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CLO3D Simulation versus Real Drape Test for Assessment of Garment Drape Coefficient

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Abstract

Nowadays, the era of virtual fashion and simulation is of prime importance in clothing technology. Virtual fashion necessitates the accuracy of the virtual garment product. On the contrary, the physical sampling trials are time and material-consuming. Herein, we suggest a method for the fashion designer to visualize the drape coefficient value of the fabric using virtual garment products, to help the designer produce an identical virtual piece of the actual product. This method is based on the fabric drape coefficient test, as the drape coefficient reflects all fabric characteristics. In this work, several trials were conducted virtually to measure the validity of the capability test, and to correlate it with a virtual standard. Three different fabrics, cotton, polyester, and cotton polyester blend (50/50), were used in this study. The physical parameters were investigated following the *CLO3D* software standard method.The assessment of the final form of garment appearance must be referred to as values to avoid the conflict of human judgment. Therefore, the drape coefficient of fabrics was measured (using shadow analysis), in both real and virtual phases, and the relationship between them was assigned. Four types of flared skirts were used to assemble the fabrics based on the angle of construction, and three skirt lengths were used virtually. The skirts were simulated using *CLO3D* software and the skirt's hemline formation shape was analyzed, to find the most descriptive flared skirt to the drape coefficient value.

Keywords: Garment simulation, fabric physical parameter, fabric drape coefficient, flared skirt analysis, *CLO3D* system

Introduction

About four decades ago, *3D* virtual clothing simulation systems were introduced into different fields of computer graphic industries; Viz. games and animation [1]. Later in the last century, new business models have been created through IT and Web*3D* technology as an innovative pattern in the digital fashion industry [2] By the dawn of the new millennium, there has been a regular upsurge in the investigation and implementation of *3D* virtual simulation software programs in the planning of long-term strategies by many fashion brands and retailers [3].The accuracy of the virtual garment product is the clue to the success of the simulation process. In addition, the quality of garment appearance depends on several fabric characteristics [4]. As the garment simulation system is a concept of sustainability concept, though they work to reduce leisure time, and material consumption and save energy. Different simulation software applications worked to get the best quality of simulation results. Different approaches were adopted to introduce fabrics on garment simulation. For example, Optitex, Modaris, and DC suite software applications are highly dependent on the “fabric low load physical system”, like the FAST system and Kawabata Evaluation System. *CLO3D* and Browzwear software applications

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developed their system to test the physical fabric parameters but in specific values and procedures. All these modules were suggested to feed the garment simulation software with accurate data [5-6].

One of the most important comfort attributes of any textile product is its drapeability and many approaches have been investigated to decrease fabric stiffness, and hence to improve the fabric drapeability [7].The drape test reflects the complete image of all the manufacturing, treatment, and finishing processes applied to the fabric. The fabric drape tester based on the Cusick's is the most popular method, using digital image processing, for its accuracy [8]. The drape coefficient is defined as the difference between the shadow of the falling fabric of a circular textile sample under its load, when it is partially supported by a cylinder holder, and the complete fabric sample shadow. The way of drapablility of the flat fabric and garment is different, which makes the scientists try to find a new assessment way [9]. This is due to the different behavior of fabric falling between the fabric used in the construction of the garment piece and the fabric used to measure the fabric drapability. The former fabric is sewn, and falls vertically on a curved human body upon wearing, whereas the latter falls horizontally under its own load, supported with a central cylinderical holder in the drape test. Whereas, Mei et. al., demonstrated that the drape analyses are required because the drape coefficient test results (the reflection of drapped sample shadow, as Cusick drape meter standard method) are not sufficient to describe well the fabric drape behavior on the human body on garment simulation software [10].Chen et al. studied the difference between the drape of square and circular samples and make a comparison [11]. Also, they made several ways of capturing the sample draped, with three methods; the 1st one is capturing the normal photo, the 2nd is *3D* scanning and the 3rd is reconstructing the sample drapped on a virtual cylinder object on *3D* software. They reported that the fabric's physical parameters have a strong effect on the fabric drape form, such as the tensile, elongation, and stiffness. The material differential effect was observed under the same condition of simulation [11]. Miguel et al. tested the fitting of two fabrics using a normal skirt to assess the fitting of a jacket, the fabrics are similar, but the first fabric is one layer and the second is a double layer [12]. The drape coefficient was analyzed, and it was found that the difference between the two fabrics was clear, as the one-layer fabric took a shape of a drape profile more than the double layer, which means that the weight of the fabric has a clear effect on the drape coefficient [12]. The flared skirt is considered the best garment piece that acts the behavior of fabric drapability, as it stimulates the flat circular drape test sample but in a *3D* form. Several previous studies worked to find a new definition of garment drapability through the flared skirt. El Gholmy studied the nodes number affected by skirt length and angles, on a small scale, and different lengths. The author concluded that, in the case of the 360º and the 270º flared skirts, the number of flares aredirectly proportional to the skirt length. The drape index can't be abbreviated on the effect of flared skirt length, but this method visualized the effect of fabric drapability on the garment [13]. The flared skirt usage in simulation confirms the hypothesis which assumes that flared skirt can describe the drape coefficient even in reality and virtually, due to the flares count and dimension. The appearance attributes are highly affected by the drape coefficient values [14]. The garment simulation software can make a new conceptfor garment production [15]. The comparison between real and virtual fabric worn on the human body, at the moment, is under study. The main factor that controls the accuracy of garment virtual results quality is the fabric drape coefficient. Different studies confirmed that the drape coefficient is an essential fabric characteristic, and it is of prime importance to express the drapability in numerical values using different garment simulation software [16]. Lee et al. studied the physical parameter and analyzed the drapability of different types of fabrics using image analysis, and compared it virtually. They found a strong relationship between the fabric profile and the final form of the garment, through the flared skirt. It has been reported that no numerical values can be used individually to assess the drapability of fabric through the analysis of the final form of the garment. It differs according to the categories of drape (stiff or drape fabric) [17]. The particle distance of virtual garment fabric must be considered, as it is highly effective on the reality of the garment's appearance [13].

Experimental

Material

Three plain woven fabrics (balanced structure) in different weights were selected. The properties of the used fabrics are summarized in Table 1.

TABLE 1. Profile of the used cotton, polyester, and cotton/polyester blended fabrics

Fabric	Fabric code	Weight (g/m^2)	Thickness (mm)	Yarn(weft) cm	Yarn (warp)	Number of yarn (Tex)
Cotton 100%	 Carreau	117	0.16	49	29	14
Cotton/ polyester (50/50%)	 Fleurie	147	0.34	30	20	18
100% polyester	 Blue	193	0.461	16	12	66

Methods

The representation of fabric drapability behavior was simulated using *CLO3D* software. The fabric's physical parameters; namely the bending length, stretchability, thickness, and weight, were investigated according to the *CLO3D* emulator method [5].

Fabric simulation

In this study, we adopted the *CLO3D* software on the flat samples of the said fabrics to simulate their drapability. The sample was draped on a 3D object constructed on blinder software to simulate the Cusick drape test meter, and the shape of the draped sample as well as the number of nodes, was studied (Figure 1).

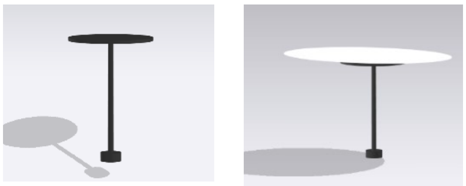
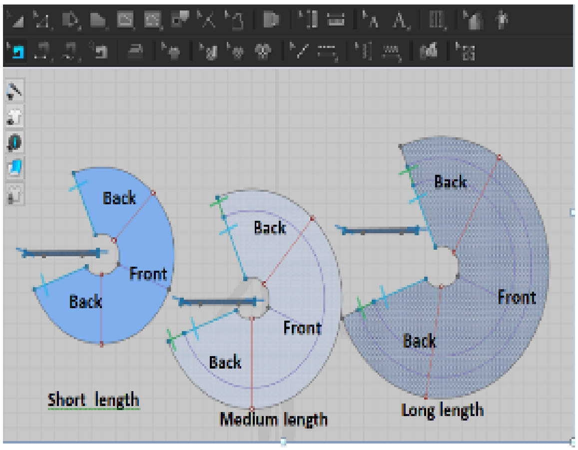


Fig. 1.(left) object constructed, and (right) fabric assigned to be simulated on the constructed object

The fabric thickness was measured according to ASTM-D1777-96, the mass per unit (weight) was measured according to ASTM-D3776-96, the pilling test using Martindale according to EN ISO 13936-1:2004, the drape resistance according to BS 5058, the dry crease recovery angles was measured using the Meterimpex crease

The construction elements of skirts were limited, with only a flat band to fix and fit the skirts on the virtual body; and the sewing property was unified throughout the skirt (Figure 2) (Circle Skirt Formulas: Calculate Your Circle Skirt Radius! -The Creative Curator). Simulation and rendering properties were common for both, the flat samples and the flared skirt, each separately, in order to unify the dimensions ratio of each. All skirts were captured from the same position (beneath the piece) to analyse the drapability of the skirt hemline on the virtual avatar. For the 3D simulation, the *CLO3D* standard avatar was used to study the flared skirt drapability.



(a)

(b)

Fig. 2. The 2D pattern window of the 270° flared skirt with different lengths (a), and skirts are worn on *CLO3D* standard Avatar (b); Avatar was hidden for a better view

Simulation process

The Flared skirt was assembled virtually using *CLO3D* simulation software. Four angles of Flared skirts were constructed using the circular geometric method (90◦, 180◦, 270◦, and 3600) [18]. The Skirts were applied in three different suggested lengths according to knee height.(Over knee height 40cm, knee height 54 cm, and lower knee height 68 cm). The skirt is virtually assembled using one back seam line (Figure 3).

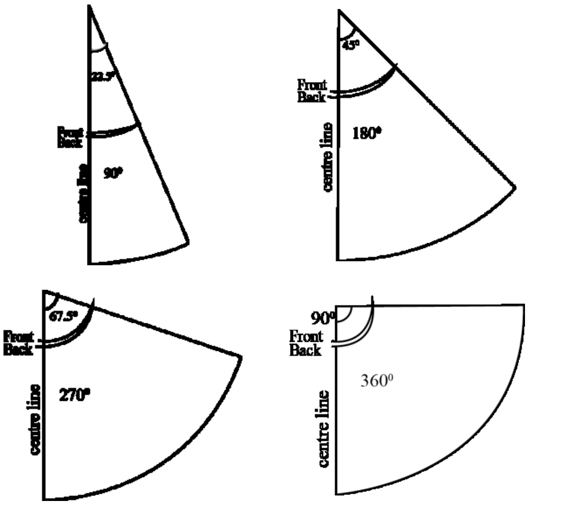


Fig. 3. Circular flared skirt method based on the angel

Analyses

Fabric drapability

The real and virtual drapability of the selected fabrics was examined using the Cusick drape meter device, where the sample circle diameter is 25 cm; hold on a 10 cm circular disk. The shadow of the fabric circular sample was digitally captured and the area of draped shadow was analyzed using Adobe photoshop to investigate the drape coefficient percentage [5]. To validate the method, the fabric drapability test was simulated as the real test on the simulated object in Figure 1, and the shadow of the said sample was analyzed according to the following equation [19].

$$\mathrm{DC}(\%) = \left[\frac{A_s - A_d}{A_D - A_d}\right] \times 100 \qquad \text{(Eq. 1)}$$

Where: "A_s" is in the area of the shadow obtained from the projection of the draping fabric specimen by cm^2, "A_d" is the area of the shadow obtained from the projection of the sample holder in the initial position by cm^2, and "A_D" is the area of the shadow obtained from the projection of the fabric specimen in the initial position by cm^2 [19].

Analysis of the skirt hemline form

To analyze the hemline form, the skirt position was captured from the bottom view. The captured photo was then illustrated and transformed to measure areas of the hemlines. These measured areas of the skirt hemline were described using pixel count ratio on Adobe Photoshop software as shown in Figure 4.

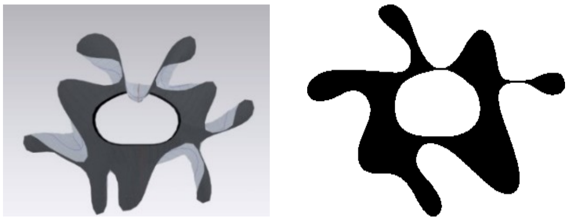


Fig. 4. The view of hemline form the capturing angle

Statistical analysis

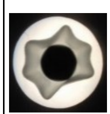
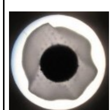
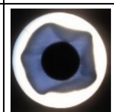
The relationship between the different hemline areas and flares number skirts, and the drape coefficient was statistically analyzed. The significance of this relationship was investigated using regression analysis and the R2 was calculated.

Results and Discussion

The relationship between real and virtual Drape coefficient

The drape coefficient (DC) values of the carreau, fleurie, and blue fabrics using the virtual method, compared to real one were summarized in Table 2. The data in this table indicates although there is a remarkable difference in the DC of the examined fabrics using the real system, yet the DC values of the three samples are relatively closer to each other upon using the virtual system. These discrepancy discrepancies in the values of the DC between the real and virtual method implies that the latter method is not the proper method to reflect the actual drapability of the examined fabrics. It is noteworthy to mention that the number of nodes in the case of real and virtual methods is the same. This finding is similar to previously reported results using Optitex [19].

TABLE 2. The nodes number of examined fabrics in both phases (Real and virtual)

	Real sample	Real DC (%)	Virtual Draped samples	Virtua l DC (%)	No. of Nodes(a)
Carreau		36.03%		39.9%	6
Fleurie		51.7 %		37.86%	5
Blue		46.4 %		39.1%	5

Results of the statistical analysis, shown in Table 3, indicate that there are is a strong negative relationship (-0.944) between the DC values in real and virtual methods. Nevertheless, the regression analysis proved that this value is not significant, as indicated by the p-value (>0.05). This finding is in harmony with the obvious visual discrepancy among the fabric shadows of the real and virtual methods.

TABLE 3. The nodes number of examined fabrics in both phases (Real and virtual).

	Weight (g/m^2)	Real DC%	Virtual DC %
Weight	1		
Real DC (%)	0.554929	1	
Virtual DC (%)	- 0.25036	- 0.94434*	1

Non-significant results (p-value more than 0.05)

The hemline area form and number of flares analysis

Figure 4 shows the different areas of the hemline of the skirt. The hemline areas were measured and traced as shown in table 4. The relationship between the fabric drape coefficient and hemline areas and the number of flares were statistically analyzed.

The differences between lengths and angles of the flared skirts were studied, for both the calculated areas of the hemline form and the number of flares of the skirts. Table 4 presents the areas of hemline forms after simulation of the skirt on the avatar on *CLO3D* software; and the difference between all lengths group in the same angle has recorded a non-significant difference between calculated areas of the hemline forms. On the other hand, the difference between the lengths of the skirts was highly significant.

Table 5 shows the number of flares of the skirts, the difference between the number of flares, and the difference between all the lengths group was not significant to expect the difference between the angles for the short length, in which, the P-Value was highlysignificant (>0.001). And the difference between lengths in the number of flares was non-significant.

The relationship between the drape coefficient and the skirt hemline area

The hemline area form is shown in Figure 5, and the results were gathered in 3 groups according to the fabric. Table 4 lists the hemline forms of the different skirts in all angles and lengths. It is clearly observed that, all angles and lengths, are differed. Each size has its characteristics in forming the hemline. The relationship between DC% and the different skirts was investigated. Different skirt sizes noted a relationship.

TABLE 4. The hemline form of the flared skirt from the bottom view angle

Angle	Fabrics	Skirts lengths		
		Long	medium	short
360 °	Blue			
	Fleurie			
	Carreau			
270 °	Blue			
	fleurie			
	Carreau			
180 °	Blue			
	Fleurie			
	Carreau			
90 °	Blue			
	Fleurie			
	Carreau			

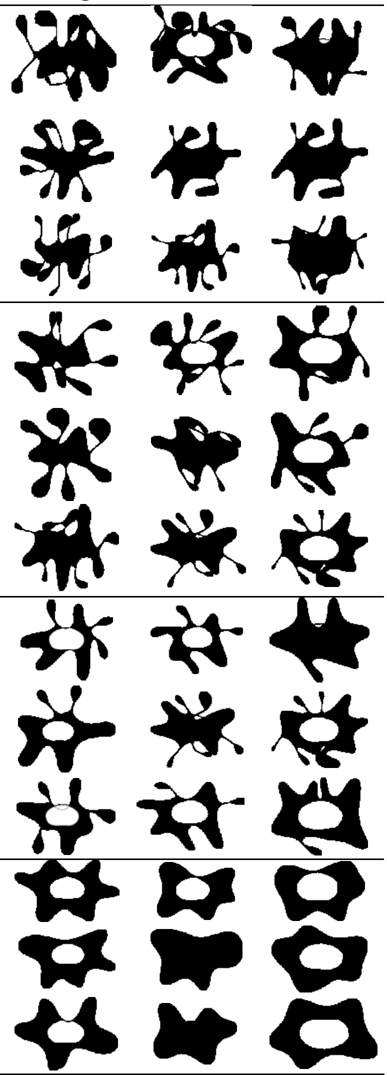


TABLE 5. The number of flares of the flared skirt from the bottom view

Skirt length	Fabric	Number of flares at			
		360°	270°	180°	90°
Long	Blue	11	9	7	6
	Fleurie	10	8	6	5
	Carreau	12	9	7	5
Medium	Blue	11	9	7	5
	Fleurie	8	8	9	4
	Carreau	10	9	7	5
Short	Blue	9	8	6	5
	Fleurie	9	8	6	5
	Carreau	11	9	7	5

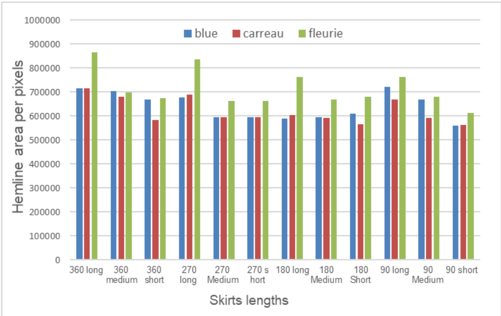


Fig. 5. The graph represents the areas of the hemline by pixels count of skirt worn on the virtual avatar, grouped by flared skirt pattern making angle

It is observed that, there are several angles of all lengths. The short 360 º skirt is strongly correlated but not significant with very low R^2. The short 180 º and the medium 90 º are also correlated but not significant with high R^2. And finally, the 90 º long length was highly correlated with a trusted R^2 with a P-value of 0.007 as shown in Table 6. This result has a great value, is that the skirt in the smallest size, even the longest length. In the future, it could be a physical sample after several virtual trials.

TABLE 6. The correlation coefficient between skirts hemline shadow area and drape coefficient

	Weight	*Thickness*	*DC %*
Weight	1		
Thickness	0.965	1.000	
DC %	0.555	0.753	1.000
360 L	-0.127	0.136	0.755
360 M	0.898	0.982	0.864
360 S	0.754	0.899	0.965
270 L	-0.197	0.065	0.706
270 M	-0.101	0.162	0.771
270 s	-0.101	0.162	0.771
180 l	-0.194	0.068	0.708
180 M	-0.080	0.183	0.785
180 S	0.263	0.505	0.948*
90 l	0.467	0.681	0.995**
90 M	0.714	0.872	0.979*
90 s	-0.172	0.091	0.724

-* correlated but not significant with high (p-value is more than 0.05)

-** correlated and significant with high (p-value is 0.07)

Relationship between drape coefficient and the skirt hemline flares number

The hemline area form is shown in Figure 6, which clarifies that the different skirts in angles and lengths are highly correlated with the real drape test results, but all of them are not significant to be used for fitting assessment. Unlike the relationship between the real test result and skirt hemline areas forms, the skirts of 360 º in all lengths has a high correlation coefficient and a high R^2, without a significant p-value as shown in table 7. The same results were repeated in the short skirt at a 270 º construction angle. This conclusion could lead to avoiding several flares, firstly, for the non-significance and there are too wide, if the designer requires assembling it for comparison.

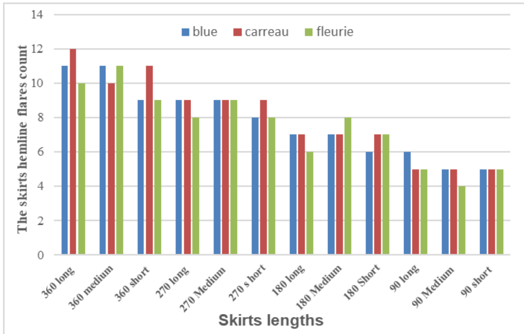


Fig. 5. The number of flares of the skirt hemline

In both of them, the skirt hemline area and the number of nodes of the skirts, there are no significant between their weight and thickness, only on limited sizes with low R^2 and they are at a non-significance level.

TABLE 7. The correlation coefficient between the skirt's hemline shadows and skirts hemline flares numbers

	Weight	Thickness	DC %
weight	1.00		
thickness	0.97	1.00	
DC%	0.55	0.75	1.00
360 L	-0.39	-0.62	-0.98*
360 M	0.80	0.93	0.94*
360 S	-0.80	-0.93	-0.94*
270 L	0.12	-0.14	-0.76
270 M	0.43	0.150	0.53
270 s	-0.80	-0.93	-0.94*
180 L	0.12	-0.14	-0.76
180 M	-0.12	0.14	0.76
180 S	-0.92	-0.79	-0.18
90 L	0.92	0.79	0.18
90 M	0.12	-0.14	-0.76
90 s	0.75	0.28	0.55

-* correlated but not significant with high (p-value is more than 0.05)

Conclusion

Based on the above findings, the garment simulation software was found to be not appropriate for attaining the optimum results of fabric drape simulation. There is no correlation between the adopted real and virtual drape coefficient values. This correlation was found to be statistically insignificant as indicated by the p-value. The 3D scanning method can be used to achieve more accurate results regarding the discrepancy between the real and virtual drape coefficients.

In harmony with the results of earlier research work, the flared skirt was the proper tool that can be approved for correlating the fabric drapability in both real and virtual phases. It is concluded also that the area of the skirt hemline declares the difference between the investigated fabrics clearly. The relationship between the real drape coefficient value was achieved only with the 3 tested skirts; namely the short skirt at an angle of 180°, and the long and medium skirt at the 90° angle. The long skirt at a 90° angle has recorded the highest significant value. These results could be the basis for an accurate assessment of the fitting and the final form of garment design conducted virtually before the garment manufacturing process. Contrary to the skirt hemline method, the flares count is an unreliable method because the latter didn't record any significance between all tested skirts and the DC%.

Finally, the simulation properties, like particular distance and rendering properties values must be considered in the garment simulation process using *CLO3D* software to reinforce the reality appearance of the simulation results. The implemented method through the *CLO3D* to reflect the fabric behavior is not accurate enough; presumably due to the limitation of measurements assumed by *CLO3D* software. We strongly recommend a wider range of fabric weights to get more accurate results regarding the drape behavior in both real and virtual phases

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest concerning the research, author-ship, and/or publication of this article

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مقارنة بين اختبار الأنسدالية الحقيقى وطريقة المحاكاه بنظام CLO3D لتعيين معامل الأنسدالية للملابس

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الملخص

حاليا، المحاكاة الافتراضية للموضة أهمية قصوى في تكنولوجيا الملابس. الموضة الافتراضية في حاجه ماسه إلى دقة المنتج الافتراضي. على العكس، فان التجارب للعينات الفيزيائية (الحقيقية) تستغرق وقت و موارد كثيرة.

وفي هذا البحث، نقترح طريقة لمصمم الازياء لتصور قيمة معامل الانسدالية للخامة من خلال منتج ملبسي افتراضي، لتساعد المصمم لانتاج منتج مطابق للقطعه الافتراضية مماثله للقطعه الحقيقية. تعتمد هذه الطريقة على اختبار معامل الانسداليه ، حيث انه يعكس جميع خواص الخامة.

في هذا البحث، تم اجراء عدة محاولات افتراضية لقياس صلاحية الاختبار المقترح، و ربطه باسس افتراضية. تم استخدام ثلاث خامات مختلفة، (قطن، بوليستر، بوليستر قطن ٥٠\٥٠) تم استنتاج الخواص الفيزيائية باتباع خطوات الطريقة القياسية لبرنامج clo3d.

لتجنب التحكيم البشري يجب ان يكون تحكيم الشكل النهائي لمظهرية الملبس عائد إلى قيمة. اذا، تم قياس معامل الانسدالية للخامات(باستخدام تحليل الظل) ، في كلا الحالتين الحقيقة و الافتراضية. و تم تحديد العلاقة بينهم. تم تشكيل الخامات باستخدام طريقة بناء الجونلة الكلوش حسب طريقة الزوايا في ثلاث اطوال افتراضيا. تمت المحاكاه للجونلات المنفذه باستخدام برنامج clo3d . حُلل ذيل الجونلة الكلوش المستنتج باستخدام طريقة تحليل الصور، و ذلك لايجاد الجونله الكلوش الاكثر تعبيرا عن قيمة معامل الانسدالية

الكلمات الدالة: محاكاه الملابس، الخصائص الفيزيائية للأقمشة ،معامل الانسدالية للقماش، الجيب الكلوش، برنامج CLO3D .