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DESIGN OF AN IMAGE PROCESSING SYSTEM FOR FABRIC DRAPE MEASUREMENT

KUMAŞ DÖKÜMLÜLÜK ÖLÇÜMÜ İÇIN GÖRÜNTÜ İŞLEME SISTEMI TASARIMI

H.İbrahim ÇELİK, Elif GÜLTEKİN, Aydın BAŞKAR, Büşra ÖZTÜRK, H.İbrahim DEMİREL*

[1] Gaziantep University, Textile Engineering Department, Gaziantep, TURKEY

*Corresponding Author: Halil İbrahim ÇELİK, hcelik@gantep.edu.tr

ABSTRACT

Fabric drapeability is an important parameter that affects the apparel comfort and appearance of the fabric. Fabric drape measurement is based on calculating the shadow area of the hanged fabric created due to its weight. This measurement is performed manually and therefore a subjective assessment is made. Today, with the developments in image acquisition technology and image processing methods, many measurements and evaluations can be made objectively and accurately by adapting vision systems. In this study, an example prototype system with which fabric drape can be measured by image processing techniques is presented. The designed system consists of machine vision hardware, equipment and image processing software. The system was tested on 12 different types of woven and knitted fabrics. The fabric samples were selected randomly. Drape measurements were performed with developed image processing software. The same samples were also applied bending length and Cusick drapeability tests to confirm the results obtained by image processing (IP) method and the relationship between the three measurements was determined by regression analysis. As a result, 0.92 and 0.84 R^2 values were obtained between IP method and bending length and Cusick drapeablility results respectively.

Keywords: Fabric drape, bending length, image processing, machine vision

ÖZET

Kumaş dökümlülük özelliği kumaşın giyim konforumu ve görünümünü etkileyen önemli bir parametredir. Kumaş dökümlülüğü ölçümü askıdaki kumaşın kendi ağırlığından dolayı oluşturduğu gölgenin alanın hesaplanması prensibine dayanmaktadır. Bu ölçüm manüel olarak yapılmakta ve dolayısı ile sübjektif bir değerlendirme yapılmaktadır. Günümüzde, görüntü alma teknolojisinde ve görüntü işleme yöntemlerinde meydana gelen gelişmeler ile beraber birçok ölçüm ve değerlendirme yapay görüntü sistemlerinin adapte edilmesi ile objektif olarak ve doğru bir şekilde gerçekleştirilebilecektir. Bu çalışmada, kumaş dökümlülüğünün görüntü işleme teknikleri ile ölçülebileceği prototip bir sistem örneği sunulmuştur. Tasarlanan sistem görüntü alma donanımları, ekipmanları ve görüntü işleme yazılımından oluşmaktadır. Sistem 12 farklı dokuma ve örme kumaş numunesi üzerinde test edilmiştir. Kumaş numuneleri rast gele seçilmiştir. Dökümlülük ölçümleri geliştirilen görüntü işleme yazılımı ile gerçekleştirilmiştir. Görüntü işleme yöntemini doğrulamak amacı ile aynı kumaşlara eğilme uzunluğu ve Cusick dökümlülük testleri uygulanmıştır ve her üç ölçüm arasındaki ilişki regresyon analizi belirlenmiştir. sonuç olarak görüntü işleme yöntemi ve eğilme uzunluğu, Cusick dökümlülük sonuçları arasında sırası ile 0.92 ve 0.84 R^2 değerleri elde edilmiştir.

Anahtar Kelimeler: kumaş dökümlülüğü, eğilme uzunluğu, görüntü işleme, yapay görme

INTRODUCTION

One of the important features that affect fabric appearance and comfort is drapeability. It is an important quality parameter that is taken into consideration by the designers especially because of its effect on my garment appearance. The drape is mainly expressed as the bending behavior of the fabric under its own weight. The drape quality of the fabric varies according to the usage area and the design criteria of the product to be produced. Since knitted fabrics are more flexible and higher in drapeability, the products made of knitted fabrics have a body-covering appearance and follow the body lines. On the other hand, since woven fabrics have a stiffer structure, garments made from these fabrics are positioned further away from the body and do not follow body lines. Curtains, tablecloths, women's clothes are preferred high-draped fabrics (Hu, 2008).

The drapeability coefficient is calculated for the purpose of evaluating the stiffness, softness and drape of the fabric. In general, the CUSICK Drapeability Tester is used for the drape measurement. The device consists of a concave mirror and light system. The image formed by the fabric placed on the sample holder due to its own weight is reflected to the upper part of the device by the concave mirror system. The boundaries of the projected image are then determined by drawing on a standard paper. Standard paper is cut and weighed at specified limits. The ratio of the weight of the cut piece to the weight of the standard paper gives the drape coefficient. The higher the drape coefficient, the stiffer the fabric is. On the other hand, the lower the drape coefficient means the flexible and soft fabric. In CUSICK drape measurement method, the determining the drape area and removing this area from the whole reference paper requires experience and attention. Since there will be a variation in measurement accuracy and the results will change from person to person, this method is evaluated as a subjective method. In literature, to perform drape measurement more accurately and objectively, different approaches that use image processing techniques are presented (Platürk, Kılıç, 2014; Tsai et.al, 2009; Behara, Pattanayak, 2008; Kenkare, May-Plumlee, 2005; Erdumlu, Sarıçam, 2015; Al-Gaadi et.al, 2012).

In this study, a prototype machine vision system was developed to automatically measure the drapeability of a fabric by means of image processing techniques. The system was tested on 12 different types of woven and knitted fabric samples. First of the drape coefficients of the samples were determined by using developed image processing algorithm from the image frames taken with the new designed machine vision system. Then, bending length and Cusick drape coefficients of the same samples were determined. The results of the three methods were compared and validation of the image processing method was achieved by applying regression analysis.

MATERIAL AND METHOD

Material

Within the scope of the study, 12 different samples consisting of knitted and woven fabrics were selected (Figure 1). The properties of the samples are shown in Table 1.

Figure 1. Fabric Samples

Table1. Fabric specimen features

	Fabric Type	Thickness (mm)	Weight (g/m^2)
1	Woven	0.12	51.53
2	Woven	0.26	118.10
3	Woven	0.63	290.25

4	Woven	0.19	84.41
5	Woven	0.23	109.90
6	Woven	0.49	194.01
7	Woven	0.38	103.11
8	Knitted	0.47	166.25
9	Knitted	0.20	61.01
10	Knitted	0.91	242.40
11	Knitted	0.88	226.66
12	Knitted	0.68	351.16

Method

Machine vision system design for drape measurement

A machine vision system and image processing algorithm have been developed to determine fabric drape. The prototype system, developed to capture the fabric samples, consists of a closed cabin, lighting unit, camera system, sample holder apparatus and computer (Figure 2). Since the external light sources affect the received image quality and image pixel values, a closed system has been prepared. The interior of the cabinet is covered with matt black paper to remove reflections. On the top of the system, a lighting unit consisting of LED strips is placed. There is space in the center of the lighting unit so that the camera can be placed. The HD web camera is positioned in this empty area. After all this system design has been realized, the design and manufacture of the apparatus where the sample will be placed has been realized. The design of the sample holder apparatus is achieved on the base of CUSICK measurement method. A cylindrical disc with a diameter of 100 mm and a height of 100 mm is manufactured and its center point is marked. A small needle was then adapted to the center of the cylinder for ease positioning of the sample. Circular samples with 300 mm diameter were taken from each fabric to be used in the drape measurement. The fabric samples were placed by attaching to the needle in the cylinder sample holder in order to get an image frame (Figure 2).

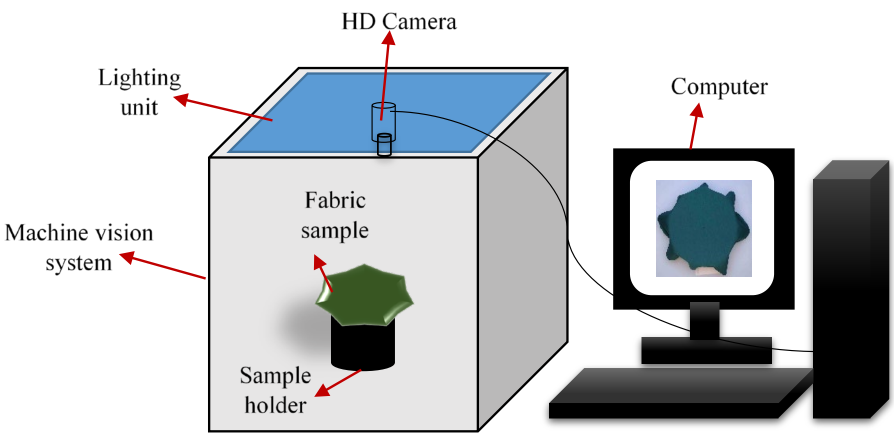

Figure 2. Machine Vision System for Fabric Drape Measurement

Image processing algorithm for drape measurement

In the image processing technique, the quality and characteristics of the image frame have a significant effect on the targeted result. Conditions such as lighting, motion blur, camera resolution, and compression of images taken while storing are factors that affect image quality. Therefore, the images taken with the camera are digitized and transferred to a computer environment and then improved by using various noise cleaning and image enhancement filters (Gonzales & Woods, 2004). Therefore, in the developed algorithm, noise cleaning and enhancement filters were applied on the image before the fabric drape area was calculated.

Image frames taken in RGB format were first converted to gray image format (Figure 3.a). Then Wiener filter (Chen, 2006) was applied to clear the noise (Figure 3.b). A contrast deepening filter was applied to clarify the boundaries of the suspended image of the fabric sample on the cylinder and to distinguish it from the ground texture (Figure 3.c). After all these preliminary operations, the images were converted to binary format consisting of 0 (black) and 1 (white) values (Figure 3.d). Opening and closing morphological operations were used to clarify the fabric boundaries on the binary image and to clear the pattern lines from the image (Figure 3.e). The image results are visualized by selecting the most complex patterns to show how the algorithm is applied. As a result, the ratio of shadow area created due to drape of laid fabric to the whole image frame covered by fabric sample is calculated (Equation 1).

$$\textbf{Drape Coefficients}\ (\%) = \frac{\textbf{Draped fabric area (pixels)} - \textbf{Supporting disc area(pixels)}}{\textbf{Fabric sample area (pixels)} - \textbf{Supporting disc area (pixels)}} \times \mathbf{100}$$
(1)

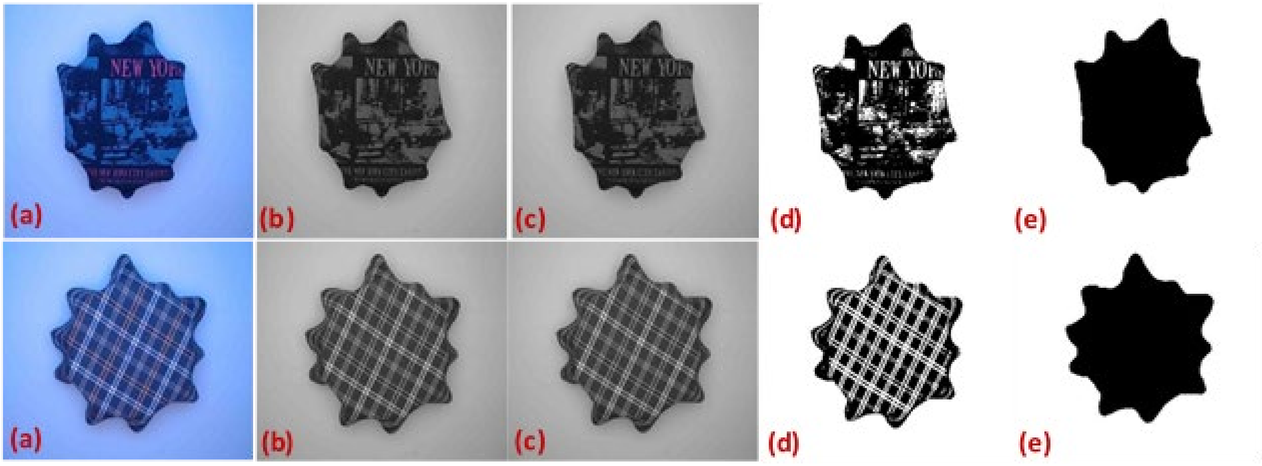

Figure 3. Measurement Algorithm of Fabric Drape. (a) RGB Image (b) Gray Image (c) Contrast Deepened Image (d) Binary Image (e) Morphologically Applied Image

Cusick drape measurement test

CUSICK Drape Tester was used for the drape measurement (Figure 4). The device consists of a concave mirror and light system. The image formed by the fabric placed on the sample holder due to its own weight is reflected to the upper part of the device by the concave mirror system. The boundaries of the projected image are then determined by drawing on a standard paper. Standard paper is cut and weighed at specified limits. The ratio of the weight of the cut piece to the weight of the standard paper gives the drape coefficient. Before testing, all fabric samples were conditioned under standard atmospheric conditions (20 ± 2 ° C temperature and 65 ± 2 relative humidity). The higher the drape coefficient is, the harder the fabric is. On the other hand, the lower the drape coefficient means more flexible and the softer fabric.

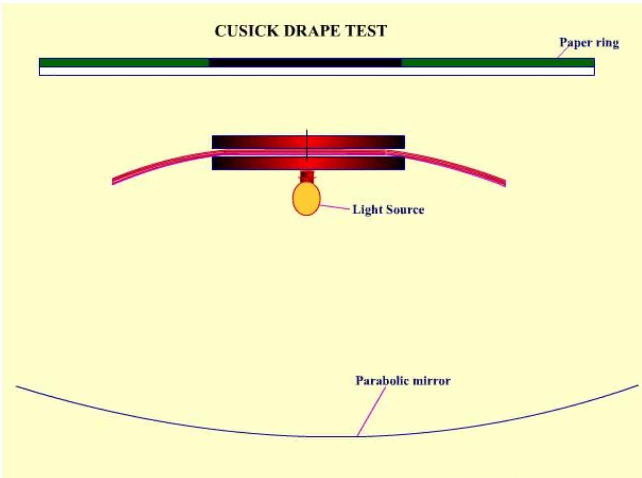

Figure 4. Cusick Drape Measurement Test Device (NPTEL)

Fabric bending strength test

The fabric bending length test was performed using the Prowhite Fabric Hardness tester (Figure 5) in accordance with BS 3356: 1990. A total of 6 samples of 25 mm × 200 mm weft / course and warp / wale directions were prepared from each fabric. A total of 4 measurements were made at both ends of the front and back sides of each sample. As a result, 24 bending lengths, 12 for weft / course and 12 for warp / wale, were measured for each fabric sample.

Before testing, all fabric samples were conditioned under standard atmospheric conditions (20 ± 2 ° C temperature and 65 ± 2 relative humidity). Using the obtained bending length values, mean bending length values were calculated for weft/course and warp/wale directions.

Figure 5. Fabric Bending Length Tester

RESULTS AND DISCUSSION

The fabric parameters that effect the drapeability performance have been investigated in many previous studies. According to findings from these studies, the drapeability property of fabrics is known to be directly related to yarn density, yarn twist, weft and warp density, type of weaving or knitting structure (Al-Gaadi et.al, 2012). It is known from the literature that high drape coefficient is obtained in fabrics where yarns containing the same direction twist are used in weft and warp way, since slip and stretching deformation will be more difficult. When examined as fabric type, the drape coefficients of twill fabrics are lower than plain fabrics. This is due to the fact that the yarns move more easily in the fabric architecture, as there are fewer connection points in the twill weave structure (Özgüney A.T. et.al, 2009).

Because of the difficulties that come from the manual drapeability tests, some attempts were made to automatically and sensitively perform drapeability test. These attempts were generally based on image processing approaches. In similar studies, the results between fabric drapeability and bending property obtained with the test applied to randomly selected fabrics were statistically compared and the difference between them was determined. The success level (high correlation coefficients 0.86-0.99) of the method proposed in similar studies in the literature has been demonstrated in this way (Platürk, Kılıç, 2014; Tsai et.al, 2009; Behara, Pattanayak, 2008; Kenkare, May-Plumlee, 2005; Erdumlu, Sarıçam, 2015; Al-Gaadi et.al, 2012, Süle, G. 2012). There is a study in the literature about determination of drape measurement using image processing technique by Kenkare, May-Plumlee, 2005, it was stated that a correlation coefficient of 0.99 R^2 demonstrate between digital image processing method and conventional cut and weight technique.

In our study, the results obtained from the developed machine vision system, bending length test and Cusick drape test were presented in Table 2. The mean of the bending length values for weft/course and warp/wale directions and drape measurements were compared with the drape coefficient values obtained from the developed machine vision system. The relationship between the drape coefficient values and the bending length were discussed with regression analysis in Figure 6. As flowed from Figure 6, there is high regression with 0.92 R^2 value was reached between image processing (IP) drapeability results and Cusick drapeability test results. This result reveals that the developed image processing method provides high accuracy in comparison to reference Cusick method. The regression value between IP drapeability and bending length was obtained as R^2=0.84. According to the obtained results, we can say that the average bending length increases when the drapeability increases in the fabric and the average bending length decreases when the drapeability coefficient decreases. As a result, it can be stated that the proposed method gives reliable and accurate results for fabric drape measurement.

Table 2. Bending Length and Drape Coefficient Values

Sample No	Bending Length (cm) Warp / Wale	Weft / Course	Average Length	IP Drape Coefficient (%)	Cusick Drape Coefficient (%)
1	4.88	4.72	4.80	65.10	35.61
2	4.13	4.30	4.21	48.46	35.00
3	4.07	3.47	3.77	33.88	29.95
4	2.23	2.88	2.55	18.51	22.55
5	2.82	1.83	2.33	20.61	22.80
6	1.98	3.61	2.79	31.60	28.04
7	1.80	3.02	2.41	17.53	22.22
8	4.55	7.26	5.90	66.55	35.90
9	2.67	4.59	3.63	18.67	22.09
10	2.64	2.75	2.70	27.62	26.21
11	1.57	2.52	2.04	14.77	19.50
12	2.37	2.25	2.31	19.29	21.95

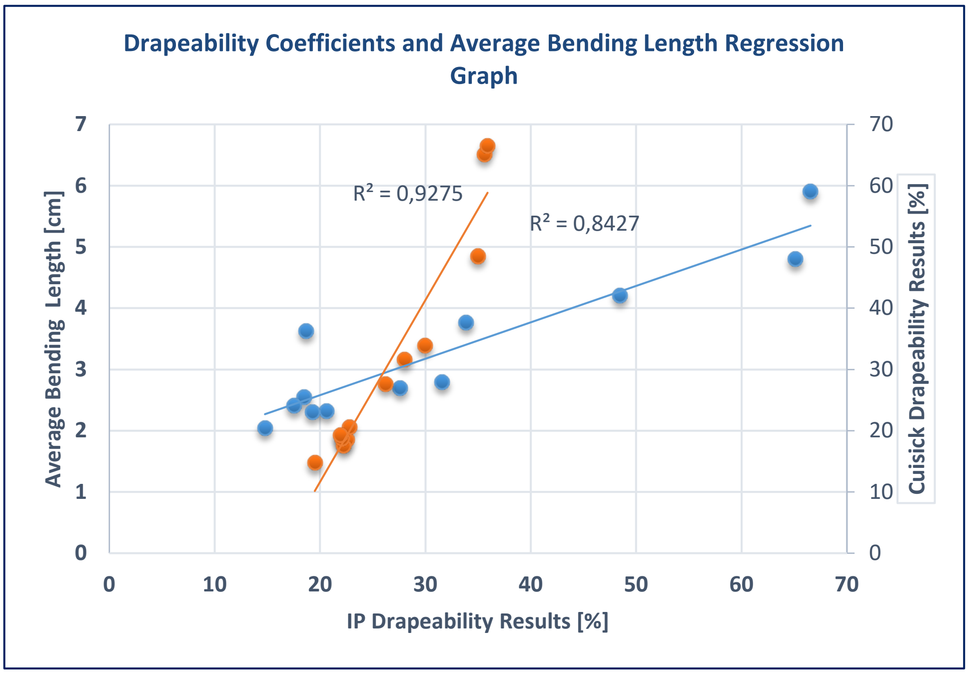

Figure 4. Regression Between Drape Coefficients and Bending Length

CONCLUSION

In this study, the relationship between developed fabric drape measurement with image processing, average bending length and traditional drape test (Cusick Drapeability) were evaluated. The presented study belongs to a prototype system at the initial stage. By applying regression analysis between the three method results, it was proofed that the developed image processing system have high accuracy and sensitivity for fabric drape measurement. On the other hand, the proposed method is easier and takes shorter time than other two methods; bending length and Cusick drape measurement.

Nowadays, developments in artificial intelligence and industry 4.0 provide important advantages in manufacturing and so they are rapidly taking place in the textile sector. Since the image processing technique provides an objective assessment of the quality control tests as well as determining the drapability properties of the fabrics, the manually applied processes can be performed both in a shorter time and with high accuracy. Image processing techniques and machine vision systems can be successfully adapted to industrial application. As a result, this modified method was recommended for reasons such as saving paper, reducing user errors, archiving images and especially reducing the testing time drastically. The manual test method (Cuisck test device) each sample takes half an hour to measure, while in image processing technique each sample is measured in less than one minute. This means a significant saving of time during the test measurement.

REFERANCES

Al-Gaadi, B., Göktepe, F., Halász, M. (2012). A new method in fabric drape measurement and analysis of the drape formation process. *Textile Research Journal*, 82(5), 502-512.

Behera, B. K., & Pattanayak, A. K. (2008). Measurement and modeling of drape using digital image processing. *Journal of Fibre & Textile Research*, 33, 230-238.

BS 3356:1990. Method for determination of bending length and flexural rigidity of fabrics

Chen, J., Benesty, J., Huang, Y., Doclo, S. (2006). New insights into the noise reduction Wiener filter. *IEEE Transactions on audio, speech, and language processing*, *14*(4), 1218-1234.

Erdumlu, N., Sarıçam, C. (2015). Metal Tel Sarımlı Hibrid İplik İçeren Dokuma Kumaşların Dökümlülüğünün Görüntü Analizi Yöntemi İle Ölçülmesi. *Tekstil Ve Mühendis*, *22*(100).

Gonzalez, R. C. In *Digital Image Processing Using Matlab-Gonzalez Woods & Eddins* 2004, pearson

Hu, J. (Ed.). (2008). Fabric testing. *Elsevier.*

Kenkare, N., May-Plumlee, T. (2005). Fabric drape measurement: A modified method using digital image processing. *Journal of Textile and Apparel, Technology and Management*, *4*(3), 1-8.

Plattürk, G. G., Kiliç, M. (2014). Kumaş Dökümlülüğünün Görüntü Analizi Temelli Yöntemlerle Ölçülmesi. *Tekstil ve Mühendis*, *21*(94).

Tsai, K. H., Tsai, M. C., Wang, P. N., Shyr, T. W. (2009). New approach to directly acquiringe the drape contours of various fabrics. *Fibres & Textiles in Eastern Europe*, (3 (74)), 54-59.

NPTEL:Textile Engineering, Textile Testing, Drape https://nptel.ac.in/courses/116102029/53 Accessed 26.07.2019.

Özgüney, A. T., Taşkin, C., Özçelik, G., Ünal, P. G., & Özerdem, A. (2009). Handle properties of the woven fabrics made of compact yarns. *Tekstil ve Konfeksiyon*, 19(2), 108-113.

Süle, G. (2012). Investigation of bending and drape properties of woven fabrics and the effects of fabric constructional parameters and warp tension on these properties. *Textile Research Journal*, 82(8), 810-819.

ORCID

Halil İbrahim ÇELİK *https://doi.org/0000-0002-1145-6471*
Elif GÜLTEKİN *https://orcid.org/0000-0003-4910-4081*
Aydın BAŞKAR………………Undergraduate Student
Büşra ÖZTÜRK……………. Undergraduate Student
H.İbrahim DEMİREL………Under-graduate Student