平成 20〜22 年度 大阪学院大学・大阪学院短期大学 研究助成費 研究概要報告

大阪学院大学 企業情報学部
教授　石倉弘樹

‘DAVID’ 3-D Digitizing Software to Scan Men's Suit Fabrics

Abstract

It used to be difficult to measure the 3D shape of dark color cloth precisely with low cost. An example to measure the 3D shape of a dark color cloth is shown by using 3D scanning software called DAVID.

1. Introduction

The designing and processing of three-dimensional computer graphics (3dcg) have become familiar operations by improving computer hardware and software because the cost for 3dcg has been decreasing rapidly for several years. Nowadays the modeling of an object and its texture mapping are easy work. Recently, a $600 3d camera was put on the market. However, the 360 degree scanning of an object is still costly work compared to the designing. In the search of this author, at least 15,000 US dollars are necessary for getting a system to scan an object in which all sides are less than 20cm. Prices of scanning systems for larger objects are more than tens of thousands of dollars. Therefore, 3d shape scanning has been done only by larger facilities; on the other hand 3dcg is widely done including personal use for hobbies. In the studies of apparel products, the measurement of 3d shapes is needed, because appearance is one of the important points of evaluation for apparel products, and measuring the 3d shape accurately is the first step to evaluate appearance. However, it is difficult on a low budget. For such situations, 3d object scanning digitalize software was developed in 2007 by Sven Molkenstruck and Simon Winkelbach in Germany[1]. The DAVID LASER SCANNER is a low-cost system for contact-free scanning of 3d objects. The software is 350 US dollars and the hardware requirements are a hand-held laser, a web camera and a Windows PC. In this system the output of the laser can be chosen freely therefore the shape of a black cloth which is absorptive of laser beams can be scanned. However, it is not enough to use just the DAVID manual, because the setting of a camera and a laser are uncertain. The example of how to use this measurement system for 3d shape of the apparel product or the cloth is described.

2. Devices

2.1 PC

OS: Widows XP Media Center Edition   CPU: Intel core 2Duo E6400 2.13GHz
Main memory: 2.75GB   Graphic Board: EN8800GTS 320MB DDR3

2.2 Web camera

Logicool 30fps

2.3 Laser

BDL210Stype1 Pop Rivets and Fasteners Ltd   Class 2, Weave length 633nm-670nm

2.4 Softwear

3D digitizer: DAVID Ver. 2.4.2[2]   3DCG: Shade 9.0 Basic

3. Experiments

3.1 Digitizing

(2) Open DAVID-Laserscanner.exe at desktop.

Select [system default] and Click 

to start an experiment at first window (Cf. Fig1 & 2)

Fig. 1 The first window for ‘DAVID’

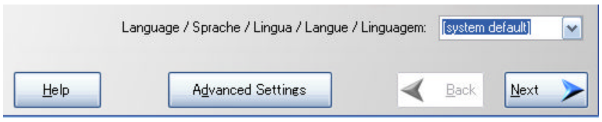


Fig. 2 The bottom part of the first window

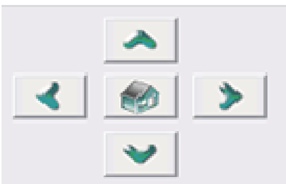
(3) Select [Logicool Qcam Orbit/Sphere AF] at [1.Choose a camera and adjust exposure and brightness] (Cf. Fig.3). The distance between the web camera and the board is 59cm.

(4) Click 

to set output size 640×480 and frame ratio 30.000.

(5) Click 

to adjust all reference points enter the image by the following buttons.



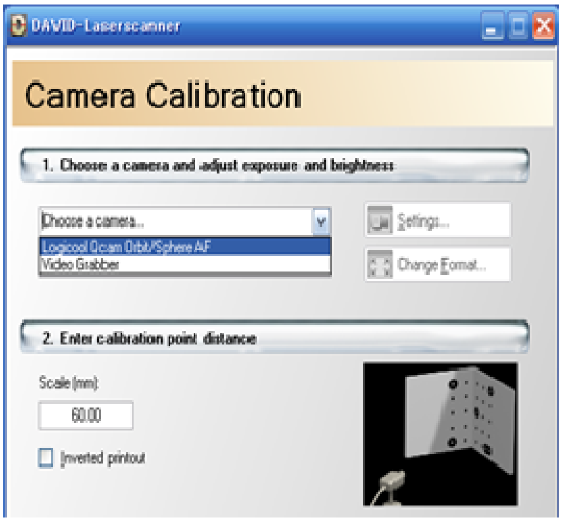


Fig.3 The window for camera calibration

(6) Enter an appropriate value to the box of ‘Scale (mm)’ in Fig. 3.

A4 form: 60.00.   A3 form: 83.00

Fig. 4 The window for ‘Device setting ’

(7) Set four above-mentioned items Brightness 6020, Contrast 1255, Chroma 1255 and Purity 8784. Check White balance and Focus for Automatic operation as shown in Fig. 4.

(8) Check 'Automatic gain control' of 'Details tab' in Fig. 5.

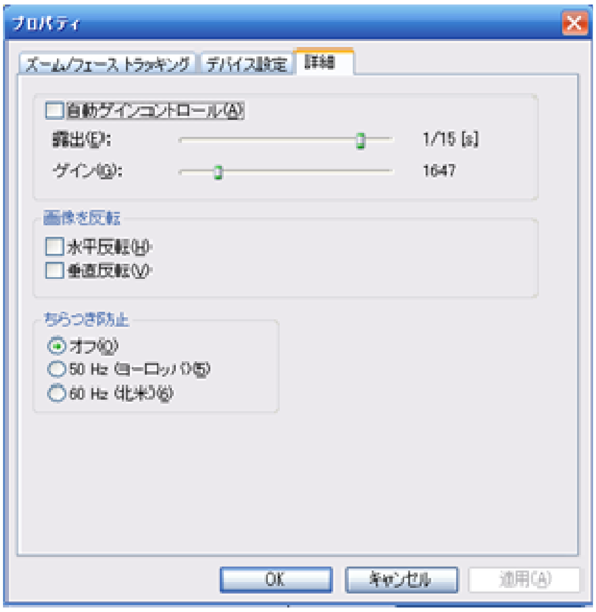


Fig.5 The window for 'Details'

(6) Click 'Calibrate Camera!' (Cf. Fig.6) and if all red × signs are displayed in 25 black round signs as shown in Fig. 7, the calibration is successful.

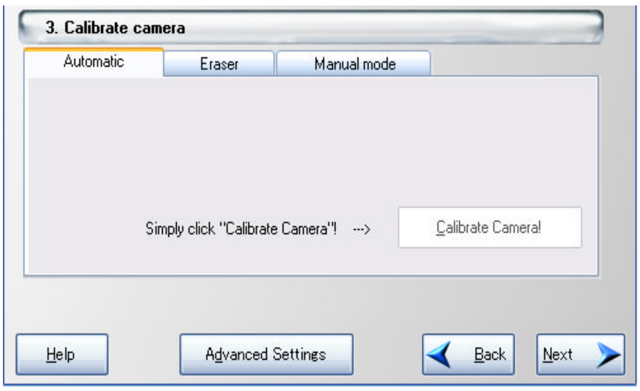


Fig.6 The window for 'Calibrate camera'

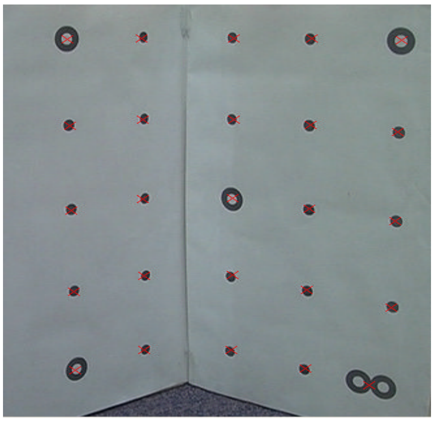


Fig.7The image that succeeds in the calibration

(10) Click ‘Eraser’ and paint out by using the mouse excluding black points as shown in Fig. 9 and 10.

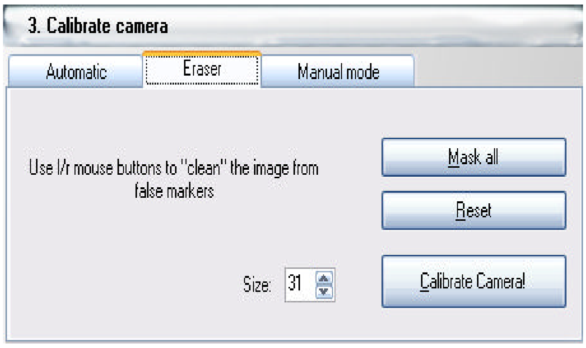


Fig.9 The window to erase causes of calibration failure.

Fig. 10 Image from which causes of calibration failure are erased

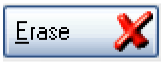
（11）Check all red × signs are displayed in 25 black round signs as same as Fig.7 and click .

(12) Click  to obtain an angle 3D data. 11 (Cf. Fig. 11) and irradiate the laser to the cloth by hand .

(13) Click  after necessary 3D data for the angle are obtained.

Fig. 11 The window to take 3D data

(14) Click ‘Interpolate’ and ‘Smooth Average’ at ‘3.Interpolation and Filtering’ in Fig. 11.
(15) Click ‘Save’ at ‘4.View and save results’ in Fig.11 for saving data..

(16) Click  and  for the next angle.

(17) Click ‘Add’ to open the obj file which was stored in (15) at ‘1.Specify list of input scans’ in Fig.12 .

Fig. 12 The window for '3D Shape Fusion'

(18) Repeat the above operation about all the data of the different angles

(19) Click 

 to display the files in turn.

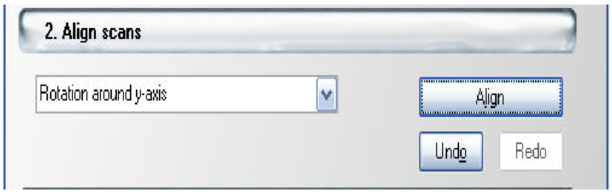


Fig. 13 The bottom part of '3D Shape Fusion'

(20) Click 

 to open Fig. 14

Fig. 14 The window for surface registration

3D shape data of a cloth are obtained by operation of the above (1) - (20).

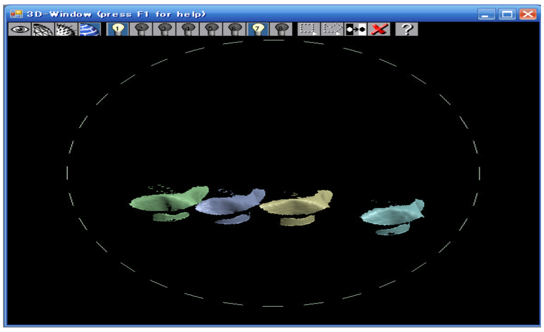


Fig. 15 Four 3D data different by 90°

Fig. 16 shows the example of composition. The perspective of the drape is obtained from 4 different angles data.

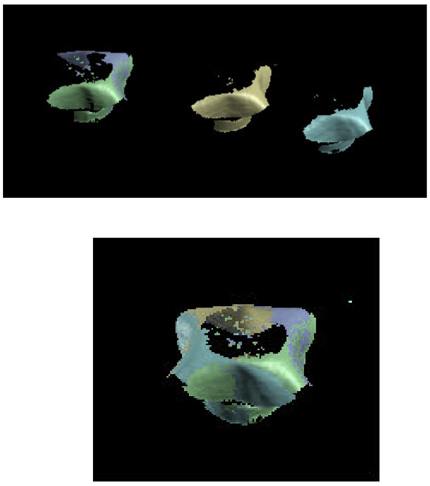


Fig. 16 The composition of 4 data

<u>3.2 Analysis and texture mapping</u>

The final purpose of this study is to estimate the texture of a cloth by the 3D shape and make 3DCG by using the mechanical properties of a cloth.

Fig. 17 shows the front elevation, top view and side view of the sample. The 3DCG of the sample is also shown in Fig. 18. It was given texture mapping by 3DCG software Shade because DAVID can obtain only 3D data.

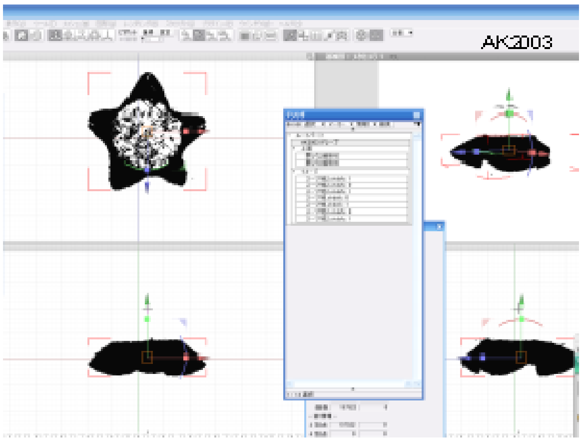


Fig. 17 The front elevation, top view and side view of the sample.

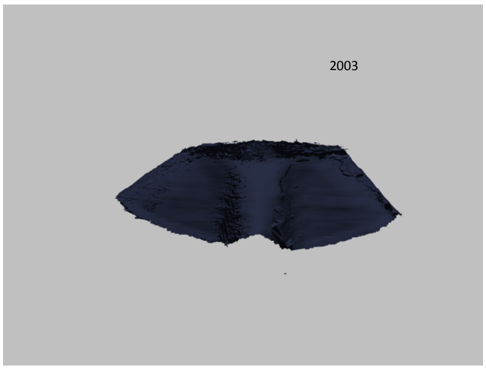


Fig 18 The Rendering image of the sample

4. Conclusions

It used to be difficult to measure the 3D shapes of dark color cloth precisely with low cost. An example to measure 3D shape of a dark color cloth is shown by using 3D scanning software DAVID.

References

1) http://www.david-laserscanner.com/

2) S. Winkelbach, S. Molkenstruck and F. Wahl, Low-Cost Laser Range Scanner and Fast Surface Regstration Approach, DAGM 2006, LNCS 4174, pp.718-728,2006, Springer Berlin Heidelberg 2006.

Study of the Objective Measurement for Woven Fabric Wrinkles
-Relationships between the Subjective Measurements of Experts and 3-D Shapes-

1. Introduction

How to make wrinkles unnoticeable is one of the important problems in the apparel and textile industries. Cloth structures and chemical processing have been researched to reduce wrinkles and a lot of new products have been developed. But the problem has not been settled. In the studies, the objective evaluation of wrinkles is the issue which should be solved first, because if the evaluation is unreliable, textile designers cannot set a clear numerical target. Wrinkles are still evaluated and ranked by engineers and/or experts in the industries. In this study it is examined whether analyzed 3-D digitizer data can replace the subjective evaluations or not. The relationships between appearances (distribution of height direction positional data) and subjective evaluations of 8 fabric samples for men’s suits are analyzed.

2. Experiments

2.1 Sample material

Samples used in this study are shown in table 1

Table1 Sample materials

No	Materials	Color
1	Wool 100%	White
2	Wool 100%	Black
3	Wool 100%	Black
4	Wool100%	Gray
5	Wool 91% Polyester Filaments 9%	Black (White stripe)
6	Wool 91% Polyester Filaments 9%	Gray
7	Wool 30% Polyester staple fibers 70%	Navy Blue
8	Wool 30% Polyester staple fibers70%	Charcoal Grey

2.2 Sun-ray wrinkle test

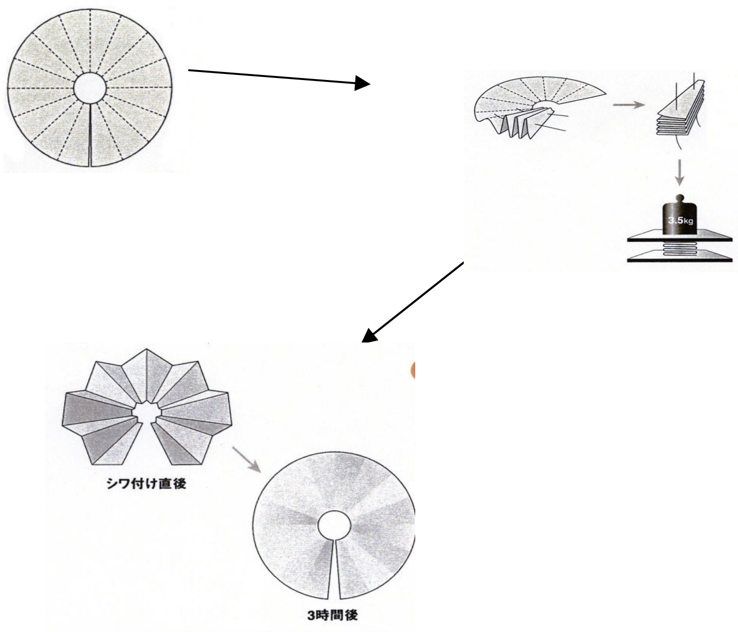


Figure 1 Sun-ray test sample

As shown in Figure 1, at first a fabric is cut into doughnut shape. Next the cut fabric is folded into 16 layers and a weight is put on the fabric. After the weight is removed the grade of a wrinkle is evaluated. In this study, standard times for weighting and recovery are ignored, because only the relationships between sample shapes and evaluations are focused on in this study.

2.3 Devices

(1) 3-D digitizer

Figure 2 VIVID 900 by MINOLTA

Vivid 900 is used as a scanner. 640×480 3-d data are taken. The accuracy is ±20μm.

(2) Software

3-D CG software Shade 8.5 by e frontier is used.

(3) System

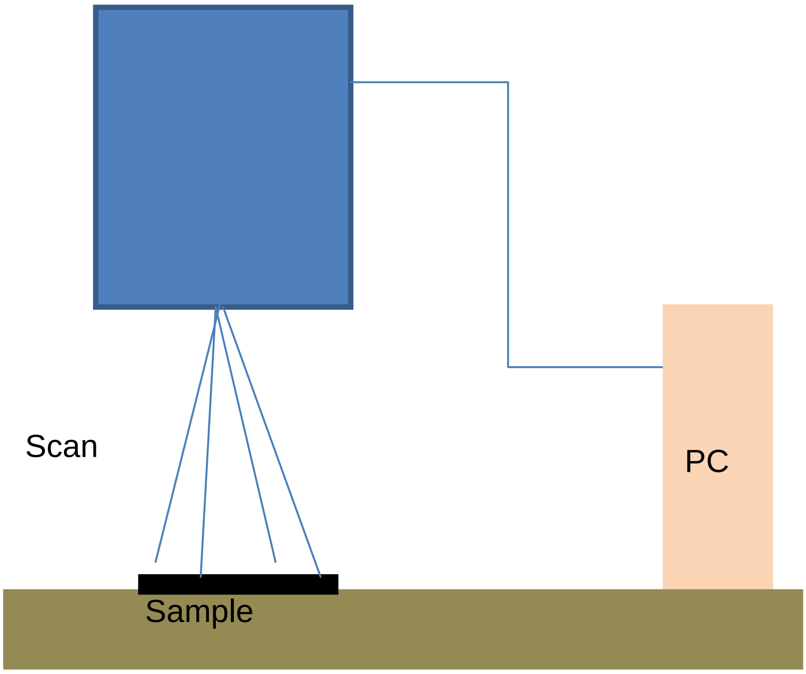


Figure 3 The outline of system

2.4 Subjective evaluation

(1) Samples are evaluated with the naked eye by two engineers.

(2) A value is chosen from grade 1 to 5. The average value is 2.5 and grade 1 is given for the most prominent wrinkle.

3. Results

Figure 4 shows the top view, front view, side view and perspective view obtained by 3-D data.

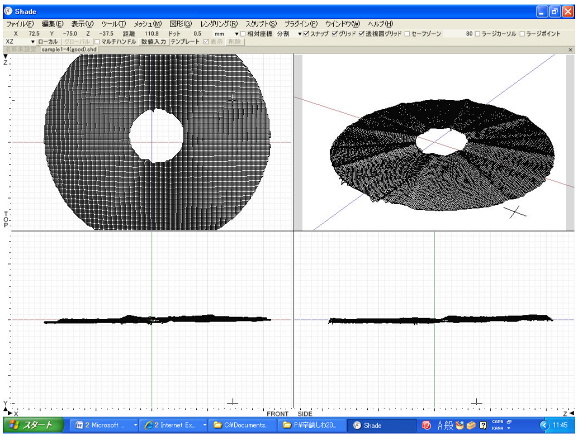


Figure 4 The Processed 3-D data of sample 1.

The rendering made from 3-D data is shown in the following figure. The wrinkles are reproduced in detail.

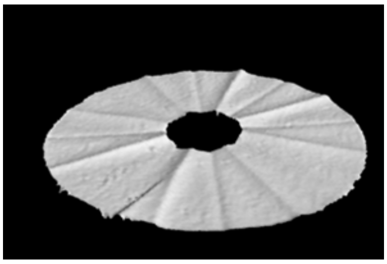


Figure 5 The rendering of Sample 1

In the next table basic statistics are shown.

Table 2 Basic statistics

Sample	Mean Height (mm)	Standard deviation height (mm)	Max. height (mm)	Experts evaluation (grade)
1	4.322	1.476	10.330	3.00
2	4.662	1.659	11.350	2.50
3	4.195	0.849	7.230	4.25
4	5.782	0.845	11.130	3.75
5	3.259	0.844	6.900	4.50
6	4.372	0.803	8.140	4.50
7	3.726	1.937	13.190	2.50
8	2.956	0.844	12.100	3.625

The height of a point = the maximum distance on a sample from the sensor －the distance of the point from the sensor.

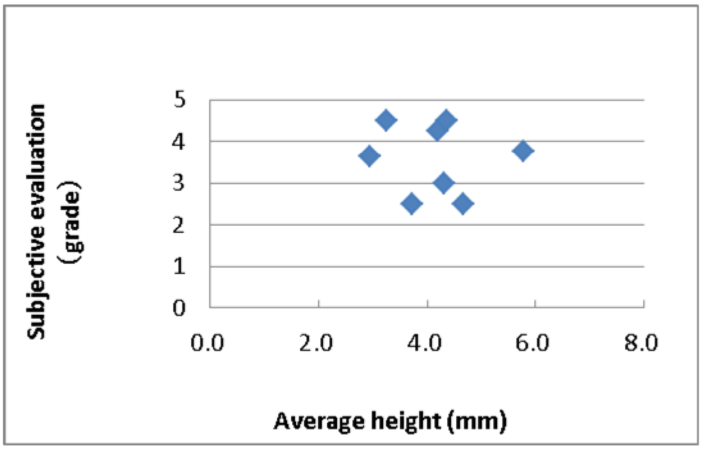


Figure 6 Relationships between subjective evaluations and average heights.

As shown in Figure 6, no correlation can be found between subjective evaluations and average heights.

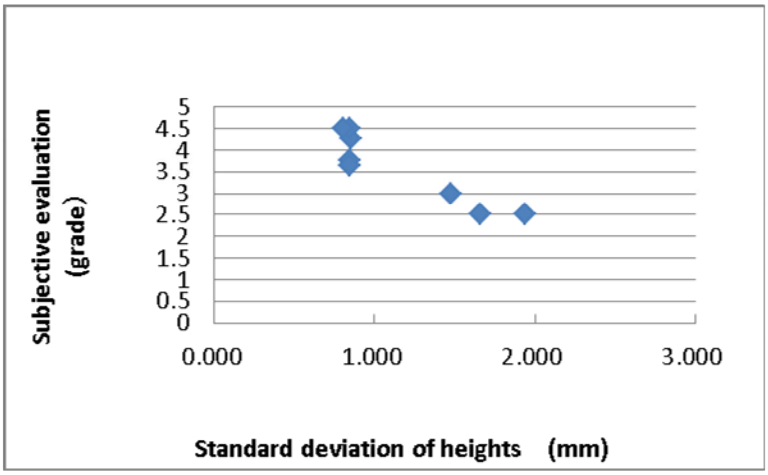


Figure 7 Relationships between subjective evaluations and standard deviations of heights.

The smaller standard deviations are, the better subjective evaluations become, as shown in Figure 7. It can also be said that the lower maximum heights are, the better subjective evaluations become, by the following figure.

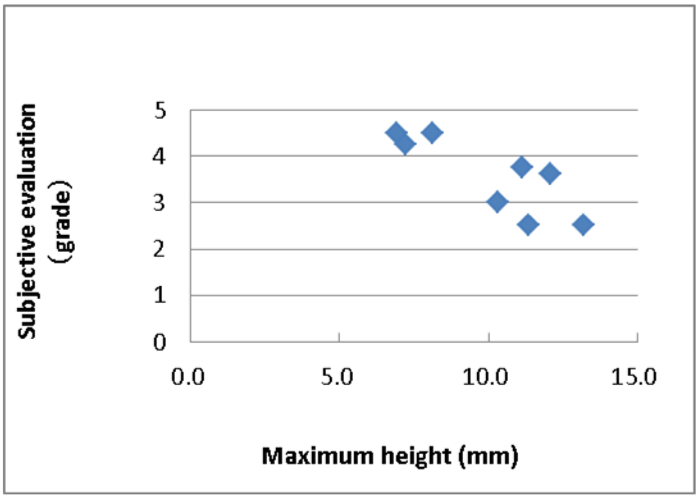


Figure 8 Relationships between subjective evaluations and maximum heights.

Figure 9 below shows the relationships between standard deviations of heights and maximum heights. There is no strong correlation between them. So it cannot be said that both properties are not independent.

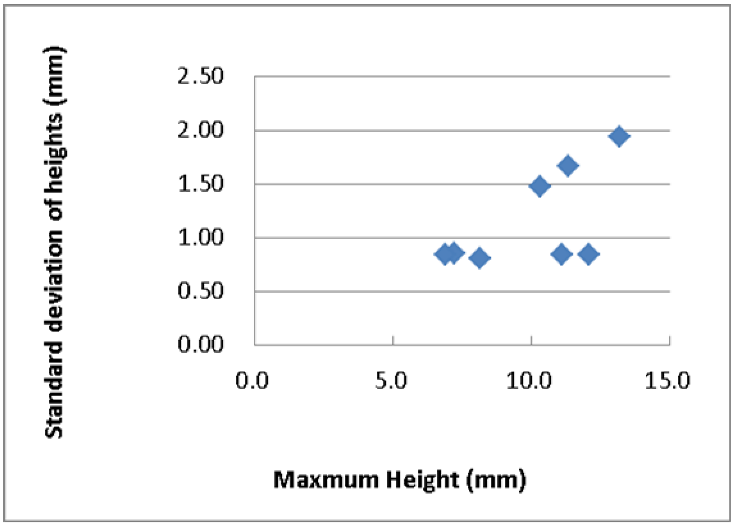


Figure 9 Relationships between standard deviations of heights and maximum heights.

Each sample's frequency distribution of heights is shown in Figures 10 to 17.

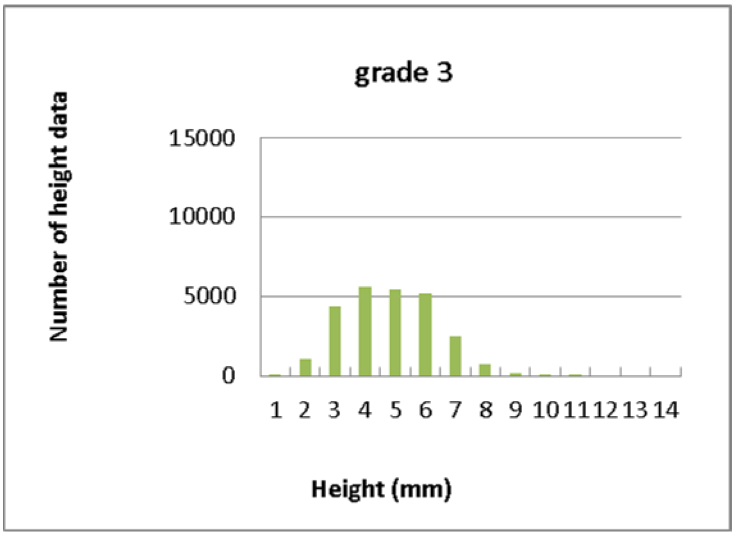


Figure 10 Frequency distribution of heights of sample

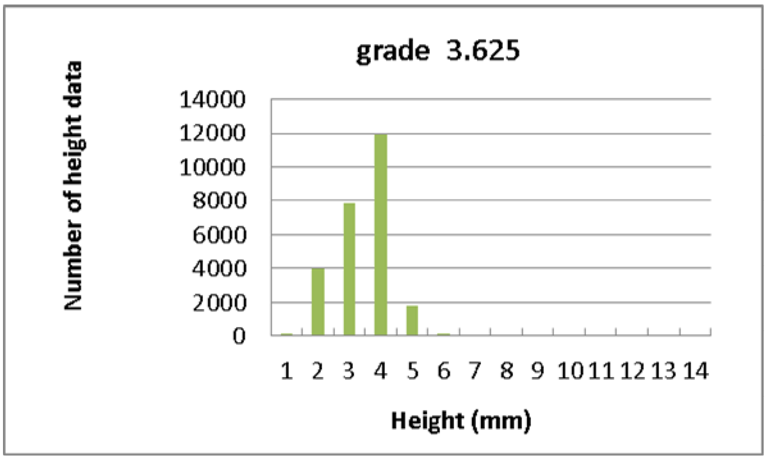


Figure 11 Frequency distribution of heights of Sample 2.

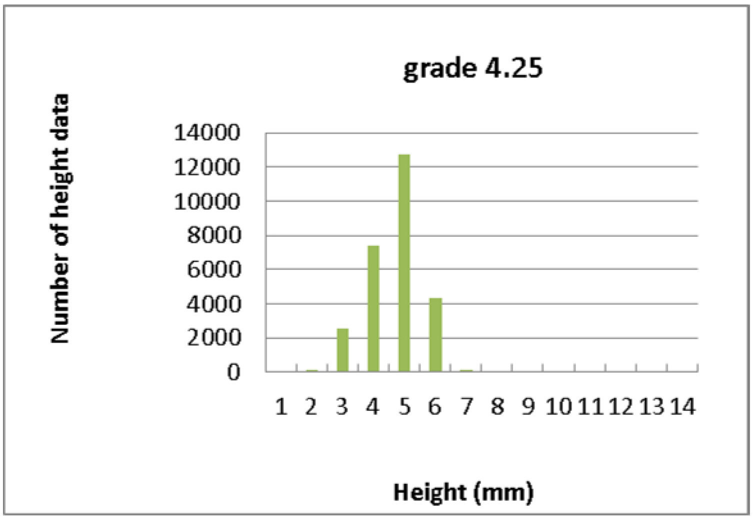


Figure 12 Frequency distribution of heights of sample 3.

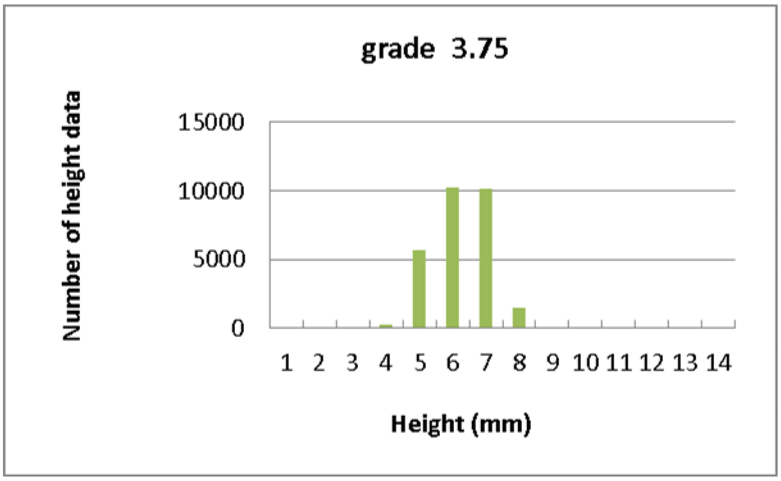


Figure 13 Frequency distribution of heights of sample 4.

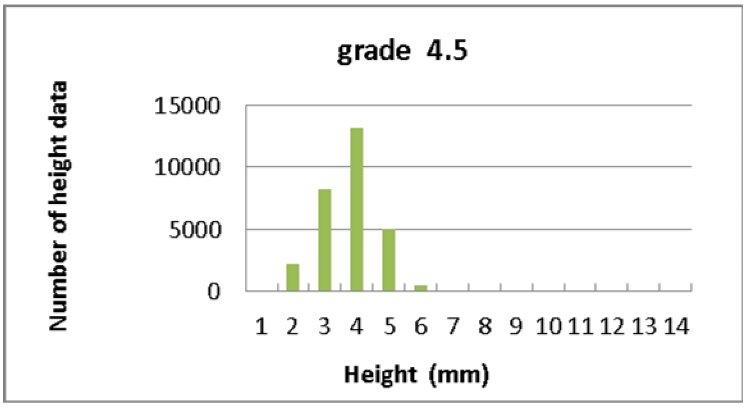


Figure 14 Frequency distribution of heights of sample 5.

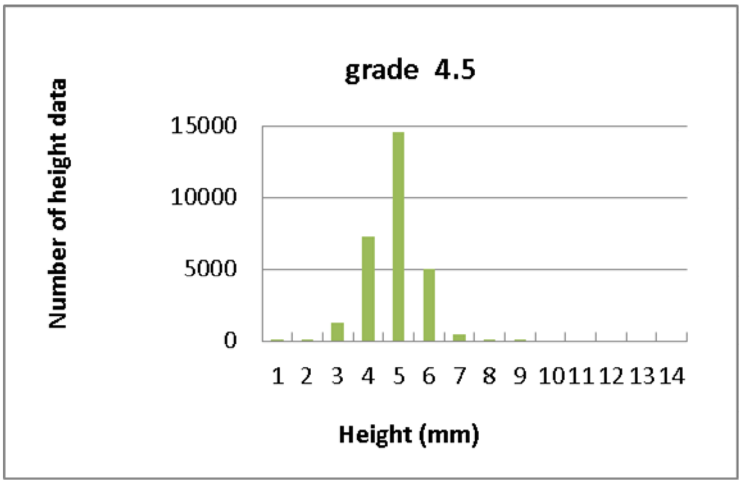


Figure 15 Frequency distribution of heights of sample 6.

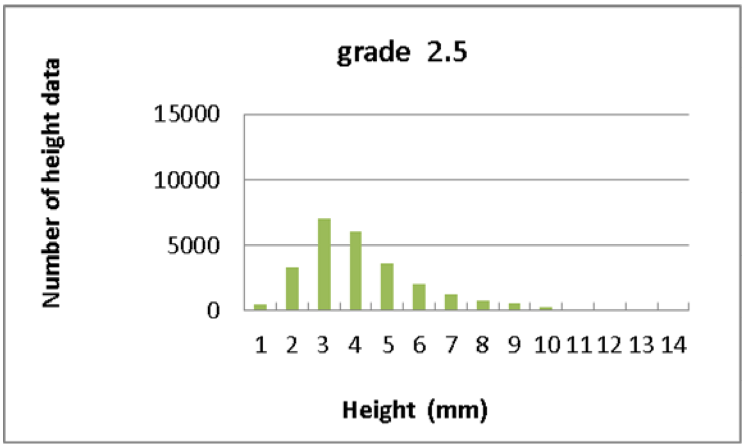


Figure 16 Frequency distribution of heights of sample 7.

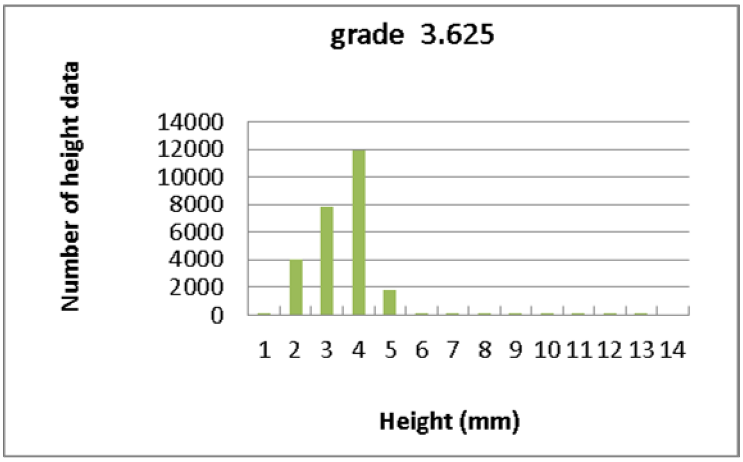


Figure 17 Frequency distribution of heights of sample 8.

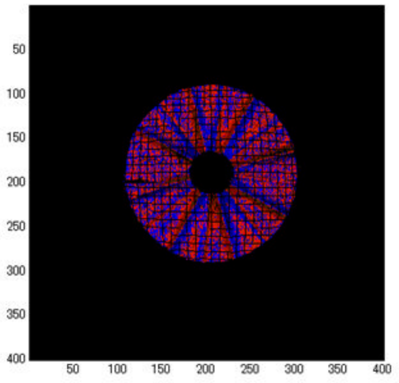
From those 8 figures, it is confirmed that the dispersion of height data and the maximum value of heights are deeply related to subjective evaluations. As the result, we try to obtain a multiple regression equation. In the equation, the standard deviations of heights and the maximum heights are used as explaining variables and the subjective evaluation is the bound variable. In the multiple regression analysis, the following equation is derived.

$$y = 6.425-1.1414 x_1 + 0.14953x_2$$

Where,
y: Experts' subjective evaluation (grade)
x_1: Standard deviation of height (mm)
x_2: Maximum height (mm).
In the results, the multiple correlation coefficient R is 0.972017 and F=0.003045 under significance level 5%.

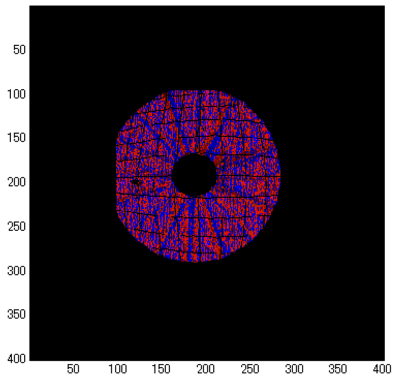
4. Discussion

Directions of normal vectors for polygons are presented in the figures below. The red and blue express deviations of the normal vector from the vertical.



Grade 3, Standard deviation of height 1.476 mm,   Max. height 10.33 mm

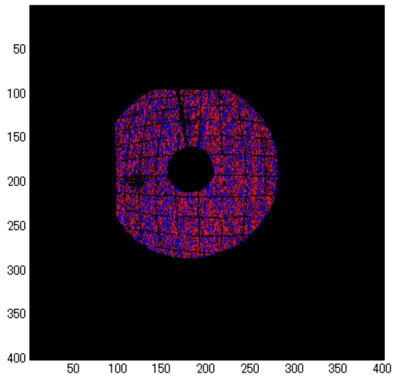
Figure 18 Directions of normal vectors for polygons on sample 1



Grade 3.75, Standard deviation of heights 0.845 mm, Max. height 11.13 mm

Figure 19 Directions of normal vectors for polygons on sample 4

The maximum height of sample 1 is smaller than sample 4, but wrinkle ridge lines of sample 1 are clearer than sample 4. It is possible that low wrinkles are continuing. Therefore, it is assumed that the standard deviation of heights is larger than sample 4, and the subjective evaluation is also lower than sample 4. Sample 6, which was evaluated very high by experts, does not have a clear line as shown in Figure 20.



Grade 4.5, Standard deviation of heights, 0.803 mm, Max. height 8.140 mm

Figure 20 Directions of normal vectors for polygons on sample 6

Analysis of normal vectors may be useful to evaluate wrinkles more precisely by using numerical data.

5. Conclusion

It becomes clear that subjective evaluations of JIS Sun-Ray wrinkle tests can be estimated by basic 3-D shape data. The subjective evaluations were given by experienced textile engineers. The maximum height and the standard deviation of heights are used as basic 3-D shape data.

References

[1] Zhifeng SU , Zhifeng HAN, Jian, YANG and Mitsuo MATSUDAIRA, Sen'I Gakaishi, Japan, Vol. 59, No. 10 (2003)

[2] Zhifeng SU, Jian, YANG, Zhifeng HAN and Mitsuo MATSUDAIRA, Sen'I Gakaishi, Japan, Vol. 60, No. 4 (2004)

研究発表

〔雑誌論文〕

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Hiroki Ishikura 大阪学院大学『企業情報学研究』 9 巻, 2 号 平成 21 年「Setting conditions for “DAVID” 3-d digitizing software to measure the 3-d shape of dark color men’s suit fabric」105－107頁