be part of a team, whilst in a very small company a designer may have to perform all the above tasks.

In both cases it could be handled by using CAD-systems at the each stage of the design process.

The clothing industry is quickly becoming a high-tech industry due to rapid advances in technology which contribute to high quality design, cutting, stitching and finishing techniques. But some stages of the design are not formalized yet. Expert systems are used to solve such problems.

About 20 years ago researchers from Southern Korea concluded that an expert system could be used to solve various garment manufacturing problems and would contribute to garment quality improvement through a standardized apparel production process [2].

Nowadays many researchers successfully apply the elements of artificial intelligence on the different stages of design process. For example, an expert system for special body shapes recognition in apparel made-to-measure [3], an expert system for clothing style selection [4], an expert system to support clothing design process [5], and formation of industrial range of garments based on expert system [6], expert system of quality assessment of clothes' designs [7].

On the previous stage of this research the prototype of expert system for rapid change in production of women's outerwear was developed [8]. Textological method was used for the forming the subject environment. Factorial analysis and the cluster analysis were used for the structuring of the subject environment.

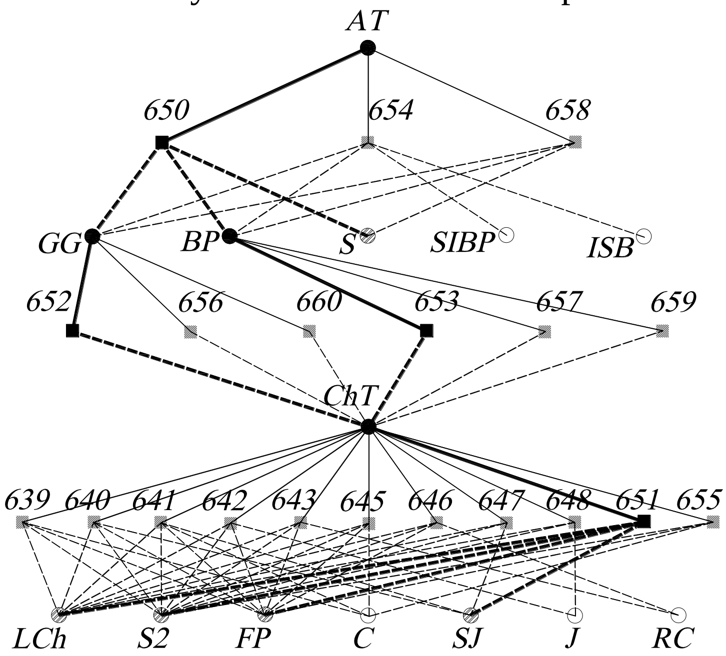
Thus, the main objective of the study was achieved through the formation of twelve separate tasks in accordance with the number of separate groups in the subject environment of rapid change in production of women's outerwear.

The base of the subject environment of rapid change is the list of rational transformations chains of the women's shoulder clothing [9]. The transformation chain could have length from 2 to 10: it could include from 2 garments types to 10 garments types.

The rules of selection the transformation chain and the amount of tolerance on the bust, waist and hip levels are formed in the tables. In each table the results are at the intersection of few antecedents.

Prototype of expert system for rapid change in production of women's outerwear is made by using the empty expert system "Rapana". "Rapana" is distributed freely and available at the official site [10].

The way of decision-maker is represented on the figure 1.



AT – amount of tolerance
GG – garments group
BP – block patterns
S – shape
SIBP – shape (intermediate block patterns)
ISB – intermediate sleeve block
ChT – transformation chain
LCh – length of the transformation chain
S2 – season (for the 2nd garment in the chain)
FP – foundation patterns
C – coat
SJ – suit jacket
J – jacket
RC – raincoat
639-660 – rules

Fig. 1 The way of decision-maker in the prototype of expert system for rapid change in production of women's outerwear

The prototype of expert system provides a dialog with the user as a series of questions and answers guide. Some of the answers could have degree of assurance. User can view the way decision making after getting results.

Thus there were created the required premises for the further development of artificial intelligence methods in the processes of managing the designer's training of clothing manufacture and for lowering the risk of making false decisions under the conditions of rapid changes of project situations.

But for now the length of the transformation chain could be entered only with degree of assurance. There is no enough knowledge in this field. And experiments with the rapid change in production of women's outerwear in real life are too expensive.

That is why the information about the relations between the length of the transformation chain and other characteristics of design process in garment industry could be obtained only by use the simulation model of the design process.

According to this purpose the simulation model of the design process in sewing industry was developed. Such model could be used for predict the results of the rapid change in production of women's outerwear.

The entity-relationship model of the design process was formed. All of entities in this model were represented as particular modules in simulation package Arena (Rockwell Automation). Each module was described with some attributes, which could be change for different sewing companies.

Analysis of the design process in sewing industry and data base of transformation elements were used as original information for simulating.

F-test was used for verification of simulation model. So simulation model of the design process in sewing industry is the base for research of the transformation chains and relationship between parameters of the design process in sewing industry.

As a result of the simulation we can get the "Statistics Collection" and analyze some parameters of the design process. Among them are the time characteristics, the number of designers (busy, scheduled), the cost characteristics, the number in (out), and the instantaneous utilization, etc (figure 2).

Usage

Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
konstryktor	0.9995	(Insufficient)	0.00	1.0000

Number Busy	Average	Half Width	Minimum Value	Maximum Value
konstryktor	2.9986	(Insufficient)	0.00	3.0000

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
konstryktor	3.0000	(Insufficient)	3.0000	3.0000

Scheduled Utilization	Value
konstryktor	0.9995

Fig. 2 The fragment of the "Statistics Collection"

If designer's instantaneous utilization coefficient comes to 1, the transformable chain is estimated as having an optimum length and designer uses rational working hours. Obviously, the main factors influencing on the designer's instantaneous utilization are the number of designers and duration of design process. That is why the plan of experiment was compiled as it presented in the table 1.

Table 1 – The plan of the experiment

№	Factors			
	code designation		named values	
	number of designers	duration of design process	number of designers, person	duration of design process, hour
1	-	-	1	1
2	+	-	5	1
3	+	+	5	40
4	-	+	1	40
5	0	0	3	11,8

The results of the simulations with different parameters (according to the table 1) are presented in the table 2.

Table 2 - Instantaneous utilization of designers' work

№	Instantaneous Utilization			Number Busy (for designers)			Number Scheduled (for designers)
	1 run	2 run	Average	1 run	2 run	Average	
1	0,82	0,83	0,83	0,82	0,83	0,83	1
2	0,17	0,16	0,17	0,83	0,82	0,83	5
3	0,99	0,99	0,99	4,99	4,99	4,99	5
4	0,99	0,99	0,99	0,99	0,99	0,99	1
5	0,99	0,99	0,99	2,99	2,99	2,99	3

As the result of the experiment the regression was obtained:

$$K = 0{,}831 + 0{,}011 \cdot t - 0{,}084 \cdot N, \quad (1)$$

where K – instantaneous utilization (for designers);

t – duration of design process, hour;

N – number of designers, person.

Fisher test confirmed that formula (1) could be used to evaluate the instantaneous utilization of designers' work ($F = 1.25 < F_{table} = 5.05$).

The instantaneous utilization of designers' work is calculated by formula (1) for different numbers of designers and various duration of design process (CAD-system is used or not). The calculation is represented in table 3.

Table 3 - Calculation of the length of the transformation chain

Number of designers	Instantaneous utilization		Length of the transformation chain			
			calculated		recommended	
	with CAD-system	without CAD-system	with CAD-system	without CAD-system	with CAD-system	without CAD-system
1	0,83	0,95	3,62	3,16	4	3
2	0,75	0,87	4,02	3,46	4	3
3	0,66	0,79	4,52	3,82	5	4
4	0,58	0,70	5,16	4,27	5	4
5	0,49	0,62	6,01	4,83	6	5

The simulation model of the design process in sewing industry was developed for the transformation chain, which length is 3. Then the value of the instantaneous utilization, which was obtained as the result of the simulation, corresponds to this length. And when the value of the instantaneous utilization is equal to 1 then the length of the transformation chain is optimum.

Thus the length of the transformation chain in table 3 is calculated by formula:

$$L = 3 / K \quad (2)$$

where L – length of the transformation chain.

The rule of the selection of the length of the transformation chain was compiled in the table 4.

Table 4 – Rule of the selection of the length of the transformation chain

Number of designers	CAD-system is	
	used	not used
1	3	2
2	3	3
3	4	3
4	4	3
5	5	4

The length of the transformation chain is at the intersection of two antecedents: 1 – “Number of designers”, and 2 – “CAD-system usage”.

Thus, this rule provides lower risk of making false decisions under the conditions of rapid changes of project situations than the prototype of expert system for rapid change in production of women's outerwear, which was described in previous researches.

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