Improvement of intelligent systems for creating personalized products

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Abstract

The article proposes an information system to ensure the functioning of artificial intelligence systems in the fashion industry. A model has been developed in the form of a graph, representing the main characteristics and structural components of a personalized product. This model consists of five main groups of characteristics (structural, aesthetic, cultural, technological, and economic), which include 114 individual parameters that can vary depending on the specifics of the product and user needs. Formalized approaches for effective interaction with artificial intelligence systems in the process of creating personalized products are proposed. Testing was conducted using synthetic data. Multiple sets of personalized products were created to meet different user needs, and the model's ability to correctly combine parameters and generate products according to specifications was evaluated. During field tests, the model was integrated into a recommendation system for clothing selection, and the results were assessed based on how well they matched user preferences. The test results demonstrate the potential of the developed system for real-world implementation in the fashion industry, enabling personalized production of clothing and accessories.

Keywords

artificial intelligence, feature graph, information system, personalized product

1. Introduction

Intelligent information systems are a trend in the use of artificial intelligence systems. Research [1] demonstrates the possibilities of creating a smart environment. The effectiveness of creating predictive models is considered. Recently, research on Intelligent information systems in the fashion industry has begun to appear [2]. The need to develop intelligent approaches, models and structures that combine graphic and text data is noted. The relevance of the implementation of artificial intelligence systems in the fashion industry is noted in [3]. Emphasis is placed on the creation of clothing collocation systems, modeling of fashion compatibility, associations between clothing elements.

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Prospects for the creation of intelligent clothing are considered in the article [4]. The authors analyze the Hedonic Information Systems Acceptance Model in relation to clothing. The need for further filling and improvement of this model for the real implementation of artificial intelligence systems in the field of clothing production was noted. Real examples of the implementation of intelligent clothing are considered in studies [5, 6].

According to the latest research, one of the urgent issues in the fashion industry is automating fashion design trend forecasting. The study [7] notes the importance of developing specialized algorithms and models that take into account the specific features of clothing design. This study focuses on aspects of color and style, without delving into a detailed analysis of individual elements of clothing.

The forecasting model of fashionable clothing elements, considered in the article [8], uses the analysis of coexistence relationships of various clothing elements to determine the key factors influencing fashion trends.

The considered models require the development and implementation of machine learning algorithms for effective personalization. Similar algorithms that simplify consumer personalization are discussed in the article [9]. The practical application of such approaches in e-commerce systems that use collaborative filtering and personalized rating methods is described in [10].

According to the study [11], the development of intelligent systems in the fashion industry is inextricably linked with the introduction of advanced visualization methods based on 3D technologies. This allows you to create more realistic and interactive representations of fashion products. The article [12] notes the insufficient amount of data for creating personalized fashion items. This problem is especially relevant when developing systems that take into account the individual features of the figure and style of each consumer. Studies [13-14] focus on methods of creating personalized data based on 3D measurements.

In a number of studies, methods of forecasting fashion trends neural networks are proposed. These approaches show significant potential in predicting future trends in the fashion industry. The article [15] discusses algorithms that take into account variations of style, color and other solutions in the process of forecasting fashion trends. Such algorithms allow analyzing large volumes of data on current trends, identifying hidden patterns in changing fashion trends, and predicting future trends with high accuracy.

The generation of exogenous knowledge about forecasting the creation of fashion goods is considered in the study [16]. Such knowledge involves the creation of a complex database on the features of fashionable clothing, the development of graphs reflecting the relationships between various elements of fashion, and the formation of algorithms for trend analysis and forecasting.

Forecasting fashion trends on the basis of style analysis, generation of structures and analysis of fashion lines determine innovative trends in industry and trade [17]. The article [18] notes the importance of analytical methods used by business to forecast fashion trends.

The work [19] presents a structure that determines the probability of popularity of clothing elements. This framework is based on the analysis of various factors influencing consumer preferences, such as social, economic and cultural changes. The development of such a structure can significantly improve the methods of forecasting fashion trends, as it allows taking into account market dynamics and changing consumer preferences in real time.

Research [20] describes the creation of a quasi-autoregressive neural network based on a complex database and relationships between its elements. Computer vision of fashionable objects was defined as a fundamental basis for ensuring the effective functioning of artificial intelligence systems. This approach made it possible to automate the process of recognition and classification of fashion products, to increase the accuracy of trend forecasting.

The formation of intelligent clothing systems, according to the study [21], also requires the creation of an extended database on color and other aspects of clothing, as well as determining the relationships and characteristics of the influence of various elements.

The development of online stylist services requires further digitization and the introduction of innovative technologies [22]. Special attention is paid to the pairwise ratio of structural elements, which requires the development of a model that determines the level of detailed compatibility of various clothing components. To digitize such aspects as material and texture, color scheme, silhouette and proportions, decorative elements and others, it is necessary to develop algorithms that take into account the relationships between different characteristics of clothing.

Research [23] proposes a network model with advanced knowledge for a series of fashion items. Such a model is able to effectively process complex elements of fashion products, but needs constant updating and expansion to meet fast-changing fashion trends. Directions for improvement of such models are given in the study [24] with specific examples.

Collaborative filtering fashion algorithms are a promising direction for introducing artificial intelligence systems into the fashion industry. Collaborative graph filtering discussed in [25] uses a convolutional graph network to extend a learnable model. This approach makes it possible to improve the personalization of recommendations for fashion products, increase the accuracy of predicting user preferences, and optimize the processes of assortment planning and inventory management in the fashion industry.

Collaborative filtering is a powerful and efficient tool in forecasting systems, especially in the context of the fashion industry. This method requires the development of advanced spectral graph filtering methods to identify the main trends and relationships [26].

Scenario modeling fashion is an important tool for implementing and supporting artificial intelligence systems in the fashion industry. Effective use of such approaches requires the use of real data sets [27]. This is because the fashion industry is dynamic and sensitive to many factors, including social, economic and cultural variables.

Research [28] determines the possibility of finding optimal solutions when creating a promising system of fashionable clothing and lays the foundation for the development of algorithms capable of generating innovative designs, taking into account current trends and forecasts. Methods of optimizing the indicators of a personalized product on specific examples are considered in [29] and allow to increase the efficiency of production, improve the conformity of products to consumer expectations.

The article [30] highlights issues related to the possibility of introducing smart clothes when using artificial intelligence systems. Studies [31-32] are devoted to the issues of introducing artificial intelligence systems into the work of fashion companies. The need to improve analytical formalized models for the creation of promising fashion products is noted.

The analysis of the state of the issue determines the urgent need for the development of analytical methods for describing fashion products with the aim of introducing artificial intelligence systems into the fashion industry. These methods should provide accurate and

comprehensive characterization of products, which will allow AI systems to generate relevant and innovative designs.

The work aims to develop a system of analytical models for creating a personalized product using artificial intelligence systems based on the analysis of the structure and features of a fashion product.

2. Development of an analytical model of a personalized product for the implementation of artificial intelligence systems

The analysis of the structure of a fashion product in the context of the dynamic and sensitive nature of the fashion industry made it possible to identify the following main groups of properties and features that characterize its structure and functioning.

Group C_0 describes the superstructure of the personalized product. Different structural components of this group differ depending on how separately the desired product works. Component C_{01} describes the functioning of individual products. The C_{02} component determines the functioning of the desired product in the style complex.

Structure C_1 provides the functional properties of the desired clothing, which determine how effectively the product performs its tasks, providing comfort and protection of the body. These properties are closely related to the purpose of clothing, the conditions of its use, and the individual needs of a person. Separate subgroups of this structure can define:

$C_{1,1}$ – purpose of the product; $C_{1,2}$ – anthropometric correspondence; $C_{1,3}$ – seasonality; $C_{1.4}$ – comfort and convenience; $C_{1.5}$ – practicality; $C_{1.6}$ – functionality. These subgroups may include the following elements:

$C_{1,1}^{1}$ – everyday, $C_{1,1}^{2}$ – sports, $C_{1,1}^{3}$ – festive, ... ;

$C_{1,21}$ – size: $C_{1,21,1}$ – XS, $C_{1,21,2}$ – S, $C_{1,21,3}$ – M, $C_{1,21,4}$ – L, $C_{1,21,5}$ – XL, ... ;

$C_{1,2}^{2}$ – figure type: $C_{1,2}^{2,1}$ – H-type, $C_{1,2}^{2,2}$ – X-type, $C_{1,2}^{2,3}$ – A-type, $C_{1,2}^{2,4}$ – V-type; $C_{1,2}^{2,5}$ – O-type ... ;

$C_{1,2}^{3}$ – age; $C_{1,2}^{4}$ – gender;

$C_{1,3}^{1}$ – summer, $C_{1,3}^{2}$ – winter, $C_{1,3}^{3}$ – demi-season;

$C_{1,4}^{1}$ – air permeability, $C_{1,4}^{2}$ – elasticity; $C_{1,4}^{3}$ – softness;

$C_{1,5}^{1}$ – wear resistance, $C_{1,5}^{2}$ – ease of care, $C_{1,5}^{3}$ – water repellency; $C_{1,6}^{1}$ –
presence of pockets, $C_{1,6}^{2}$ – fastener, $C_{1,6}^{3}$ – hood, ...

Structure C_2 provides the aesthetic properties of the desired clothing, which determine its appearance, perception and attractiveness. They are key to defining style, fashion direction and emotional impact on consumers. Separate subgroups of this structure can define:

$C_{2,1}$ – product style; $C_{2,2}$ – color; $C_{2,3}$ – print; $C_{2,4}$ – decor; $C_{2,5}$ – silhouette; $C_{2,6}$ – cut. These subgroups may include the following elements:

$C_{2,1}^{1}$ – classical, $C_{2,1}^{2}$ – sports, $C_{2,1}^{3}$ – avant-garde, ... ;

$C_{2,4}^{1}$ – lace, $C_{2,4}^{2}$ – embroidery, $C_{2,4}^{3}$ – application ... ;

$C_{2,4}^{3,1}$ – adhesive application, $C_{2,4}^{3,2}$ – sequin application; $C_{2,4}^{3,3}$ – appliqué from rhinestones...;

$C_{2,5}^{1}$ – fitted, $C_{2,5}^{2}$ – free, $C_{2,5}^{3}$ – straight, ... ;

$C_{2,6}^{1}$ – sewing sleeve, $C_{2,6}^{2}$ – raglan sleeve, $C_{2,6}^{3}$ – combined sleeve.

Framework C_3 provides the cultural and social aspects of desired clothing, which determine how clothing affects the culture and social identity of an individual or group of people. These aspects include the influence of cultural norms, traditions, societal standards and social factors on the choice, style and perception of clothing. The importance of these elements lies in the fact that clothing not only performs the function of protection, but also becomes a means of self-expression, communication and formation of social ties. Separate subgroups of this structure can define:

$C_{3,1}$ – target audience; $C_{3,2}$ – cultural context; $C_{3,3}$– social role; $C_{3,4}$ – ethical aspects. These subgroups may include the following elements:

$C_{3,1}^{1}$ – youth, $C_{3,1}^{2}$ – business class, $C_{3,1}^{3}$ – mass market;

$C_{3,2}^{1}$ – national motives, $C_{3,2}^{2}$ – subculture, $C_{3,2}^{3}$ – religiosity;

$C_{3,3}^{1}$ – uniform, $C_{3,3}^{2}$ – special purpose, $C_{3,3}^{3}$ – carnival costume;

$C_{3,3}^{2,1}$ – eco-clothes, $C_{3,3}^{2,2}$ – technological clothing; $C_{3,4}^{1}$ –
ecological production, $C_{3,4}^{2}$ – ethical production.

The C_4 structure provides the technological properties of the desired garment, which determine its production aspects and functionality. Also, this structure forms the basis for innovations in production, which allows brands to remain competitive and meet the requirements of modern consumers. Separate subgroups of this structure can define:

$C_{4,1}$ – fabric type; $C_{4,2}$ – material texture; $C_{4,3}$ – innovative materials; $C_{4,4}$ – smart technologies; $C_{4,5}$ – production technologies.

These subgroups may include the following elements:

$C_{4,1}^{1}$ – natural, $C_{4,1}^{2}$ – synthetic, $C_{4,1}^{3}$ – mixed;

$C_{4,2}^{1}$ – smooth, $C_{4,2}^{2}$ – embossed, $C_{4,2}^{3}$ – shiny, $C_{4,2}^{4}$ – matte;

$C_{4,3}^{1}$ – smart fabrics, $C_{4,3}^{2}$ – biomaterials;

$C_{4,4}^{1}$ – fitness trackers, $C_{4,4}^{2}$ – technologies for tracking, $C_{4,4}^{3}$ – monitoring of physiological indicators, ... ;

$C_{4,5}^{1}$ – 3D printing; $C_{4,5}^{2}$ – digital printing; $C_{4,5}^{3}$ – laser cutting.

Structure C_5 provides the economic and marketing factors of desirable clothing that determine its commercial aspects. An important aspect is the integration of data from different sources, such as social networks, online stores and analytical platforms, which provides a more accurate modeling of the probability of popularity of specific items of clothing. This allows you to create adaptive systems that can quickly respond to changes in fashion trends and consumer preferences. Separate subgroups of this structure can define:

$C_{5,1}$ – price range; $C_{5,2}$ – brand; $C_{5,3}$ – promotion strategy; $C_{5,4}$ – product life cycle.

These subgroups may include the following elements: $C_{5,1}^{1}$ –
budgetary, $C_{5,1}^{2}$ – average, $C_{5,1}^{3}$ – premium segment;

$C_{5,2}^{1}$ – well-known brands, $C_{5,2}^{2}$ – designer clothes, $C_{5,2}^{3}$ – mass market;

$C_{5,3}^{1}$ – advertising, $C_{5,3}^{2}$ – social media, $C_{5,3}^{3}$ – collaborations; $C_{5,4}^{1}$ – new
collection, $C_{5,4}^{2}$ – sale, $C_{5,4}^{3}$– disposal.

The resulting graph of product connections for the formation of forecasting algorithms based on artificial intelligence is shown in Fig. 1. This structure is basic and can be improved in the process of training the AI-system, which allows to increase the effectiveness of predictions in the dynamic environment of fashion. This, in turn, can significantly influence production strategies, marketing campaigns and the development of new collections, providing brands with competitive advantages in the market.

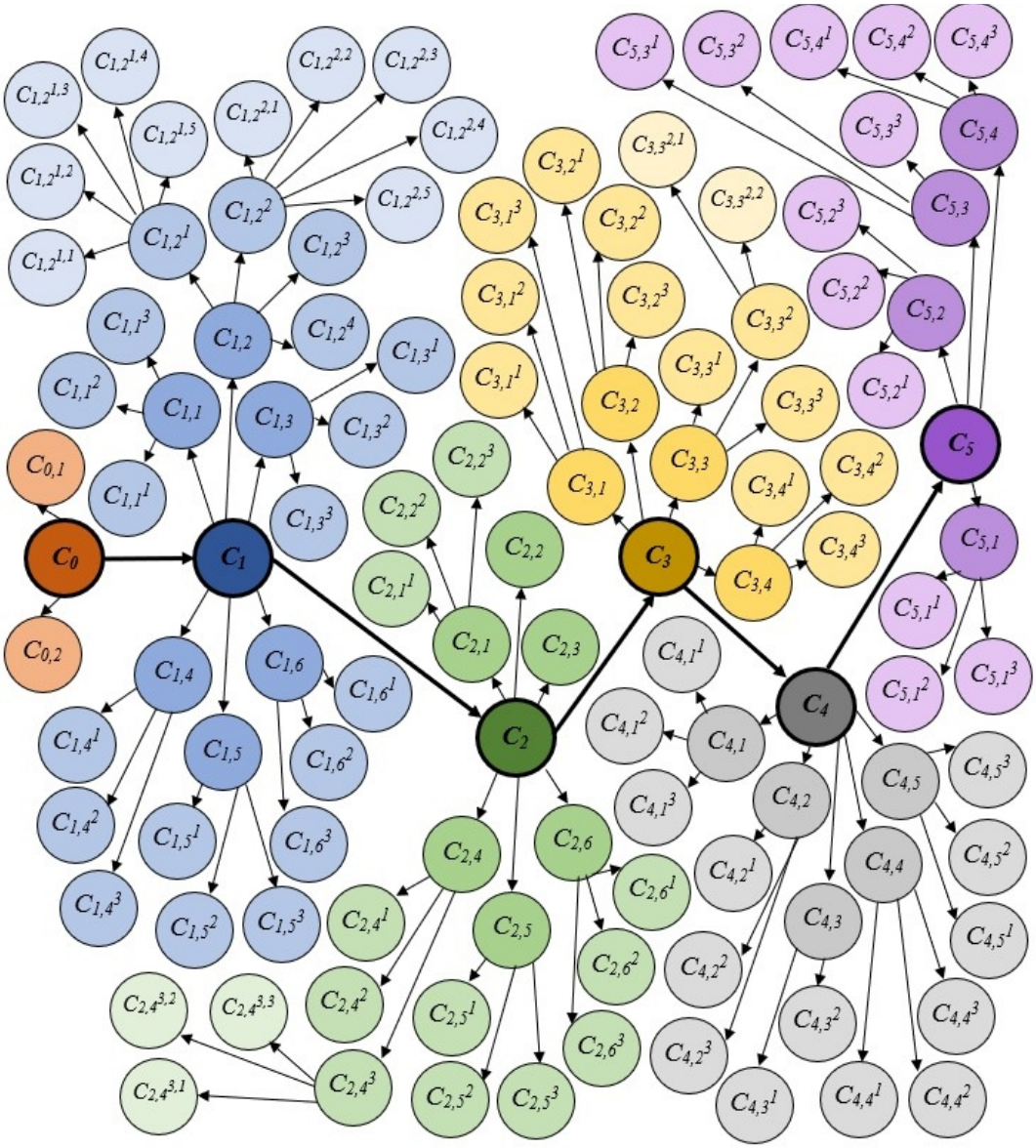

Figure 1: Graph of features of a personalized product.

Based on the constructed graph of the organization of the personalized product, its morphological map can be developed. In the process of morphological analysis, the artificial intelligence system can select features or elements. Fig. 2 shows a diagram of the algorithm for creating a personalized product with the following components. A dress (C_0) for everyday use ($C_{1,1}^1$) for women aged 25-30 ($C_{1,2}^3$) for wearing in the spring-autumn period ($C_{1,3}^3$). The dress must have patch pockets ($C_{1,6}^1$), a central button fastening ($C_{1,6}^2$) and a hood ($C_{1,6}^3$). The style of the dress is classic ($C_{2,1}^1$), the color of the main material ($C_{2,2}$) is blue.

Individual parts of the product are decorated with sequin appliqué ($C_{2,4}^{3,2}$) and rhinestone appliqué ($C_{2,4}^{3,3}$). The silhouette is fitted ($C_{2,5}^1$), slightly widened to the bottom. The sleeve is sewn in ($C_{2,6}^1$), elbow-length, with a wide cuff at the bottom of the sleeve. Dress for a business class woman ($C_{3,1}^2$) made of natural materials ($C_{4,1}^1$), which ensures ecological production ($C_{3,4}^1$). Matte

fabric ($C_{4,2}^{4}$). The product includes a sensor for monitoring physical parameters of a person ($C_{4,4}^{3}$). The price range of the dress is average ($C_{5,1}^{2}$). A product of a well-known brand ($C_{5,2}^{1}$).

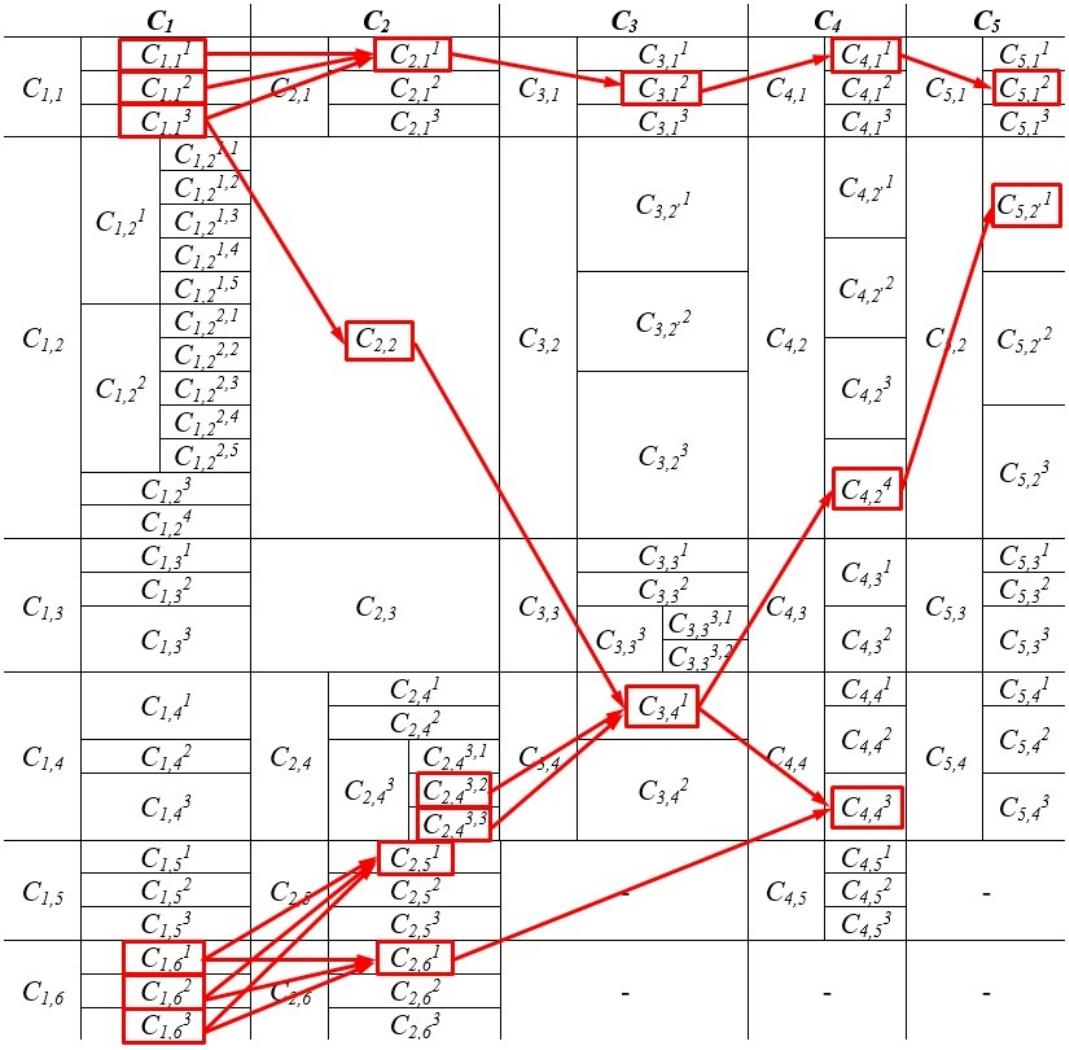

Figure 2: General morphological map of creating a personalized product.

Based on the morphological map, such a product can be defined as:

$$W = [C_0, (C_{1,11} \wedge C_{1,23} \wedge C_{1,33} \wedge C_{1,61} \wedge C_{1,62} \wedge C_{1,63}), (C_{2,11} \wedge C_{2,2} \wedge C_{2,43,2} \wedge C_{2,43,3} \wedge C_{2,51} \wedge C_{2,61}), (C_{3,12} \wedge \wedge C_{3,41}), (C_{4,11} \wedge C_{4,24} \wedge C_{4,43}), (C_{5,12} \wedge C_{5,21})].$$

An example of creating a personalized product based on the algorithm is shown in Figure 3.

Figure 3: A personalized product created using artificial intelligence based on a developed algorithm.

Considering the number of finite elements in each group, it is possible to predict a fairly large number of combinations of the main features and the appearance of personalized products with new properties. As a preliminary step, it is necessary to determine the basic rules according to which individual characteristics can be combined in a separate group. Obviously, the elements of each group cannot be chosen arbitrarily. Examples of possible combinations for the first group of features are given in Table 1.

Table 1
Combinations of group C_1 are possible

	$C_{1,11}$	$C_{1,12}$	$C_{1,21,1}$	$C_{1,21,1}$	$C_{1,22,1}$	$C_{1,22,2}$	$C_{1,31}$	$C_{1,32}$	$C_{1,61}$	$C_{1,62}$
$C_{1,11}$		∨	∨	∨	∧	∧	∨	∨	∧ ∨	∧ ∨
$C_{1,12}$	∨		∨	∨	∧	∧	∨	∨	∧ ∨	∧ ∨
$C_{1,21,1}$	∨	∨		¬	∧	∧	∨	∨	∧ ∨	∧ ∨
$C_{1,21,2}$	∨	∨			∧	∧	∨	∨	∧ ∨	∧ ∨
$C_{1,22,1}$	∧	∧	¬ ∧	∧		¬	∨	∨	∧ ∨	∧ ∨
$C_{1,22,2}$	∧	∧	∧	∧	¬		∨	∨	∧ ∨	∧ ∨
$C_{1,31}$	∨	∨	∨	∨	∨	∨		∨	∧ ∨	∧ ∨
$C_{1,32}$	∧ ∨	∧ ∨	∨	∧ ∨	∨	∧ ∨	∧ ∨		∧ ∨	∧ ∨
$C_{1,61}$	∧ ∨	∧ ∨	∧ ∨ ∧ ∨	∧ ∨	∧ ∨	∧ ∨	∧ ∨	∧ ∨		
$C_{1,62}$					∧ ∨					

General approaches to the formation of algorithms for the selection of a personalized product will be based on the calculation of statements with the help of sentential relations. Complex systems of personalized products consist of elements of the graph of morphological features. In

a formalized form, each product will represent a complex statement consisting of simple signs connected by means of actions that can be expressed sententially:

- The conjunction ("and") is used to indicate the simultaneous presence of several features. For example, "the presence of pockets and a hood" indicates that both elements are present in the product;
- Disjunction ("or") is used to choose between alternatives. For example, "sewn sleeve or raglan sleeve" means that the product can have one of these two types of sleeves;
- The negation ("not") is used to indicate the absence of certain features. For example, "no collar" indicates that the product does not have this element;
- Implication ("if... then") - this relationship allows you to determine the dependence between features. For example, "if the product does not have an insulating lining, then it is intended for summer" indicates that the absence of an insulating lining is an indicator of the product's seasonality.

These words or combinations of words are sentential connections for which the following symbols are traditionally used:

¬ - for "no", ^ - for "and", ˅ - for “or”, ⟶ - for "if...then".

The mandatory list of the main features characterizing a fashion product as a structurally homogeneous object looks like this: $(C_1 \wedge C_2 \wedge C_3 \wedge C_4 \wedge C_5)$.

The use of simplified formulas and approaches to communication with the artificial intelligence system leads to unsatisfactory results. A possible result of the application of simplified approaches is illustrated in Fig. 4, which, of course, lags far behind the results presented in Fig. 3, which were obtained on the basis of the developed graph.

Figure 4: Unsatisfactory appearance of the model synthesized using simplified formulas.

This indicates that in order to achieve more accurate and effective results in interaction with artificial intelligence systems, it is necessary to use more complex and formalized approaches.

In order to formalize the described properties of combinations of the main features, we will present them in mathematical form. Then the main subgroups of features for the first group based on Figs. 2 will be presented in the form:

$C_{1,11} \vee C_{1,12}$; $C_{1,11} \vee C_{1,22,1}$; $(C_{1,11} \wedge C_{1,61})$ $(C_{1,11} \vee C_{1,61})$;

$C_{1,21,1}$ $C_{1,12}$; $C_{1,21,1} \neg C_{1,21,2}$; $C_{1,211} \vee C_{1,31}$; $(C_{1,21,2} \wedge C_{1,61})$ $(C_{1,21,2} \vee C_{1,61})$

Similar expressions can be written for all groups. By combining features and formulas, it is possible to synthesize a variety of personalized products with various combinations of features selected from the list of rational combinations.

3. Conclusions

To ensure the functioning of artificial intelligence systems for creating personalized products, a morphological analysis of potential products, presented as a feature system, was carried out. Five groups, including 114 features, were identified. Basic rules and formal approaches to combining these key features were established. A graph of personalized product features was developed, along with the rationale for the main connections, which formed the basis for creating a morphological data table used for communication with the AI system. An analysis of the depth of use of this morphological data in the AI system was conducted. The effectiveness of using logical connections in forming algorithms for selecting personalized products was demonstrated, allowing for the creation of flexible and adaptive models. These models can consider various combinations of features, improving the accuracy of forecasting consumer needs and enhancing the effectiveness of personalization in the fashion industry.

In contrast to known advancements in artificial intelligence, the proposed model incorporates a complex structure that includes precise indicators for clothing characteristics. Machine learning algorithms, including spectral graph filtering and recurrent neural networks, were used to train the model. This enabled the system to analyze data and identify relationships between clothing characteristics, facilitating the creation of personalized recommendations for users.

The model is capable of self-improvement during operation through machine learning on new data sets, allowing for the automatic addition of new characteristics and parameters to the existing graph structure.

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