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STUDY OF THE PROSPECTS FOR THE APPLICATION OF DIGITAL TECHNOLOGIES IN THE FASHION INDUSTRY IN THE DEVELOPMENT OF THE CREATIVE ECONOMY

KAMOLOVA MAFTUNA

Researcher of Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan
Phone.: (0891) 412-0441, e-mail.: maftuna2797@gmail.com

ABDUKARIMOVA MASHKHURA

Professor of the National Institute of Art and Design named after Kamoliddin Behzod, Tashkent, Uzbekistan
Phone.: (0888) 033-6383, e-mail.: mashkhura1720@gmail.com

USMANOVA NARGIZA

Researcher of Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan
Phone.: (0893) 534-8420, e-mail.: nargiza.usmanova.88@bk.ru

MAHSUDOV SHOHRUHMIRZO

Associate professor of Namangan Institute of Engineering and Technology, Namangan, Uzbekistan
Phone.: (0894) 309-7790, e-mail.: shohruxmahsudov@gmail.com
**Corresponding author*

Abstract: The article explores the capabilities of creating clothing forms and visualizations in a virtual environment. It examines the shape formation of women's loincloths designed using the Clo3D program, which leverages advanced digital technologies for 3D modeling, focusing on fabrics with identical fiber compositions. The study addresses the compatibility between virtual models and actual clothing forms, evaluates the quality of visualization in relation to the accuracy of the virtual model, and investigates the factors influencing material simulation during the shape acquisition process. The fiber composition of women's clothing models from various brands across different price segments was analyzed, revealing key characteristics that will guide the formulation of future research tasks.

Keywords: 3D modeling, Clo3D, virtual clothing, simulation, clothing patterns.

Introduction. Today, significant efforts are underway to enhance and support the creative economy in our republic. Notably, the 4th World Creative Economy Conference took place in Tashkent in early October, coinciding with the adoption of the "On Creative Economy" law in Uzbekistan [1]. This law aims to foster the development of the creative economy and regulate relations within this sector.

It is essential to highlight that design and art hold a prominent position among the various activities in the creative industry. By showcasing creative and scientific products globally, our country can enhance its international cooperation. The integration of digital technologies and artificial intelligence within the design and fashion sectors is particularly vital. This integration can significantly reduce the time, labor, and resources required to create new models. Moreover, the implementation of modern technologies in the light industry can elevate the methods used to aesthetically evaluate the quality of clothing and design to a new level.

By utilizing 3D scanning and modeling techniques, we can create virtual clothing models and simulate their appearance and fit on digital avatars derived from real data.

This capability is enabled by software such as CLO 3D, Browzwear, and Marvelous Designer, which leverage the physical properties of fabrics to accurately simulate how garments will fit on a virtual mannequin. The quality of visualization is closely tied to the precision of the 3D clothing model and its simulation.

These 3D models facilitate the analysis of aesthetic parameters such as shape, symmetry, proportions, and the combination of textures and colors. They provide insights into how harmoniously clothing appears on a virtual mannequin or avatar, considering various factors such as body type, movement, and diverse stylistic choices, thereby broadening the possibilities for design testing [2-7].

Methodology & empirical analysis. In research [8-9], to address the shortcomings in the realization of specific clothing model forms generated through 3D modeling systems, the initial information necessary for three-dimensional design was established. This information reflects the arrangement of volumetric forms in space relative to the surface of the mannequin. To predict the external form's development when creating new clothing models, the relationship between the silhouette angle of products (α) and the drape coefficient of fabrics (Kd) was identified, based on a series of measurements taken at the hip level and hemline of the garments. For the experiment, five different fabric compositions and properties were selected, and 150 variations of layouts with different lengths of two fundamental trapezoidal and oval shapes were examined. Additionally, in study [10], numerical values for landing quality criteria were established to predict landing defects in the Rhinoceros virtual environment, and subsequent adjustments were made to the drawings to rectify these defects.The aim of this article is to evaluate the quality of visualization of the 3D clothing model created using the Clo3D program and to assess its simulation accuracy. Additionally, the article analyzes the factors influencing material simulation during the shaping process. According to studies [7-8], the changes in shape-forming parameters of fabrics, characterized by varying lengths, fiber compositions, and properties, have been established. Our objective is to determine whether the simulation of materials in the shape formation of garments with identical lengths and fiber compositions adheres to these established principles. To achieve accurate visualization of clothing quality in a 3D environment, the following steps are proposed:

- accurate and correct input of height dimensions;
- construction drawing quality;
- criteria such as the accuracy of information about fabric properties are important.

The product development process in CLO3D begins with selecting avatar models, which are available as representations of men, women, and children. The Avatar Size interface allows for adjustments to the parameters of the selected avatar, including height, width, and body dimensions (Figure 1). This graphical editor also enables customization of the digital mannequin's appearance, allowing experimentation with skin tone, hair color, and pose adjustments. Several visualization options are available for the avatar; it can resemble a human with a textured surface that mimics a human body, be stylized with a monochrome surface featuring eyes, or take the form of a mesh mannequin with eyes.

To ensure accurate simulation, it is essential to input body dimensions correctly; otherwise, the results may not reflect reality [3, 11-12]. It is known that the study presented in reference [10] discusses the virtual appearance and positioning of women's shoulder garments, such as blouses, along with the causes of defects and methods for their elimination. For our research, we selected a women's skirt as the focal point to analyze its shape and silhouette in virtual reality, followed by an assessment of its compatibility with a real sample. Initially, measurements were taken for the waistline of the existing real mannequin, which has dimensions of 88-69-96 (Vlt - waistline height, Dsb - height from the waist to the floor, Dsp - height from the waist to the floor, Vps - height of the buttock fold, Dlob - length of the groin area, Vb - height of the bed, db - transverse diameter of the hip circumference, dpzb - front-back diameter of the hip circumference).

A total of 11 height symbols were recorded, including H (height), IH (height of the buttock fold), WH (waistline height), LHH (hip line height), BC (chest circumference), WC (waist circumference), LHC (hip circumference), TR L (arc through the groin area), as well as the height of the hip line for control, front-back in LM1,2 (hip line) and transverse diameter linear lengths. These measurements were then entered to create an avatar (Figure 1).

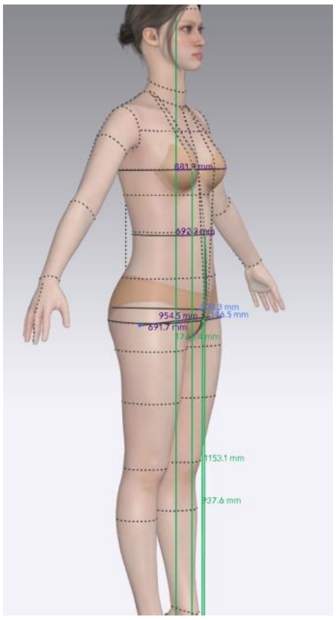


Figure 1. Edit parameters of the avatar using the Avatar Editor menu.

A trapezoidal shape was selected for the skirt model. Based on the analysis of shaping methods, it was established that trapezoidal forms of model constructions are developed using techniques of conical expansion of the basic construction details【9】. The model construction of this shape is projected based on BK, which is built according to the "Muller & Sohn" method, with a typical figure of 164-88-96.Based on the construction of the prepared model, a corresponding virtual model was created using the Clo3D program (Figure 2). Nine different fabrics (F1-F9), all comprising 100% cotton, were selected based on four fundamental parameters—Construction, Composition, Weight, and Thickness (Figure 3)—to analyze the simulation of the virtual shape obtained in Clo3D and the contours of the external borders. To avoid ambiguity in visualization against the program's white background, the majority of the white fabrics in the database were assigned a light pink color (#F2A4A6) when applied to the virtual mannequin.

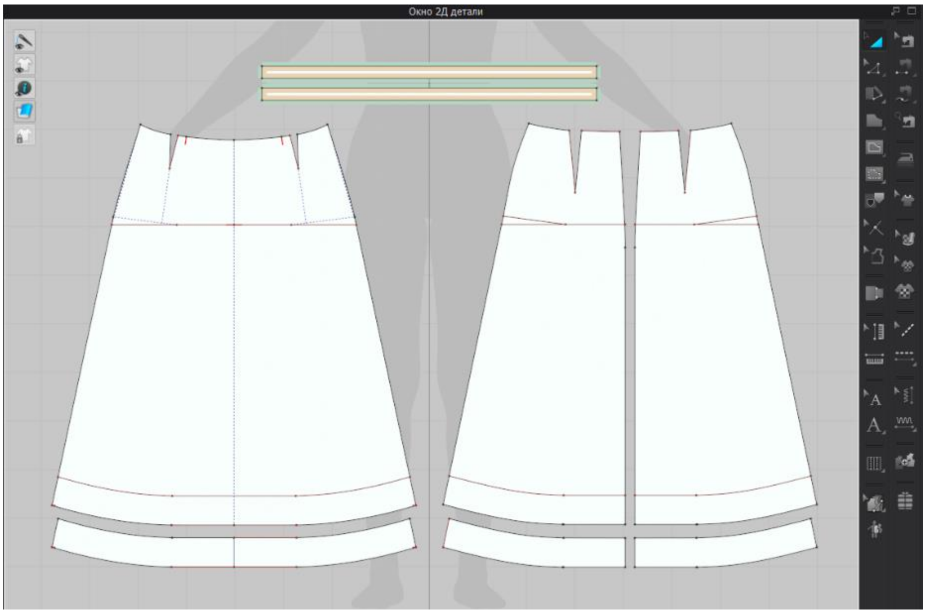
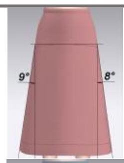
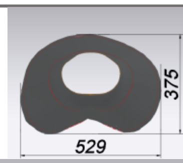
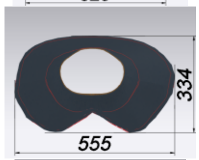
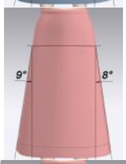
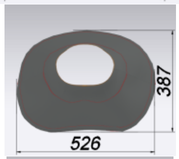
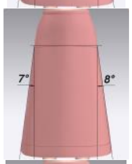
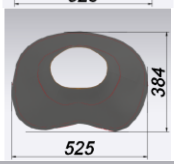
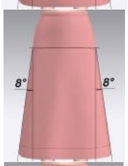
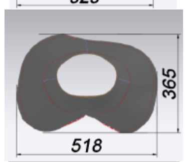
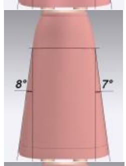
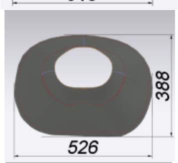
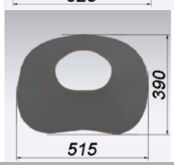
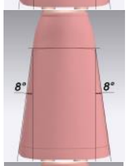
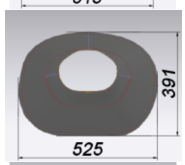
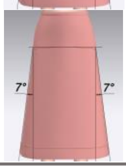
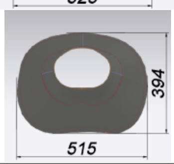


Figure 2. 2D model of the model made in Clo3D.

Figure 3. Indicators of test materials based on the Clo3D program.

Results. The obtained results were photographed and analyzed based on it. The front-back and transverse diameters of the skirt, the angle of spread from the bust line, and the visual appearance of the skirt were studied from the front, back and side sides, as well as the bottom view of the skirt, created on the basis of simulation. The obtained data were recorded in the form of a table (Table 1).

Table 1

№	Fabric name	Density (g/m2)	Thickness (mm)	Front	Bottom view
F1	Cotton Voile	79,29	0,21		
F2	Cotton 40s Chambray	81,31	0,23		
F3	Cotton 50s Poplin	108,08	0,24		
F4	Cotton 40s Poplin	129,29	0,27		
F5	Cotton Sateen	137.87	0,32		
F6	Cotton Gabardine	192,42	0,38		
F7	Cotton Twill	193,43	0,44		
F8	Cotton Canvas	246,97	0,55		
F9	Heavy Cotton Twill	277,77	0,62		

The dynamics of size changes in the test skirt forms are illustrated in a diagram in Figure 4, which exemplifies the relationship between the front-back and transverse diameters, as well as the surface densities of the fabrics.

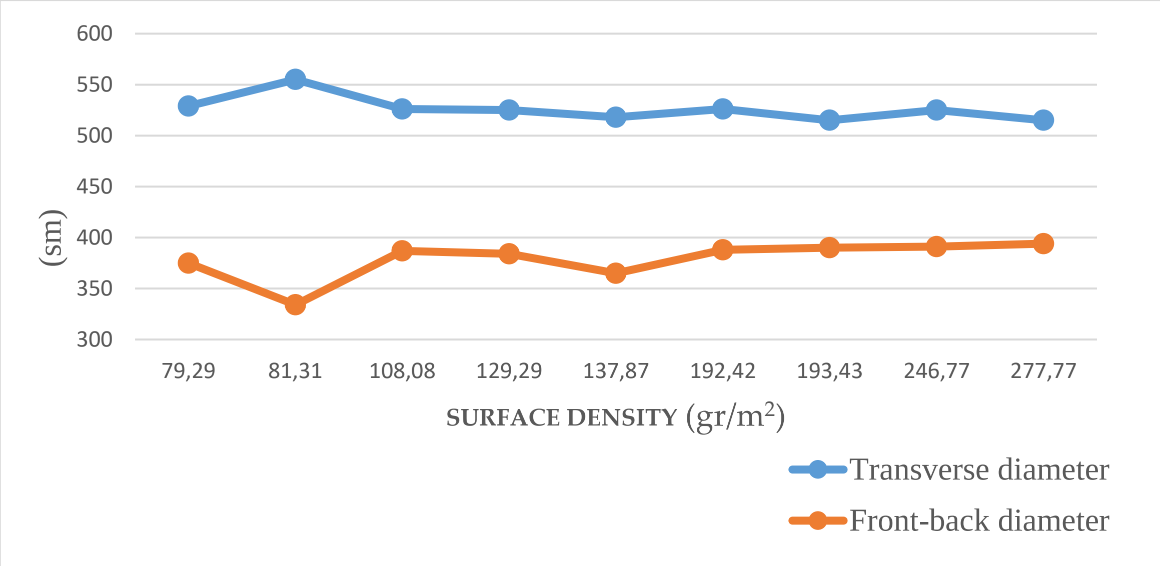


Figure 4. The dynamics of changes in the front-back and transverse diameters of the maximum width of skirts with a change in surface density.

According to the diagram, the maximum width of the simulated skirt shape using fabric F1, which has the lowest surface density among Clo3D-based cotton fiber fabrics at 79.29 g/m², measures 529 mm in transverse diameter and 375 mm in front-back diameter. It is evident that these measurements vary with changes in the surface density and thickness of the fabrics. Specifically, for the second fabric (F2), the transverse diameter increased to 555 mm, representing a 26 mm increase compared to F1, while the front-back diameter decreased to 334 mm, a reduction of 41 mm, resulting in more folds in the hem's projection shade. In other fabrics, a nearly periodic decrease in both measurements was observed. For the last fabric (F9), the transverse diameter measured 515 mm, and the front-back diameter was 394 mm, showing a decrease of 14 mm and 19 mm compared to F1, and differences of 40 mm and 60 mm when compared to F2. In conclusion, it can be stated that as the thickness and surface density of most fabrics increase, the transverse diameter of the skirts decreases (F1 to F9: -14 mm), while the front-back diameter tends to increase (F1 to F9: -19 mm) (Figure 4).

Building on this experience, the first objective was to evaluate how accurately the simulation of the skirt created using the basic data in the Clo3D program reflects the shape of the actual model. For this purpose, three fabric samples were selected according to the first experiment, and their properties related to four specific characteristics were determined under laboratory conditions. The fabric characteristics were analyzed in the "SANTEXUZ" laboratory at the Tashkent Institute of Textile and Light Industry, and the results for properties such as composition, weaving, thickness, and surface density are presented in Table 2. Since the surface density of the analyzed fabrics is similar to that of fabric F4 (129.29 g/m²) in Clo3D, these properties were selected for simulation. The determined indicators were then input and converted into actual fabric properties.

Table 2. Physical and mechanical properties of selected gases.

Fabric number	Fiber content	weaving	thickness (mm)	Surface density (g/m²)
1	100% cotton	satin	0,20	121,83
2	100% cotton	polotno	0,25	112,76
3	100% cotton	satin	0,20	119,9

To ensure the visual appearance of the models closely matched, the real fabric color and print were imported into the Clo3D program and simulated on the skirt model from the previous experiment. To analyze the virtual shape, the model was photographed from four angles—front, back, right, and left—as well as from the bottom. A real skirt was also sewn using the same selected fabric and based on the pre-designed trapezoidal skirt pattern, with corresponding photographs taken. The back diameter and other parameters, such as length, were verified. The data was processed using AutoCAD software (Figure 5).

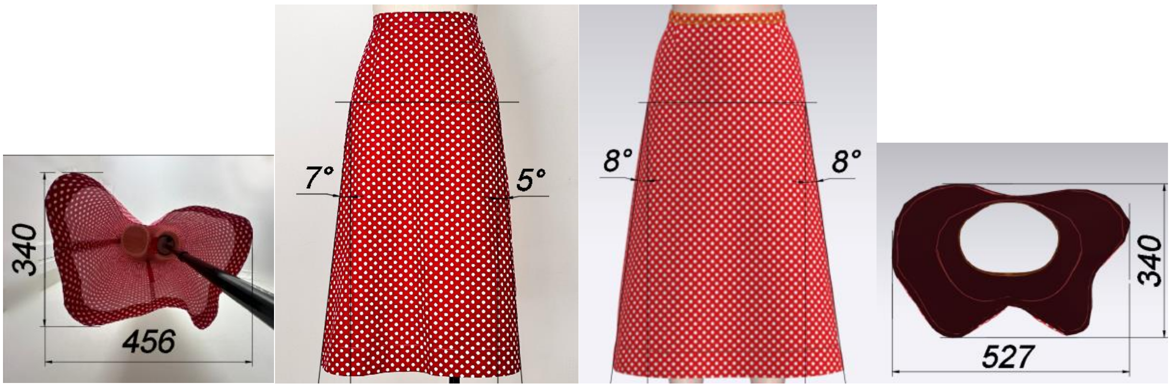


Figure 5. Comparative analysis of skirt shape in real (left) and virtual reality (right).

To assess the compatibility between the virtual skirt shape obtained in Clo3D and the actual sewn skirt, the angles of the garment's hem relative to the bust line were measured. In the real skirt, the left hem spread was 5°, and the right hem spread was 6°. However, in the virtual skirt, both the left and right hem spreads measured 8°, revealing a difference of 3° on the left side and 2° on the right side. Additionally, the real skirt's transverse diameter was 456 mm, while its front-back diameter was 340 mm. In contrast, the virtual skirt's transverse diameter was 527 mm, with the front-back diameter remaining the same at 340 mm, indicating a 71 mm difference in the transverse diameters. These discrepancies suggested that inputting only four parameters into the Clo3D database was insufficient. This realization led to a deeper exploration of the program's capabilities. Specifically, the "Property Editor" window, which provides detailed fabric characteristics beyond the basic properties, was examined. This window is activated by selecting a specific base fabric and provides detailed information divided into three main categories. The first category, "Information," includes general details such as fabric name, coding, and information about the individual involved in its creation, along with construction and artistic elements. The second category, "Material," offers details on the fabric's appearance, structure, and optical properties. The third and most critical category for material simulation is "Physical Property." This section contains information on the fabric's physical-mechanical attributes, including longitudinal and diagonal stretching (Shear), bending, buckling (Buckling Ratio), stiffness (Buckling Stiffness), moisture absorption (Internal Damping), density, friction, thickness, and others. Input is required for each property in the weft, warp, and 45º diagonal directions (Bias), as well as for the right and left sides (Figure 6).

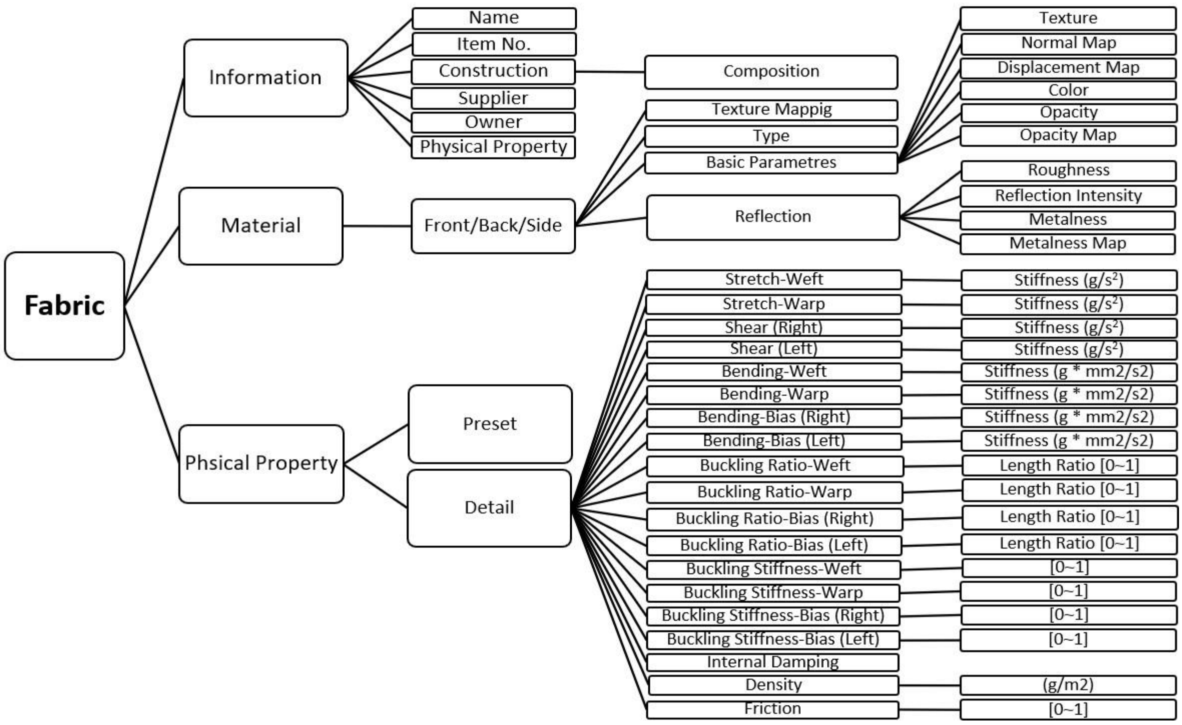


Figure 6. Data entry system for gasification in CLO3D automated software.

Although the program provides baseline values for each of these fabric properties, they do not always correspond to the actual characteristics of real fabrics. Specifically, when reviewing the parameters offered by the program for the 9 fabrics used in the first experiment described in the article, it was observed that all the fabrics shared identical numerical values for the Buckling Ratio and Buckling Stiffness properties, as shown in Table 3.

To assess the reliability of this data, the non-creasing index of three real fabric samples was tested under laboratory conditions. The results revealed a significant difference in the non-creasing properties of fabrics that share the same fiber composition, surface density, and thickness (density variation: ±9 g/m²; thickness variation: ±0.05 mm), as shown in Table 4. However, in the Clo3D program, despite the fact that the 9 virtual fabrics exhibited a substantial variation in surface density (almost 200 g/m²) and thickness (0.41 mm), they all displayed identical creasing and non-creasing properties.

Table 3.

№	Name of Fabric	Stretch (g/s2)				Bending (g*mm2/s2)				Buckling Ratio [0-1]				Buckling Stiffness [0-1]				Density (g/m2)	Friction [0-1]
				Bias				Bias				Bias				Bias			
		weft	warp	right	left	weft	warp	right	left	weft	warp	right	left	weft	warp	right	left		
F1	Cotton Voile	36	49	15	15	41	50	48	48	30	30	30	30	25	25	25	25	5	3
F2	Cotton 40s Chambray	42	33	10	10	38	48	43	43	30	30	30	30	25	25	25	25	5	3
F3	Cotton 50s Poplin	57	58	29	29	49	57	51	51	30	30	30	30	25	25	25	25	8	3
F4	Cotton 40s Poplin	57	49	32	32	50	53	51	51	30	30	30	30	25	25	25	25	10	3
F5	Cotton Sateen	36	49	20	20	39	57	51	51	30	30	30	30	25	25	25	25	11	3
F6	Cotton Gabardine	61	60	48	48	57	66	63	63	30	30	30	30	25	25	25	25	16	3
F7	Cotton Twill	58	58	55	55	51	65	59	59	30	30	30	30	25	25	25	25	16	3
F8	Cotton Canvas	61	59	45	45	63	68	66	66	30	30	30	30	25	25	25	25	22	3
F9	Heavy Cotton Twill	59	58	58	58	63	68	66	66	30	30	30	30	25	25	25	25	25	3

Table 4.

Fiber number	Fiber content	No wrinkling (%)	
		Body	Weft
1	**100% cotton**	**48,8**	**51,1**
2	100% cotton	46,6	45,5
3	100% cotton	51,1	53,3

At the same time, the materials available in the Clo3D database in terms of fiber composition are diverse. To establish parameters for further research, it was necessary to analyze which types of fabrics, based on fiber content, are primarily used for women's dresses in the mass-market, middle-up, and premium segments. For the study, brand stores in "Tashkent City Mall," "Podium," and "Glamour" boutiques were selected. About 200 dress models from three major price segments were reviewed, including mass-market brands like Zara, Stradivarius, Mango, H&M, adL; middle-up brands such as Maje, Massimo Dutti, Pinko; and premium brands like Twinset, Hugo Boss, Gucci, Dior, Carolina Herrera, Lanvin, MaxMara, and Tory Burch. Significant differences were observed in the fiber content between the mass-market and premium segments. In the mass-market brands (Stradivarius, Zara, and Mango), fabrics like 100% cotton, polyester, viscose, cotton-linen blends, and various polyester-elastane, viscose-polyester-elastane combinations were common. H&M and adL, on the other hand, primarily used mixed fiber fabrics such as polyester-elastane, cotton-linen, linen-rayon-viscose, and ecovero-polyester.

In the premium segment, a variety of mixed and natural fiber fabrics were prominent, including 100% viscose, polyester, cotton, linen, silk, and wool, along with blends like cotton-elastane, viscose-spandex, wool-mohair, silk-viscose, and wool-cashmere. These premium fabrics exhibited a wide range of mixed fiber compositions, including cotton-polyamide-elastane, polyester-viscose-elastane, triacetate-polyester, and others. The fiber content percentages of these mixed fiber fabrics are presented in Table 5.

Table 5.

Analysis of shirts of different brands of the world

Segment	Brend nomi	Mato tarkibi
Mass production (mass market)	Stradivarius	100% polyester; 95% cotton 5% elastane; 83% cotton 17% flaxen; 66% viscose 30% polyamide 4% elastane
	H&M	62% viscose 33% polyamide 5% elastane; 87% polyester 13% spandex; 55% cotton 45% viscose
	ZARA	100% polyester; 100% viscose; 100% cotton; 92% cotton 8% elastin; 97% polyester 3% elastin
	MANGO	100% polyester; 100% cotton; 70% viscose 24% polyester 6% elastane; 56% polyester 44% viscose; 96% cotton 4% elastane
	adL	93% ecovero 7% polyester; 88% polyester 12% elastane; 55% cotton 45% flaxen; 47% flaxen 36% rayon 17% viscose; 58% viscose 42% rayon
Middle (middle, middle-up) segment	Massimo Dutti	100% polyester; 100% atsetat; 86% flaxen 14% viscose; 59% viscose 37% cotton 4% metallized fiber; 82% viscose 18% flaxen
	PINKO	100% viscose; 94% polyester 6% elastane; 91% atsetat 9% polyester; 79% cotton 18% polyamide 3% elastane; 59% flaxen 38% viscose 3% elastane
	maje	100% polyester; 83% polyester 15% polyamide 2% elastane; 46% polyester 42% viscose 11% polyamide 1% elastane; 45% polyester 27% polyamide 26% metallized fiber 2%elastane
High (premium, luxury) segment	TWIN SET	100% polyester; 100% viscose; 100% cotton; 96% cotton 4% elastane; 95% viscose 5% spandex; 85% viscose 13% polyamide 2% elastane; 75% liosel 25% flaxen
	HUGO BOSS	100% viscose; 96% polyester 4% elastane; 64% polyester 31% viscose 5% elastane; 51% polyester (retreaded) 49% polyester; 22% viscose 7% elastane
	TORY BURCH	100% flaxen; 100% silk; 100% viscose; 100% cotton; 96% cotton 4% elastane; 83% viscose 17% polyester
	MaxMara	97% silk 3% elastane; 85% wool 15% moxer; 71% triatsetat 29% polyester; 56% triatsetat 44% polyester
	LANVIN	100% wool; 100% viscose; 67% viscose 31% acetate 3% elastane; 58% cotton 24% polyester 14% acrylic 4% polyamide
	CAROLINA HERRERA	100% wool; 97% wool 3% elastane; 90% wool 10% kashemir; 92% polyester 8% poliuretan; 83% viscose 17% polyester; 75% cotton 23% poiester 2% elastane
	GUCCI	100% wool; 100% viscose; 100% cotton; 100% polyester; 55% silk 45% viscose; 52% acetate 29% silk 19% viscose
	DIOR	84% wool 16% silk; 83% polyester 17% polyamide; 82% cotton 18% polyamide; 77% wool 23 silk

The use of fabrics with a wide variety of fiber content in the garments of global brands necessitates that the base data in Clo3D align with these requirements. These factors play a crucial role in determining the quality of clothing visualization.

Conclusions:

- In virtual models generated using the default fabric data provided by the Clo3D program, it was observed that fabrics with identical fiber content exhibit variations in shape based on factors such as silhouette angles and the transverse and front-back diameters of the hem width. As the surface density and weight of the fabrics increased, a reduction in the transverse diameter of the garments was noted, while the front-back diameter expanded.
- When comparing the visual form of virtual garments created in Clo3D with real clothing models using photographic images, a significant discrepancy is observed between them. This indicates that uncertainties still exist in optimizing the program for efficiently designing new clothing models, enabling virtual try-ons without material costs and excessive time, and providing visual assessments of the design. Specifically, the quality and precision of the visualized model are directly influenced by the accurate input of virtual mannequin dimensions, precise construction drawings, and proper simulation of fabric properties. These factors necessitate standardizing the anthropometric points and size markers when entering mannequin dimensions, selecting appropriate structural elements, and defining all fabric characteristics. Additionally, accurately simulating fabric features is a time-intensive and costly process. To address these issues, it is essential to determine a coordination coefficient at each stage of the process.

When analyzing the fiber composition of women's dress models presented by global brands, notable variations are observed in both material coverage and percentage. This raises the potential for discrepancies when aligning fabric property data within the Clo3D database to these models. Such challenges encourage further exploration of the program's full capabilities and promote the task of comprehensive learning.

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