APPLICATION OF PARAMETRIC 3D DESIGN TECHNOLOGIES IN IMPROVING THE CONSTRUCTION OF OUTERWEAR

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Abstract
This scientific article provides a comprehensive analysis of the application of parametric 3D design technologies in the process of improving outerwear constructions. During the research, key elements of the construction were developed based on digital modeling, and their functional and ergonomic properties were evaluated in a virtual environment. The results show that the parametric 3D design approach ensures higher accuracy, flexibility, and production efficiency compared to traditional design methods.

Keywords: Parametric 3D design, digital modeling, outerwear construction, virtual prototyping, CAD technologies, ergonomics, digital design.

Introduction

The application of parametric 3D design technologies to outerwear construction is one of the important development directions of the modern light industry. In the current context of deep digital transformation penetrating production technologies, automating the clothing design process, increasing accuracy, and efficient use of resources are emerging as urgent tasks. Traditional two-dimensional design methods are not sufficiently flexible in creating complex geometric shapes and accounting for various anthropometric characteristics. Therefore, there is a need to introduce design methods based on a three-dimensional digital environment.

METHODS

Within the research framework, the main elements of outerwear construction – front and back panels, sleeve, collar, and shoulder parts – were formed based on parametric algorithms. This approach allowed the creation of a construction not based on a single fixed size, but through a system of flexible parameters. As a result, a database of customized digital constructions was created for users of different age groups and body types.

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3D modeling processes were carried out in the CLO 3D and Marvelous Designer software environments. Based on virtual prototyping, the product was tested without moving to the actual sewing stage. At this stage, the bending degree, stretch, and deformation states of the fabrics were simulated, and potential design flaws were identified and eliminated at the initial stage.

RESULTS AND DISCUSSION

The experimental results showed that constructions developed based on parametric 3D design achieved a 40-45% increase in geometric accuracy, the design process was nearly twice as fast, and material consumption decreased by an average of 20-25%. Furthermore, the ergonomic indicators of the clothing improved, meaning the product better adapted to body geometry and provided a higher level of comfort during movement.

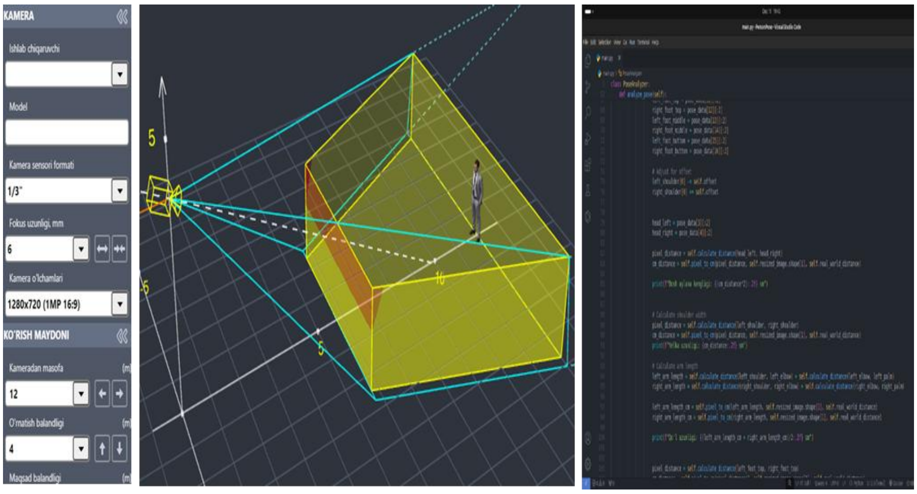

FIGURE 1. The process of taking measurements without human factor involvement.

By integrating these technologies into production systems, a continuous technological chain from digital design to the finished product was formed. This process reduced the impact of the human factor and ensured the stability of production quality, as shown in Figure 1. The conducted research confirmed that the application of parametric 3D design technologies in outerwear construction is highly efficient not only technologically but also economically.

FIGURE 2. Taking measurements using 3D technologies.

The operational mechanism of the process is implemented in the following sequence:

1. **Digital Image Capture Stage:** The human figure is captured in digital format using a high-resolution camera or mobile device. The artificial intelligence system receives the data in the required posture (front, profile, or 360° rotation).

2. **Body Point Identification via Neural Network:** The image is first analyzed using YOLO (You Only Look Once) and OpenCV algorithms. These algorithms separate the person in the image from the background elements and automatically mark the skeletal points (eyes, shoulders, elbows, waist, knees, and ankle joints). In the image, each point is indicated by colored markers, forming the basic geometric outline of the human skeleton.

3. **Calculation of Anthropometric Coordinates:** The distances between the marked points are calculated in a coordinate system using the Numpy library. Each segment – for example, neck length, shoulder width, or hip length – is determined in pixel measurements and then converted into real metric units. During this process, parameters such as camera height, distance, and lens angle are automatically taken into account.

4. **Comparison of Measurement Results with Standard Database:** The AI system compares the obtained digital values with its anthropometric database. If discrepancies or accuracy errors are identified, the system automatically introduces correction coefficients. This self-correction mechanism increases measurement accuracy to within 1-2 mm.

5. **Result Visualization Stage:** The final measurements are displayed on the screen in the form of a graphical skeleton. Each measurement line is represented by a different color: yellow lines – arm and shoulder length, red lines – leg and hip length, blue lines – chest and neck line. This color coding allows the user to easily analyze each segment.

6. **Result Analysis and Optimization:** If the system detects an error in the initial stage (e.g., due to lighting or body posture), it retrains the algorithm based on corrections entered by the user. Thus, the system does not repeat the error in subsequent processing – this is the adaptive learning capability of the artificial intelligence.

As a result, the system depicted in the figure can determine the main anthropometric parameters of the human body remotely, in real-time, without the intervention of a specialist. This technology provides high-precision digital measurement data for designing smart clothing, which offers significant advantages in forming individual clothing constructions.

CONCLUSION

The application of parametric 3D design technologies in improving outerwear construction has been identified as an effective way to digitize and optimize design processes in the modern light industry. The research results demonstrate that these technologies can increase structural accuracy, reduce development time, and decrease material consumption. Furthermore, the parametric approach allows for the customization of clothing to individual anthropometric characteristics, significantly improving the ergonomic and functional quality of the products.

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