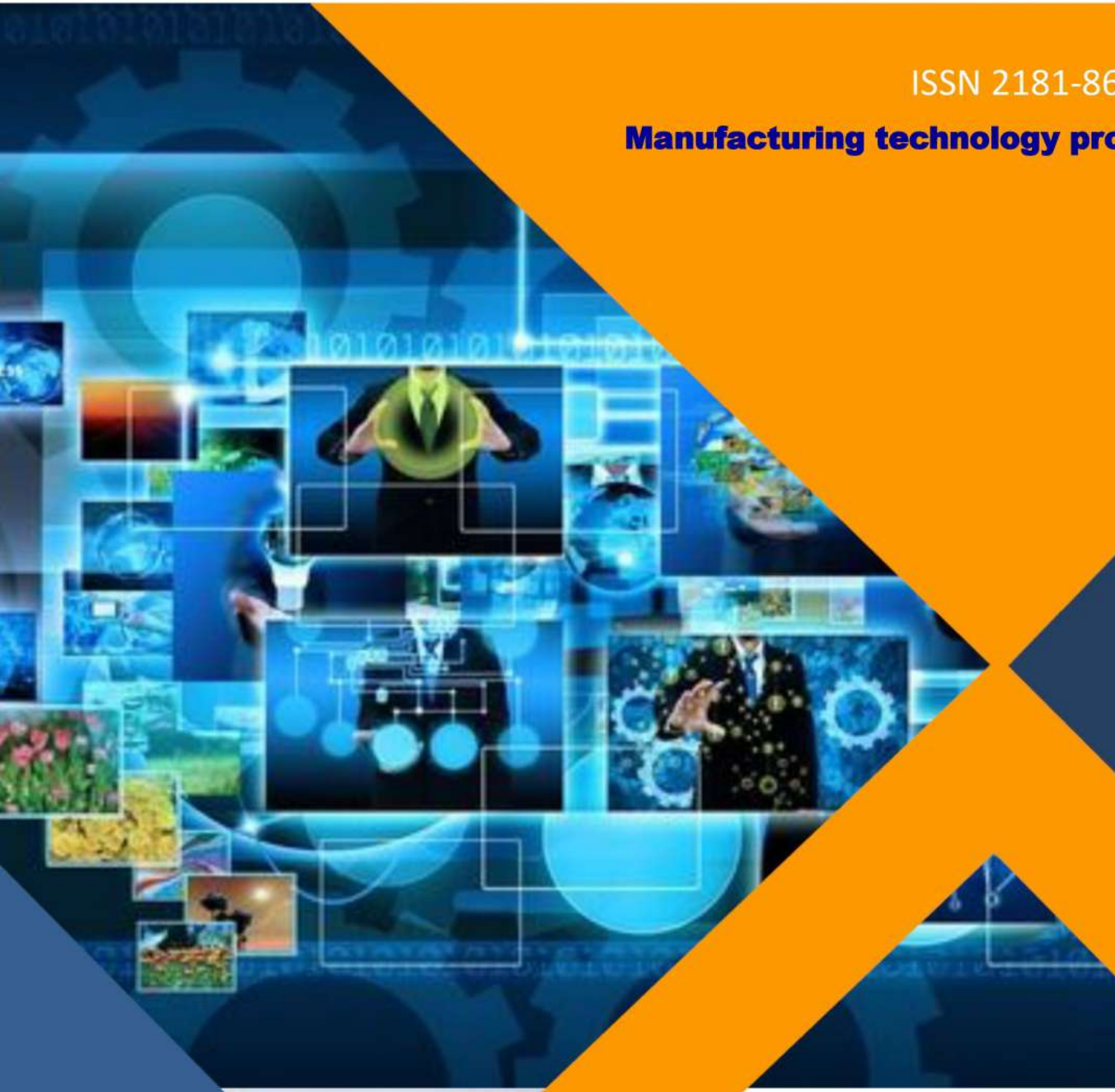
ISSN 2181-8622

Manufacturing technology problems



Scientific and Technical Journal Namangan Institute of Engineering and Technology

Volume 9
Issue 4
2024

EVALUATION OF AESTHETICITY OF WOMEN'S DRESS MODELS BASED ON DEEP LEARNING MODELS

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Abstract: Currently, the assessment of aesthetic appeal is conducted through a visual analysis of the product, which includes a professional evaluation of its appearance in terms of harmony, proportionality, and originality. These assessments are based on the subjective perception of experts in the fields of fashion or design. This study presents the results of an aesthetic evaluation of women's dress models using deep learning neural network algorithms. To prepare the database of dress images used for training the network to assess aesthetic appeal, the following criteria were selected as key parameters of aesthetics: novelty of the model and construction, and the degree of compositional refinement of the design. For building the neural network model and conducting computations, the "Google Colaboratory" cloud platform was utilized, as it is specifically designed for implementing machine learning and deep neural network algorithms. Based on the proposed neural network architecture, a program was developed for recognizing the aesthetic appeal of images.

Keywords: machine learning, aesthetics assessment, women's dresses, expert assessment, neural network models.

Introduction. Currently, the clothing market is characterized by a high level of competition, where such major brands as Zara, Mango, H&M, Uniqlo, Massimo Dutti, Hugo Boss, Michael Kors, MaxMara, Gucci, Dior, etc. offer a diverse range of products covering a wide range of target groups. The success of these companies is due to their ability to quickly adapt to dynamic changes in market conditions through the introduction of innovative technologies in the design and production processes. At the same time, one of the key problems of the global clothing market is the difficulty of forecasting demand prospects. Mistakes at this stage can lead to the loss of relevance of design solutions, an increased risk of obsolescence of the collection and the accumulation of excess warehouse stocks. In the context of these challenges, the task of optimizing the creative process of developing aesthetic clothing models is becoming more relevant. Methods for assessing the aesthetic indicators of clothing include consideration of various aspects related to the appearance, style and emotional perception of the product. Currently, visual analysis of the product is most often used to assess aesthetics, including a professional assessment of the appearance of the product for harmony, proportionality and originality and are assessed based on subjective perception by experts in the field of fashion or design. The advantage of this method is its flexibility, since experts can evaluate clothing in the context of modern fashion trends, color combinations and original solutions. The disadvantage of the method is the subjectivity of the assessment. Assessments depend on the tastes and aesthetic preferences of experts, which can lead to different opinions on the quality of the same product, as well as the need for professional qualifications. This method requires deep knowledge of fashion trends.

Attempts to quantitatively assess the aesthetic indicators of clothing for specific figures are proposed by the authors [1-5]. The essence of the proposed methods is to construct proportionally harmonious forms of clothing models that are adapted to the human figure by correcting the vertical and horizontal parameters of the sketch using a proportioning grid based on an A-diamond. In this case, the aesthetics of the original model is assessed visually.

The priority areas in this context are research based on artificial intelligence (AI) and machine learning technologies (ML) [6-9]. These technologies not only optimize data analysis processes, but also develop more adaptive and accurate tools for demand forecasting. One of the first attempts to apply deep machine learning algorithms in the fashion industry is the Fashion-MNIST project, which is a dataset that includes images of fashionable clothes, shoes, and accessories of various types. [10-11].

Methods. To solve the problem of assessing the aesthetics of clothing silhouette shapes, an approach based on the use of machine learning methods for recognizing silhouette shapes presented in images is proposed. Images are classified into two types: aesthetic and unaesthetic. To implement the problem, the deep learning method was used, namely, training neural networks for image recognition. This approach was implemented through the use of convolutional neural networks (CNN), using libraries for scientific computing in the Python programming language. Convolutional neural networks (CNN) are a set of transformations called convolutions, performed on sequences of various network layers - a convolutional layer, a pooling layer, an inception module, a residual block, etc. Each transformation is formalized through a mathematical convolution model:

$$O_{x,y}=\sum_{i,j} W_{i,j} \sum_{t,k} I_{t,k}, \quad |t-i|<l,\ |k-j|<l$$

Where **I** is the input data, O is the output data, W is the convolution kernel, and l is the expansion coefficient. Convolution is an operation on a pair of matrices A (of size nx x ny) B (of size mx x my) the result of which is a matrix C=A∗B of size (nx−mx+1)×(ny−my+1), where

$$C_{i,j}=\sum_{u=0}^{mx-1} \sum_{v=0}^{my-1} A_{i+u,j+v} B_{u,v}$$

The **logical meaning of convolution** is as follows: the larger the value of an element in the convolution result, the more similar that part of matrix **A** is to matrix **B** (in terms of scalar product similarity). In this context, matrix **A** is interpreted as an image, while matrix **B** serves as a filter or reference sample. The **training process of a Convolutional Neural Network (CNN)** involves finding the optimal network configuration that satisfies the criterion of minimizing a specific loss function (error function). The **object recognition task** for type **S** consists of determining its category (class) based on its description. The quality of the recognition algorithm can be characterized by the algorithm's **loss function (error function)**.

The selection of the **best-suited algorithm** for recognizing a set of objects **{Sj}** is carried out through **training**, which involves determining the algorithm parameters that minimize the loss function over a given training set of objects **{Sj}o**.

If E(W)- loss (error) function of the network,

$$\nabla E(W) = \left[\frac{dE}{dw1}, \dots, \frac{dE}{dwn}\right]$$

the gradient of the loss function from the matrix of neural network weights, $\frac{dE}{dwi}$ where is the partial derivative of the error function with respect to the weight of the i-th neuron of the network, n is the total number of weights.

The optimal network configuration corresponds to the minimum value of the loss function and the optimal set of weights. The search direction is determined by the gradient of the loss function. The optimal network configuration corresponds to the minimum value of the loss function E (W) and the set of optimal weights (w1, w2,…wn)min . The search direction is determined by the gradient of the loss function ∇E(W).

Results and discussion

Aesthetic indicators of garments include such characteristics as:

- compliance with fashion trends: relevance of the model in the context of current or future fashion trends;
- emotional impact: perception of the product as expressive, stylish or unique;
- color: shade, saturation and harmony of color solutions;
- shape: proportions, balance, symmetry, originality of cut;
- fabric texture: smoothness, relief, shine, texture;
- design and decorative elements: presence and harmony of accessories, embroidery, trim and other decorative elements.

To prepare a database of dress images used to train the network to assess aesthetics, the following parameters were selected as criteria for aesthetics: novelty of the model and design, degree of perfection of the model composition. Taking into account sustainable fashion, a selection of samples of elegant dresses was carried out to form a database of aesthetic models, including examples of clothing of the first ladies of the world. To train the network with the help of fashion industry experts, 300 models were selected: aesthetic, non-aesthetic, and for testing the recognition program of test images.

A fragment of the image database is shown in Fig. 1

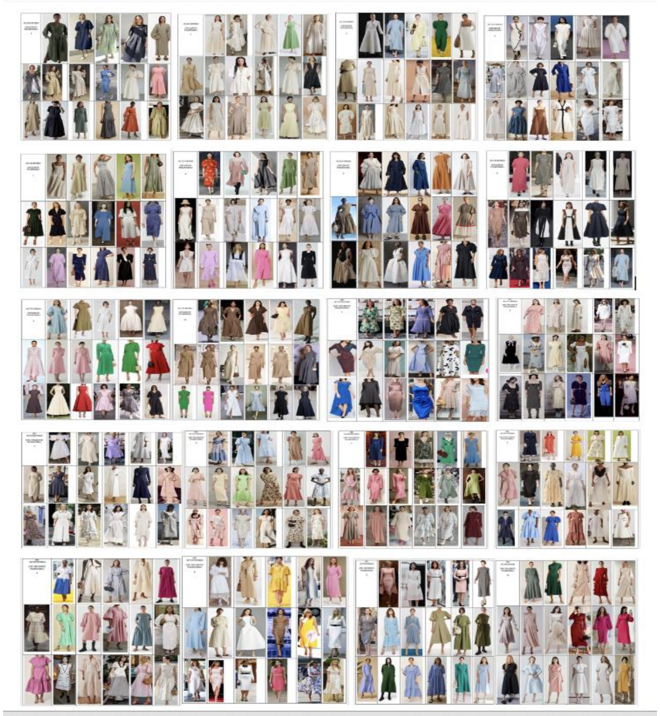

Fig. 1. Databases of aesthetic models for machine learning

To build a neural network model and perform calculations, the Google Colaboratory cloud platform was used, which is designed to implement machine learning algorithms and deep neural networks. Based on the proposed neural network architecture, a program for recognizing the aesthetics of images was developed. The image of a dress presented for recognition can be assigned to one of the specified types (classes): the number of classes is two and is characterized by the corresponding value (label), 0.1. The recognition result is presented as a value, the proximity of which to 1 indicates a high level of aesthetics, and the proximity to 0 - a low level.

Fig. 2 shows fragments of a program screenshot demonstrating the results of aesthetics recognition using the developed neural network model.

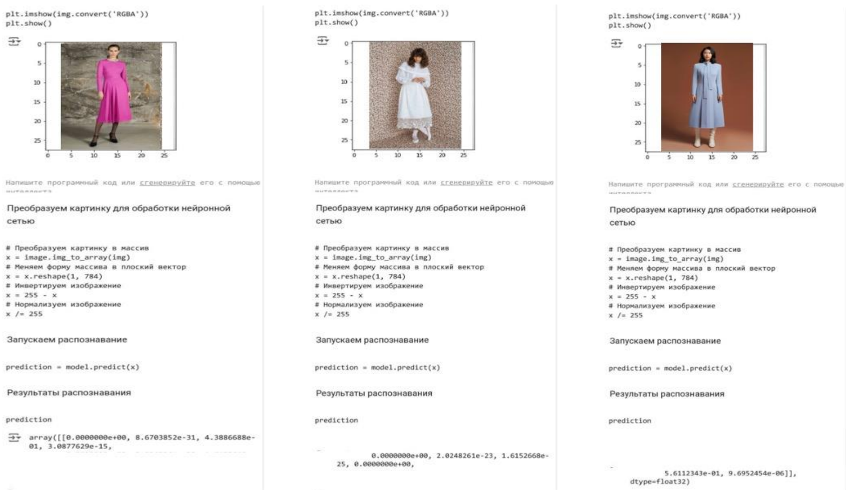

Figure 2. Results of Aesthetic Evaluation of Women's Dress Models

At the subsequent stage of the research, in order to determine aesthetically harmonious fundamental dress silhouettes of the "hourglass" type, adapted to standard body typologies with variations in stature and corpulence, a matrix of graphical form combinations was developed. This matrix encompasses an array of structural elements: bodice configurations featuring diverse upper segment designs and skirts exhibiting variability in width and length of the lower section. A total of 36 combinatorial variations were formulated, ensuring a comprehensive spectrum of graphical design solutions.

The aesthetic value of each configuration was assessed through expert evaluation. The selection of experts was predicated upon their depth of knowledge, professional experience, and specialized competencies within the domain of fashion and apparel design. The evaluative process was conducted using a tripartite grading scale: 2 points – the configuration was deemed aesthetically refined, 1 point – the configuration was considered moderately aesthetic, 0 points – the configuration was classified as aesthetically deficient.

For the empirical investigation of dress silhouette harmony in accordance with the established conceptual framework, a morphological profile corresponding to individuals of short stature (155–160.9 cm) with pronounced corpulence was designated as the primary subject of analysis. Specifically, this category was characterized by a differential measurement between hip and bust circumferences ranging from 12 to 19.9 cm. The selection of this morphological type was justified by the inherent complexity of constructing an aesthetically cohesive silhouette for such a body configuration. The results of the aesthetic assessment, along with their statistical analysis, are presented in Figures 3, 4, and 5.

№	1A	1B	1C	1D	1E	1F	2A	2B	2C	2D	2E	2F	3A	3B	3C	3D	3E	3F
Ekspertlar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	2	2	1	1	0	2	2	2	1	2	0	2	0	0	0	1	0	1
2	2	1	0	0	2	1	1	0	0	0	2	2	1	0	0	0	1	0
3	1	2	1	0	2	1	1	1	0	0	2	1	1	0	0	1	2	0
4	1	1	0	0	2	2	1	2	1	1	2	1	1	0	0	0	2	1
5	1	1	0	0	0	1	2	2	1	0	2	2	0	1	0	0	0	0
6	2	0	0	0	1	1	2	0	1	0	1	1	2	0	1	0	1	1
7	1	0	0	0	1	2	1	1	0	1	2	2	1	0	0	2	2	0
8	1	0	0	1	0	2	2	0	0	2	0	1	0	0	0	1	1	2

№	4A	4B	4C	4D	4E	4F	5A	5B	5C	5D	5E	5F	6A	6B	6C	6D	6E	6F
Ekspertlar	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	2	0	0	2	1	2	0	0	0	1	0	2	2	0	0	2	1	2
2	0	0	0	0	1	0	1	2	0	0	1	1	2	0	0	0	2	1
3	1	1	0	1	2	0	1	1	0	0	2	1	2	1	0	0	2	2
4	1	1	0	0	2	1	1	1	0	0	2	1	2	1	0	0	2	2
5	1	1	0	0	0	0	0	1	0	0	0	1	1	2	0	0	1	1
6	2	0	1	0	1	1	0	0	0	0	0	1	2	0	1	0	2	1
7	0	1	0	2	2	1	1	0	0	1	2	1	0	0	1	1	2	1
8	2	0	0	1	0	1	1	0	0	2	0	2	1	1	0	2	0	2

Figure 3. Results of the Aesthetic Evaluation of Silhouette Forms

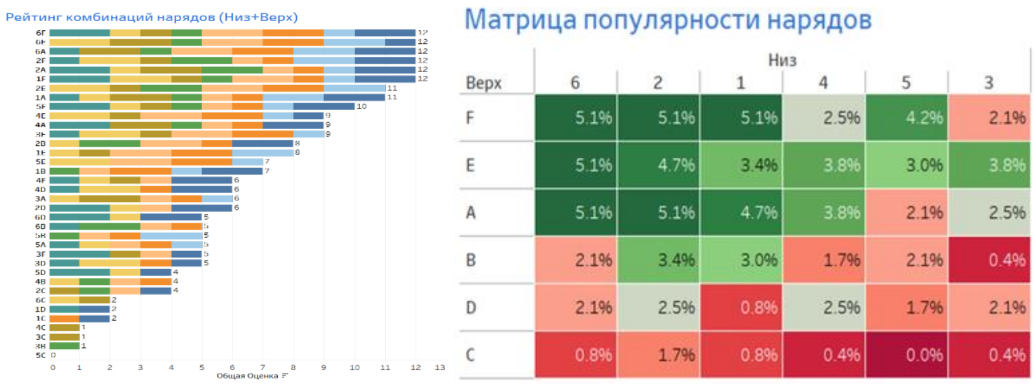

Figure 4. Statistical Processing of Expert Evaluation Results

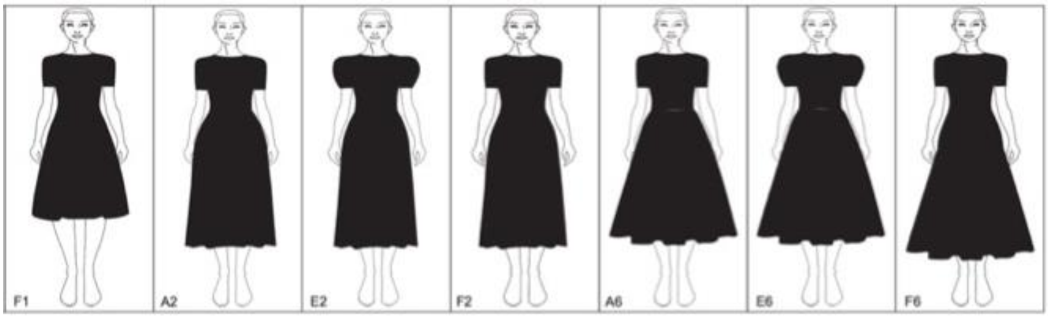

Figure 5. Variants of Aesthetic Silhouette Forms for Standard Body Types of Short Stature and Pronounced Fullness

The results of the expert evaluation formed the basis for the analysis and subsequent optimization of the proposed graphical solutions aimed at enhancing the harmony and aesthetic appeal of the developed models.

To assess the degree of consensus among experts, Kendall's coefficient of concordance (W) was employed, calculated using the following formula:

$$W = \frac{12 \sum (R_i - \bar{R})^2}{m^2 (n^3 - n)},$$

where:

R_i — the sum of ranks for each evaluated object, $\bar{R}$ — the mean value of the rank sums, m — the number of experts, n — the number of evaluated objects.

To compute Kendall's coefficient of concordance, a custom Python script was developed utilizing the **scipy** library, which provides functions for statistical calculations.

The computed coefficient yielded a value of W = 0,316634 indicating a low level of agreement among expert assessments.

These findings underscore the necessity of integrating artificial intelligence (AI) methodologies with expert evaluations to achieve greater objectivity and precision in the analysis of fashion model aesthetics. The synergy between technological advancements and human expertise facilitates a more comprehensive understanding of aesthetic perception, allowing for a nuanced consideration of various interpretative aspects.

Conclusions. A method for evaluating the aesthetic appeal of fashion silhouette forms has been developed based on deep learning neural network models. A database of dress images with varying degrees of compositional integrity, considering the principles of sustainable fashion, has been compiled. To construct a dataset of aesthetically refined models, a selection of elegant-style dresses was curated, including examples of attire worn by First Ladies worldwide.

For neural network training, involving experts from the fashion industry, 300 models were selected—comprising aesthetically appealing, non-aesthetic, and test images for recognition system validation.

The consistency of expert opinions was assessed using Kendall's coefficient of concordance, focusing on the aesthetic evaluation of fundamental dress forms for standard body types of varying height and fullness.

A combined approach—leveraging artificial intelligence (AI) alongside expert judgment—has the potential to yield more objective and comprehensive assessments. AI enables the rapid processing of vast datasets, providing preliminary insights that can subsequently be refined and enriched through expert analysis. The synergistic integration of technology and human expertise fosters a deeper understanding of aesthetics, allowing for a nuanced consideration of diverse perceptual dimensions.

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