Oral Presentation

The 7th TSME International Conference on Mechanical Engineering
13-16 December 2016

AMM0006

An Application of Image Processing Technology in Automatic Crease Recovery Tester

Mai Huong Bui[1], Tuong Quan Vo[2]

[1]*Department of Textile-Garment Engineering,* [2]*Department of Mechatronics*
Faculty of Mechanical Engineering, Ho Chi Minh city University of Technology, Viet Nam (VNU-HCM)
E-mail: bmhuong@gmail.com, Telephone Number: +84 983 11 09 78

Abstract

Crease recovery testing is one of the most important step in the process of evaluating the quality of cotton and some other fabrics. The Crease Recovery Tester (CRT) measures the angle of recovery and is used to define Easy Care and Easy Iron labeling. The crease recovery angle (CR angle) indicates the ability of the fabric to recover to its original state. The recovery angle is normally determined by visual observation of people, which much depends on human being such as their observation and their experiences. Therefore, this can cause quite remarkable errors in the measuring result. In order to avoid this, we focus on the design and control of the automatic crease recover tester which can be measure a certain number of samples at the same time automatically. In this tester, the digital image technology are used to measure the crease recovery angle automatically. This tester can be programmed to test the fabric samples with some different impacts. The measuring process is carried out by the image taken by a suitable camera inside the tester. After the appropriate testing time, the result will be report via the monitor. The real automatic recovery tester is designed and fabricated to check the suitability and feasibility of our propose methods.

Keywords*:* crease recovery tester (CRT), image processing, samples, fabric, measure, crease recovery angle.

1. Introduction

The concept of crease recovery tester is quite new in the human life. However, this type of tester or machine play a very important role in the textile engineering. This is a good tool to use for checking the characteristic of clothes.

Creased or folds of textile materials is a complex effect related to tensile strength, compression, bending and torsion stresses. Crease recovery is one of the most important features of the fabric which must be evaluated regularly to improve the quality of the products. The crease of fabric is usually measured by tracking the changes in the form of a corner crease cloth folded in a certain time.

The CRT is a specialized equipment in the textile industry to measure the crease angles of fabric samples according to standards BSEN: 22313 - 1992, ISO 2313: 1972 and other equivalent standards of other countries [1]. If the angle is 0 degree, this means that the recovery creased is zero. If the angle is 180 degree, then the recovery is absolutely complete.

In this paper, the automation method which is used image processing technology has been proposed to measure the creased corner of the fabric. This machine/tester is capable of performing measurements with five samples of fabric for one measurement. The research results will give an automation solution using image processing technology to measure the angle of the fabric restoration. In addition, with the combination of the mechanical structure of the tester, we can develop the CRT to substitute for the manual measurement methods.

Image processing technology is a filed of science that has been used for quite long time and is has many applications in some fields as: medical, space science and weather forecast, etc. Nowadays, with the development of the science and technology, there are many type of cameras have been developed to be applied in to the automation process in industries.

2. The measurement process

2.1 Definition

The crease recovery angle is the capability to recover the initial position of the sample fabric under the pressing force and time [1].

The standard to be used for measure the crease recovery angle: BSEN: 22313 – 1992, ISO: 2313 – 1972.

Equipment and facilities used in the experimental process: CRT, sample clip, clock.

Preparing 20 samples, 10 vertical tapes samples (5 right tapes, 5 left tapes) and 10 horizontal tapes sample (5 right tapes, 5 left tapes). Vertical tape is the fabric sample that is cut in vertical direction and horizontal tape is the fabric sample that is cut in horizontal direction. The right tape is that we will fold 2 right sides of fabric sample. The left tape is that we fold 2 left side of fabric sample. Using the 40mm x 45mm calibration tool to prepare sample on fabric that having length parallel with vertical or horizontal in order to make the samples not coincide with the vertical or horizontal direction. Using scissors to cut the right size 400mm x 15 mm; marking right, left samples [1].

2.2 Experimental steps

Those steps are carried out which is based on standard BSEN: 22313 – 1992, standard ISO: 2313- -1972. The crease recovering measurement is performed by 8 steps as follow:

- Step 1: Prepare the samples – vertical tape (right marking)
- Step 2: Double folding and put a piece of paper between the two sides along the length of the sample.
- Step 3: Using clips to grip 2 samples that have just folded (no more than 5mm into the edge of sample). Put the sample into the compressed position.
- Step 4: Using force 10N = 1.019 kg (standard ISO 2313: 1972), lower down the load to compress samples.
- Step 5: Using the clock to measure time and pull the clip out of sample.
- Step 6: Measure the clock to compress sample in 5 minutes ± 5 seconds.
- Step 7: After 5 minutes, gently lift up the load and using clip grab samples out of position then put on the sample holder, so that 1/2 folded sample is in the free state; Measure the clock to recover sample in 5 minutes ± 5 seconds.
- Step 8: After 5 minutes, adjust the free part of sample to verticality in order to let the lower edge of the sample parallel with the edge, read the correct angle at the edge. If the result is incorrect, we should adjust the position of sample edge cross with the edge and then read the correct angle at the measure edge.

Continue to measure the next following other sample (left marking) with the same procedure.
Continue to measure the horizontal samples with the same process with the vertical ones.
At the end of the measurement process, the result is the average value of 5 times measurements of each side of the sample fabric. The measurement angle must have the following angle values: the vertical left angle, the vertical right angle, the horizontal left angle, the horizontal right angle. If the final value of the angle values have the errors over $\pm 10^0$, we must redo the whole process.

3. Design of the automatic crease recovery tester

The crease recovery tester (CRT) must be designed to meet the measure standard as in [1]. Besides, the number of fabric samples in one test must be considered to be suitable for the size and the purpose of the tester.

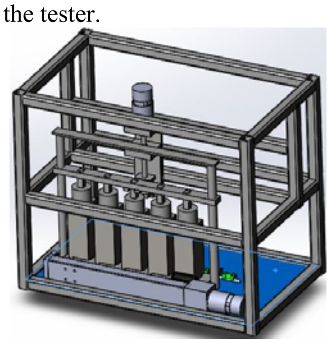

Fig. 1 The automatic crease recovery tester

With the design of this CRT, we proposed the measure process with 5 fabric samples at the same time as in [1]. This means that we need totally 20 sample for each type of fabric. The 20 samples including 10 vertical samples (5 left side and 5 right side) and 10 horizontal samples (5 left side and 5 right side). The design of the CRT is introduced as in Fig. 1 and the real CRT is described in Figs. 2-3.
The operation principle of the CRT:
+ Step 1: Firstly, control the lifting system take the loads off the sample positions.
Step 2: Each fabric samples is fold with a sheet is put between to sides of the fabric; Put the sample into the correct position; Control the 5 clamping structure to keep the 5 fabric samples at the initial position.
Step 3: Control the lifting system put the loads on the 5 fabric samples.
Step 4: After 5 minutes, the lifting system will carry the loads off the surface of the fabric samples. The upper side of the sample (free side) will move up and make an angle with the lower side of the sample. This angle is called the crease recovery angle.
Step 5: Wait for 5 minutes for the fabric completely recover. The camera will capture the 5 angles of the samples.
The automatic CRT is introduced in Fig. 2, 3 below:

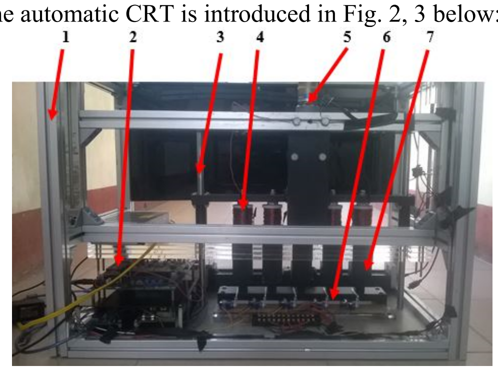

Fig. 2 The automatic crease recovery tester. (Front view)

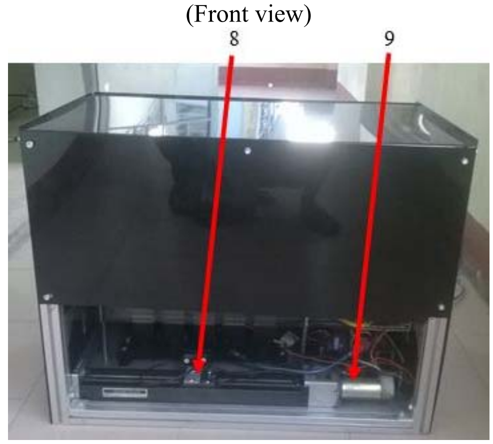

Fig. 3 The automatic crease recovery tester. (Back view)

In this CRT, the components of the tester are:
(1) The CRT frame made by aluminum.
(2) Control circuit.
(3) Slider.

(4) Electrical magnetic.
(5) Lifting loads DC motors.
(6) Fabric sample clamp.
(7) Load impact direcly on the fabric samples.
(8) Camera.
(9) Motor control the position of the camera.

4. Application of image processing technology in measuring the crease recovery angle.

Most of the CRT is not the automatic machine. The users have to measure the recovery angle by the observation of their own eyes. This will cause the big errors of the measurement process. Besides, the fabric is quite soft and not easy to measure by traditional methods and conventional tools. So, in order to measure this recovery angle, the image processing technology is the most suitable method.

The application of the image processing technology for measuring this crease recovery angle is proposed as follow.

The coordinate to measure the crease recovery angle as introduced in Figs. 4, 5, 6. [2][3]

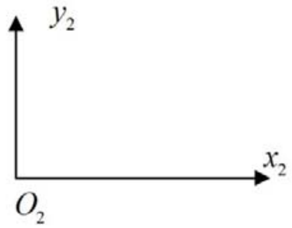

Fig. 4 The measure coordinate.

The practical coordinate of the camera:

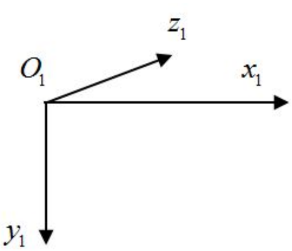

Fig. 5 The practical coordinate.

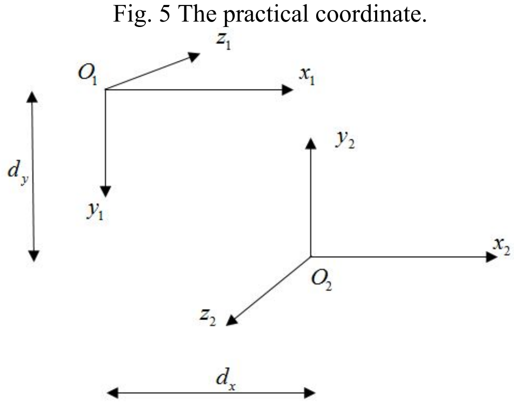

Fig. 6 The translation coordinate from O_1 to O_2.

The methods to change to practical coordinate $O_1x_1y_1z_1$ to the measure coordinate $O_2x_2y_2z_2$ is carried out as follow:

$$R = R_x(180^0) \quad (1)$$

With: $R_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\beta & -\sin\beta \\ 0 & \sin\beta & \cos\beta \end{bmatrix}$

Then: $$\Rightarrow R = R_x(180) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \quad (2)$$

In order to finish the process to convert the practical coordinate to the measure coordinate, we need the translation of the O_1 to O_2.

We have the position of the point P in the two coordinates as P1 and P2:

$P_1 = (a_1 \quad b_1 \quad c_1)$, $P_2 = (a_2 \quad b_2 \quad c_2)$.

The position of O_1 in the $O_2x_2y_2z_2$ coordinate is: $O_1\left(d_x \quad d_y \quad d_z\right)$. (with $d_z = 0$)

Then, we have: $$P_2 = O_1 + P_1 \quad (3)$$

The position of $P_1 = \begin{bmatrix} a_1 \\ b_1 \\ 0 \end{bmatrix}$ in the $O_1x_1y_1z_1$ when considered in the $O_2x_2y_2z_2$ coordinate as:

$$P_2 = R\begin{bmatrix} a_1 \\ b_1 \\ 0 \end{bmatrix} + \begin{bmatrix} d_x \\ d_y \\ 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} x \begin{bmatrix} a_1 \\ b_1 \\ 0 \end{bmatrix} + \begin{bmatrix} d_x \\ d_y \\ 0 \end{bmatrix} = \begin{bmatrix} d_x + a_1 \\ d_y - b_1 \\ 0 \end{bmatrix}$$

Then, based on the position of P2, the crease recovery angle is calculated as:

$$\alpha = \arctan(\frac{d_y - b_1}{d_x + a_1}) \quad (4)$$

In our automatic control CRT, the frame of the image is chosen as 640x480 pixels, the position of O_2 in the $O_1x_1y_1z_1$ coordinate: O_2 (320 480 0). Therefore, the position of O_1 in the $O_2x_2y_2z_2$ coordinate: O_1 (-320 480 0).

$$P_2 = \begin{bmatrix} d_x + a_1 \\ d_y - b_1 \\ 0 \end{bmatrix} = \begin{bmatrix} a_1 - 320 \\ 480 - b_1 \\ 0 \end{bmatrix} \quad (5)$$

Then, the crease recovery angle is calculated by:

$$\alpha = \arctan(\frac{480 - b_1}{a_1 - 320}) \quad (6)$$

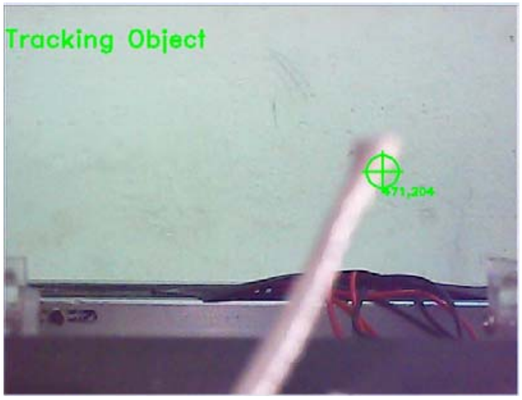

Fig. 7 The tracking object using camera.

5. Control the operation of the crease recovery tester

- **Condition**

The operation of the tester must meet the following conditions:

+ The time condition: The total time to measure the crease recovery tester do not exceed 5 seconds for each test of one fabric sample. During this 5 seconds, the measurement of the crease recovery angle must be less than 2 seconds, than we can see that the moving for the camera does not exceed 3 seconds. In this process, the postion controller is design the control the camera move with the condition of time and position.

+ The position condition: The initial position of the camera and the position of each fabric samples is introduced as in Fig. 8.

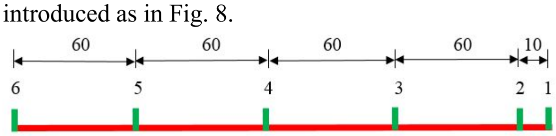

Fig. 8 The arrangement of the fabric sample position and camera postion.

Where:

(1) The initial position of the camera.

(2) (3) (4) (5) (6): The positions of the 5 fabric samples.

The table 1 presents the errors between the position errors and the measure angle errors.

Table 1: The relationship between the position error and the measure angle error.

Angular angles	-3 mm	-2 mm	-1 mm	1 mm	2 mm	3 mm
15°	13,06°	13,65°	14,29°	15,78°	16,64°	17,6°
30°	26,2°	28,63°	27,37°	31,5°	33,13°	34,93°
45°	39,52°	41,22°	43,04°	47,1°	49,35°	51,77°
60°	53,11°	55,28°	57,58°	62,54°	65,21°	67,99°
75°	67,06°	69,62°	72,27°	77,8°	8,66°	83,57°
90°	81,47°	84,29°	87,14°	92,86°	95,71°	98,53°
105°	96,43°	99,34°	102,2°	107,73°	110,38°	112,94°
120°	112,01°	114,79°	117,46°	122,42°	124,72°	126,89°
135°	128,23°	130,65°	132,9°	136,96°	138,78°	140,48°
150°	145,07°	146,87°	148,5°	151,37°	152,63°	153,8°
165°	162,4°	163,36°	164,22°	165,71°	166,35°	166,94°

From the values in table 1, when the position errors of the camera is smaller than ± 3mm, the crease recovery angle is smaller than ± 10°. This is the good compatible to the criteria of the standard for measuring the crease recovery angles.

- **The design of the position PID controller.**

The conventional PID controller [4][5] is design to control the position of the camera for each measure step of the whole process. The responses of the motor positions are introduced as:

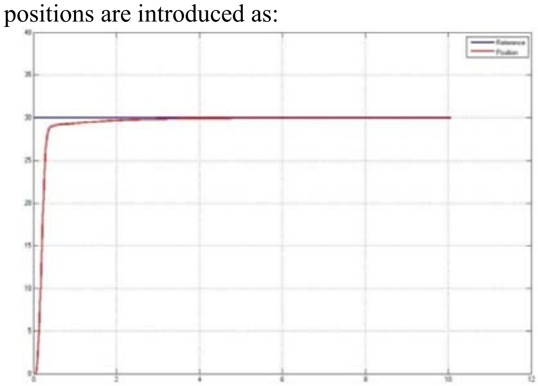

Fig. 9 The response of the camera position controlled by PID controller.

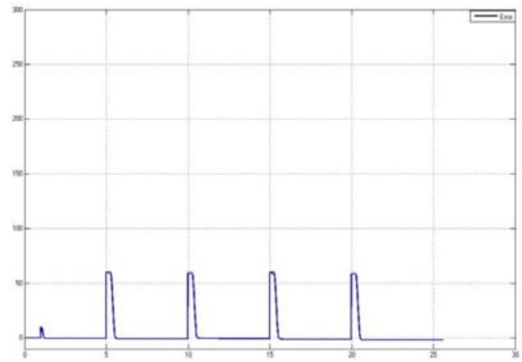

Fig. 10 The error of the camera position using conventional PID controller.

The error of the system when using PID controller is in Fig. 10. In this figure, the PID controller has quick response but it has quite big error: from 0 to 3mm.

In order to overcome the big error of the PID controller, the Fuzzy PI controller [6] is proposed to control the camera position.

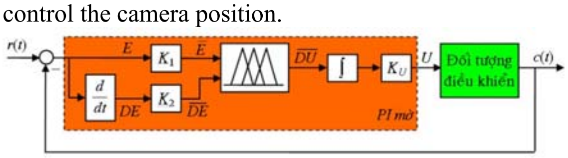

Fig. 11 The diagram of the Fuzzy PI controller.

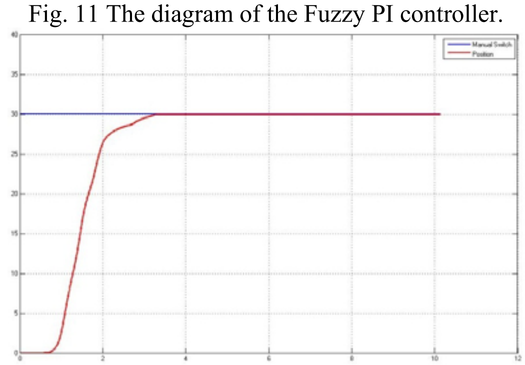

Fig. 12 The response of the camera position using Fuzzy-PI controller.

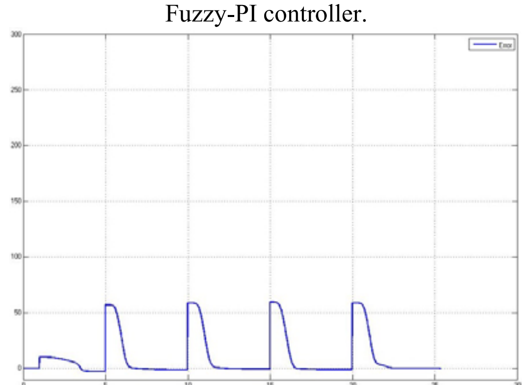

Fig. 13 The error of the camera position using Fuzzy-PI controller.

From Figs. 12, 13, the response of the camera positions is a little slower than the conventional PID controller. However, the errors is smaller (0mm to 1mm). This is the improvement of the Fuzzy-PI controller.

Finally, both controllers PID and Fuzzy-PI controllers meet the condition about time and position of the camera's position control process. However, the error using the Fuzzy-PI controller is quite smaller than the conventional PID controller.

6. The experimental results

The automatic CRT developed in this research is controlled directly by computer program. The main menu of the control program is introduced in Fig. 14.

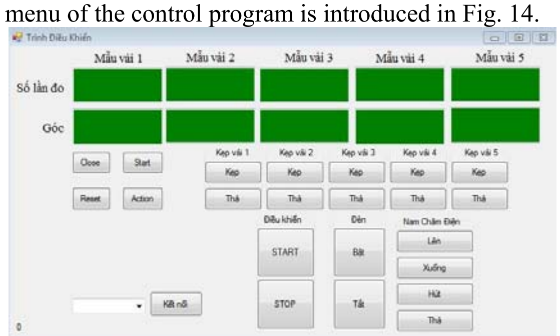

Fig. 14 The control program in computer.

The operation principles of the automatic CRT follows these steps:

+ Step 1: Open the control program in computer as in Fig. 14.
+ Step 2: Connect the computer and the CRT (using RS232 standard)
+ Step 3: Control the lifting system to put the loads into correct position on the fabric samples.
+ Step 4: Press the Start button of the control program dialog.
+ Step 5: The results values of the measurement are exported into file.

The whole process of the automatic measuring the crease recovery angle is introduced by the following figures below.

In the first step, clamp the fabric sample as introduced in Fig. 15. Then, the loads are placed on the fabric samples. The load will be placed on the fabric samples for 5 minutes (Fig. 16). Then, the lifting system will put the load off the fabric samples (Fig. 17).

Fig. 15 Clamp the fabric samples by RC servo motors.

AMM0006

Fig. 16 Place the loads on the fabric samples.

Fig. 17 Lift the load off the fabric samples.

Fig. 18 Measure the crease recovery angle.

After the operation of the measurements, the results will be exported to a *.txt file in computer with the structure as in Fig. 19.

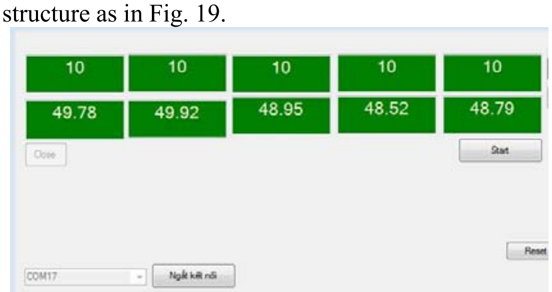

Fig. 19 The results of the measurement process.

In order to check the stability of the tester, the same fabric sample are measure by 10 times and it results in the same values as introduced in Fig. 20.

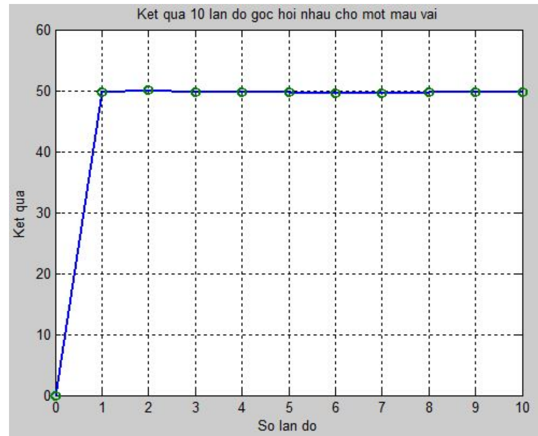

Fig. 20 The result of 10 times measurement of one fabric sample.

Besides, to make the image processing system work effectively and stability, the whole CRT is put into a black and tight cover. A suitable light source is also put inside of the CRT. These things have the role to keep the inside environment of the CRT be stable with the suitable light and it does not be impact from the outside disturbance.

6. Conclusion

In this paper, we survey the method to measure the crease recovery angle by manual to make it as the concept to propose the automatic crease recovery tester. This tester is design and fabricate with respect to the standards for crease recovery angle testing. The image processing method is applied to measure the angle automatically. At the primary experiments, the tester gives good results that meet all the requirements of the textile process. The result of the measurement can also be save as the text file in computer. This is a better ways to help the user to arrange and manage their measurement process. In the next steps, the experiments of the tester will be carried out more and more to get the best results and to improve the quality of the tester.

References

[1] British Standards Institution, BSEN 22313:1992, ISO 2313:1972 - Textile fabrics - Determination of the recovery from creasing of a horizontally folded specimen by measuring the angle of recovery (1999).

[2] Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing (3rd Edition), Pearson Prentice Hall, 2007.

[3] Gerhard X. Ritter, Joseph N. Wilson, Handbook of Computer Vision Algorithm in Image Algebra, CRC Press, 2000.

[4] Richard C. Dorf, Robert H. Bishop, Modern Control Systems, 8th Edition, Addition-Wesley Longman, INC, 1998.

[5] Katsuhiko Ogata, Modern Control Engineering, 5th Edition, Prentice Hall, 2010.

[6] Kazuo Tanaka, Hua O. Wang, Fuzzy Control Systems Design and Analysis, John Willey & Son, 2011.