DESIGN VISION SYSTEM TO RECOGNIZE THE SCRIBED NUMBER ON THE WAFER

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Control, Instrument and Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

"I hereby declare that I have read through this report entitle "Design of Vision System to Recognized the Scribed Number on the Wafer" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)"

Signature : .....

Supervisor's Name : Mr.Lim Wee Teck

Date : .....

I declare that this report entitle “Design of Vision System to Recognized the Scribed Number on the Wafer” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

To my beloved mother and father

ACKNOWLEDGEMENT

In preparing this report, I was in contact with many people, researchers, academicians and practitioners. They have contributed towards my understanding and thought. In particular, I wish to express my sincere appreciation to my main project supervisor, Mr. Lim Wee Teck, for encouragement, guidance critics and friendship. I am also very thankful to my panel Pn. Saleha Binti Mohamad Saleh and Dr. Lim Kim Chuan for their guidance, advices and motivation. Without their continued support and interest, this project would not have been same as presented here. My sincere appreciation also extends to all my classmate and others who have provided assistance at various occasions. Their views and tips are useful indeed. Lastly, I am grateful to all my family members.

ABSTRACT

This project is carry on as industrial implementation with Silterra. Sdn. Bhd. The company existing vision machine very expensive and the sample being scanned and stored in the database unable to modified or editable. The company requested to design vision system to replace the existing one. Therefore, the objective of the project is to design a vision system by using Matlab Simulink to recognize the scribed number on the wafer and store the detected scribed number in Excel file. Due to unable to physically test at the company, therefore the testing sample and hardware setup to mimic the environment at the production line should be considered. Besides that, the theory for techniques of Optical Character Recognition (OCR) and previous work related to project are studied and a concept of designing the vision system is carried out. To validate the result, the hardware setup to mimic the environment at the Silterra production line and testing sample both are considered. Besides being valid, a test should also be reliable, to ensure the vision system able to perform well, three experiments are carry out and each experiment are tested by 100 good and 100 not good testing samples which is to identify the best image size, median filter, and the matching percentage respectively. For the confirmation test, with the best identified parameter from previous experiment, to test others 100 good and 100 not good testing sample to the system in the existing of white and yellow color of light to ensure system can produce up to 95% of recognition, and this also can identify whether the final result will or will not be affected by color of light. Based on the result finding, the vision system design actually can have up to 100% of recognition, and cheaper price compare to the existing vision machine at the company. As the conclusion, hopefully the vision system design can really apply at Silterra Sdn. Bhd.

ABSTRAK

Projek ini berjalan seperti pelaksanaan industri dengan Silterra. Sdn. Bhd syarikat yang sedia ada mesin visi yang sangat mahal dan sampel scan dan disimpan dalam pangkalan data tidak dapat diubah atau disunting. Syarikat itu meminta untuk mereka bentuk sistem penglihatan untuk menggantikan yang sedia ada. Oleh itu, objektif projek ini adalah untuk merekabentuk satu sistem penglihatan dengan menggunakan Matlab Simulink untuk mengenali nombor tersebut scribed pada wafer dan menyimpan nombor scribed yang dikesan dalam fail Excel. Oleh kerana tidak dapat fizikal menguji di syarikat itu, oleh itu sampel ujian dan persediaan perkakasan untuk meniru alam sekitar di barisan pengeluaran perlu dipertimbangkan. Selain itu, teori untuk teknik Aksara Optik (OCR) dan kerja-kerja sebelum ini yang berkaitan dengan projek yang dikaji dan konsep mereka bentuk sistem penglihatan yang dijalankan. Untuk mengesahkan keputusan, persediaan perkakasan untuk meyerupai alam sekitar di barisan pengeluaran Silterra dan sampel ujian kedua-dua akan dipertimbangkan. Selain menjadi sah, ujian juga perlu boleh dipercayai, untuk memastikan sistem penglihatan yang dapat menunjukkan prestasi yang baik, tiga eksperimen yang menjalankan dan setiap uji kaji diuji oleh 100 baik dan 100 sampel ujian tidak baik iaitu untuk mengenal pasti saiz imej yang terbaik, iaitu median menapis, dan peratusan yang hampir sama masing-masing. Untuk ujian pengesahan, dengan parameter yang terbaik yang dikenal pasti daripada eksperimen sebelum ini, untuk menguji dengan mengunakan 100 baik dan 100 sampel ujian tidak baik kepada sistem yang sedia ada dalam keadaan yang bercahaya warna putih dan kuning untuk memastikan sistem boleh menghasilkan sehingga 95% daripada pengiktirafan, dan ini juga boleh mengenal pasti sama ada keputusan akhir akan atau tidak akan terjejas oleh warna cahaya. Berdasarkan penemuan hasil, reka bentuk sistem penglihatan sebenarnya boleh mempunyai sehingga 100% daripada pengiktirafan, dan harga lebih murah berbanding dengan mesin yang sedia ada di syarikat itu. Sebagai kesimpulan, diharapkan reka bentuk sistem penglihatan boleh diaplikasikan di Silterra Sdn. Bhd

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CHAPTER 1

INTRODUCTION

This chapter will discuss the background of machine vision with Optical Character Recognition; problem statement, objective and scope of the project.

1.1 Motivation

Machine vision provided important advantage in term of cost and precision. It has been proven successful in controlled environment such as factory production line to ensure repeatability and reproducibility in good quality control, and can run continuously without rest.

However, the existing sorting machine in Silterra manufacturing plant is used as a wafer tracking process to scan and sort the wafer base on the scribed number and this can help the workers to determine the wafer position. Unfortunately, the sorting machine is very expensive (around RM600 000).Therefore, this causes the limited number of sorting machine available in the production line.

Furthermore, the large quantities of wafer produced in short period with good quality which can saving cost and time. Due to limited number of sorting machine available in the production line, this will take a long time when large quantities of wafer need to process, and if any system breakdown will causes loss to the company in both cost and time. Figure 1.1 shows the existing tracking process in Silterra Sdn. Bhd.

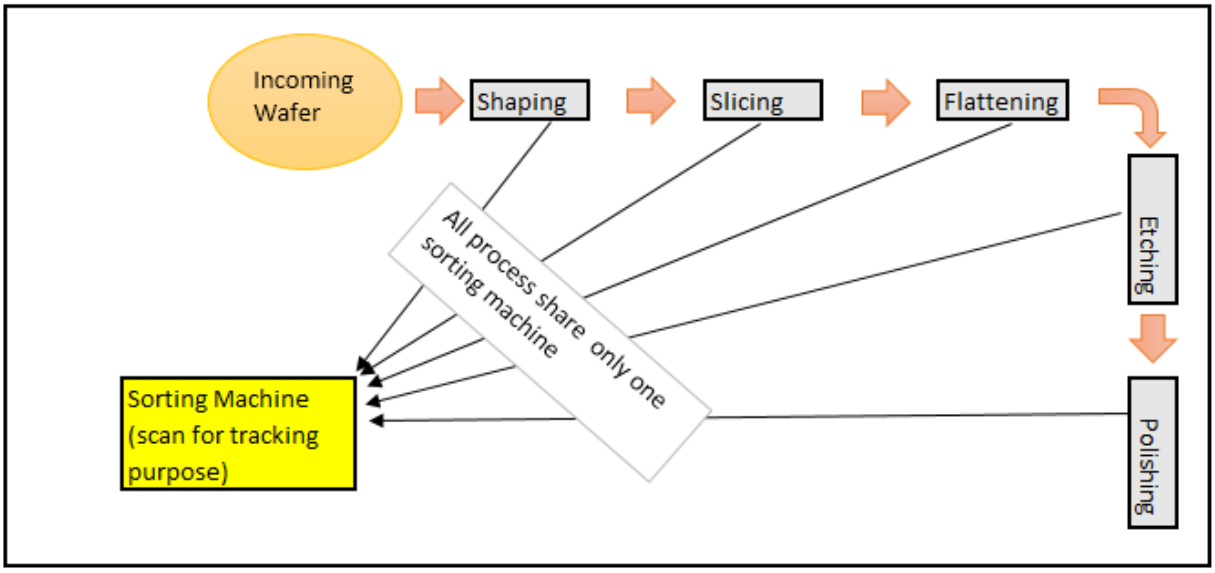


Figure 1.1: The existing tracking process in Silterra Sdn. Bhd.

For this reason, a low cost vision system design with Optical Character Recognition is created to increase the number of sorting machine in industry, especially dealing with high volume of wafer produced. Figure 1.2 shows after implement the low cost vision system design.

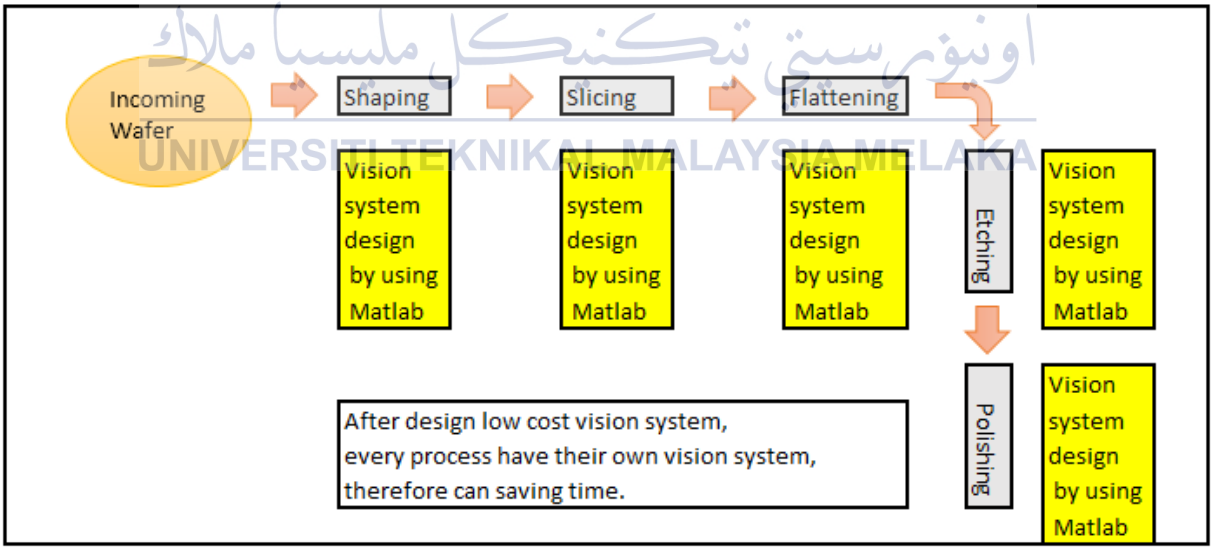


Figure 1.2: After implement the proposed low cost vision system

1.2 Problem Statement

As a semiconductor manufacturing company, Silterra Sdn. Bhd produces microchip and the wafer processing are one of the existing process in the production. The existing sorting machine are used to scan the scribed number on wafer and store data to an Excel file for wafer tracking process to determine the position of the wafer. But the machine is very expensive (around RM 600,000) and causes limited number of machine available in the manufacturing plant, therefore the time taken of the scanning process will be long and if any breakdown will directly cost the company in both money and time.

1.3 Objective

The aim of this project are:

1) To design a vision system to recognize the scribed number on the wafer.
2) To store the detected scribed number to Excel file.

1.4 Scope

The scope of this project are the vision system design by using Matlab Simulink and low cost Logitech Webcam HD C615 (RM 200) to captured the image. Due to unable to get the real wafer sample, therefore to prepare the printed sample based on standard SME M12/M13. Required percentage of recognition up to 95%. To mimic the environment illuminated by white and yellow light. The prototype with the size of 18cm width x10.5cm height and the distance between the webcam and sample is 5cm.

CHAPTER 2

LITERATURE SURVEY AND PROJECT BACKGROUND

This chapter discuss the summary of previous work related to the project, the theory of OCR technique and proposed model of the vision system design.

2.1 Journal Literature

The comparison between all the previous works related to project such as Optical Character Recognition for Automatic License Plate Recognition, Optical Character Recognition on document reading, and Optical Character Recognition on surface product item. All this previous work are very helpful by giving a lot of ideas and knowledge which can implement and apply to the project.

2.1.1 Automatic License Plate Recognition

In 2003, Muhammad Sarfraz, Mohammed Jameel Ahmed, and Syed A. Ghazi et al.[1] presented the license plate recognition methods as shown in Table 2.1. Recognition rate proved to be 96.22% for the extraction of plate region, 94.04% for the segmentation of the characters and 95.24% for the recognition unit accurate, giving the overall system performance 95% recognition rate. This approach having some problem in extracting the plate, diplomatic cars and military vehicles, are not addressed since they are rarely seen. Detection only for white, black, red, and green color plate or numbers.

Table 2.1: The OCR techniques used by Muhammad Sarfraz, Mohammed Jameel Ahmed, and Syed A. Ghazi to recognize the license plate.

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
Digital camera			Vertical edge detection by sobel algorithm, Filtering by seed filling algorithm, Vertical Edge Matching	Normalization, Template matching	

In 2005, Serkan Ozbay, and Ergun Ercelebi et al.[2] recognized OCR techniques as shown in Table 2.2. Final output it is proved to be 97.6% for the extraction of plate region, 96% for the segmentation of the characters and 98.8% for the recognition unit accurate, giving the overall system performance 92.57% recognition rate. This system is designed for the identification of Turkish license plates only.

Table 2.2: The OCR techniques used by Serkan Ozbay, and Ergun Ercelebi to recognize the license plate.

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
		Smearing algorithms, Filtering, Morphological algorithms	Edge detection algorithms, Smearing algorithms	Template matching	

In 2010, Kumar Parasuraman and P.Vasantha Kumar et al. [3] proposed an algorithm consists of three major parts as shown in Table 2.3. The overall system performance 98% recognition rate. The proposed method is mainly designed for real-time Malaysian license plate, and can be readily extended to cope with license plates of other countries, especially those using Latin characters.

Table 2.3: The OCR techniques used by Kumar Parasuraman and P.Vasantha Kumar to recognize the license plate.

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
	Thinning	Vertical and horizontal projection	Edge detection algorithm, Vertical projection	Chain code	

2.1.2 Optical Character Recognition on document reading

In 2010, G.Vamvakas, B.Gatos, N. Stamatopoulos, and S.J.Perantonis et al. [4] proposed a methodology for recognizing historical documents as shown in Table 2.4. The overall system performance 98.4% of recognition for the test line detection rate, 98% for the text line recognition accuracy and 97% for the word segmentation detection rate, 90.3% for word segmentation recognition accuracy, giving the overall system performance 95.8% recognition rate. This methodology can be applied to either machine printed or handwritten documents. It requires neither any knowledge of the fonts nor the existence of standard database because it can adjust depending on the type of documents that want to process.

Table 2.4: The OCR techniques used by G.Vamvakas, B.Gatos, N. Stamatopoulos, and S.J.Perantonis to recognize the historical documents.

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
	Binarization and Enhancement	Text line segmentation, Word and character segmentation	Normalization, Zoning, Upper and lower character profiles, Left and right character profiles	Radial basis function (RBF) kernel	

In 2010, Junaid Tariq, Umar Nauman, and Muhammad Umair Naru et al. [5] presented a simple, efficient, and less costly approach to construct OCR for cards reading or any document that has fix font size and style are shown in Table 2.5. Line extraction accuracy is 100%. Character extraction accuracy is 100%. The accuracy result of both the hard matching and soft matching (2 value range) also 100% but in soft matching (4 value matching) is 96.15%. It having some limitation like to use soft matching. For example: character explanation mark "!" might be matched with character capital "L" or small letter "I".

Table 2.5: The OCR techniques used by Junaid Tariq, Umar Nauman, and Muhammad Umair Naru to recognize for name cards reading.

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
scanner	Binarization	Line segmentation, Character segmentation	"height", "width", and "checksum"	Hard matching, Soft matching	

In 2011, Teresa Vania Tjahja, Anto Satriyo Nugroho, Nur Aziza Azis, Rose Maulidiyatul Hikmah, and James Purnama et al. [6] proposed Indonesian Automated Document Reader (IADR) is an assistive system for Indonesian citizens with visual impairment, which converts textual information on papers to corresponding speech that are used as shown in Table 2.6. The average accuracy for text segmentation result without recursion is 98%, for text segmentation result with recursion is 100%, and for text segmentation result with color images is 96%. Besides that, the recognition rate for character recognition result for letters and numbers is 98.31%, for character recognition result for symbols and punctuation marks is 95%, and giving 95% in word correction result. The proposed algorithm for grayscale images also serves as the basis of text segmentation algorithm for color images.

Table 2.6: The OCR techniques used by Teresa Vania Tjahja, Anto Satriyo Nugroho, Nur Aziza Azis, Rose Maulidiyatul Hikmah, and James Purnama to recognize for (IADR)

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
	Noise removal, Binarization (Otsu's thresholding)	Text and character Segmentation	Normalization, histogram analysis	Multilayer Perceptron (MLP) neural network	lexicon-based, Longest Common Subsequence (LCS)

2.1.3 Optical Character Recognition on surface product item

In 2003, Ernest Valveny, and Antonio L´opez et al. [7] proposed an application of OCR techniques for quality control in industrial production which is to verify the correct printing of numerical information in sachets with surgical material. OCR technique used as shown in Table 2.7. The percentage of rejected sachets due to printing errors has been 0.22%. There are only three different numerals, which is the minimal difference between two reference numbers.

Moreover different numerals are 3 and 8, 0 and 3, and 9 and 6, some of which could be easily confused.

Table 2.7: The OCR techniques used by Ernest Valveny, and Antonio L´opez to recognize for numerical information in sachets with surgical material

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
Webcam	Skew correction, Binarization (Optimal threshold), Thinning	Connected components	Zoning	Template matching	

In 2010, Huihuang. Zhao, and Zhaohua. Wu et al. [8] presented an approach to recognizing characters in surface mount technology (SMT) product. The process of SMT product character recognition based on BP neural network can be described as shown in Table 2.8. Experimental results indicate the proposed character recognition can obtain satisfactory character-recognition rate and the recognition rate reached over by 98.6%.

Table 2.8: The OCR techniques used by Huihuang. Zhao, and Zhaohua. Wu to recognize characters in surface mount technology (SMT) product

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
Image sampling equipment	Binarization	Low pass filter, Median filter	Character segmentation, Character normalization, Character compact		BP neural network

In 2009, Rakhi P. Ghugardare, Sandip P. Narote, P. Mukherji, and Prathamesh M. Kulkarni et al. [9] a generalized module for automatic calibration of any measuring instruments (e.g. Temperature Monitoring System) using optical character recognition approach that are shown in Table 2.9. Final output is proved to be 92% for the recognition accuracy in digital multi-meter, and 100% for temperature measuring instrument. The current restrictions are: The distance between the camera and display, the skew in the image and these should be dealt with if required depending on the factory environment.

Table 2.9: The OCR techniques used by Rakhi P. Ghugardare, Sandip P. Narote, P. Mukherji, and Prathamesh M. Kulkarni to recognize Temperature Monitoring System

Image Acquisition	**Pre-processing**	**Segmentation**	**Feature Extraction**	**Recognition**	**Post-processing**
	Binarization	Image scissoring algorithm, Character normalization	Statistical extraction	Template matching	

2.2 Summary Previous Works Related to Project

To analysis the OCR technique used by all the researcher as the reference which can apply and use the techniques to project. Table 2.10 show the summary of all the previous work related to the project and the proposed model that implement to the project after studied. The proposed method is obtain by referring to the OCR techniques that majority researcher are used and related to the requirement from the Silterra. Sdn. Bhd.

Table 2.10: The summary of all the previous work related to the project and the proposed model that implement to the project after studied all the previous work.

	Year	Journal Title	Image Acquisition	Preprocessing	Segmentation	Feature Extraction	Recognition	Post-processing
Car Plate Recognition	2003	Automatic License Plate Recognition(A State of Art Review)	digital camera			Vertical Edge Detection by sobel algorithm, Filtering by seed filling algorithm, Vertical Edge Matching	Normalization, Template matching	
	2005	Distance and Color Invariant Automatic License Plate Recognition			Smearing algorithms, Filtering, Morphological algorithms	Edge detection algorithms, Smearing algorithms	Template matching	
	2010	Automatic License Plate Recognition			Thinning, Vertical and Horizontal projection	Edge detection algorithm, Vertical projection	Chain code	
Document Recognition	2010	A Complete OCR Methodology for Historical Document		Binarization and Enhancement	Text Line segmentation, word and character segmentation	Normalization, Zoning, Upper and lower character profiles, Left and right character profiles	Radial Basis Function (RBF) kernel	
	2010	α-Soft: English Language OCR	Webcam	Binarization	Line Segmentation, Character Segmentation	"height", "width", and 'checksum''	Hard matching, soft matching	
	2011	Recursive Text Segment for Color Image for Indonesian Automated Document Reader		Noise removal, Binarization	Text and character Segmentation	Normalization, histogram analysis	Multilayer Perceptron (MLP) neural network	lexicon-based, Longest Common Subsequence (LCS)
Character Product Recognition	2003	Numeral Recognition for Quality Control of Surgical Sachets		Skew correction, Binarization, Thinning	connected components	Zoning	Template Matching	
	2010	SMT Product Character Recognition Based on BP Neural Network	image sampling equipment	Binarization, Low Pass Filter, Median Filter, Grey processing	Character Segmentation, Character Normalization, Character compact and rearrangement		BP neural network	
	2009	OCR System for Seven Segment Display Images of Measuring Instrument		Binarization	Image Scissoring Algorithm, Character Normalization	Statistaical Extraction	Template Matching	
The proposed model apply to project after studied all the previous work								
Proposed model	2013	Design of Vision System to Recognized the Scribed Number on the Wafer	Webcam	Binarization, Grey processing, Median Filter	Character Segmentation, Character Normalization	Zoning	Template Matching	

Based on the previous work related, the proposed model that implement to vision system design to recognize the scribed number on the wafer as shown in Table 2.11:

Table 2.11: The idea of apply OCR technique that get from the previous work related.

OCR technique that decide to implement to the vision system design	
OCR technique	Description
Image Aquisition	**Webcam** • Due to the hardware setup, the device should be hang on top of the testing sample to scan the image, therefore require less weight and small device. By choosing webcam because have less weight and smaller size compare to cheap price camera.
Preprocessing	**Gray processing** • Based on the requirement from the company, the incoming wafer are color image. Therefore, according to the previous work, the researcher using gray processing to convert the color image to gray image for easier visualization of detail. **Median filter** • The vision system design by choosing the median filter rather than low pass filter because median filter is the method effective method that can suppress isolated noise without blurring sharp edges whereas for loss pass filter can reduce noise but it will the blurs image **Binarization** • There are most of the previous researcher used binarization to convert the gray image to black and white image The skew correction and thinning are not suitable use in this vision system design, because the incoming wafer sample all are in well print condition, therefore unable to use the correction method.

Segmentation	**Character segmentation and normalization** • The character are then segmented to separate each character and normalize to same size, this is easier for further recognition. • Text and line segmentation usually use to segment the character on document which consist a sentences and paragraph.
Feature Extraction	**Zoning method** • Is the simple and easier method compare to others
Recognition	**Template Matching** • Based on the scope of the project, the vision system design by using Matlab Simulink, therefore the Multilayer Perceptron neural network is not suitable for this system. • Template matching is the one of the simple and easier to understand method compare to radial basic function kernel.

2.3 Journal Theory Literature

The theory discussed is based on the OCR technique normally used from each previous works related. Optical Character Recognition means a technique of recognition of machine printed or hand written text by computer and then its conversion to an editable form as per the requirement. The various phases of OCR technique are shown in Figure 2.1. [10]

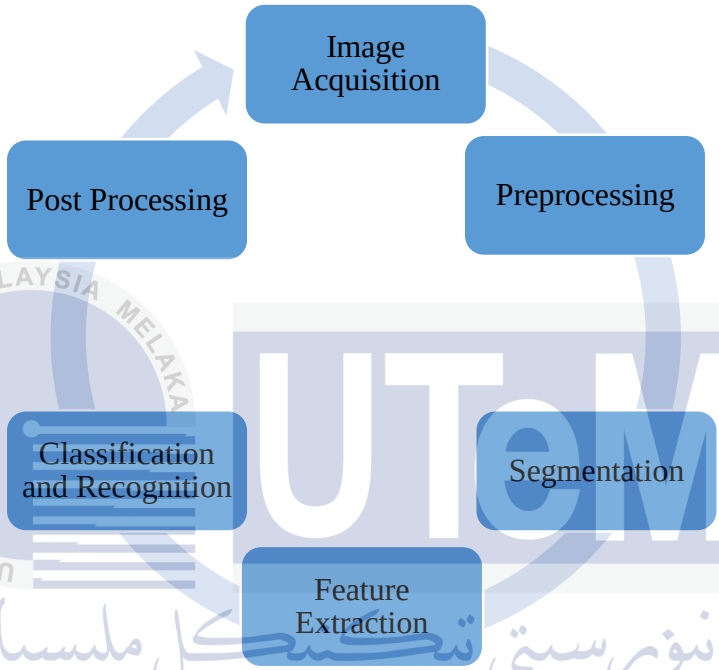


Figure 2.1: Phases of OCR technique

2.3.1 Image Acquisition

The recognition system obtains a scanned image as an input image and have a particular format such as JPEG which can be obtain by a scanner, webcam or any other suitable digital input device [11]. OCR can be divided into two, which is online recognition and offline recognition. The online recognition is linked with dynamic application where need to recognized result simultaneously or within a fraction of time whereas the offline recognition is linked with static application which means entire document first scanned and then processed to recognize. [12].

2.3.2 Preprocessing

After document scanned, a sequence of data preprocessing operations are normally applied to the images of the documents in order to put them in a suitable format ready for next operation. Preprocessing are usually specialized image processing operations that transform the image into another with reduced noise and variation to enhance the visual appearance of images. The conventional preprocessing step as shown in Figure 2.2. [13]

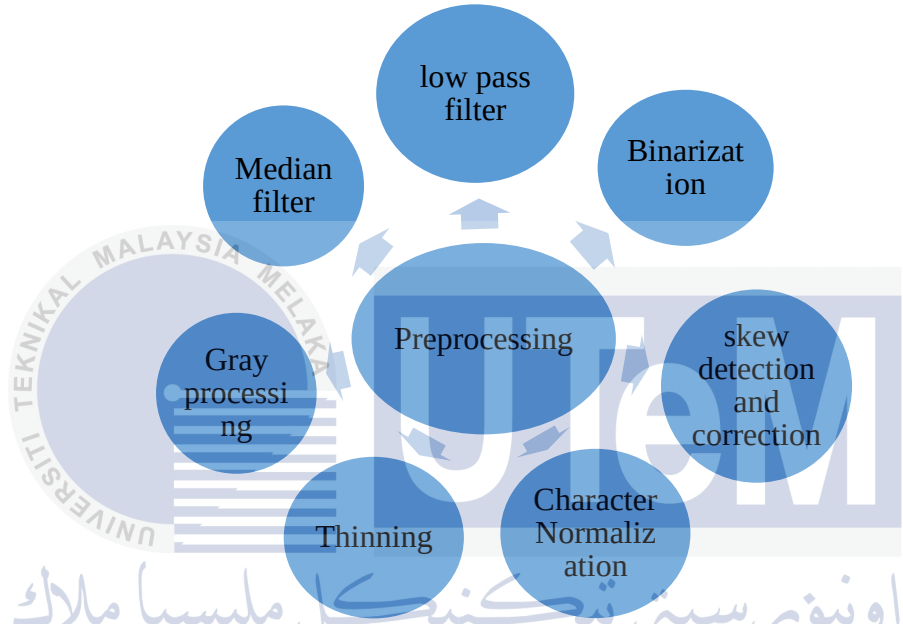


Figure 2.2: Conventional preprocessing steps

Grey Processing

Convert the color image into a grey image. The gray-scale image contains all the details of information, it is easy for understanding and has not ambiguities typical of black-and-white images. In a gray scale image a particular pixel takes an intensity value lying between 0 to 255 where as a binary image it could take only two values either 0 or 1. Figure 2.3 and Figure 2.4 show the color image and grey image respectively. [14]

Figure 2.3: Color image [8]

Figure 2.4: Grey image[8]

Low Pass Filter

Low–pass filter are used for image smoothing and noise reduction. The effect is an averaging of current pixel with the value of its neighbors, most of the time blurring the output image and just allow to pass the low frequency of the image. However, low pass filter can reduce noise but it will the blurs image. The worse the noise, the image need to blur to remove the noise. In Figure 2.5 and Figure 2.6 show the ship image before and after the low pass filter is applied respectively.[15]

Figure 2.5: Original ship image [16]

Figure 2.6: After low pass filtering image [16]

Median Filter

Median filtering is a very important and widely used technique of filtering and best known for its excellent noise reduction ability. During filtering it keeps the edges while removing the noise. This makes the image not to blur as other smoothening methods. Figure 2.7 shows the original image and for Figure 2.8 the image is first exposed to a noise then applied to the median filtering technique to remove the noise. The resulting image noise free is in Figure 2.9 has a better view and, as can be seen.[17]

Figure 2.7:Intensity Image[18]

Figure2.8: Noise applied[18]

Figure 2.9:Median Filter applied[18]

Binarization

Binarization is the processes of translating a gray-scale image to a binary image by choosing threshold selection method to categorize the pixels of an image, if above the threshold value is classified as white and if below than the threshold value is classified as black. Binarization is classified in otsu' threshold and optimal threshold as shown in Figure 2.10. [19]

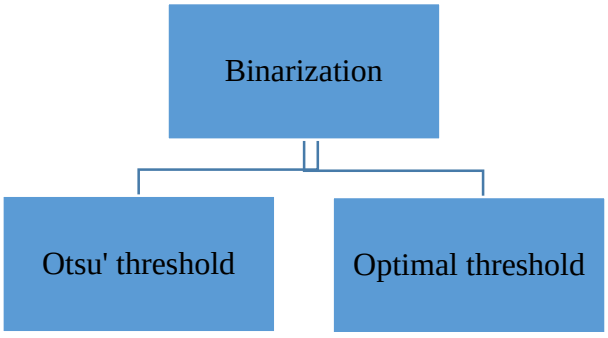


Figure 2.10: Method for binarization

Otsu's Threshold

Convert intensity images to binary images. Otsu method is one of the best automatic thresholding methods. The basic principle in Otsu method is to split the image into two classes which are the objects and the background. For Figure 2.11 and Figure 2.12 is show the image before and after the otsu' threshold is applied respectively. [19]

Figure 2.11: Before Otsu' method [19]

Figure 2.12: After Otsu' method [19]

Optimal Threshold

Optimal threshold should near the cross where the object and the background intersect, the probability of occurrence at the threshold value should divide into two parts. Its half belongs to object and half belongs to background. For Figure 2.13 and Figure 2.14 shows the image before and after the optimal threshold is applied respectively. [19]

Figure 2.13: Before Optimal threshold [19]

Figure 2.14: After Optimal threshold[19]

Skew Detection and Correction

Document skew often occurs during document scanning or copying. However, and it should be eliminated because it dramatically reduces the accuracy of the subsequent processes. Skew detection necessary for aligning a document image before further processing. In Figure 2.15(a) and (b) shown the before and after the skew correction is applied respectively. [20]

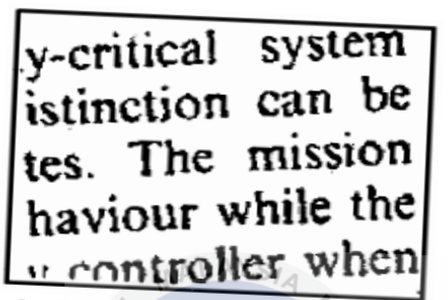


Figure 2.15(a): Before skew correction [20]

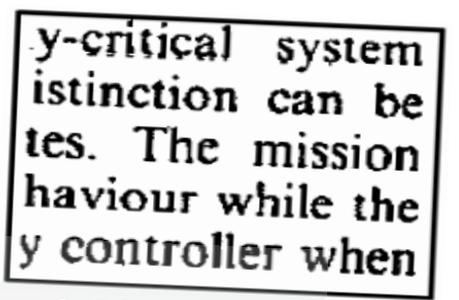


Figure 2.15(b): After skew correction [20]

Thinning

Thinning is the process of peeling off a pattern as many pixels as possible without affecting the general shape of the pattern. In other words, after pixels have been peeled off, the pattern can still be recognized as shown in Figure 2.16 (a) and (b).[20]

Figure 2.16 (a): Before thinning [20]

Figure 2.16(b):After thinning[20]

2.3.3 Segmentation

After the preprocessing stage, many OCR systems isolate the individual characters or strokes before recognizing them. It is one of the hardest, crucial, and time-consuming phases. It represents the main challenge in many character recognition systems, even more than the recognition process itself. It is considered as the main source of recognition errors. A poor segmentation process produces misrecognition or rejection. The strategies for segmentation shown as Figure 2.17.[21]

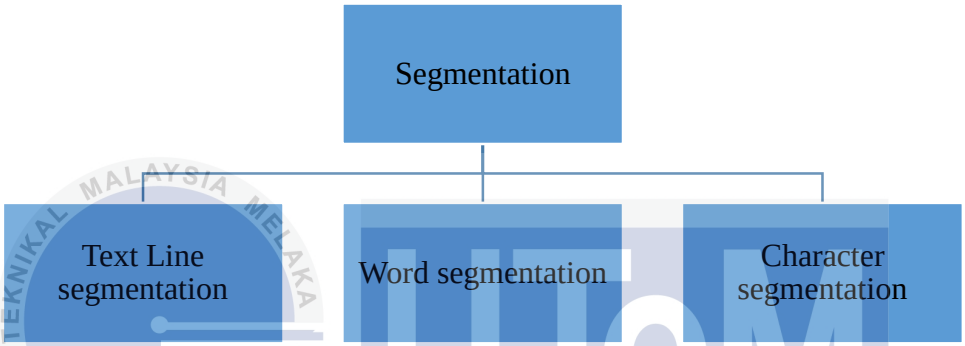


Figure 2.17: Strategies for character segmentation

Text Line Segmentation

To separate each sentences by text line segmentation. If the script is composed by a type-machine therefore the font size will be uniform and the text line are almost same height provided that script is written in specific font size.[21] Between two text lines there is a narrow horizontal band with either no pixel or very few pixels as shown in Figure 2.18.


समाज की ऐसी व्यवस्था, जिसमें कुछ लोग मौज करें और अधिक लोग पीसें और खपें, कभी सुखद नहीं
हो सकती। पूँजी और शिक्षा, जिसे मैं पूँजी ही का एक रूप समझता हूँ, इनका क़िला जितनी जल्द टूट
जाय, उतना ही अच्छा है। जिन्हें पेट की रोटी मयस्सर नहीं, उनके अफ़सर और नियोजक दस-दस पाँच-

Figure 2.18: Line Segmentation [22]

Word Segmentation

From the extracted text line words get separated. Word segmentation aims to determination individual word in a script document. This is done based on the boundary of each word. [21] The boundary of each word is identified and word separation is done according to it as shown in Figure 2.19.

Figure 2.19: Word Segmentation [23]

Character Segmentation

Character segmentation is used to isolate and separate the character. During the process, check for full white pixel column at starting and ending point of the isolated character. Initial character is identified when any red pixel is scanned in the column. Scan continuous until another white pixel column is identified. [21]Every separate image of isolated character is now completely void on four sides as shown in Figure 2.20.

Figure 2.20: Character Segmentation [24]

2.3.4 Feature Extraction

Feature extraction is one of the most difficult and important problems of recognition and an important step in achieving good performance of character recognition system. Figure 2.21 shows that the three feature extraction method. [24]

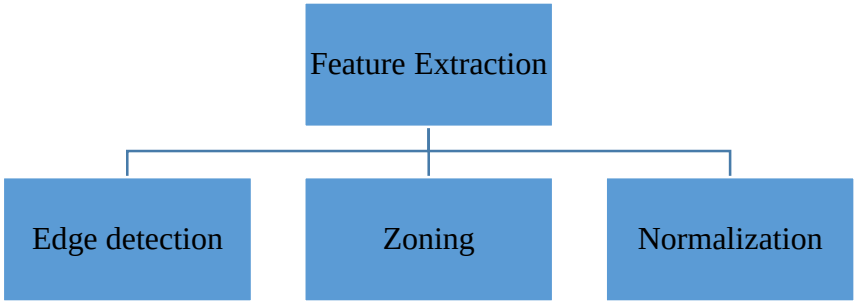


Figure 2.21: Three feature extraction method

Edge Detection

Edge detection is to produce a line drawing of a scene from an image of that scene and also is important features can be extracted from the edges of an image. [24] A set of connected curves that indicate the boundaries of objects and try to find out the edges in an image as shown in Figure 2.22 (a) and (b) shows the before and after the edge detection.

Figure 2.22(a): Before edge detection[25]

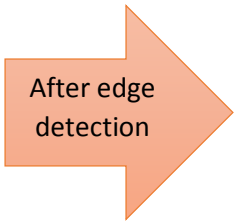


Figure 2.22(b): After edge detection[25]

Zoning

Character matrix is divided into small portions or zones. The densities of pixels in each zone are calculated and used as features. Figure 2.23 shows that the difference size of image after zoning.

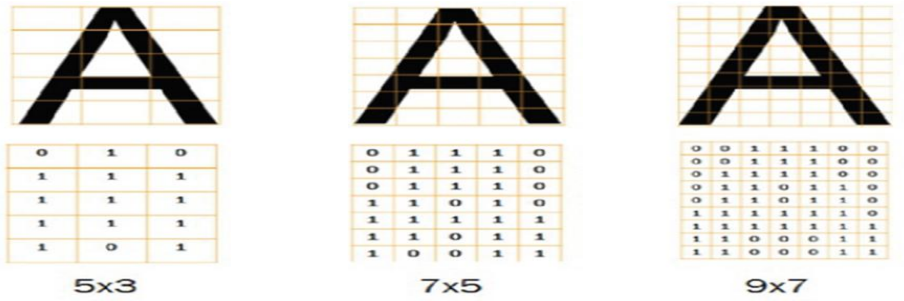


Figure 2.23: The difference size of image after zoning [26]

Character Normalization

The results of segmentation process provides isolated characters which are ready to pass through feature extraction stage, thus the isolated characters are reduced to a specific size depending on the methods used. The goal for character normalization is to reduce the within-class variation of the shapes of the characters/digits in order to facilitate feature extraction process and also improve their classification accuracy. After normalization in each difference size of character will become same size. Figure 2.24 (a) and (b) shows that the before and after the character normalization. [27]

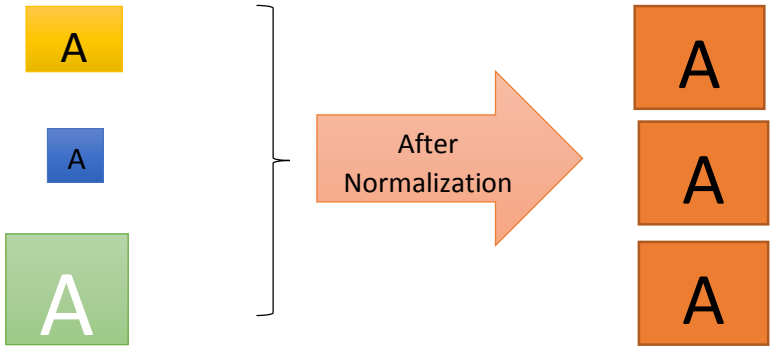


Figure 2.24(a): Before character normalization Figure 2.24(b): After character normalization

2.3.5 Classification

Classification is usually done by comparing the feature vectors corresponding to the input character.

Template Matching

Template matching and correlation methods basically compare a pattern pixel by-pixel to a set of pattern templates; the pattern is considered to belong to the class of the template to which it is most similar. [28]

A gray-level or binary input character is directly compared to a standard set of stored prototypes. The matching techniques can be as simple as one-to-one comparison or as complex as decision tree analysis in which only selected pixels are tested. Although direct matching method is intuitive and very fast to execute, the recognition rate of this method is very sensitive to noise. [28]

2.3.6 Post- processing

Post-processing stage is the final stage of the proposed recognition system. It prints the corresponding recognized characters in the structured text form by calculating equivalent ASCII value using recognition index of the test samples. [29]

2.4 Proposed Model After Studied the Previous Work Related to Project and Theory

Furthermore, after studied all the previous work related to project and the theory of OCR techniques that often used by the researcher, then comes out the proposed OCR model for design vision system to detect the scribed number on the wafer as shown in Figure 2.25.

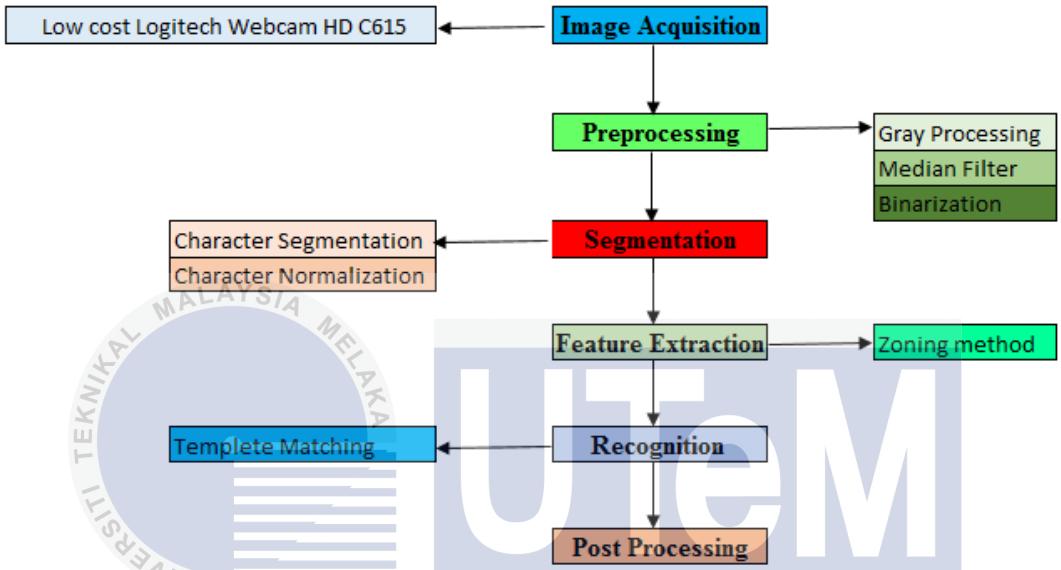


Figure 2.25: The proposed OCR model to designing the vision system.

2.4.1 Image Acquisition

By using the webcam to scan the sample image as shown in Figure 2.26.

Figure 2.26: The sample ‘ABC123’ with noise

2.4.2 Preprocessing

The first step to read the script number on wafer in image processing is to convert the color image into a grey image. After convert to grey image the median filter is apply as noise remover to make the image become clearer. Binarization process converts a gray scale image into a binary image. Figure 2.27 shows the process of preprocessing.

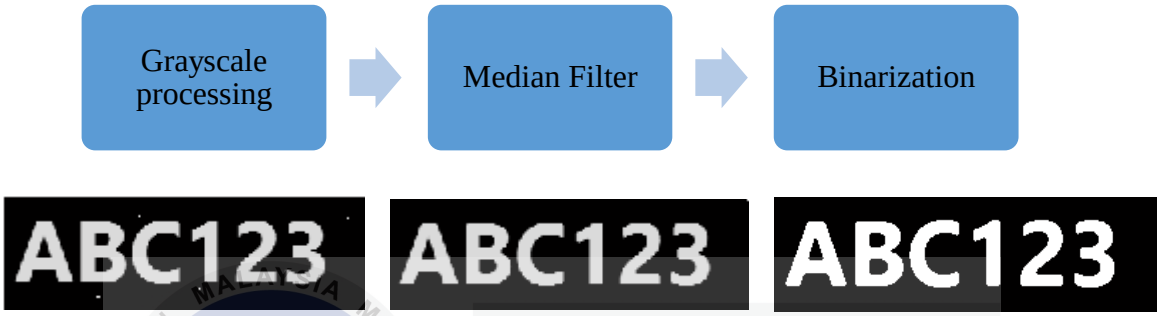


Figure 2.27: The process in preprocessing.

2.4.3 Segmentation and Character Extraction

In the segmentation stage, an image of sequence characters is decomposed into sub-images of individual character. In the proposed system, the pre-processed input image is segmented into isolated characters by assigning a number to each character using a labelling process. Each individual character is uniformly resized(Character Normalization) as shown in Figure 2.28.

Figure 2.28: The segmented character in 30x20 size image

2.4.4 Recognition

Due to the script number on the wafer is well printed and the font type and font size is fix, then the matching percentage and the recognition rate must be very high and the template matching method for recognition is suitable for the application. In the character recognition model in Figure 2.29 shows that at training section the template is created in system database for matching purpose. When the input image is scanned and go through the several process and need to recognize the character then the template matching involved to identify and recognized the character.

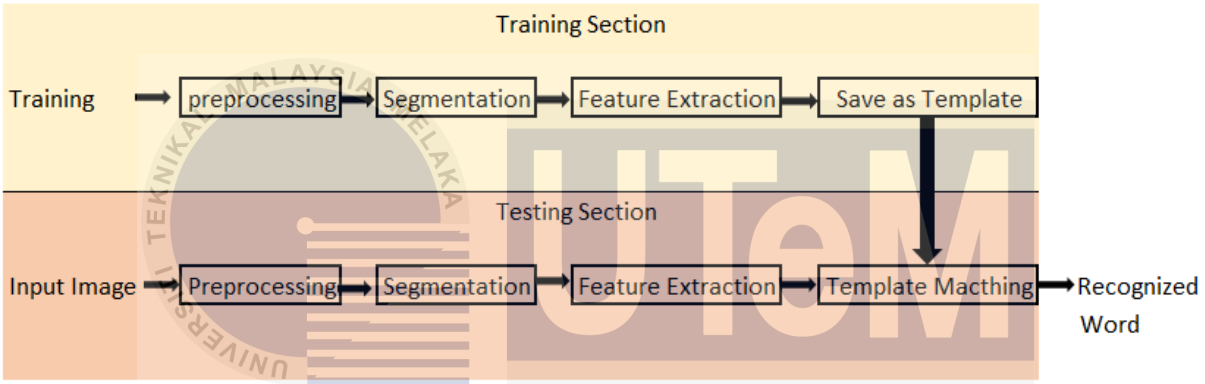


Figure 2.29: Generic of Character Recognition Model [29]

In recognition stage, the recognition process as shown in Figure 2.30. From the matching process, can obviously notice that if less white pixel left means the sample and template are same character or match with the template whereas if sample matching with difference template the more of the white pixel left means the sample is not match with the template or different to the template.

a) Sample b) Template c)White pixel left after match

d)White pixel left after sample "A" match match with template "B"

e)White pixel left after sample "A" with template "C"

Figure 2.30: (a), (b), (c), (d), (e) shows that the white pixel left after match between Sample and the Template [26]

According to the Ivy Tan [26], the diagonal of the Table 2.11 is taken out and find the maximum white pixel left after match. The sample 'A' has the less white pixel left (70) after matching with template 'A' compared to match with others template such as 398, 398, 323, 345, and 284.

Table 2.12: White pixel left after match with sample and template in size 30x20. [26]

Template \ sample	A	B	C	1	2	3
A	70	398	398	323	345	284
B	432	74	363	334	333	370
c	416	256	80	199	234	334
1	287	378	308	75	378	299
2	300	376	265	267	76	377
3	298	254	245	289	178	75

Hence, calculation for the percentage of recognition:

$$\text{Matching Percentage} = \frac{Size\ of\ image\ -White\ pixel\ left\ after\ match}{Size\ of\ image} \quad \text{------Equ(1)}$$

$$\text{Percentage of Matching} = \frac{(30x20) - (80)}{(30x20)} x100\%$$

$$= \frac{(600) - (80)}{(600)} x100\%$$

$$= 86.67\%$$

This is the minimum percentage of character matching in 30x20 image size. Therefore the system can only recognize the character when less than 80 white pixel value left after match.

The process to recognize the character with the range of pixel difference as shown Figure 2.31. All the alphabets and numbers have the range of pixel difference respectively. For this example, the white pixel left after matching for character 'A' is 70, and the pixel difference is set a range less than 75. Therefore, only the white pixel left after matching less than 75 then the character 'A' will display 'A' if not the system not to read. The large white pixel left because of the sample and template not match whereas the smaller the white pixel left because of sample and template is match.

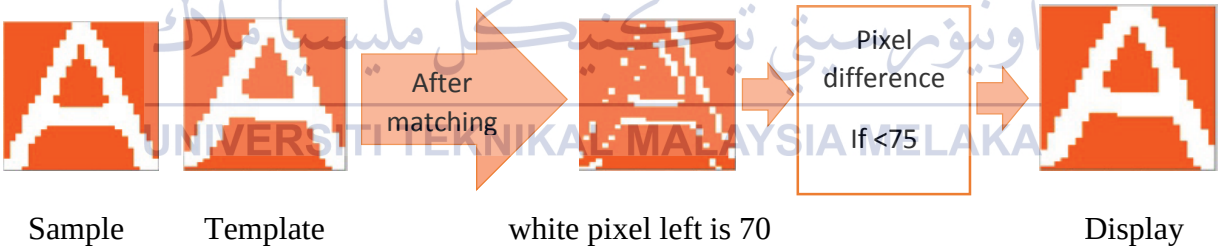


Figure 2.31: The process to recognize the character with the range of pixel difference. [26]

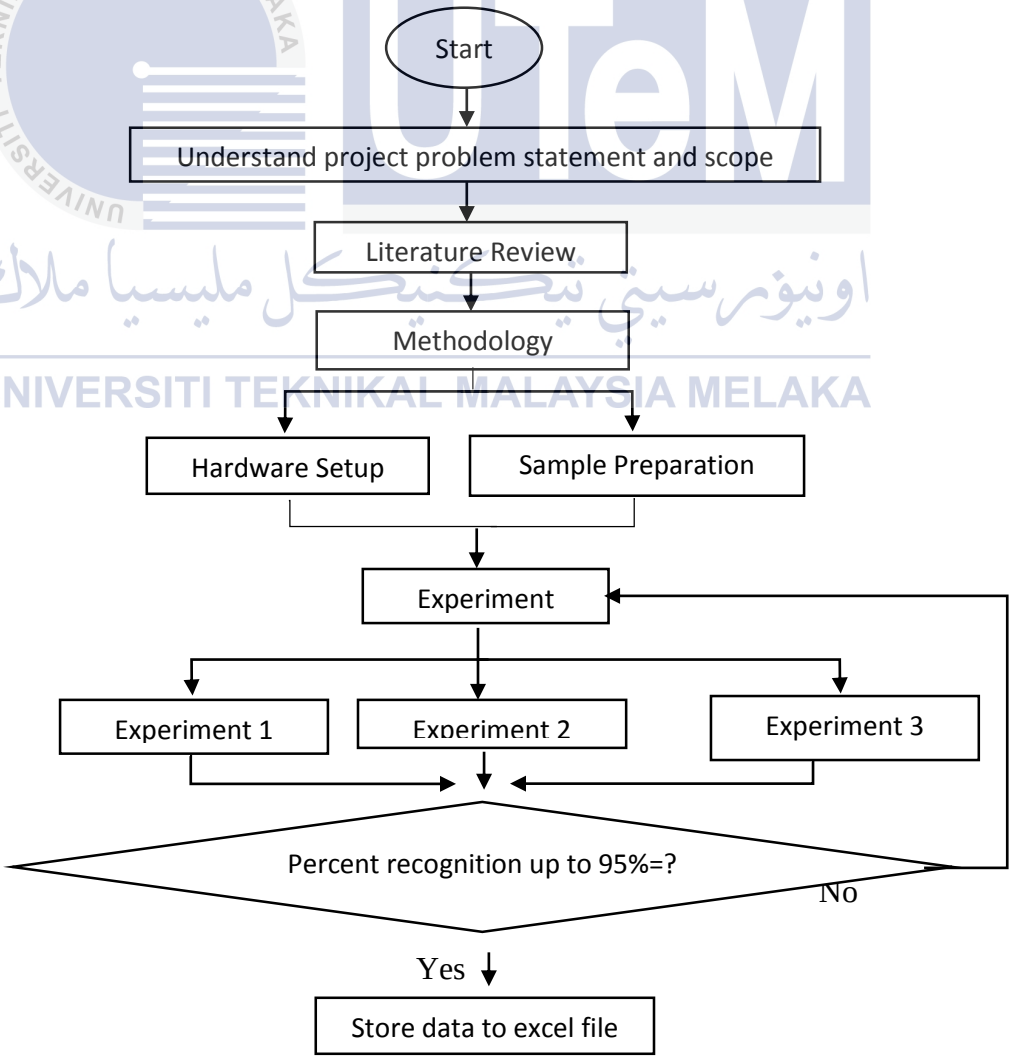
2.4.5 Post processing

Store the detected character to Excel file by using the related coding. Due to Matlab workspace unable to display character, therefore need to insert alphabet to represent the character. For example, 11 represent character A, 12 represent character B and etc. After that, by using Lookup Function in Excel to convert and display the actual character in the Excel file.

CHAPTER 3

RESEARCH METHODOLOGY

The methodology of this project is described and represented in a flow chart as shown in Figure 3.1. The methodology declare and explain on how the validity and reliability test to produce high percentage of recognition. In mechanical part of the hardware implementation, the prototype to mimic the environment at Silterra is done and the testing sample are created due to the real wafer sample are not provided.



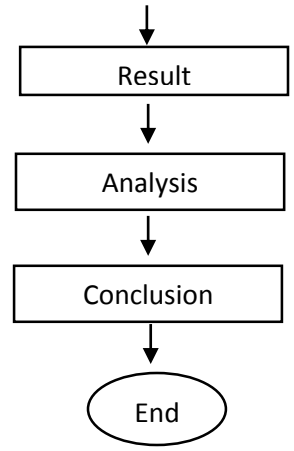


Figure 3.1: The flow chart of project

3.1 Test Validity and Reliability

The two most important and fundamental characteristics of any measurement procedure are reliability and validity. Whenever a test is used as part of the data collection process, the validity and reliability of that test is important. After all, everyone relying on the results to show support or a lack of support for our theory and if the data collection methods are erroneous, the data analyze also will be erroneous. The overview flow to carry out validity and reliability test as shown in Figure 3.2.

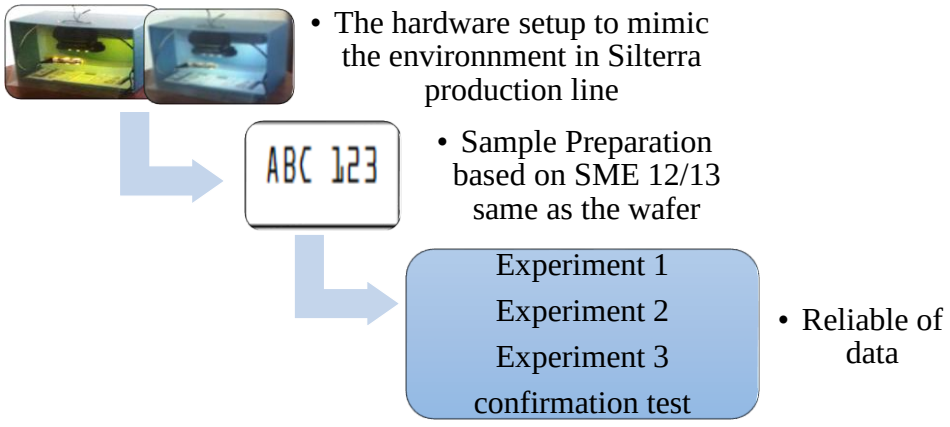


Figure 3.2: Overview flow to carry out validity and reliability test

3.2 Validity

Validity is an indicator of how much meaning and trust can be placed upon a set of test results. However, the accuracy of tests is paramount, but the validity is crucial to gather enough evidence to defend the work. Therefore to validate the result, the hardware setup and sample preparation to mimic the environment and the wafer should be considered as well.

3.2.1 Hardware Setup

To mimic the environment at Silttera production line, the hardware is setup as Figure 3.3. The workspace, the distance between webcam and workspace, and the position to place the light are fix. The available workspace is 9cm length and the distance between camera with the workspace is 5cm therefore the webcam able to capture 6 character in one shot.

Figure 3.3: The hardware setup to mimic the environment in the Silterra Sdn. Bhd. manufacturing plant.

'

Besides that, the color of light for the production line in the Silterra Company also should be considered, to validate the result should not simply assume and used the color of light as what researcher prefer, therefore the preparation for different color of light is necessary to test, identify whether different color of light either will or will not have different effect to the result.

Furthermore, due to unable to get the exact color of light from the company, therefore the color that decided to test is white and yellow color which is more likely to the environment in the Silterra production line as shown in Figure 3.4 and Figure 3.5.

Figure 3.4: White color of light

Figure 3.5: Yellow color of light

3.2.2 Sample Preparation

The scribed number on wafer is fixed font type, size and in well printed based on standard M12/M13, due to unable to get the real wafer, therefore the testing sample need to prepare which is same as the character on the wafer. There are 3 testing sample that are used in the experiment which is the sample for creating the template, two good testing sample, and 2 not good testing sample as shown in Figure 3.6, 3.7, and 3.8 respectively.

Figure 3.6: The sample for creating the template

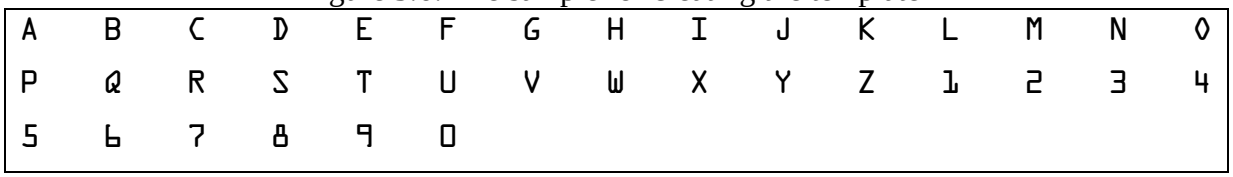


Figure 3.7: The two set of good testing sample(G sample)

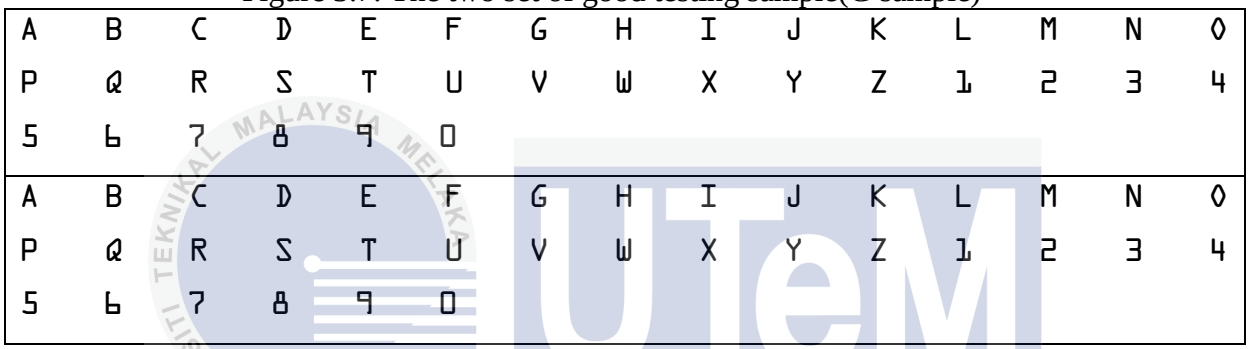
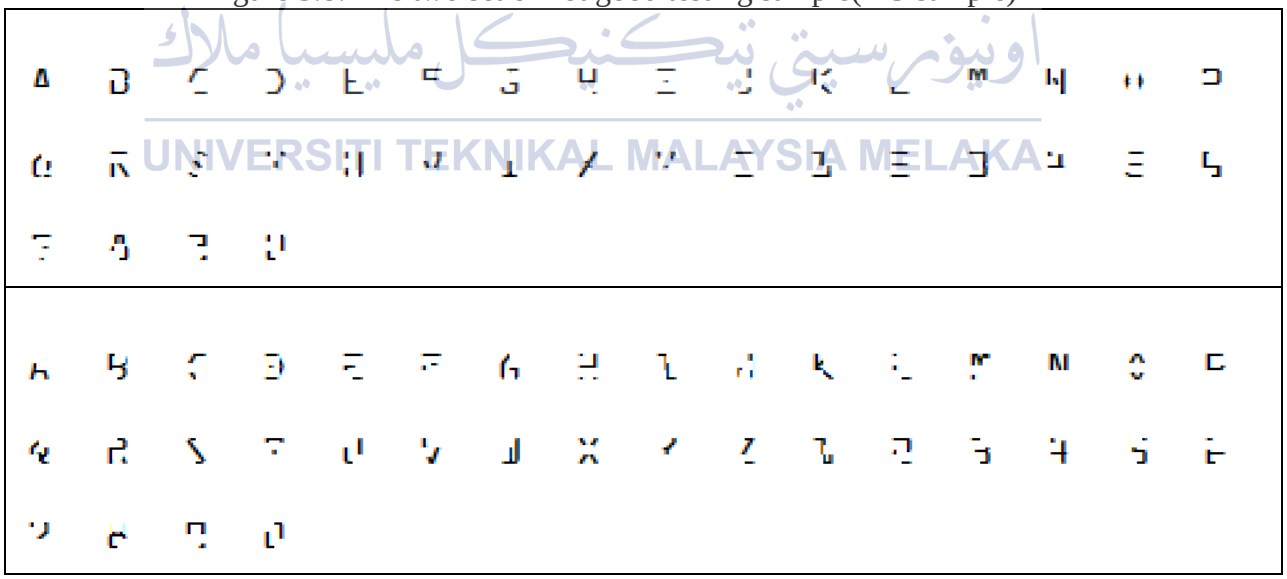


Figure 3.8: The two set of not good testing sample(NG sample)



The step for preparation the sample as below:

1) Open Paint.
2) Write 100 good(G) group combination of character based on the Standard SME 12/13. For example:

ABC123 JKL245
GHI789 YUI876
DEF456 HUI976

3) Write 100 not good(NG) group combination of character based on the Standard SME 12/13. For example:

4) Crop equal size for all the sample have been write.
5) Print each sample on 80mg paper and cut equally.
6) For the example in Figure 3.9 and 3.10:

Figure 3.9: A group of not good(NG) sample printed on 80mg paper with the size of 12cm width x 4cm height.

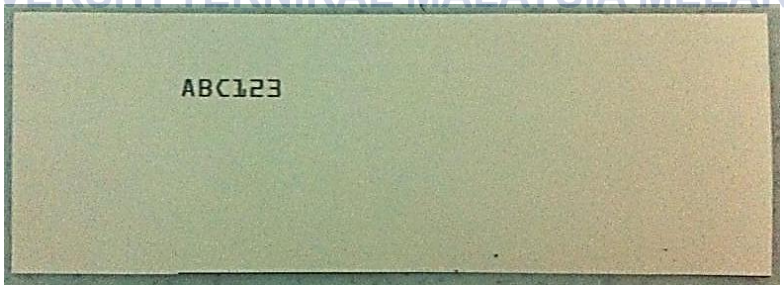


Figure 3.10: A group of good(G) sample printed on 80mg paper with the size of 12cm width x 4cm height.

3.3 Technique

To achieve the objective, the vision system design based on the theory studied in literature review and the previous work related to project as shown in Figure 3.11. The vision system will be built in Matlab Simulink by using Computer Vision Toolbox.

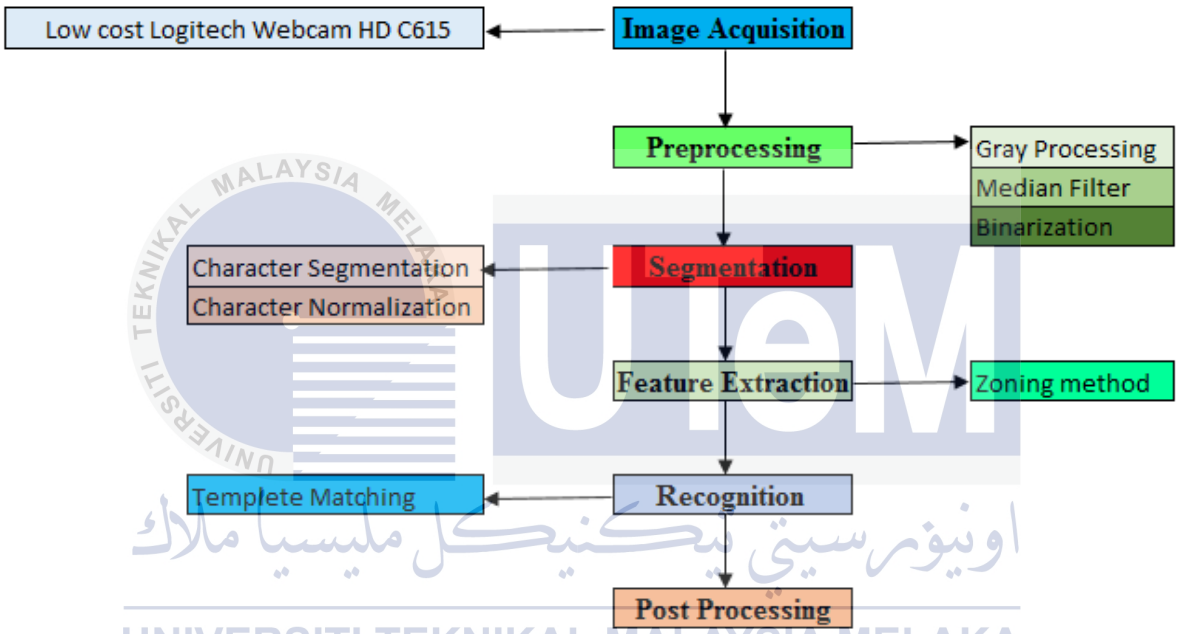


Figure 3.11: The proposed OCR technique to vision system.

For the vision system design, the methodology can be separated into two phase as shown in Figure 3.12. First phase is the training phase and for second is the matching phase. The training phase is regarding to saving the template in the system for the purpose of recognition process which is template matching process. For the matching phase, by using the template from the training phase to implement the template matching process with the incoming sample.

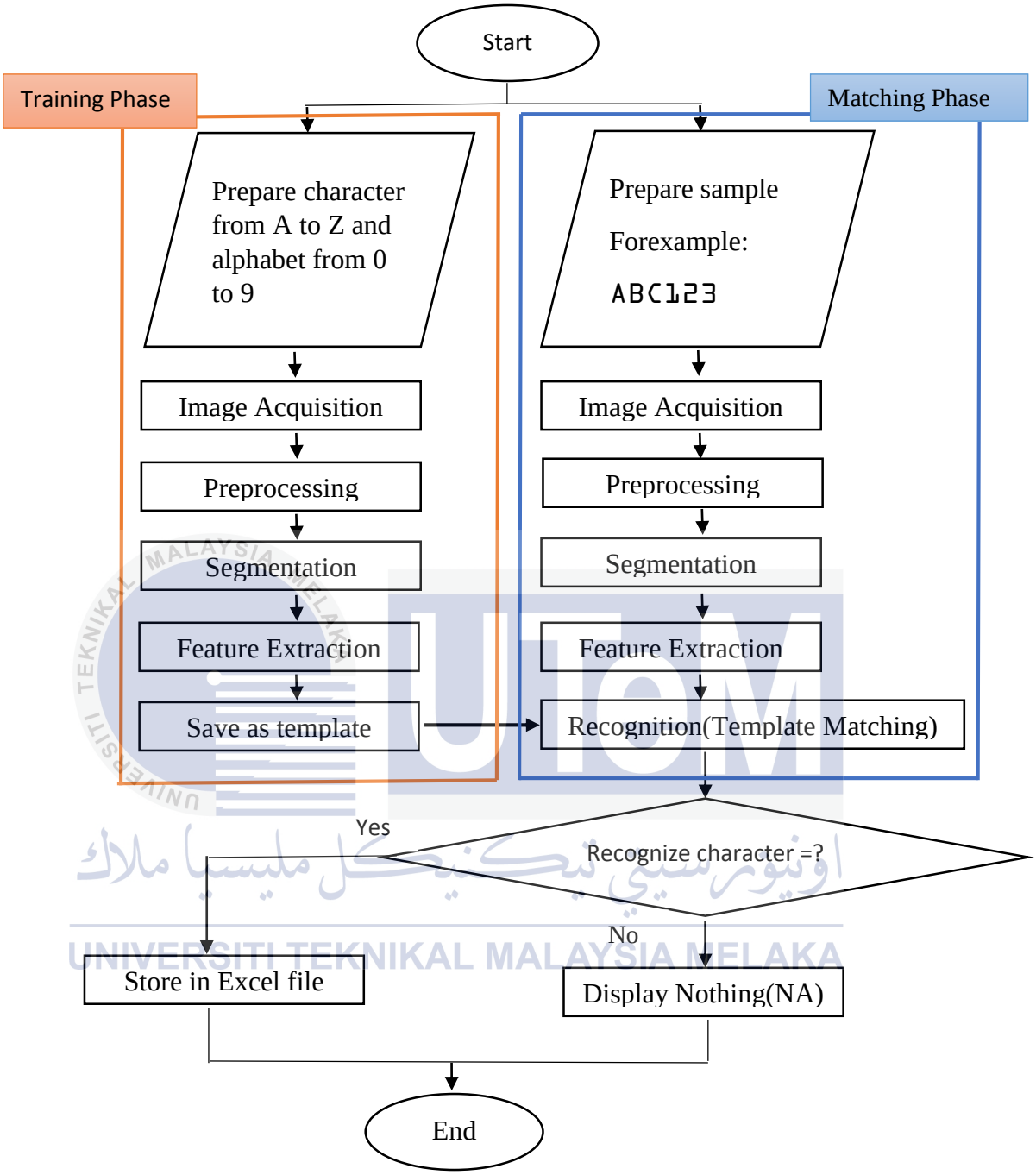


Figure 3.12: The methodology for vision system design.

3.3.1 Training Phase

Figure 3.13 shows that the overall vision system design for template saving in Matlab Simulink by using the Computer Vision Toolbox.

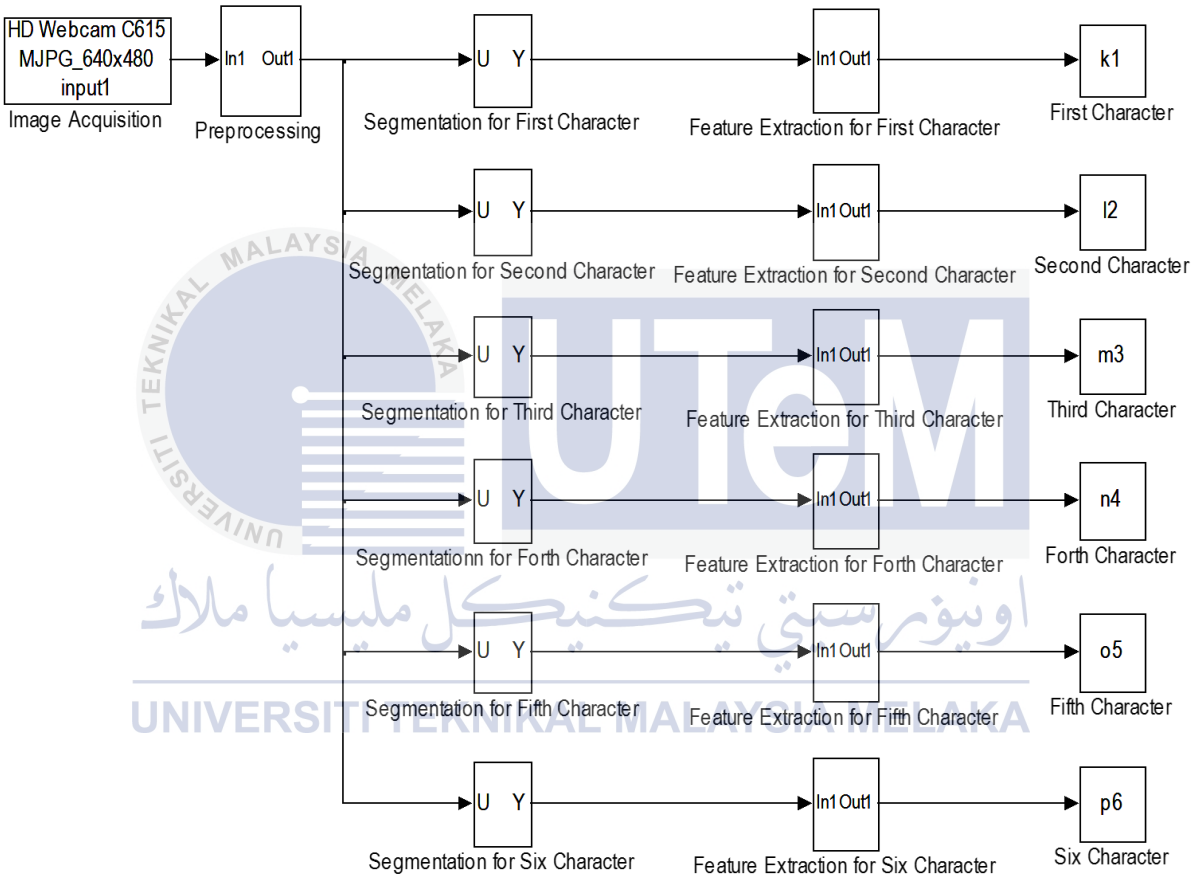
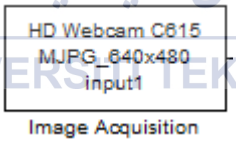
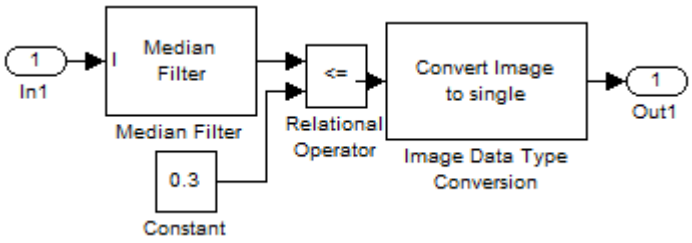


Figure 3.13: Simulink block diagram for template saving in training phase.

Besides that, Table 3.1 shows that the overall process for template saving in training phase. The first column is process of OCR technique, second column is the Simulink block diagram to implement the process and the last is the result.

Table 3.1: The description for each process in training phase.

Process	**Vision system design using Matlab Simulink**	**Result**
Prepared character from A to Z and alphabet from 0 to 9		ABCDEF GHIJKL MNOPQR STUVWX YZ0123 456789 For example: 
Image Acquisition	In this stage, camera capture the image with the existing of white and yellow color of light, after that camera directly change the image into grey image (grey processing). 	For example: 
Preprocessing	In this stage, the image is filtered by using median filter such as 3x3,5x5,7x7, and 9x9 and convert to binary(0 and 1) image which is black and white image. 	For example 3x3 median filter: 

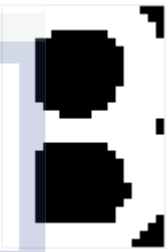
<table>
<tr>
<td>Segmentation</td>
<td>
Each character has their own selector block and index number. Selector block used to segment the character and the index number is represent of each character's position whereas the output size for each character are the same.

For example:
The index number for First Character:
<table>
<tr><th></th><th>Index Option</th><th>Index</th><th>Output Size</th></tr>
<tr><td>1</td><td>Starting index (dialog)</td><td>73</td><td>32</td></tr>
<tr><td>2</td><td>Starting index (dialog)</td><td>212</td><td>19</td></tr>
</table>

The index number for Second Character:
<table>
<tr><th></th><th>Index Option</th><th>Index</th><th>Output Size</th></tr>
<tr><td>1</td><td>Starting index (dialog)</td><td>73</td><td>33</td></tr>
<tr><td>2</td><td>Starting index (dialog)</td><td>245</td><td>21</td></tr>
</table>

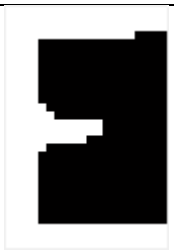
The index number for Third Character:
<table>
<tr><th></th><th>Index Option</th><th>Index</th><th>Output Size</th></tr>
<tr><td>1</td><td>Starting index (dialog)</td><td>73</td><td>33</td></tr>
<tr><td>2</td><td>Starting index (dialog)</td><td>278</td><td>21</td></tr>
</table>

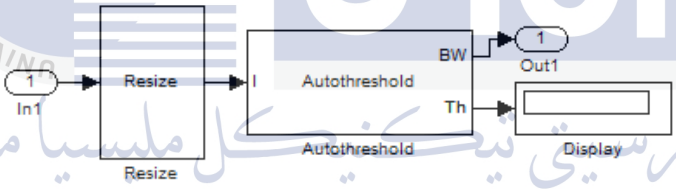
The index number for Forth Character:
<table>
<tr><th></th><th>Index Option</th><th>Index</th><th>Output Size</th></tr>
<tr><td>1</td><td>Starting index (dialog)</td><td>73</td><td>33</td></tr>
<tr><td>2</td><td>Starting index (dialog)</td><td>311</td><td>21</td></tr>
</table>
</td>
<td>
First Character:

Second Character:

Third Character:

Forth Character:

Fifth Character:
</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td>
The index number for Fifth Character:
<table>
<tr><th></th><th>Index Option</th><th>Index</th><th>Output Size</th></tr>
<tr><td>1</td><td>Starting index (dialog)</td><td>73</td><td>33</td></tr>
<tr><td>2</td><td>Starting index (dialog)</td><td>344</td><td>21</td></tr>
</table>
The index number for Six Character:
<table>
<tr><th></th><th>Index Option</th><th>Index</th><th>Output Size</th></tr>
<tr><td>1</td><td>Starting index (dialog)</td><td>73</td><td>33</td></tr>
<tr><td>2</td><td>Starting index (dialog)</td><td>377</td><td>21</td></tr>
</table>
</td>
<td>

Six Character:

</td>
</tr>
<tr>
<td>Feature Extraction</td>
<td>
In this stage, the normalization take place, all set of the character are resize to 10x7, 15x10, 30x20, and 40x25. The Autothreshold block is used to thresholding the resize image.


</td>
<td>
For example 30x20 image:
First Character:

Second Character:

Third Character:

Forth Character:
</td>
</tr>
</table>

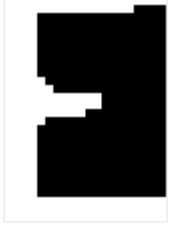
		 Fifth Character:  Six Character: 
Template saving	For template saving, all the character and alphabet(A to Z and 0 to 9) are resize to 10x7, 15x10, 30x20, and 40x25 with different median filter such as 3x3,5x5,7x7, and 9x9 respectively at different color of light and save as template in the system. As the conclusion, the Table 3.2 shows that the group of template need to save in the system for the purpose of template matching for matching phase with the incoming sample:	

Table 3.2: The list of template need to save in the system. (Kindly refer to Appendix B).

Template saving			
with White Light		with Yellow Light	
Image size	Median Filter	Image Size	Median Filter
10x7	3x3	10x7	3x3
15x10		15x10	
30x20		30x20	
40x25		40x25	
10x7	5x5	10x7	5x5
15x10		15x10	
30x20		30x20	
40x25		40x25	
10x7	7x7	10x7	7x7
15x10		15x10	
30x20		30x20	
40x25		40x25	
10x7	9x9	10x7	9x9
15x10		15x10	
30x20		30x20	
40x25		40x25	

3.3.2 Matching Phase

Figure 3.11 shows that the overall vision system design for template matching process or recognition in Matlab Simulink by using the Computer Vision Toolbox.

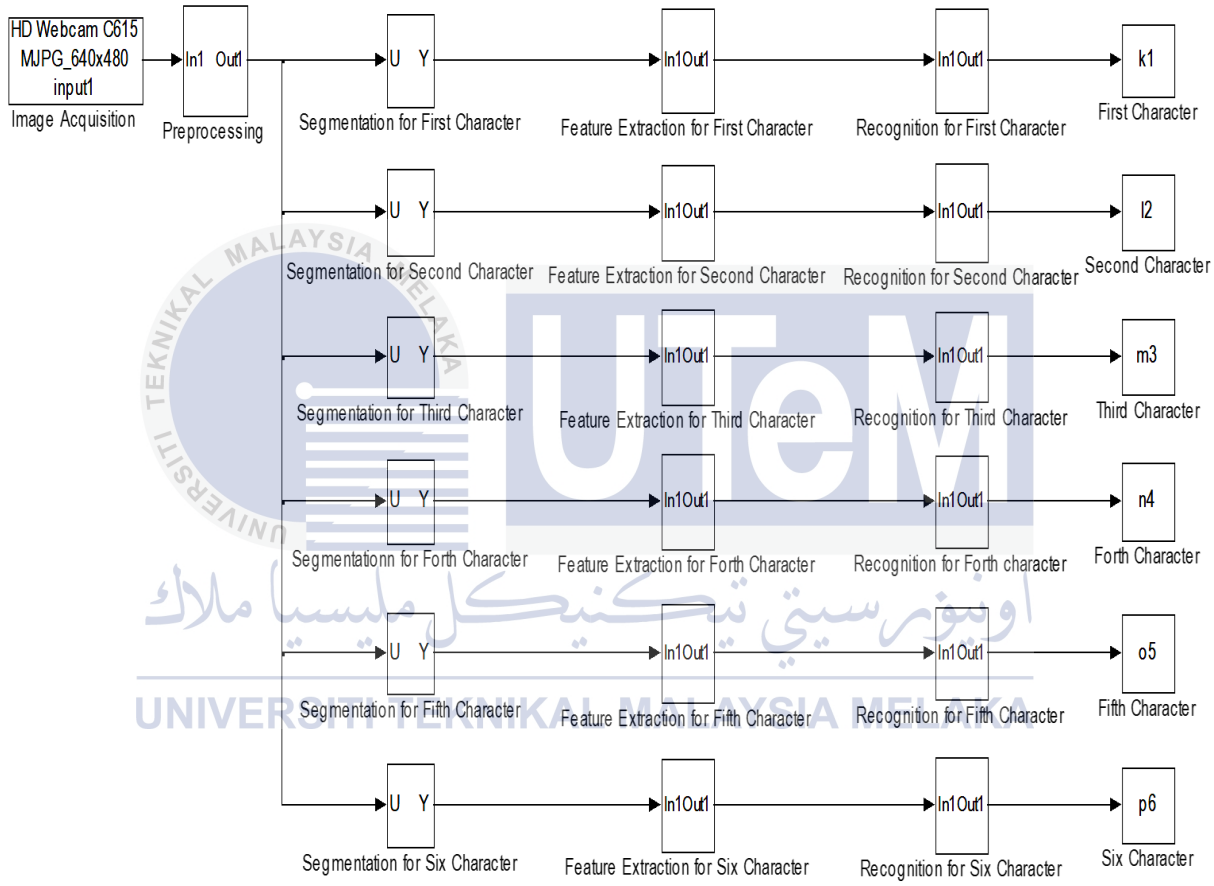
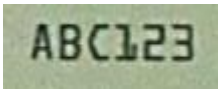
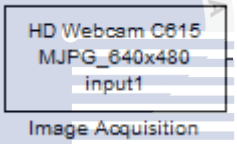
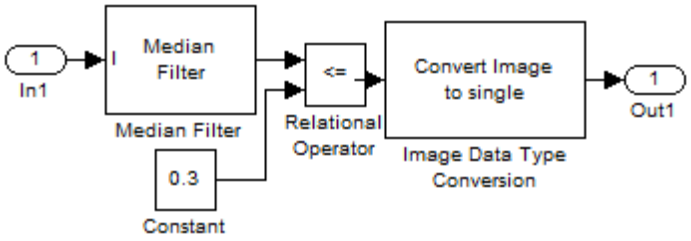


Figure 3.14: Simulink block diagram for recognition process in matching phase.

Besides that, Table 3.3 shows that the overall process for recognition process in matching phase. The first column is process of OCR technique, second column is the Simulink block diagram to implement the process and the last is the result.

Table 3.3: The description for each process in matching phase.

Process	**Vision system design using Matlab Simulink**	**Result**
Sample preparation as in Appendix B		For example: 
Image Acquisition	In this stage, camera capture the incoming sample with the existing of white light and yellow light, camera directly change the image to grey image (grey processing). 	For example: 
Preprocessing	In this stage, the image filtered by using median filter such as 3x3,5x5,7x7, and 9x9 and convert to binary(0 and 1) image which is black and white image. 	For example 3x3 median filter: 
Segmentation	Each character has their own selector block and index number. The index number is represent of each character's position whereas the output size for each character are the same.	

For example:

The index number for First Character:

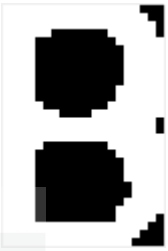
	Index	Option	Index	Output Size
1	Starting index (dialog)		73	32
2	Starting index (dialog)		212	19

First Character:

The index number for Second Character:

	Index	Option	Index	Output Size
1	Starting index (dialog)		73	33
2	Starting index (dialog)		245	21

Second Character:



The index number for Third Character:

	Index	Option	Index	Output Size
1	Starting index (dialog)		73	33
2	Starting index (dialog)		278	21

Third Character:

The index number for Forth Character:

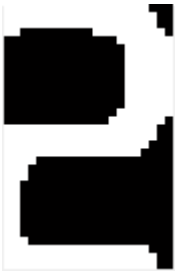
	Index	Option	Index	Output Size
1	Starting index (dialog)		73	33
2	Starting index (dialog)		311	21

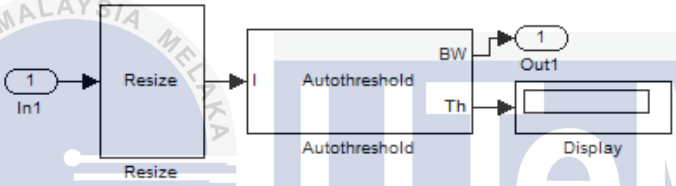
Forth Character:

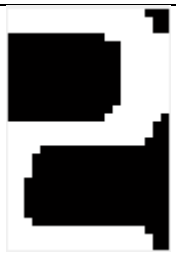
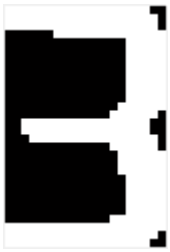
The index number for Fifth Character:

	Index	Option	Index	Output Size
1	Starting index (dialog)		73	33
2	Starting index (dialog)		344	21

Fifth Character:



<table>
<tr>
<td></td>
<td>The index number for Six Character:
<table>
<tr><th></th><th>Index Option</th><th>Index</th><th>Output Size</th></tr>
<tr><td>1</td><td>Starting index (dialog)</td><td>73</td><td>33</td></tr>
<tr><td>2</td><td>Starting index (dialog)</td><td>377</td><td>21</td></tr>
</table>
</td>
<td>Six Character:
  </td>
</tr>
<tr>
<td>Feature Extraction</td>
<td>In this stage, the normalization take place, the sample can resize to 10x7, 15x10, 30x20, and 40x25. The Autothreshold block is used to thresholding the resize image.
 
</td>
<td>For example 30x20 image:
First Character:
 
Second Character:
 
Third Character:
 
Forth Character:
 
Fifth Character:</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td> 
Six Character:
  </td></tr>
<tr><td>Recognition</td><td colspan="2">In recognition part, the incoming sample undergoing several process which is from image acquisition to feature extraction and then the sample matching with the template have been save. In matching process, able to set the matching percentage such as 80%, 85%, and 90%. For example, if the matching percentage set to 85% which means at the IF block (Figure 3.12) in Matlab Simulink need set to 90 of white pixel left because:

For example:
Matching Percentage = $\frac{Size\ of\ image\ -\ White\ pixel\ left\ after\ match}{Size\ of\ image}$ Equ(1)

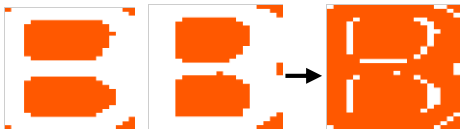
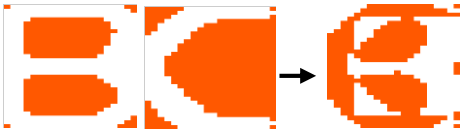
Percentage of Matching = $\frac{(30x20)-(90)}{(30x20)}$x100%

= $\frac{(600)-(90)}{(600)}$x100%

= 85%

However, when the sample matching with the template and the number of white pixel left is less than 90 then the output will be send to further recognition, whereas if the number of white pixel left is more than 90 then the output unable to recognize. For example in Table 3.4 below:</td></tr>
</table>

Table 3.4: The difference result between more and less than 90 white pixel left.

After matching less than 90 of white pixel left	After matching more than 90 of white pixel left
Sample(B) Template(B) Output 	Sample(B) Template(C) Output 
Therefore, the less of the white pixel left, then consider is correct match. The output then send to If Action block for recognition process. Due to the Matlab Simulink unable to support char data type in workspace therefore require use the alphabet to represent the character. Refer to Figure 3.15, the white pixel left in this case is 61 and is less than 90 then the output send to the If Action block and the character will be display at workspace which is 12, 12 is represent B. The list of declaration of character will be explain in next process as shown in Table 3.8.	Therefore, the more of the white pixel left, then consider wrong matching. However, since there is wrong matching and the output unable send to If Action Block for further recognition. The output at workspace will present zero(0) and unable to represent any of character and alphabet. Refer to Figure 3.16, the white pixel left in this case is 267 and is more than 90 then the output unable send to the If Action block and the output will not be correctly display at workspace.

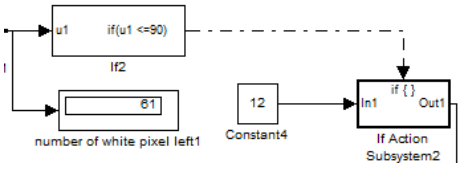
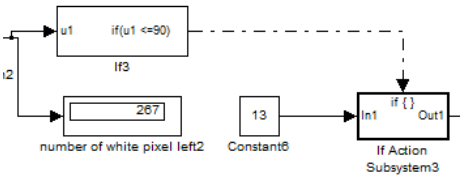
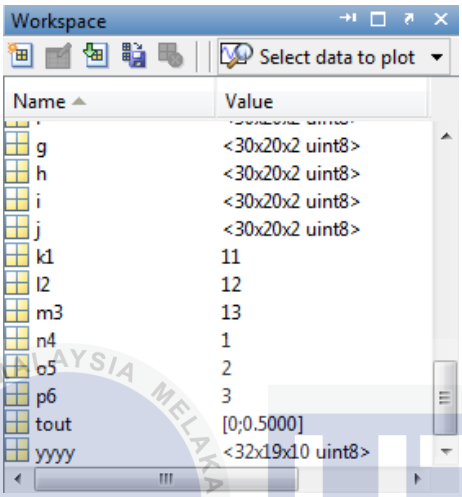

	

Figure 3.15: Simulink block for recognition of sample B when the	Figure 3.16: Simulink block for recognition of sample C when the sample is matching with template B.

sample is matching with template B.

For example, the following is the output of ABC123 after recognition.



k1 =First Character

l2 =Second Character

m3 =Third Character

n4 = Fourth Character

o5 = Fifth Character

p6 = Sixth Character

Store data to Excel file

As mention before, the Matlab Simulink in workspace unable to support char data type, therefore require used the alphabet to represent the specific character. The Table 3.5 shows that the declaration of character that can be obtained out from workspace.

Table 3.5: The list for declaration of character.

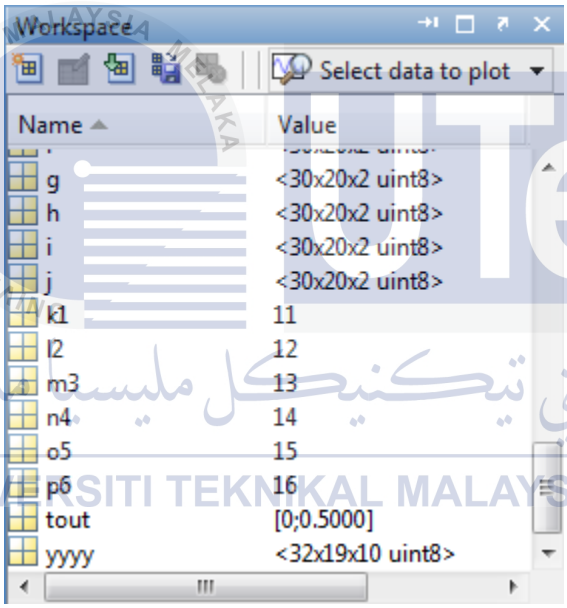
Data from Simulink	1	2	3	4	5	6	7	8	9	10
Character	1	2	3	4	5	6	7	8	9	0

Data from Simulink	11	12	13	14	15	16	17	18	19	20
Character	A	B	C	D	E	F	G	H	I	J

Data from Simulink	21	22	23	24	25	26	27	28	29	30
Character	K	L	M	N	O	P	Q	R	S	T

Data from Simulink	31	32	33	34	35	36	37	38	39	40
Character	U	V	W	X	Y	Z	-	-	-	-

However, each alphabet represent their own character. For example:



k1 =First Character = 11 = represent as A

l2 =Second Character = 12 = represent as B

m3 =Third Character = 13 = represent as C

n4 = Forth Character = 14 = represent as D

o5 = Fifth Character = 15 = represent as E

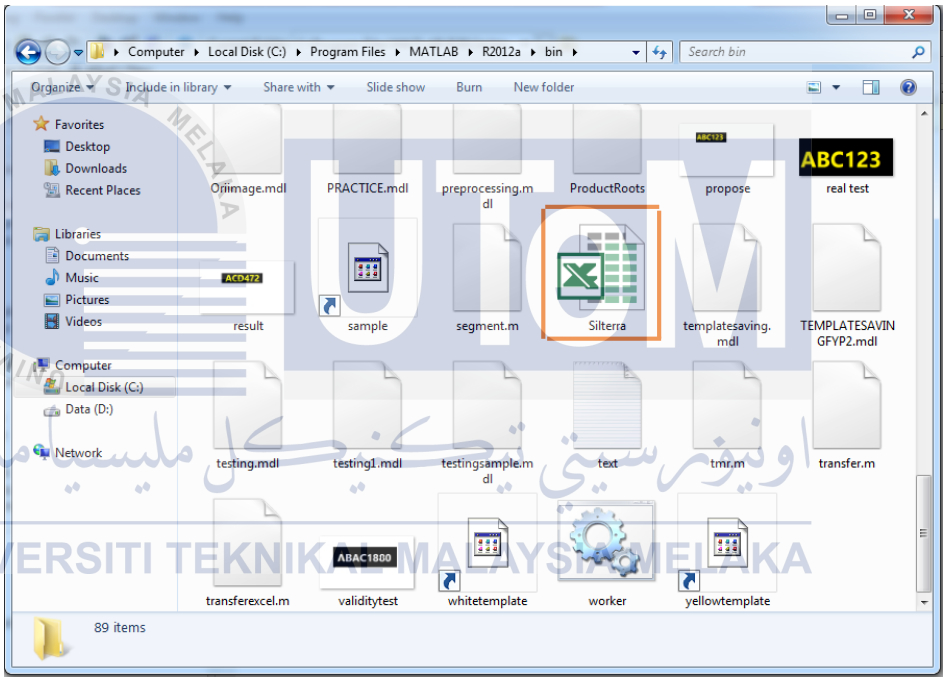
p6 = Six Character = 16 = represent as F

Besides that, the objective is to store the character in the Excel file, therefore the following coding are used:

```
offset =5
for i=1:1

   xlswrite('Silterra.xls', [k1 l2 m3 n4 o5 p6], 1,
sprintf('A%d',offset));
```

After that, open Excel file as name(Silterra) it in the coding:



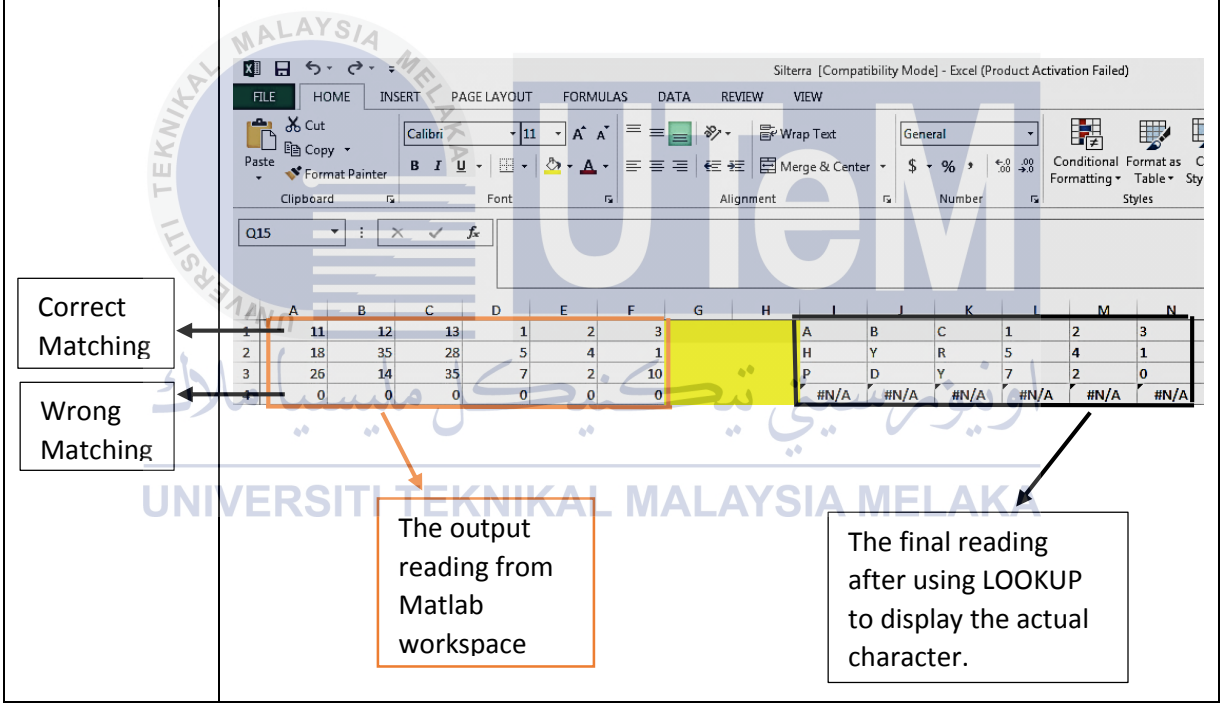
By using Lookup in Excel,

```
=LOOKUP(A1,{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36},{"1","2","3","4","5","6","7","8","9","10","A","B","C","D","E","F","G","H","I","J","K","L","M","N","O","P","Q","R","S","T","U","V","W","X","Y","Z"})
```

After the recognition process,

1. The output reading will be display at Matlab workspace.
2. Insert coding to store the reading to Excel file.
3. Using LOOKUP to display the actual character.

From the Figure below, the left side of the Excel file is the output reading from Matlab workspace whereas on the right side of Excel file is the final reading after using LOOKUP to display the actual character. If there is correct matching then the system can recognize correctly and able to display the correct character. For example, if there is a good sample which is ABC123 then in Excel file will display ABC123. Whereas if there is a not good sample ABCDEF then in Excel file will display nothing(NA).



3.4 Reliability of data

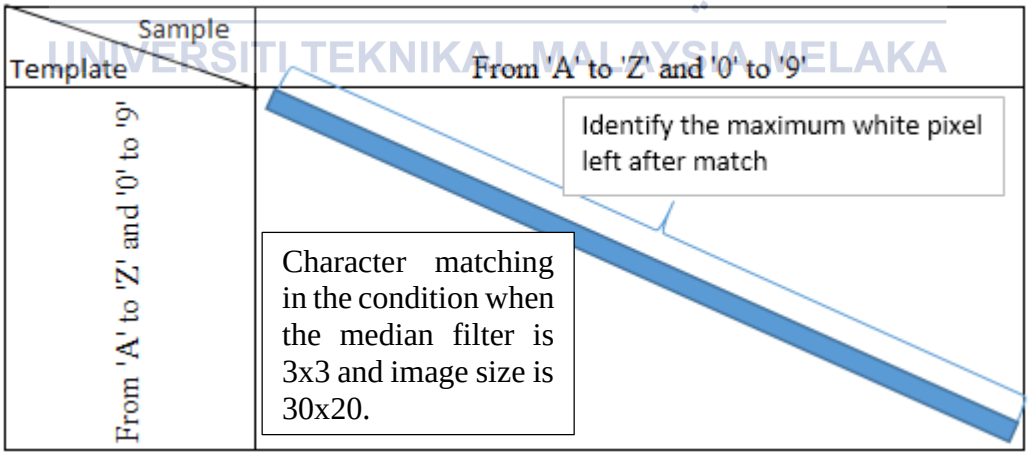
Reliability is concerned with questions of stability and consistency, does the same vision system yield stable and consistent results when repeated over time. However, there are three experiment are carry out to identify the best parameter respectively, and used these parameter apply to the vision system to perform a confirmation test, which is to ensure the system can produced up to 95% of recognition.

3.4.1 Experiment 1

The objective for experiment 1 is to determine and identify the best image size which can produced the highest recognition rate.

1) Initially set median filter to 3x3 and matching between the sample for creating the template in Table 3.6 and template in the database in image size of 30x20 to identify the matching percentage. In Table 3.4 shows the white pixel left after match for character from 'A' to 'Z' and '0' to '9' .

Table 3.6: The white pixel value left after match for character from 'A' to 'Z' and '0' to '9'



After identify all the white pixel left after match, therefore the range for pixel difference can be set for each alphabets and numbers. However, to calculating matching percentage, the

diagonal of each table is taken out then find the largest white pixel left and to calculate the percentage of the matching by Equation 1 for each image size:

$$\text{Matching Percentage} = \frac{Size\ of\ image\ -White\ pixel\ left\ after\ match}{Size\ of\ image} \quad \text{------Equ(1)}$$

2) Fix the identified matching percentage, set the median filter to 3x3 matrix, and prepared 100 difference testing samples by choosing from the good testing sample in Table 3.2 and arrange them into a word form such as 'ABC123' in the experiment.
3) After that, matching these 100 difference testing samples with template in difference image size which is 40x25, 30x20, 15x10, and 10x7 respectively. For example, if the template in database after matching with 100 different good testing samples in image size of 40x20, then have 90 samples can be recognized correctly means that the percentage of recognition is 90%. The comparison between the percentages of recognition with difference image size when the 3x3 median filter and matching percentage is fixed.as shown in Table 3.7.

Table 3.7: The comparison between the percentages of recognition with difference image size.

Image Size / Matching Template with 100G testing sample	40x25	30x20	15x10	10x7
Fixed Parameter 3x3 median filter Matching Percentage	% of recognition	% of recognition	% of recognition	% of recognition

4) After the comparison, the best image size is identified which is able to produce the highest percentage of recognition.

3.4.2 Experiment 2

The objective for experiment 2 is to determine and identify the best median filter which can produced the highest recognition rate.

1) Fix the identified image size and matching percentage as in Experiment 1.
2) Prepare same 100 difference good testing sample as in Experiment 1.
3) After that, matching these 100 difference good testing samples with template with difference median filter which is 3x3, 5x5, 7x7, and 9x9 respectively. For example, if the template in database after matching with 100 difference test samples with 3x3 median filter, then have 90 samples can be recognized correctly means that the percentage of recognition is 90%. The comparison between the percentages of recognition with difference median filter when the image size and matching percentage is fixed as shown in Table 3.8.

Table 3.8: The comparison between the percentages of recognition with difference median filter

Median Filter / Matching Template with 100G testing sample	3x3	5x5	7x7	9x9
Fixed Parameter Image Size Matching Percentage	% of recognition	% of recognition	% of recognition	% of recognition

4) After the comparison, the best median filter is identified which is able to produce the highest percentage of recognition.

3.4.3 Experiment 3

The objective for experiment 3 is to determine and identify the best matching percentage which can produced the highest recognition rate.

1) Fix the identified median filter and image size as in Experiment 2.
2) Prepare same 100 difference good testing samples as in Experiment 1.
3) Prepare other 100 difference not good testing samples by choosing from the not good testing sample in Table 3.3 and arrange them into a word form such as 'ABC123' in the experiment.
4) After that, matching these 100 difference good testing samples with template with difference matching percentage which is 90%, 85%, and 80% respectively. For example, if the template in database after matching with 100 difference good testing samples and 100 difference not good testing samples with 90% of matching percentage, then have 90 good samples can be recognized correctly and 0 not good sample can be recognized means that the percentage of recognition is 90% and 0%. The comparison between the percentages of recognition in difference matching percentages when the image size and median filter is fixed as shown in Table 3.9.

Table 3.9: The comparison between the percentages of recognition with difference matching percentages.

Matching Percentage / Matching Template with **100G** testing sample	80%	85%	90%
Fixed Parameter Image Size Median Filter	% of recognition	% of recognition	% of recognition
Matching ercentage / Matching Template with **100NG** testing sample	80%	85%	90%
Fixed Parameter Image Size Median Filter	% of recognition	% of recognition	% of recognition

5) After the comparison, the best matching percentage is identified which is able to produce the highest percentage of recognition.

3.4.4 Confirmation Test

All the best parameter is identified from the previous experiments. After that, apply these parameter to the vision system design and test with others 100 good and 100 not good samples to ensure the system can produced percentage of recognition up to 95%. Figure 3.17 shows the process flow to carry out the confirmation test.

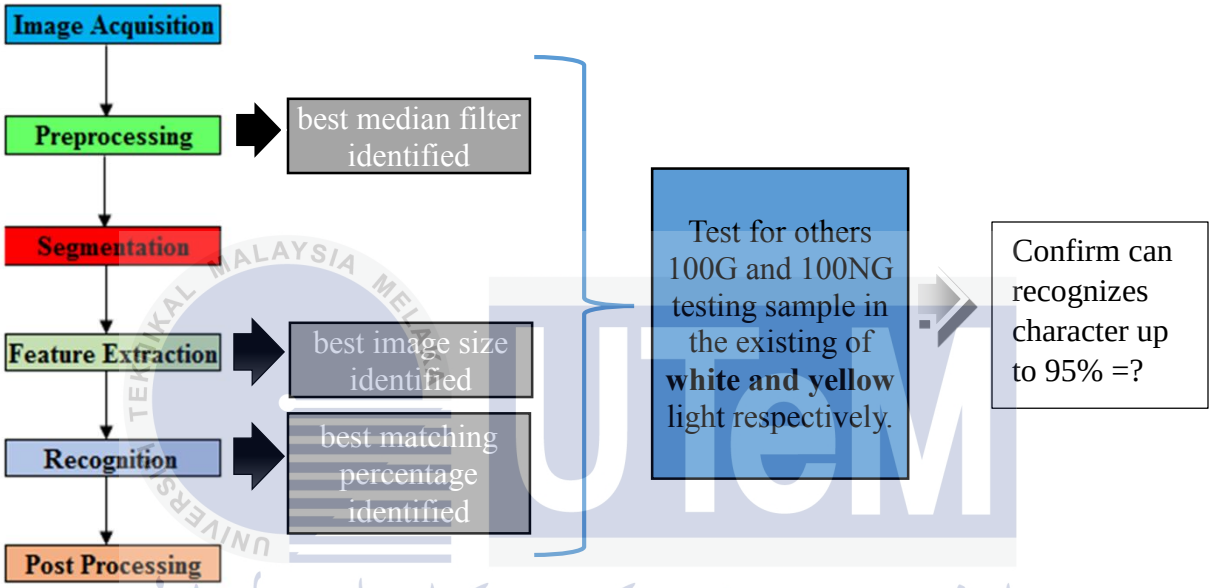


Figure 3.17: The flow chart to carry out the confirmation test.

CHAPTER 4

RESULT AND DISCUSSION

This chapter will discuss about the result and discussion of the project. Validity and reliability test is carry out to show how the vision system achieved the objective. However, because of unable physically testing at Silterra Sdn. Bhd, therefore the environment and testing sample are created as shown in Appendix A to carry out the experiment.

4.1 Experiment 1- To determine and identify the best image size which can produced highest percentage of recognition.

According to the previous work related, before started the experiment, the initial parameter for the matrix of median filter, image size, and matching percentage should be determined first. Therefore, based on the result from the previous researcher[26], by using 3x3 median filter and 30x20 of image size to determine the matching percentage.

If there are occur correct character match then have less white pixel value left whereas if wrong character match have more white pixel value left as shown in Appendix C. However, to determine the matching percentage, first which is identified the largest white pixel value left(84) after match from the diagonal of the table as shown in Appendix C, and calculate percentage of the matching by using Equation 1.

$$\text{Matching Percentage} = \frac{Size\ of\ image\ -White\ pixel\ left\ after\ match}{Size\ of\ image} \text{------Equ(1)}$$

$$\text{Percentage of Matching} = \frac{(30\text{x}20) - (84)}{(30x20)}\text{x}100\%$$

$$= \frac{(600) - (84)}{(600)}\text{x}100\%$$

$$= 86\%$$

After that, set the white pixel value left after match for the recognition block in Matlab Simulink which is 84. Besides that, the initial parameter which is 3x3 median filter, 86% of matching percentage.

However, for this experiment, to identify the best image size which can produced highest percentage of recognition when the 3x3 median filter and 86% of matching percentage are fixed in the existing of white light condition. The result as shown at Table 4.1, after matching the template with 100 good testing samples, the percentage of recognition for 10x7, 15x10, 30x20, and 40x25 of image size are 63%, 72%, 81%, and 78% respectively.

Therefore, 30x20 of the image size produced the highest percentage of recognition and this image size will be used for next experiment.

Table 4.1: The comparison between the percentages of recognition with difference image size.

Image Size / Matching Template with 100G testing sample	40x25	30x20	15x10	10x7
Fixed Parameter 3x3 median filter 86% of Matching Percentage	78% of recognition	81% of recognition	72% of recognition	63% of recognition

However, there are also have some limitation for recognition the character with difference image of size which is the character unable to read(NA) as shown in Appendix D.

From Table 4.2 show the list of character are unable to read at 10x7, 15x10, 30x20, and 40x25 of image size are NU0O9Q, NUOIQ9, UI9QV, and U9ONI0Q respectively. This is because the parameter will affect the articulation and identification precision to the image.

Table 4.2: The list of character unable to read occur at difference image size

Image Size / Matching Template with 100G testing sample	40x25	30x20	15x10	10x7
Character unable to read	N,U,0,O,9,Q	N,U,O,Q,9	U,I,9,Q,V,O	U,9,O,N,I,0,Q

As the conclusion, when system set to 3x3 median filter, 86% of matching, and 30x20 of image size able to produced 81% of recognition and can recognize more character compare to others image size. Therefore, 30x20 of image size are chosen to use for second experiment.

4.2 Experiment 2- To determine and identify the best median filter which can produced highest percentage of recognition.

In the second experiment, to identify the best matrix of median filter which can produced highest percentage of recognition when the 30x20 of image size and 86% of matching percentage are fixed and in white light condition.

The result as in Table 4.3 show that the percentage of recognition for 3x3, 5x5, 7x7, and 9x9 of median filter are 83%, 41%, 11%, and 0% respectively. Therefore, 3x3 of the median filter produced the highest percentage of recognition and this matrix of median filter will be used for next experiment.

Table 4.3: The comparison between the percentages of recognition with difference matrix of median filter.

Median Filter / Matching Template with 100G testing sample	3x3	5x5	7x7	9x9
Fixed Parameter 30x20 of Image Size 86% of Matching Percentage	83% of recognition	41% of recognition	11% of recognition	0% of recognition

However, there are also have some limitation for recognizing the character with each matrix of median filter which is the character unable to read(NA) and some of the character occur wrong recognition such as for 7x7 median filter occur wrong recognize character E as character F and so forth as shown in Appendix E.

From Table 4.4 show that the list of character are unable to read at 3x3, 5x5, 7x7, and 9x9 of median filter are NUOQ9, HIJPQSUW0579, BHMNOPQSUVW025789, and BCDEHMNOPQRSUVWY01256789 respectively.

However, for wrong recognition occur at 7x7 and 9x9 of median filter are E=L, F=EU, L=FU and F=E9, L=EF69, U=J2 respectively. Besides that, E=F means that, the character E occur wrong recognize as character F and character F wrong recognize as character E.

Table 4.4: The list of character unable to read and character wrong recognition occur at difference matrix of median filter

Median Filter / Matching Template with 100G testing sample	3x3	5x5	7x7	9x9
Character unable to read	N,U,O,Q,9	H,I,J,P,Q,S,U,W, 0,5,7,9	B,H,M,N,O,P,Q,S, U,V,W,0,2,5,7,8,9	B,C,D,E,H,M,N,O, P,Q,R,S,U,V,W,Y, 0,1,2,5,6,7,8,9
Occur wrong recognition	NA	NA	E=L F=EU L=FU	F=E9 L=EF69 U=J2

From the observation, at each matrix of median filter also have the character unable to read by system and this is because the matrix of median filter will affect the articulation and identification precision to the image and also due to the problem of accuracy to insert the sample into the hardware workspace.

Therefore, sometime the system unable to read the character due the samples are different from the template then causes the character unable to perfectly matching with the template and finally system unable to read the character.

The wrong recognition occur due to the shape and pattern of the character are nearly the same to the template. This is because after apply median filter, the image is filtered, even though the median filter is used to make the image clearer and increase the sharpness of the image but if used over the limit will causes the image become different, and make the system confuse when during the matching process.

Therefore, the wrong recognition occur. For example, the image for character B with different matrix of median filter when 30x20 of image size and 86% of matching percentage is fixed and in white light condition as Table 4.5.

Table 4.5: The comparison between the characters B with different matrix of median filter

Median Filter / Matching Template B with B testing sample	3x3	5x5	7x7	9x9
Fixed Parameter 30x20 of Image Size 86% of Matching Percentage				

As the conclusion, when system set to 30x20 of image size, 86% of matching, and 3x3 of median filter can produced 83% of recognition and can recognize more character compare to others image size and does not occur any wrong recognition. Therefore, 3x3 of median filter are chosen to use for next experiment.

4.3 Experiment 3 - To determine and identify the best matching percentage which can produced highest percentage of recognition.

In the third experiment, to identify the best matching percentage which can produced highest percentage of recognition when the 30x20 of image size and 3x3 of median filter are fixed and in white light condition.

The result as in Table 4.6 show that the percentage of recognition for good sample at 80%, 85%, and 90% of matching percentage are 38%, 100%, and 0% respectively whereas for not good(NG) sample at 80%, 85%, and 90% of matching percentage are 100%, 28%, and 4% respectively

Therefore, 85% of the matching percentage produced the highest percentage of recognition for recognize good sample and 28% of recognition for not good sample. The 80%, 85%, and 90% of matching percentage represent the white pixel value left need to set at the recognition block in recognition stage, only the white pixel value left after match less than the value have been set then the character can be send for further recognition.

Therefore the white pixel value left at 80% of matching percentage when 30x20 of image size and 3x3 of median filter is fixed as below:

$$\text{Matching Percentage} = \frac{Size\ of\ image\ -White\ pixel\ left\ after\ match}{Size\ of\ image} \quad \text{------Equ(1)}$$

$$\text{Percentage of Matching} = \frac{(30\text{x}20) - (120)}{(30x20)}\text{x}100\%$$

$$= \frac{(600) - (120)}{(600)}\text{x}100\%$$

$$= 80\%$$

The white pixel value left after match at 85% of matching percentage when 30x20 of image size and 3x3 of median filter is fixed as below:

$$\text{Percentage of Matching} = \frac{(30\text{x}20) - (90)}{(30x20)}\text{x}100\%$$

$$= \frac{(600) - (90)}{(600)}\text{x}100\%$$

$$= 85\%$$

However, the white pixel value left after match at 90% of matching percentage when 30x20 of image size and 3x3 of median filter is fixed as below:

$$\text{Percentage of Matching} = \frac{(30\text{x}20) - (60)}{(30x20)}\text{x}100\%$$

$$= \frac{(600) - (60)}{(600)}\text{x}100\% \qquad = 90\%$$

Therefore, this means that increase the matching percentage, the less is the number of white pixel left after match.

Table 4.6: The comparison between the percentages of recognition with difference matching percentage.

Matching Percentage / Matching Template with **100G** testing sample	80%	85%	90%
Fixed Parameter 30x20 of Image Size 3x3 Median Filter	38% of recognition	100% of recognition	0% of recognition
Matching ercentage / Matching Template with **100NG** testing sample	80%	85%	90%
Fixed Parameter 30x20 of Image Size 3x3 Median Filter	100% of recognition	28% of recognition	4% of recognition

There are also have limitation for recognizing the character with each matching percentage and shows the word 'NA' means that the character unable to read and some of the character occur wrong recognition such as for 80% of matching percentage occur wrong recognize character H as character B and so forth as shown in Appendix F1 and F2.

From Table 4.7 show that the list of character are unable to read only at 90% of matching percentage are ABDNOQRSTVWZ02345679. Only for the 80% of matching percentage have occur wrong recognition which is E=L, F=E, H=B, I=T, L=E, T=I, 0=BU whereas at 85% of matching percentage can read 100% correctly.

However, after matching 100 not good(NG) samples with the template, the wrong recognition occur at 80% of matching percentage are B=0,2=E,7=Z,7=F,D=0,5=G,E=L6,I=T,I=E,Z=E,3=C, for 85% and 90% of matching percentage are C=C,F=F,3=3, and F=F respectively.

Table 4.7: The list of character unable to read and character wrong recognition with difference matric of median filter.

Matching Percentage / Matching Template with **100G** testing sample	80%	85%	90%
Character unable to read	NA	NA	A,B,D,N,O,Q,R,S,T, V,W,Z,0,2,3,4,5,6,7,9
Occur wrong recognition	E=L, F=E, H=B, I=T, O=BU	NA	NA
Matching ercentage / Matching Template with **100NG** testing sample	80%	85%	90%
Character unable to read	A,C,E,B,D,F,L, Z,2,3,4,6,9	NA	NA
Occur wrong recognition	B=0,2=E,7=Z,7=F D=0,5=G,E=L6, I=T,I=E,Z=E,3=C	C=C F=F 3=3	F=F

4.4 Confirmation test

Even though 85% of matching percentage can produced 100% of recognition but have some limitation which is have 28% of recognition when recognize the flaws sample.

This is because some of the character in flaws sample have only small different compared with the template, when the recognition block is set to 90 of white pixel value left after match, the sometime the flaw character will also less than the 90 of white pixel value left.

Therefore, to solve this problem can do the adjustment and increase the matching percentage up to 92% for the specific character which is character C, F, and 3

Therefore, after the adjustment of white pixel value left for the specific character, now the system unable to read all the flaws character even though a small different from template as shown in Table 4.8 and Appendix G1 :

Table 4.8: The comparison between the percentages of recognition after adjustment of white pixel value left at character C, F, and 3 in white light condition.

Best Parameter / Matching	Image Size	Median Filter	Matching Percentage
	30x20	3x3	85%(only 92% for C,F,3)
Template 100 Good Samples	100%		
Template 100 Not Good Samples	0%		

As the conclusion, when system set to 30x20 of image size, 3x3 of median filter, and 85%(92% for character C,F,3) of matching percentage can produced 100% of recognition Therefore, all these best parameter are chosen to use for next test.

However, all the experiment have been done only in existing of white light condition, therefore able to identify and determine whether the different color of light either have or have not different effect to the result.

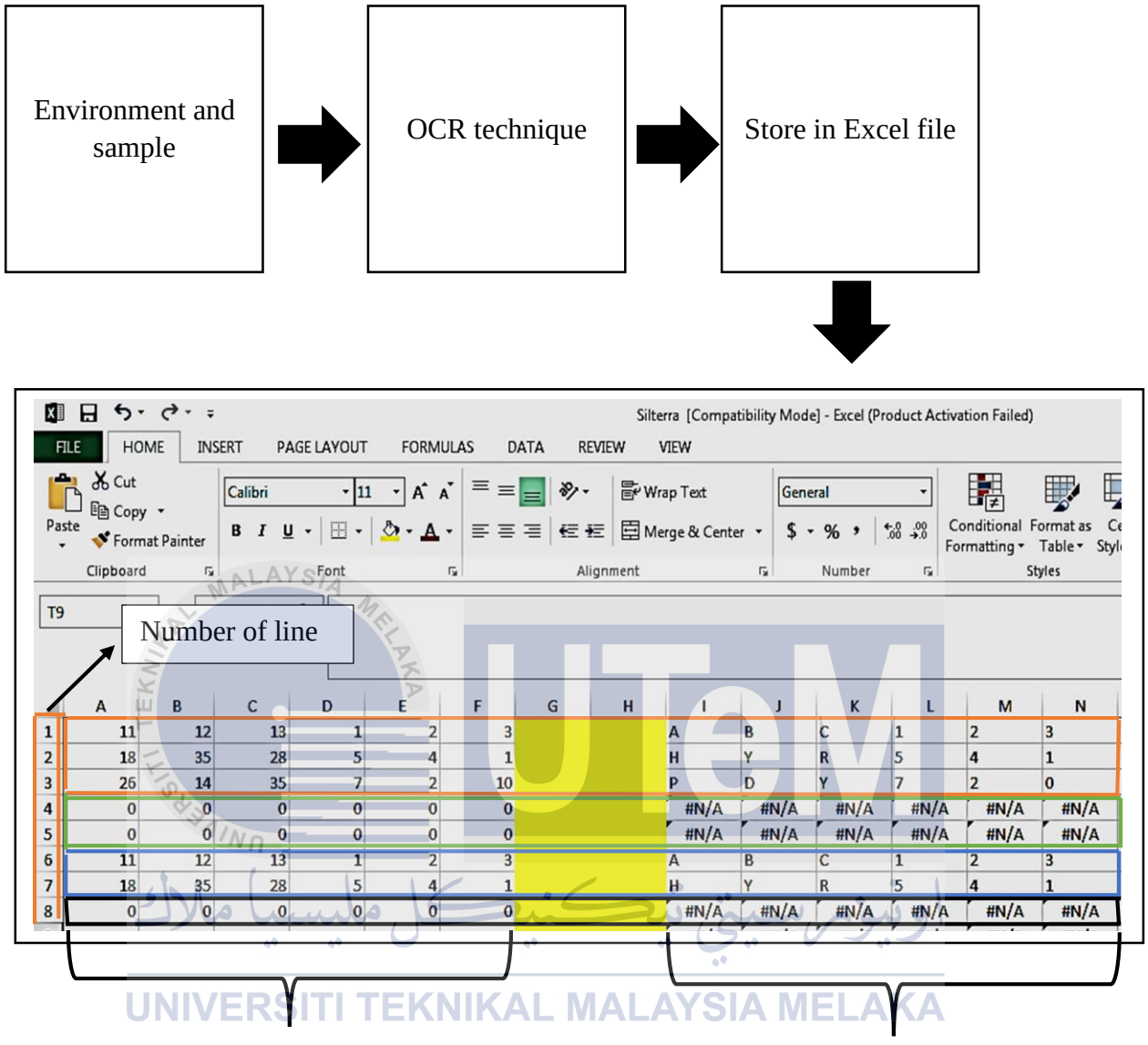
Therefore, used the best identified parameter and installed yellow color of light to the hardware and save template with the existing of yellow light condition. Refer to Table 4.9 and Appendix G2 can conclude that by using different color of light have not affect the result and able produced same result as white color of light when apply that three identified parameter, the important thing is that all the process such as template saving and recognition process must at same light condition. For example, if the environment is green color, then the process for template saving and recognition process also must in green light condition.

Table 4.9: The comparison between the percentages of recognition after adjustment of white pixel value left at character C, F, and 3 in yellow light condition

Best Parameter / Matching	Image Size	Median Filter	Matching Percentage
	30x20	3x3	85%(only 92% for C,F,3)
Template 100 Good Samples	100%		
Template 100 Not Good Samples	0%		

4.5 Store data to Excel file

However, after the vision system able to scan, recognize scribed number correctly and next is to store data in Excel file for tracking the wafer position. Therefore, the Excel file will store data from incoming sample after undergoing the OCR technique as in Figure 4.1:



**Noted

Orange color = good sample(ABC123,HYR541,PDY720) with yellow light condition.

Green color = not good sample(ABC123,HYR541,PDY720) with yellow condition

Blue color = good sample(ABC123,HYR541) with white light condition.

Black color = not good sample(ABC123) with white light condition.

Figure 4.1: The overall process of the project and data in Excel file.

4.6 Project Expenses

Besides that, the sorting machine in Silterra Company consist of two part. First is vision system and other part is dual paddle robot for an Automation Retrofitting Wafer Sorting Machine which is 'Rotating and Indexing Movement Paddle' and this machine cost Siterra Company a lot. According to the Senior Engineer Silterra Company- Mr.Ravi, he declared that the machine price is around RM 600,000, therefore as one of the project objective which is produced low cost sorting machine to solve the existing problem in the company. Therefore, the combination price for the vision system design and the mechanical mechanism design which is RM11,525. Therefore compared with the existing sorting machine, Silterra Company can save up to RM588,475 and directly solve the existing problem. The calculation as shown in Table 4.10:

Table 4.10: The expenses for sorting machine design.

No	Description	Quantity	U/Prices (RM)	Amount (RM)
Vision System Design				
1	Logitech Webcam HD C615	1	200.00	200.00
	Sum			200.00
Mechanical Mechanism Fabrication				
1.	Robot Arm –Aluminium 6061 • Primary Arm • Secondary Arm	2	470.00	940.00
2.	Hub – Aluminium 6061	1	120.00	120.00
3.	Arm Shaft –Aluminium 6061	2	240.00	480.00
4.	Flange for Joint Couple-Alum 6061	1	180.00	180.00
5.	Outer Hollow Shaft-Alum 6061	1	340.00	340.00

6.	Inner Hollow Shft - Alum 6061	1	350.00	350.00
7.	Main Holder - Alum 6061	1	250.00	250.00
8.	Base Hub - Alum 6061	1	150.00	150.00
9.	Joint Couple - Alum 6061	1	300.00	300.00
10.	Bottom Base - Alum 6061	1	450.00	450.00
	Sum			2,620.00
Mechanical Component Parts				
1.	HIWIN Ball Screw +L480	1	800.00	800.00
2.	IKO Ball Spline +L381mm	1	1400.00	1,400.00
3.	Ball Screw End-support	1	350.00	350.00
4.	BOSCH Shaft SZ 20, L 300mm	4	42.50	170
5.	Ball Screw Lubrication	1	50.00	50.00
6.	Ball Bearing id20 od35	8	20	160.00
7.	Ball Bearing id45 od 58	3	60	180.00
	Sum			3,110.00
Tim ing Pulley & Timing Belt				
1.	MXL-140T Alum.T/Pulley	1	120.00	120.00
2.	MXL-70T Alum.T/Pulley	1	80.00	80.00
3.	MXL-589.3-15mm Alum.T/Belt	1	245.00	245.00
4.	OD:75Alum.T/Pulley	1	90.00	90.00
5.	OD:75Alum.T/Pulley	1	60.00	60.00
6.	MXL-520.1-15mm	1	225.00	225.00
7.	Alum. Flange	1	40.00	40.00

8.	MXL-40T Alum.T/Pulley	1	145.00	145.00
9.	MXL-48T Alum.T/Pulley	1	175.00	175.00
10.	MXL-104T Alum.T/Belt	1	220.00	220.00
11.	MXL-48T Alum.T/Pulley	1	160.00	160.00
12.	OD:25Alum.T/Pulley	1	50.00	50.00
13.	OD:50Alum.T/Pulley	1	75.00	75.00
14.	OD:30Alum.T/Pulley	2	60.00	120.00
15.	OD:120Alum.T/Pulley	1	120.00	120.00
16.	OD:60Alum.T/Pulley	1	80.00	80.00
17.	OD:70Alum.T/Pulley	1	85.00	85.00
18.	OD:45Alum.T/Pulley	1	75.00	75.00
	Sum			2,165.00
Electronic Component				
1.	R-Series Minetia Motor R01SAKOE UTOPI – 100MX	2	900.00	1,800.00
2.	R-Series Minetia Motor R02SAKOE UTOPI – 200SE	1	1300.00	1,300.00
3.	Switching Power Supply 12V 8.5A	1	45.00	45.00
4.	Switching Power Supply 24V 6.5A	1	135.00	135.00
5.	Arduino & Sheild Set	1	150.00	150.00
	Sum			3,430.00
Total				11,525

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This chapter will discuss about the conclusion and recommendation of the project. In conclusion part, regarding about an overview of content and summarize of the project. However, the recommendation presents suggestions relating to the project.

5.1 Conclusion

A lot of literature reviews had been done through this few months. Any relevant work, article, journal, and sources had been put into the project chapter two. From study, the detail of OCR technique that used to carry out the project had been explain in section 2.4.

The methodology explain on how the validity and reliability test to produce high percentage of recognition. For validity, the prototype to mimic the environment at Silterra production line is done and the testing sample are created due to the real wafer sample are not provided. The validation is important but a test should also be reliable, three inter related experiment and confirmation test are carry out to identify the best parameter that used in the system and also verify the system performance.

According to the result, the best image size, matrix of median filter, and matching percentage in the system are 30x20, 3x3, and 85% respectively. Besides that, there have some limitation when using 85% of matching percentage, which is the system occur wrong recognition when system read the flaws sample in character C, F, and 3, but can read and recognize all the good sample correctly. Therefore, to solve this problem, the adjustment value of white pixel left at recognition block for character C, F, and 3 is necessary to make the system recognize correctly. However, the environment is the important matter and should be consider.

From the result finding, for both white and yellow light condition can produce same result which is produced 100% of recognition when read good sample and 0% of recognition when read flaws sample. This can conclude that by using different color of light have not affect the result and able to produce same result but the important thing is all the process in training phase and matching phase must at same light condition. For example, if the environment is green color, then the process for template saving and recognition process also must in green light condition.

However, from the requirement from the Silterra Company, all the data are needed to store in Excel file for tracking purpose. Therefore, by applying Matlab coding and LOOKUP function in Excel, finally all the data can store to Excel file for tracking process and help the workers to have a better visualization and it is more user friendly.

Through this, the first and second objective had achieved.

5.2 Recommendation

For future work, implementation of Graphical User Interface(GUI) into the vesion system design to allow everyone have a better visualization and more user friendly. The GUI will enhance the system with graphical image, and include button that can check error and adjust the alignment on the incoming wafer.

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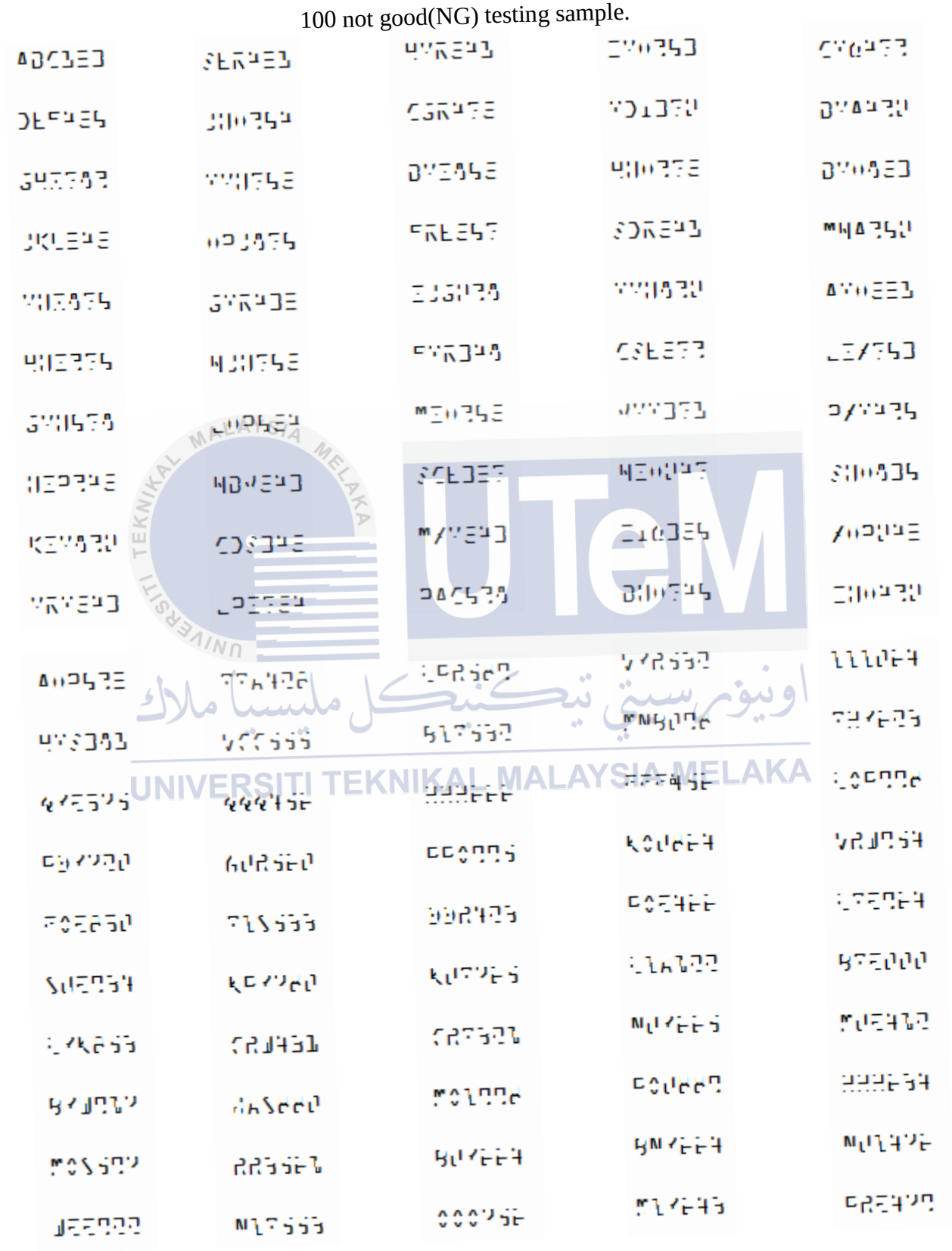
APPENDIX A1

100 good(G) testing sample.

ABC123	SER421	HYR541	HU0975	BY0853
DEF456	JU0964	CGR475	SDR541	MNA960
GHI789	TYU765	BYI865	TYU890	AT0521
JKL245	0PJ876	FRE567	CSE579	LIX763
YUI876	GTR432	MI0965	VYT371	PXT496
HUI976	NJU765	SCE327	NI0047	SU0836
GYU678	L0P654	MXY543	ZWQ356	X0P042
UIP945	NBV543	PAC698	BU0746	ZU0490
KIY890	CDS345	ZY0963	CTQ479	A0P692
YRT543	LPI754	TDW370	BYA490	HTS381
QYE375	QQQ456	HHH666	FFF456	III064
PDY720	GUR560	PP0995	K0U864	THY623
F0E830	TIS533	DDR423	P0E466	L0P998
SUE934	KPY780	KUT765	LIA122	VRW954
LYK853	CRW431	CRT321	NUY665	LTE964
BYW917	JAS880	M0I998	P0U889	BTE000
M0S597	RR3561	BUY664	BNY664	MUE412
WEE922	NIT553	000756	MIY643	HHH634
TTA428	LPR589	VYR532	PRG754	NUI476
VCC555	BIT532	MNB098	M00874	PRE479

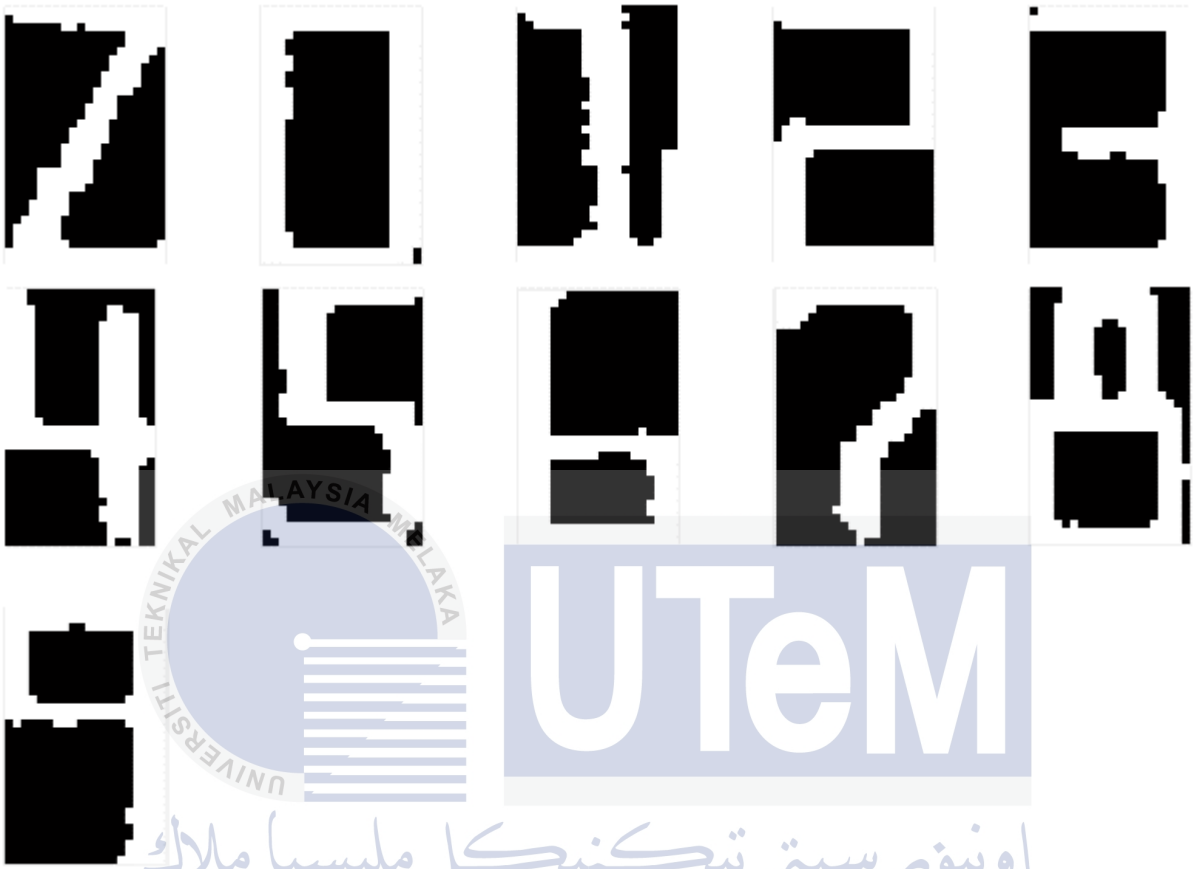
APPENDIX A2

100 not good(NG) testing sample.



APPENDIX B1

The original template with white color light.



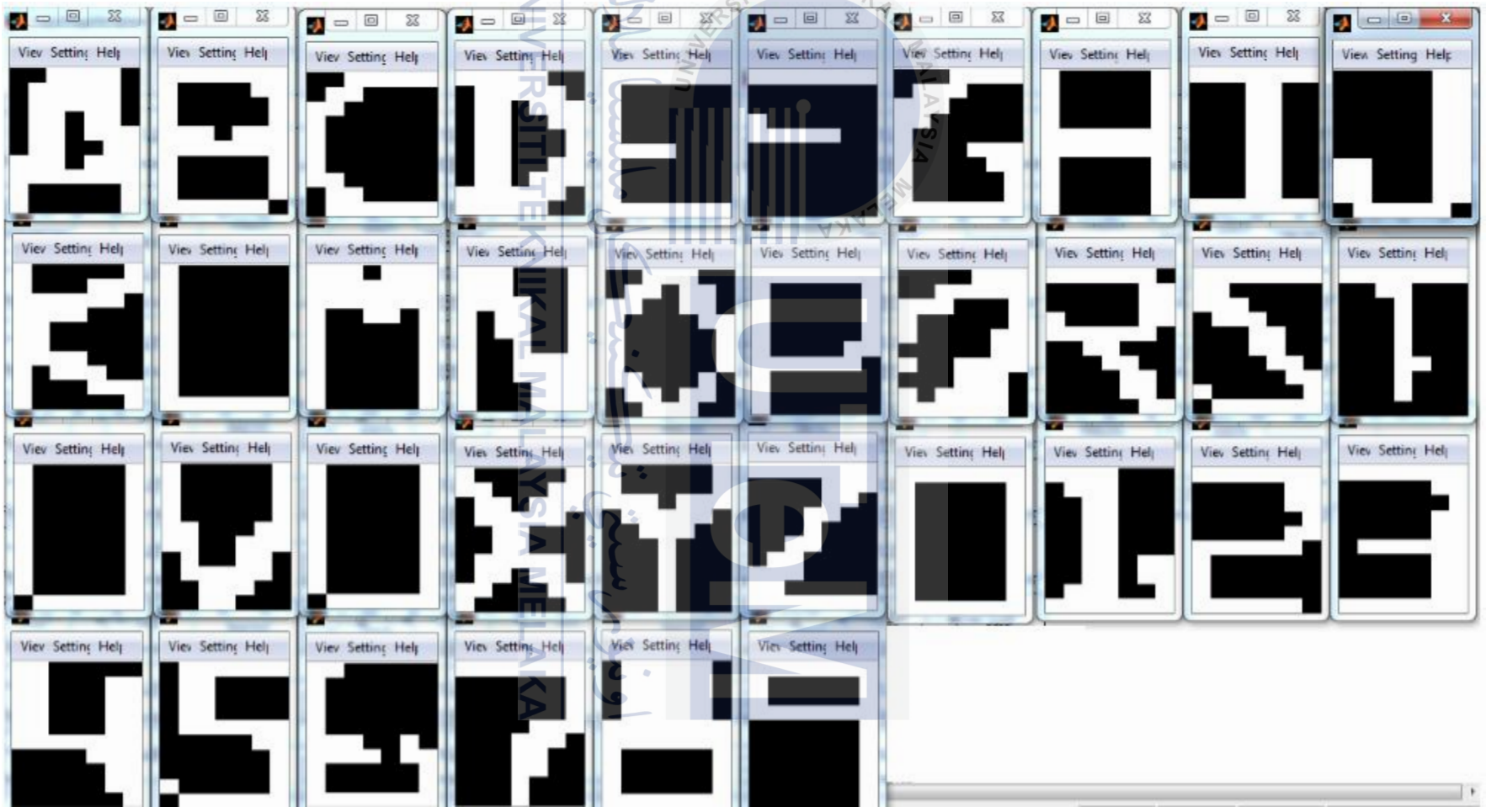
APPENDIX B2

The original template with yellow color light.

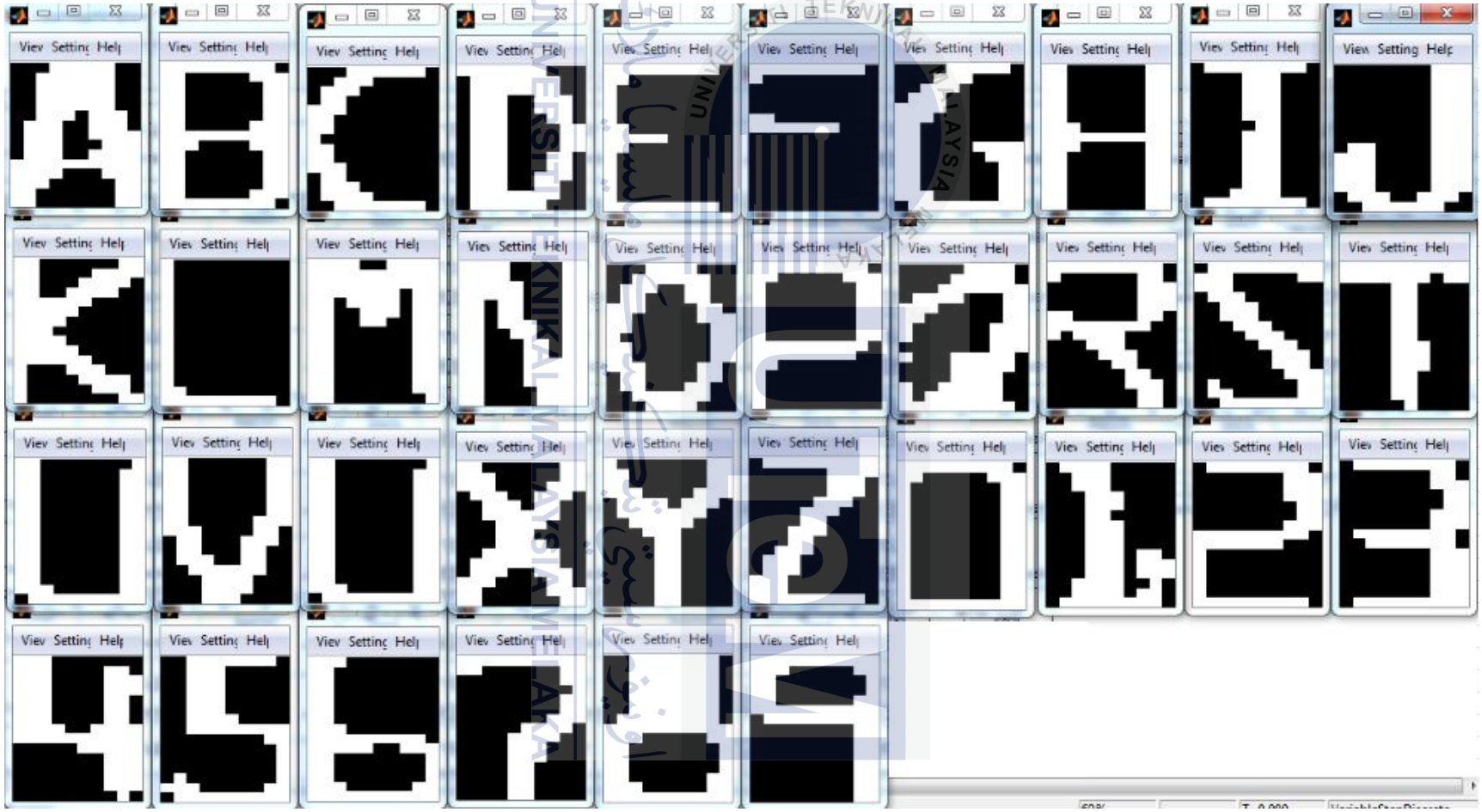
APPENDIX B3

The template with different image size and median filter with **white color light** stored in database of the vision system.

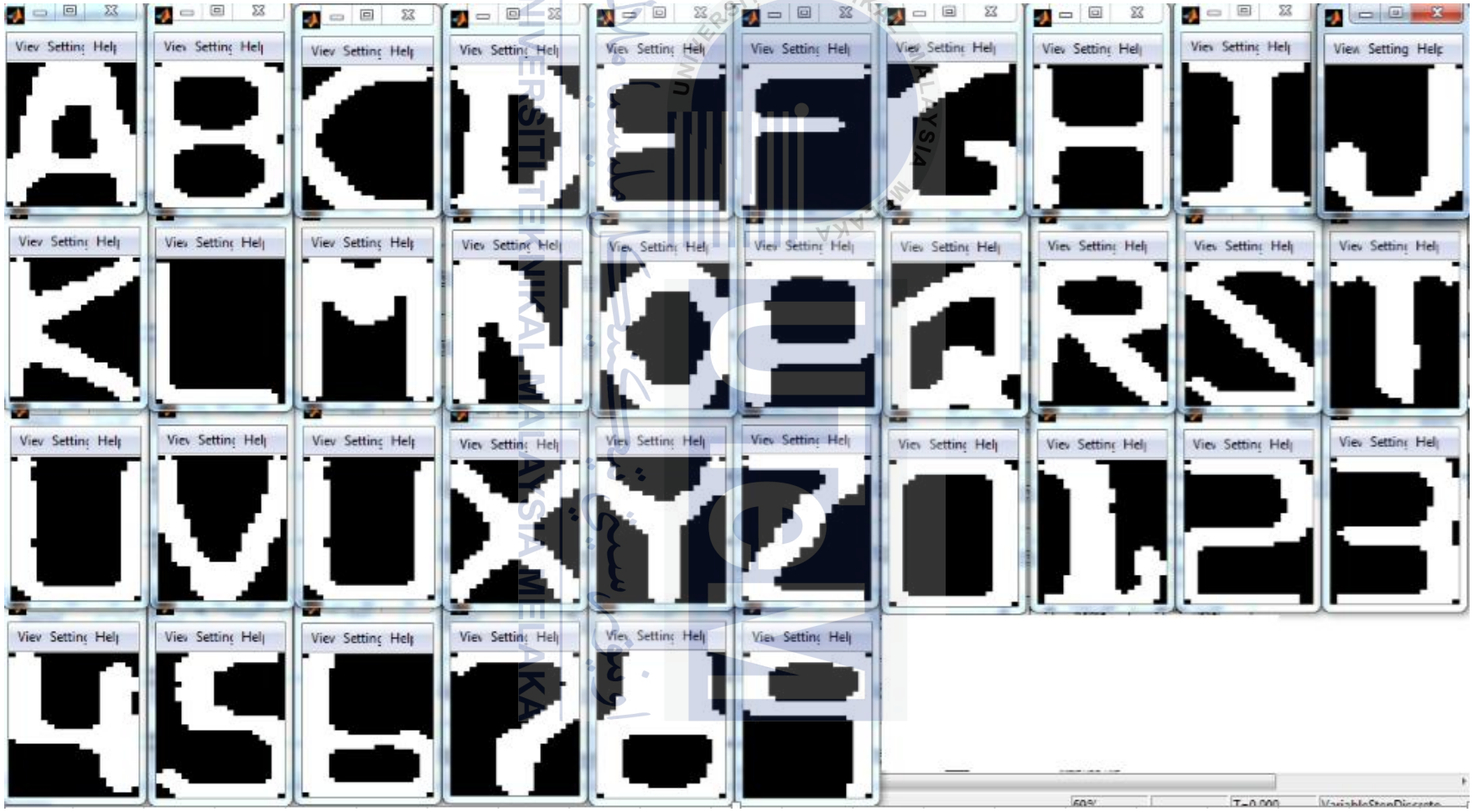
The template with 3x3 of median filter and 10x7 of image size.



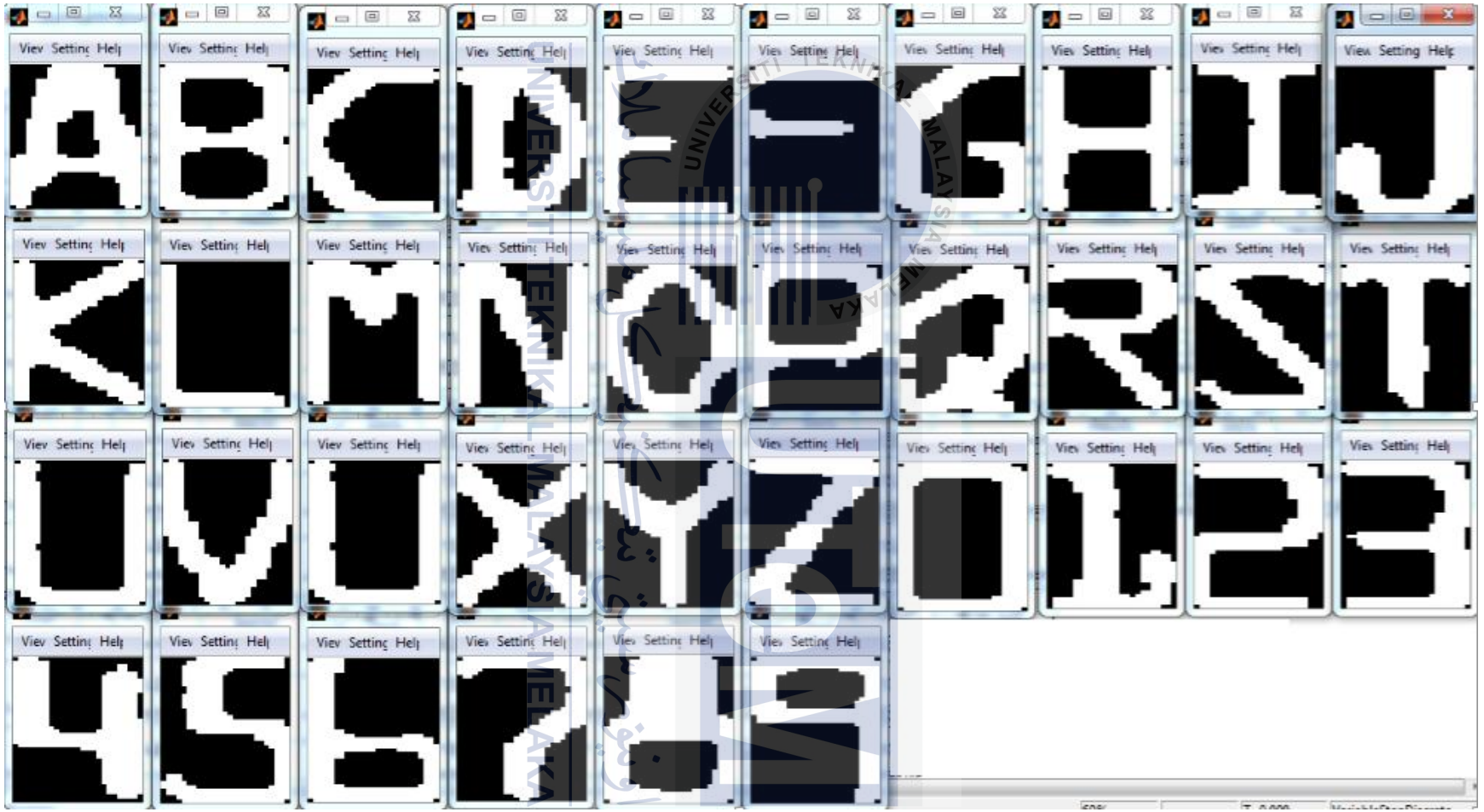
The template with 3x3 of median filter and 15x10 of image size.



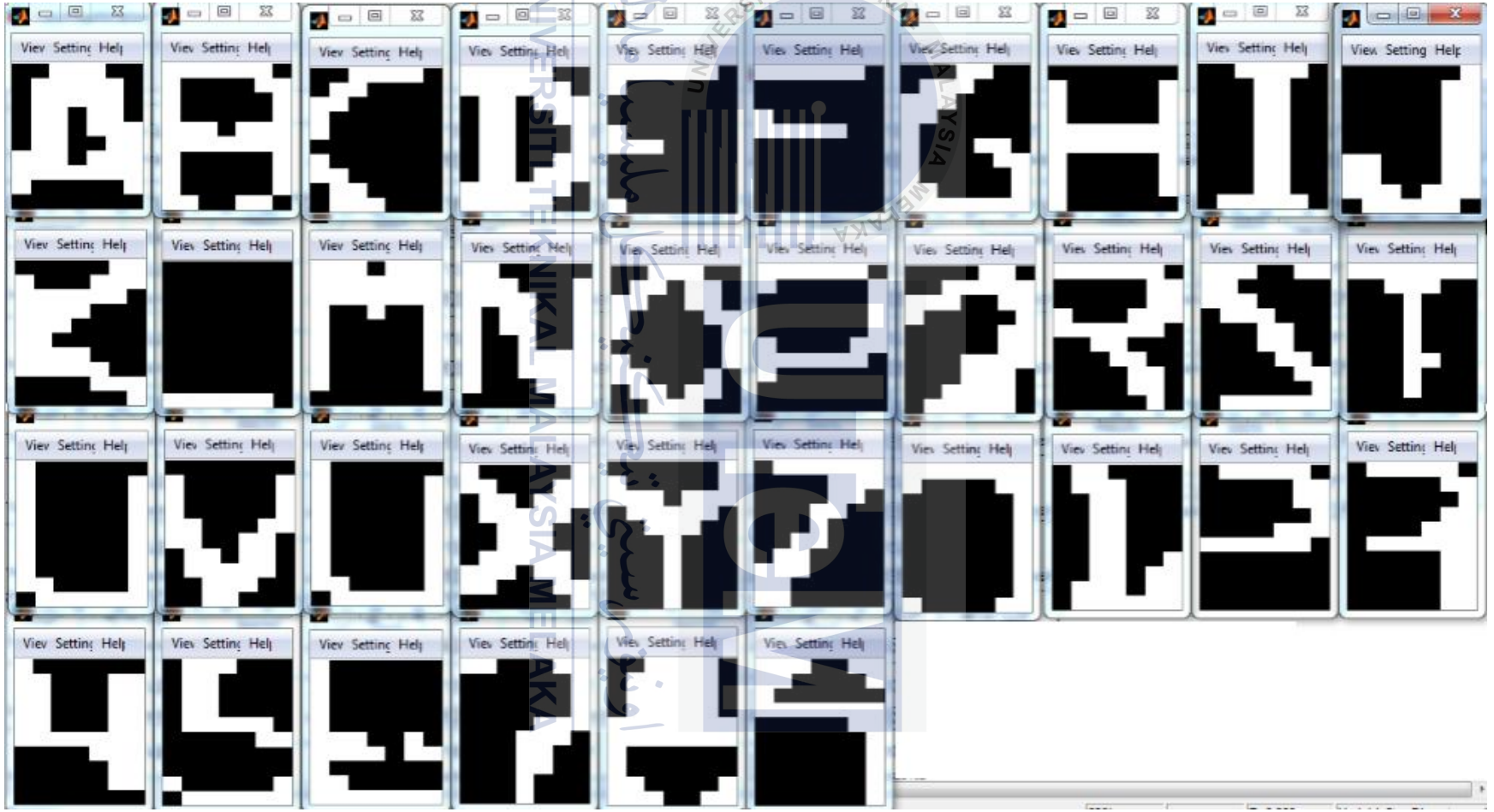
The template with 3x3 of median filter and 30x20of image size.



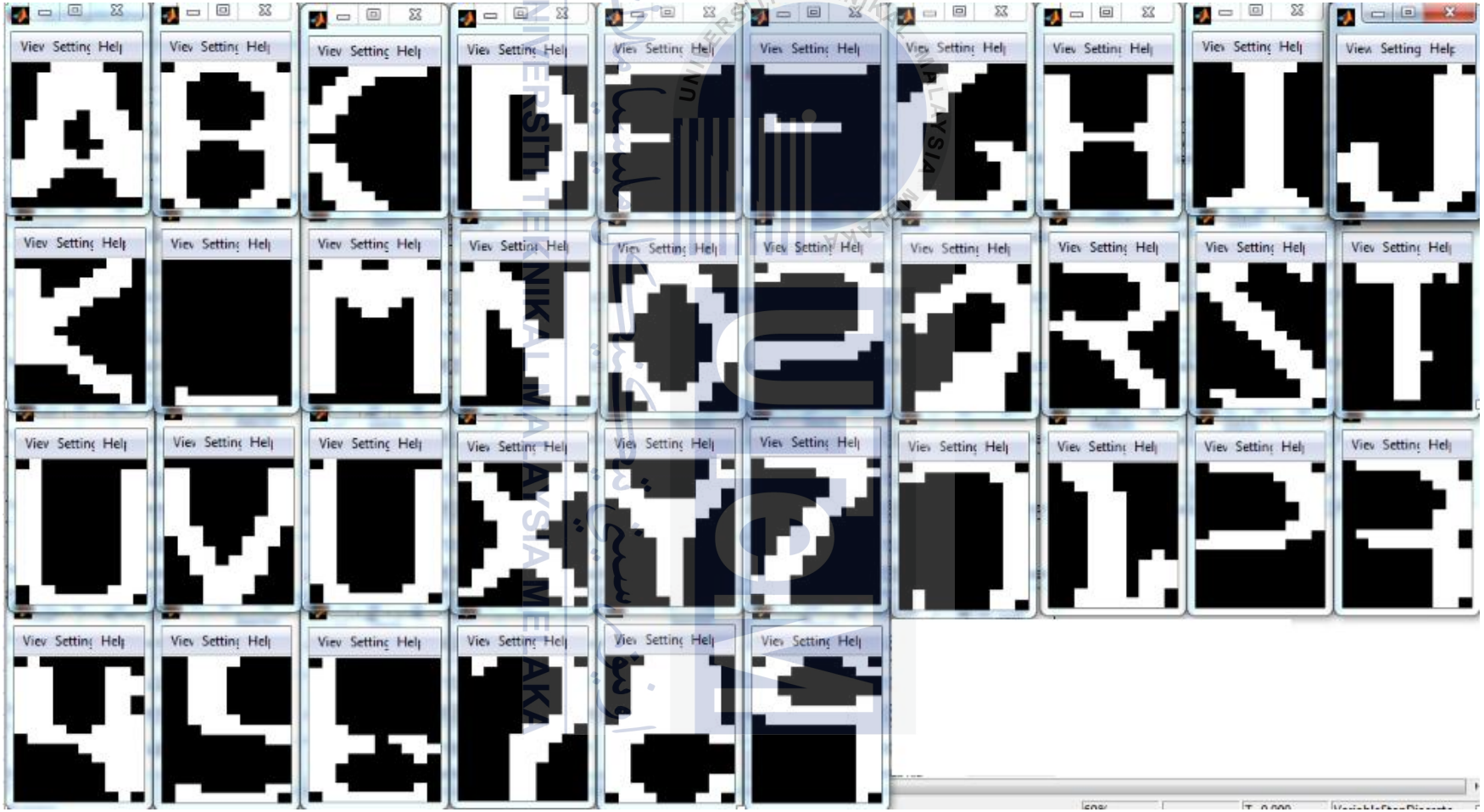
The template with 3x3 of median filter and 40x25 of image size.



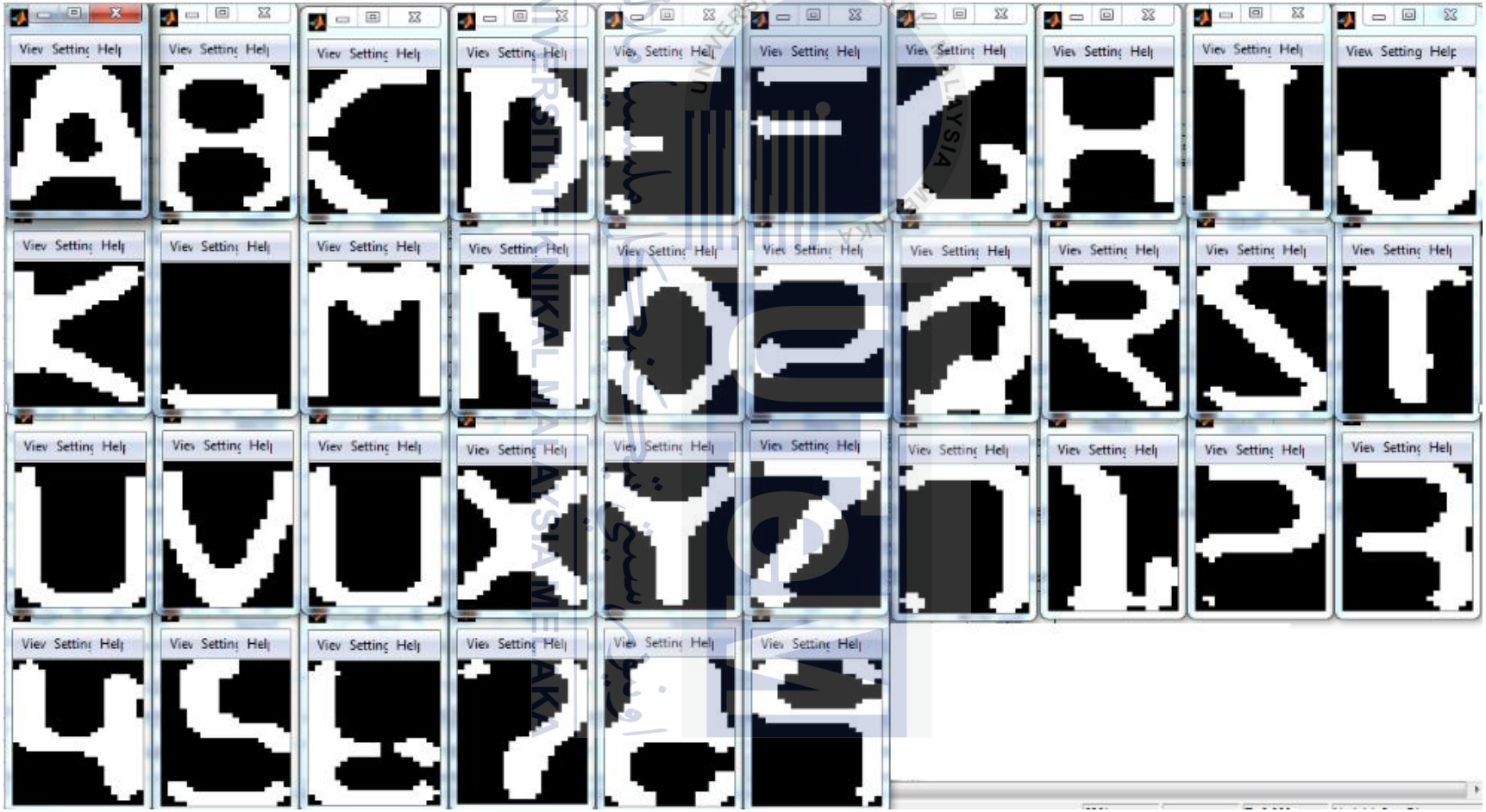
The template with 5x5 of median filter and 10x7 of image size.



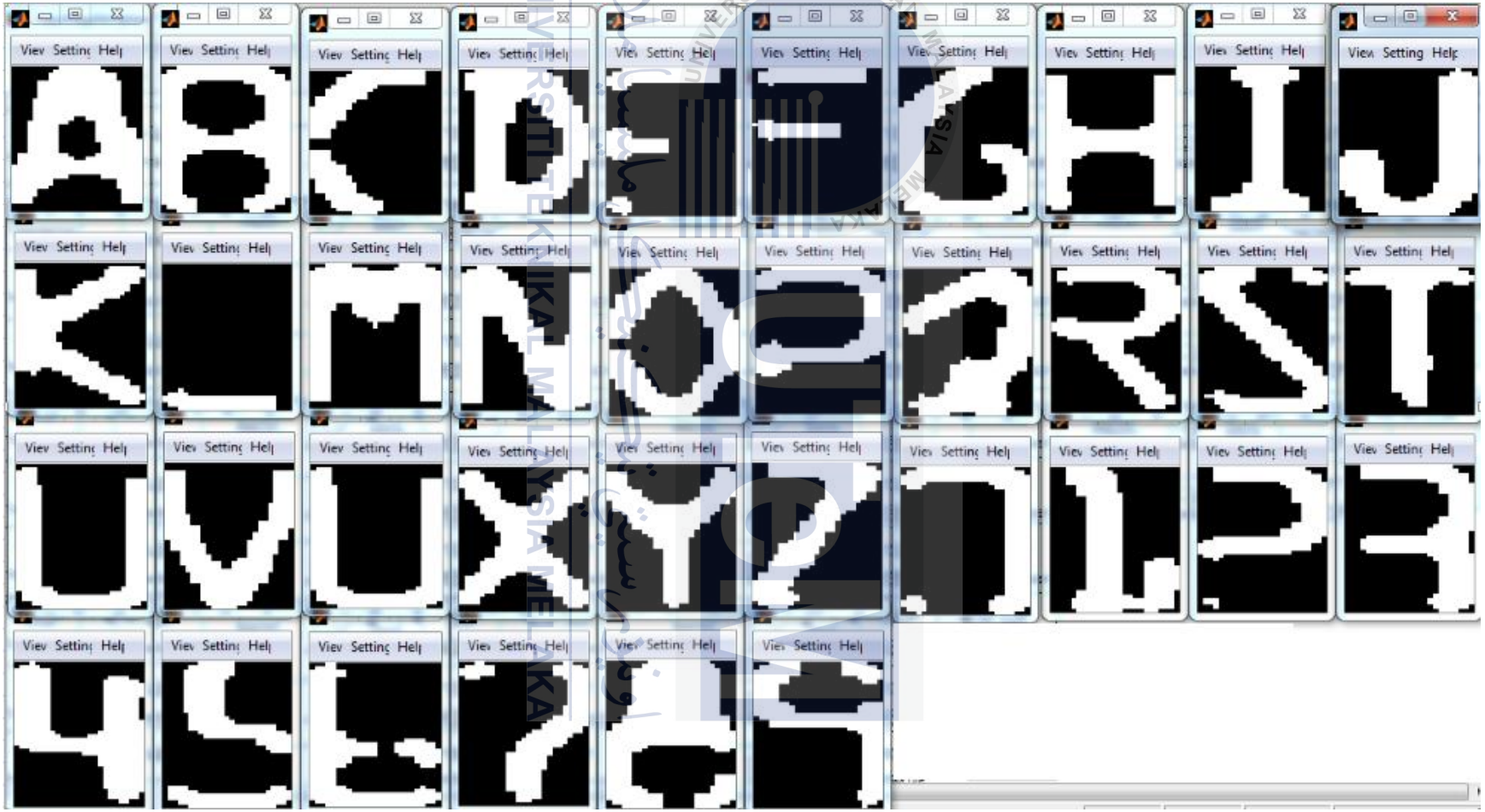
The template with 5x5 of median filter and 15x10 of image size.



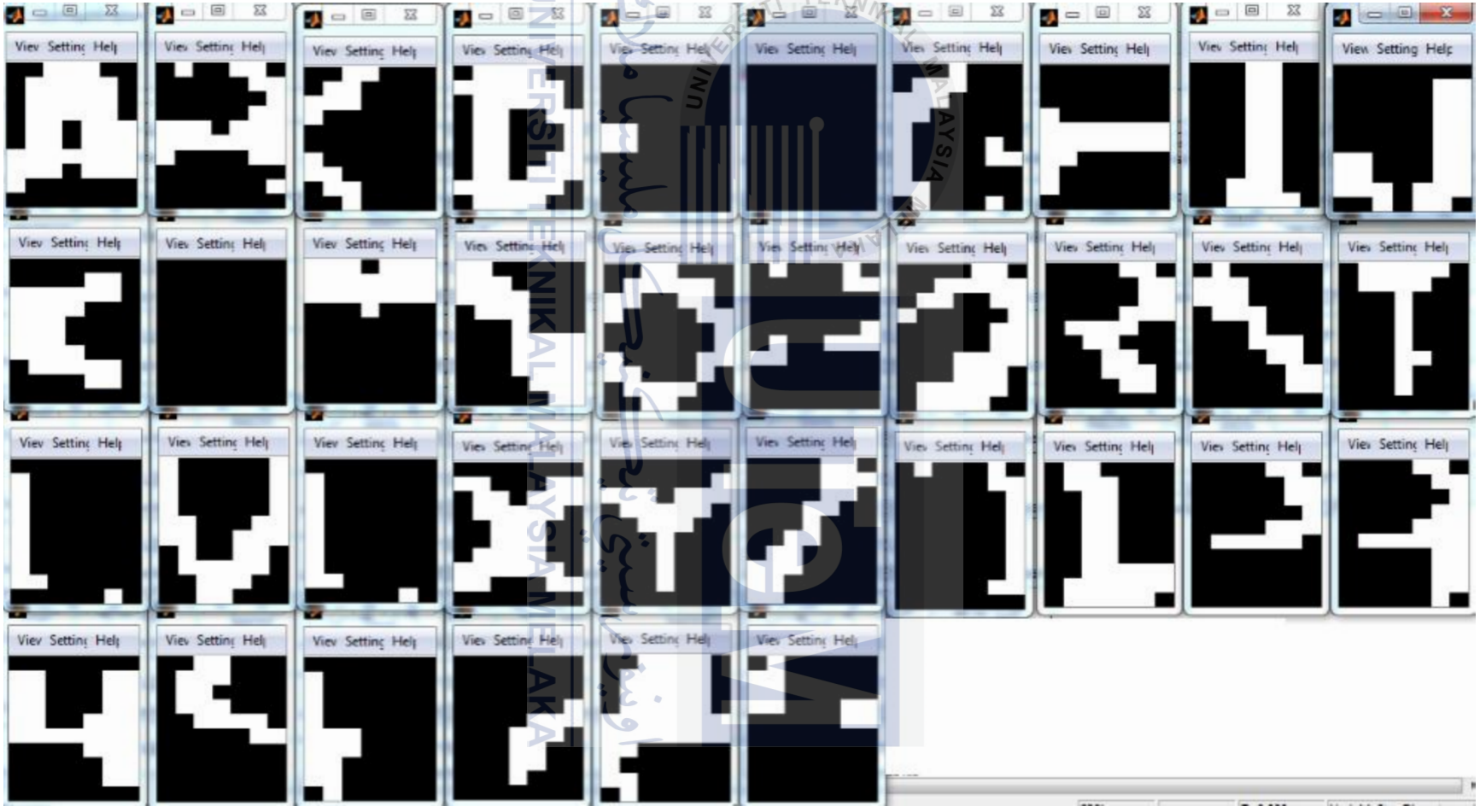
The template with 5x5 of median filter and 30x20 of image size.



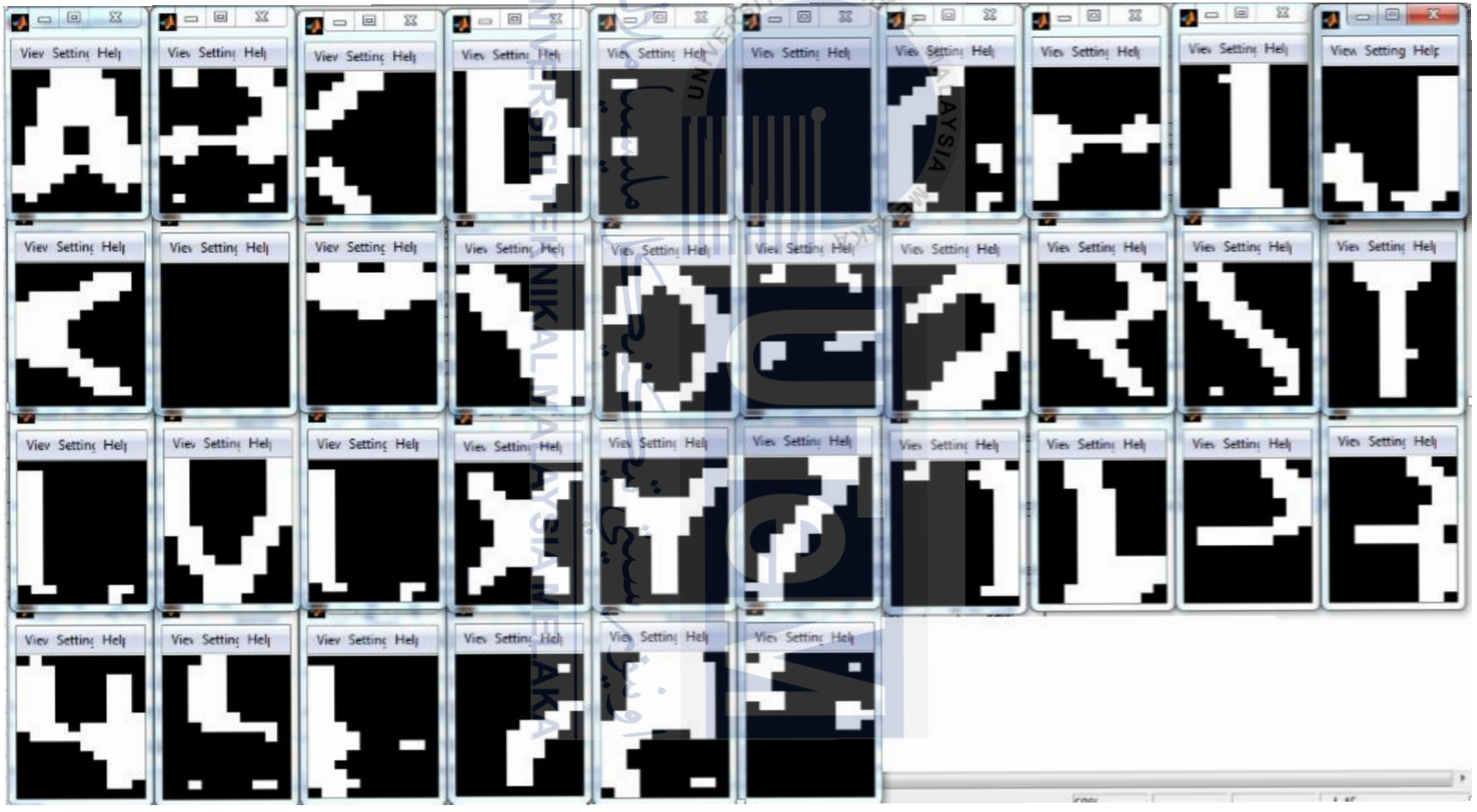
The template with 5x5 of median filter and 40x25 of image size.



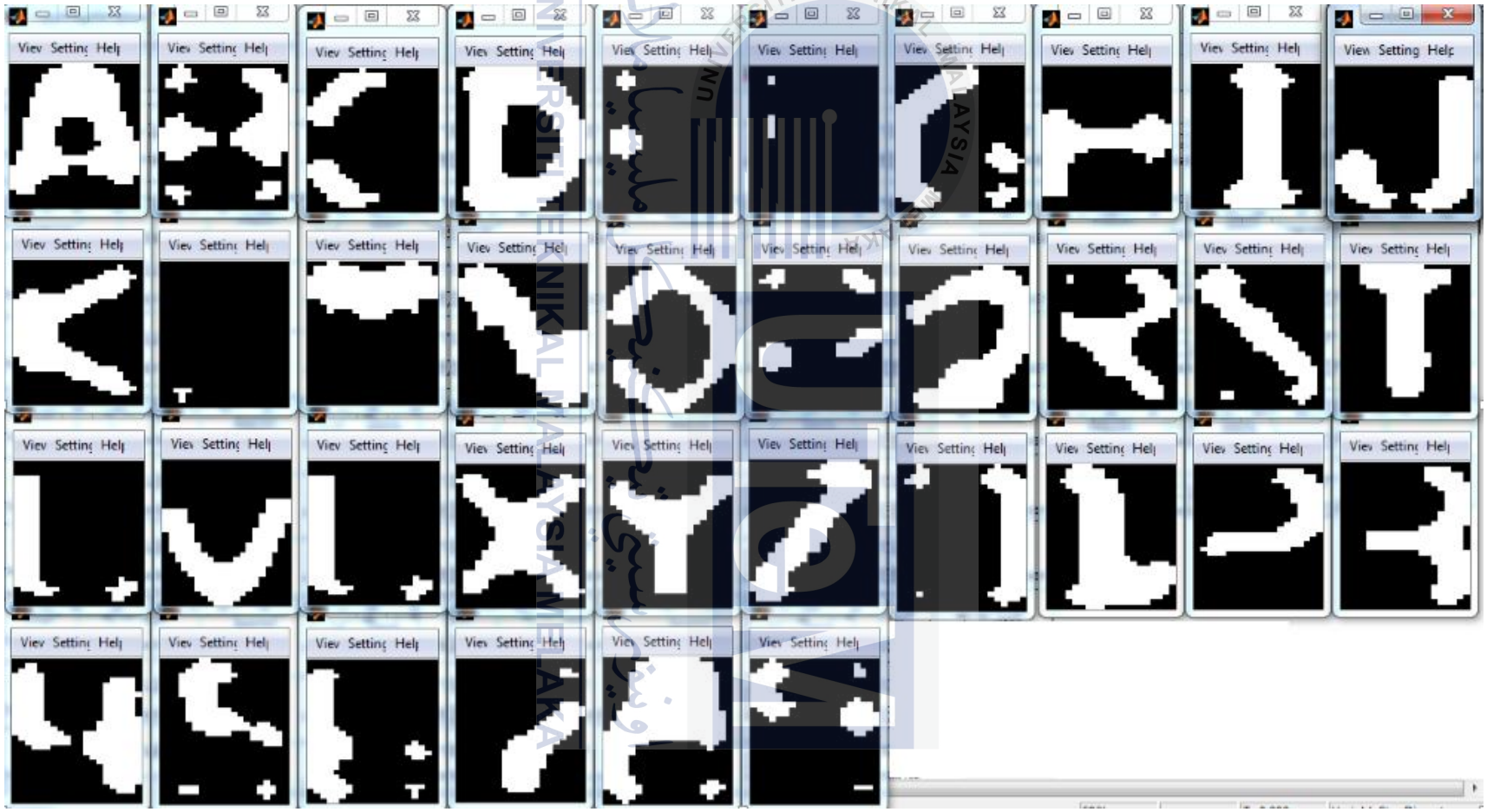
The template with 7x7 of median filter and 10x7 of image size.



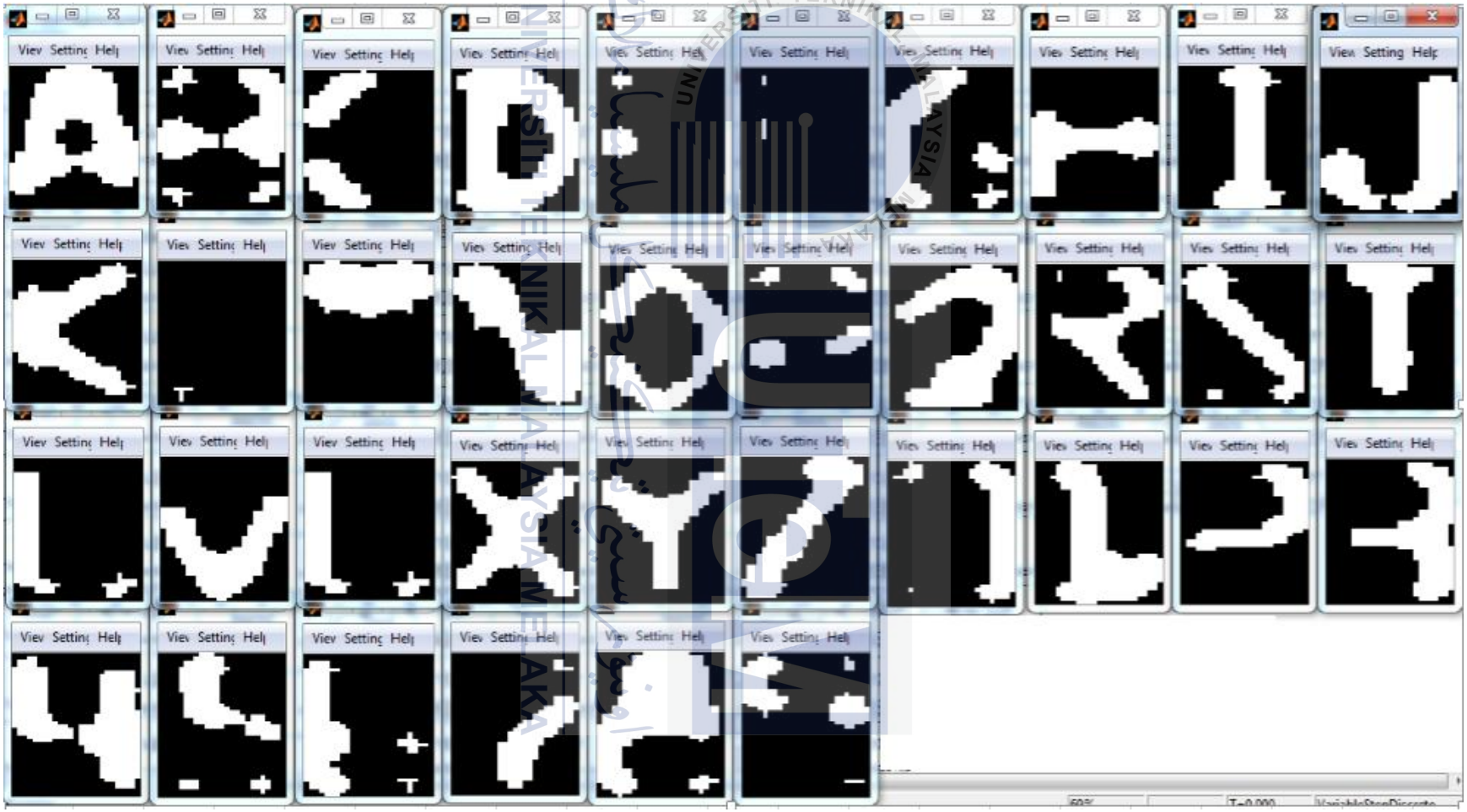
The template with 7x7 of median filter and 15x10 of image size.



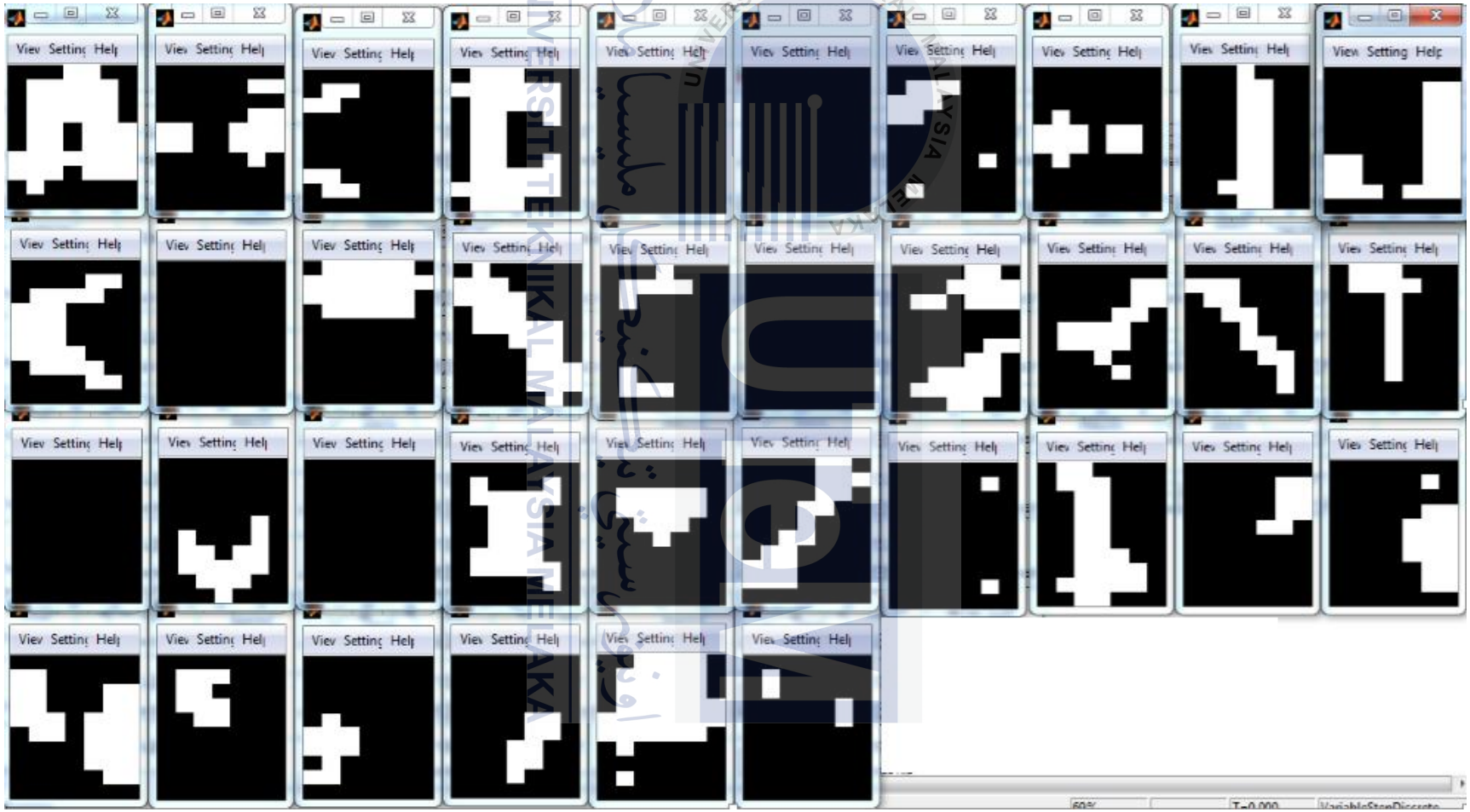
The template with 7x7 of median filter and 30x20 of image size.



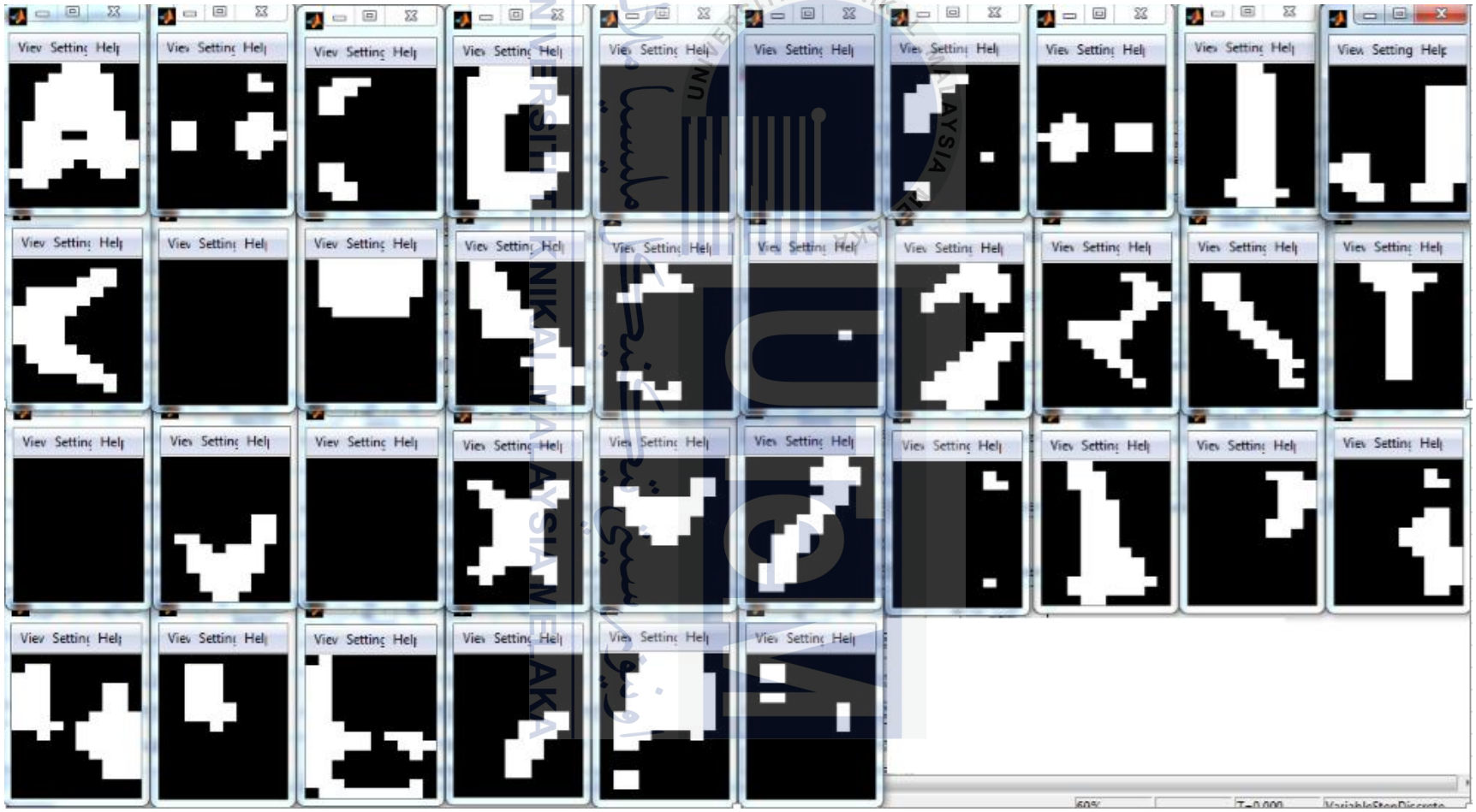
The template with 7x7 of median filter and 40x25 of image size.



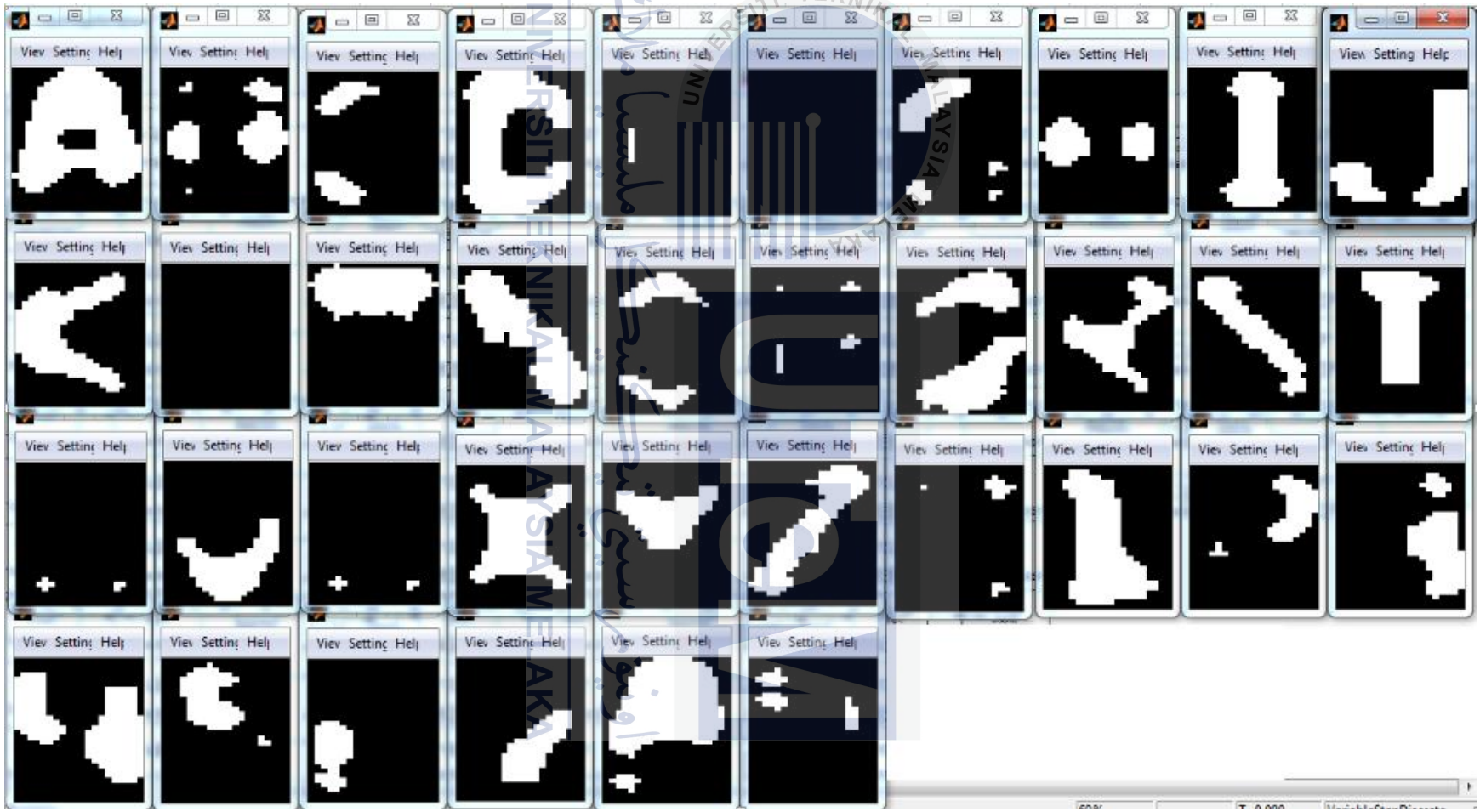
The template with 9x9 of median filter and 10x7 of image size.



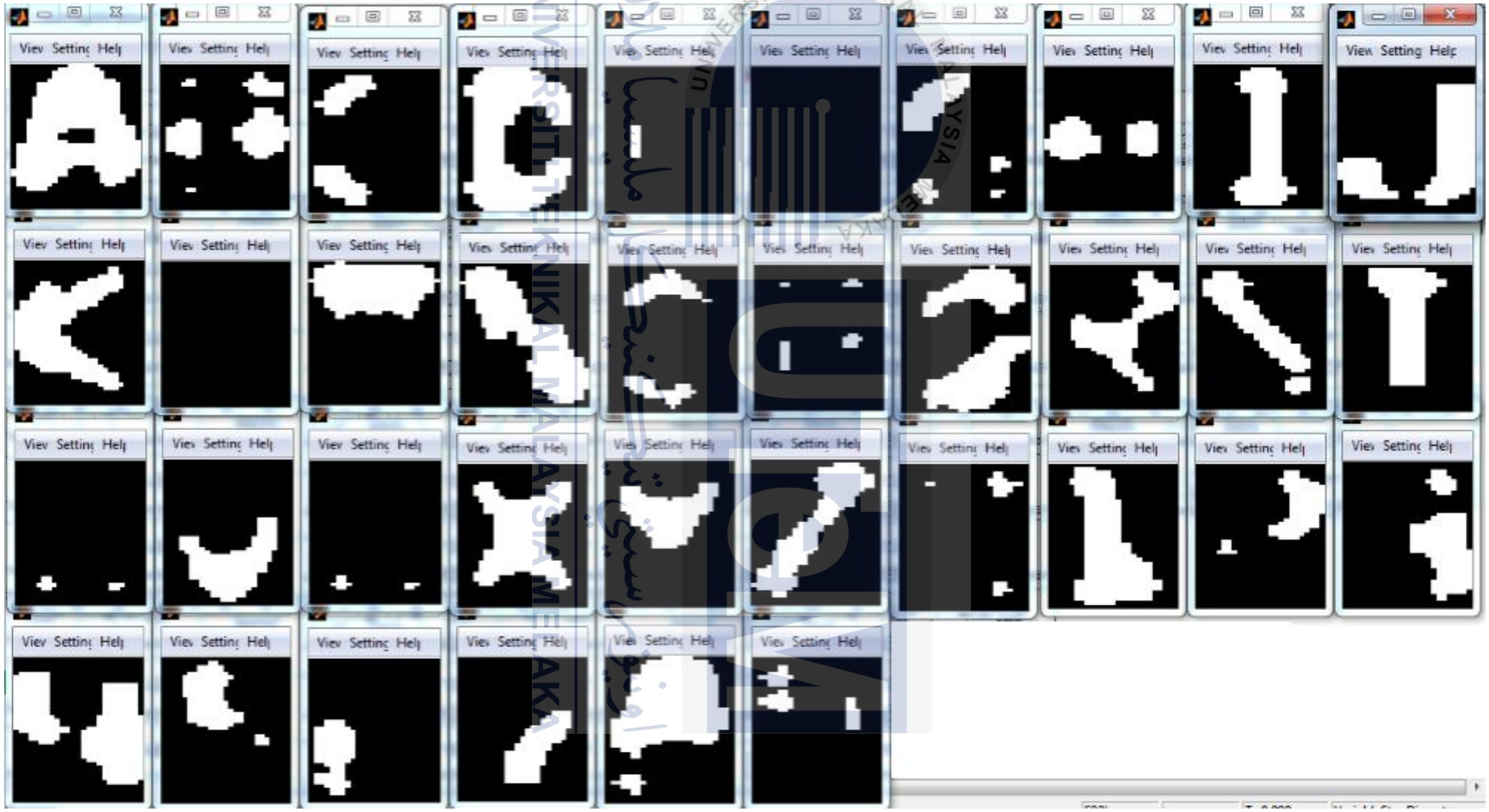
The template with 9x9 of median filter and 15x10 of image size.



The template with 9x9 of median filter and 30x20 of image size.



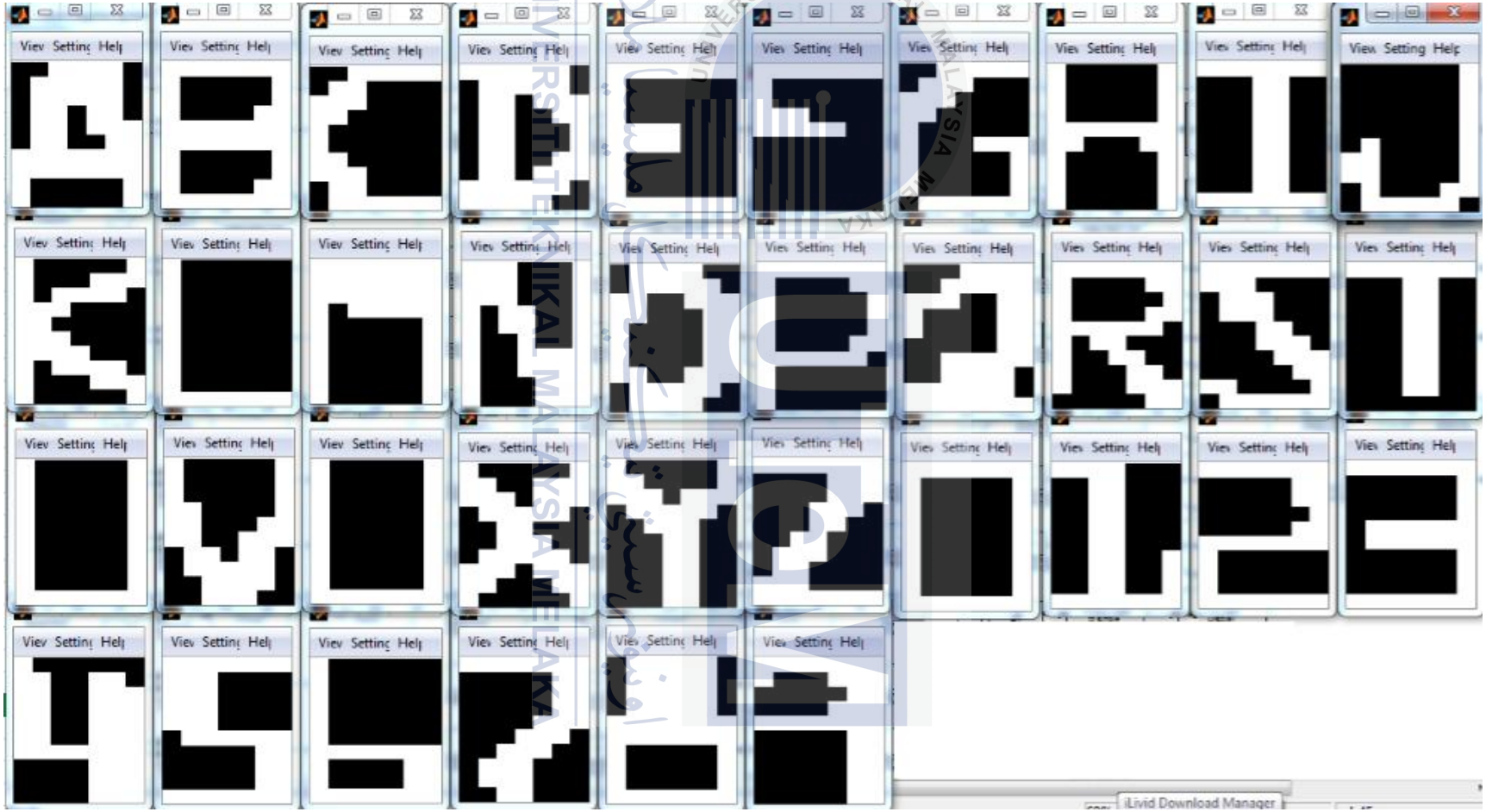
The template with 9x9 of median filter and 40x25of image size.



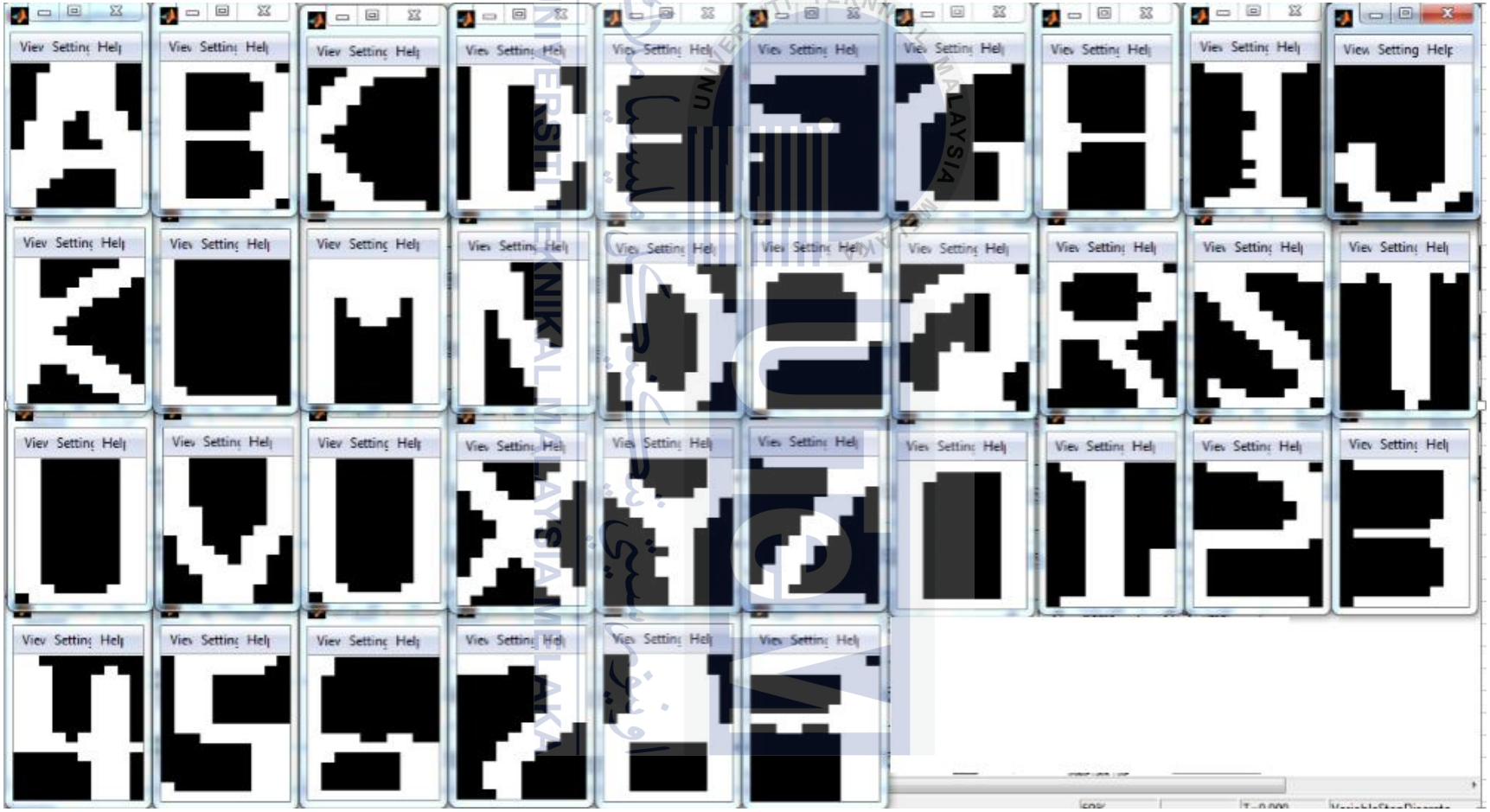
APPENDIX B4

The template with different image size and median filter with **yellow color light** stored in database of the vision system.

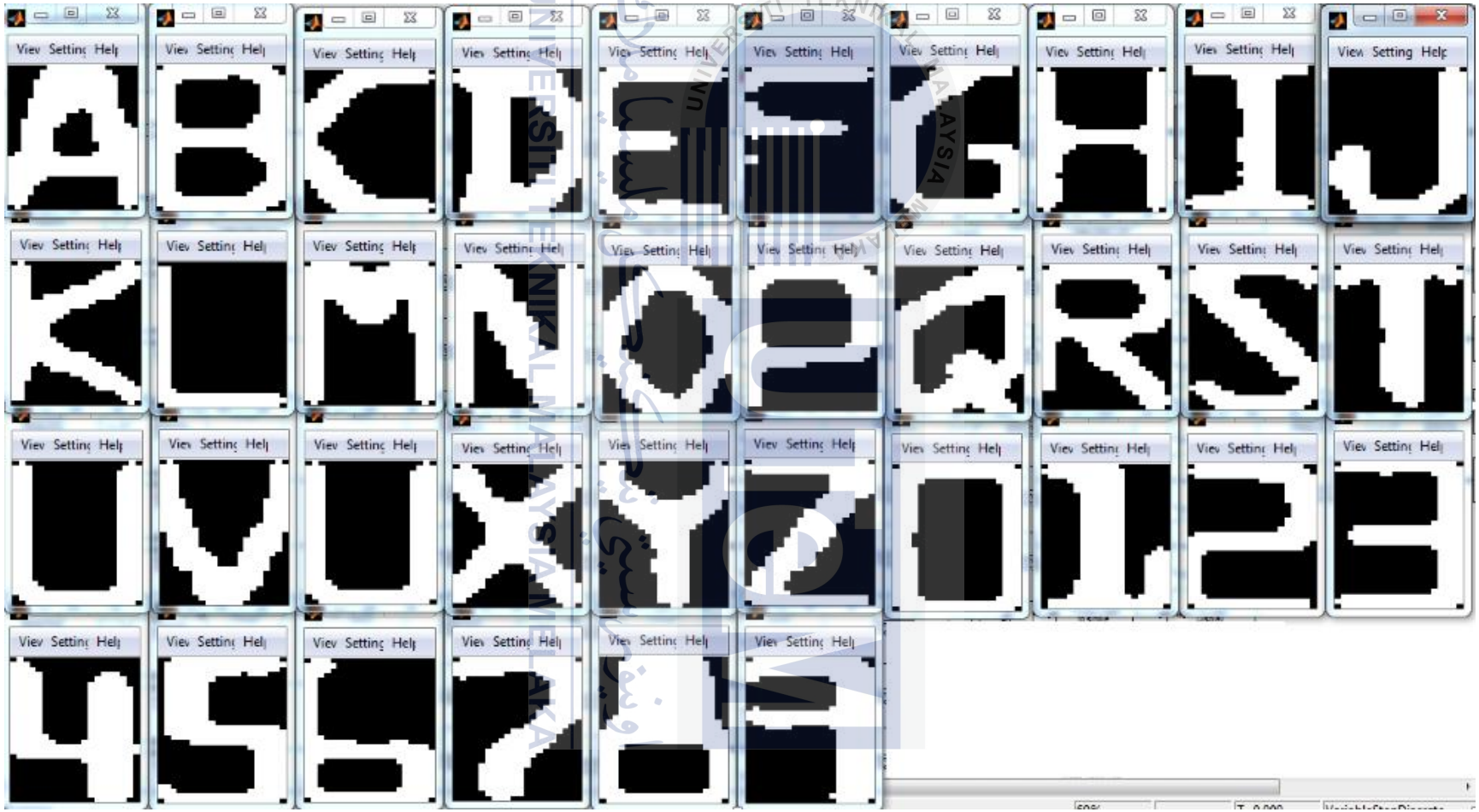
The template with 3x3 of median filter and 10x7 of image size.



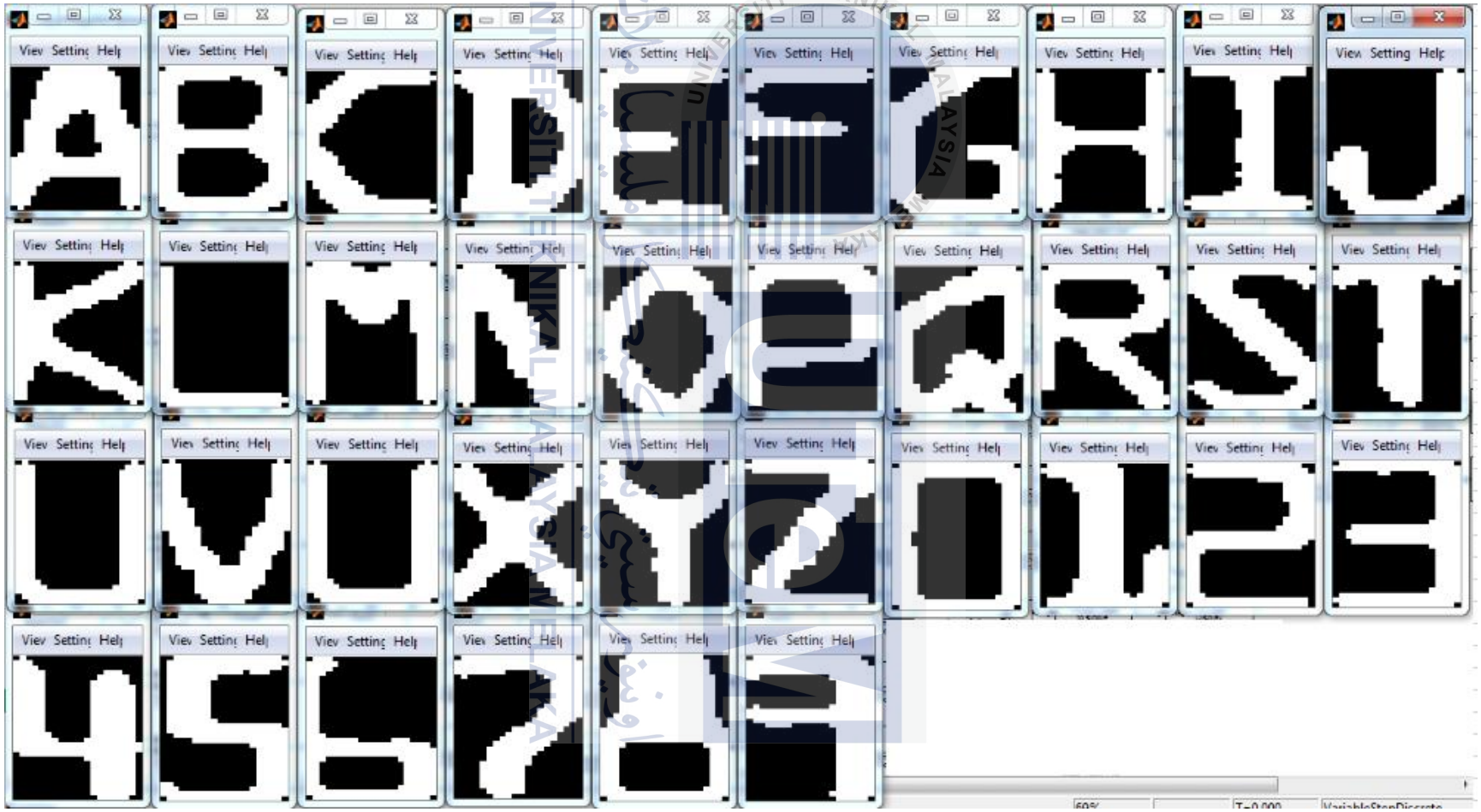
The template with 3x3 of median filter and 15x10 of image size.



The template with 3x3 of median filter and 15x10 of image size.

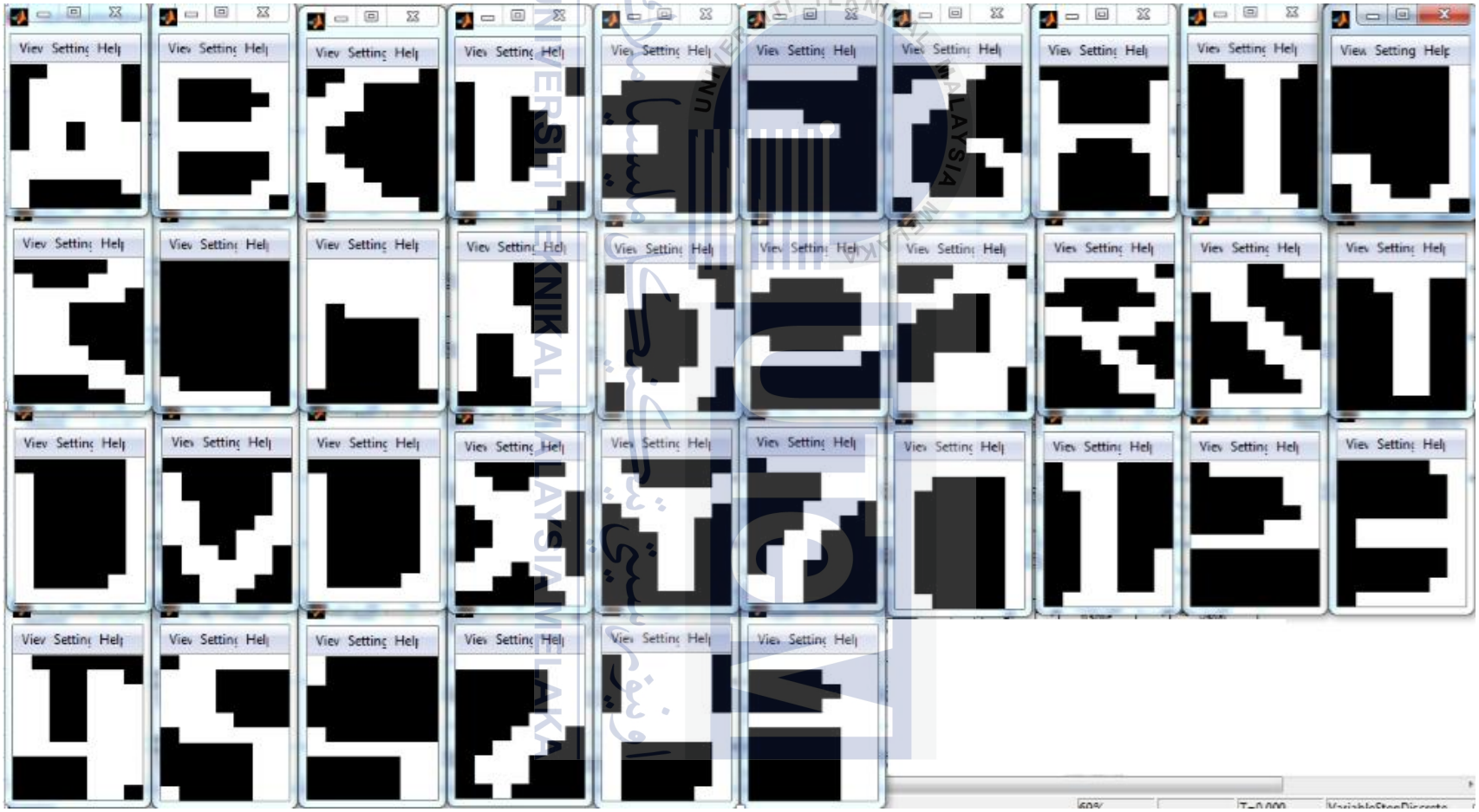


The template with 3x3 of median filter and 30x20 of image size.

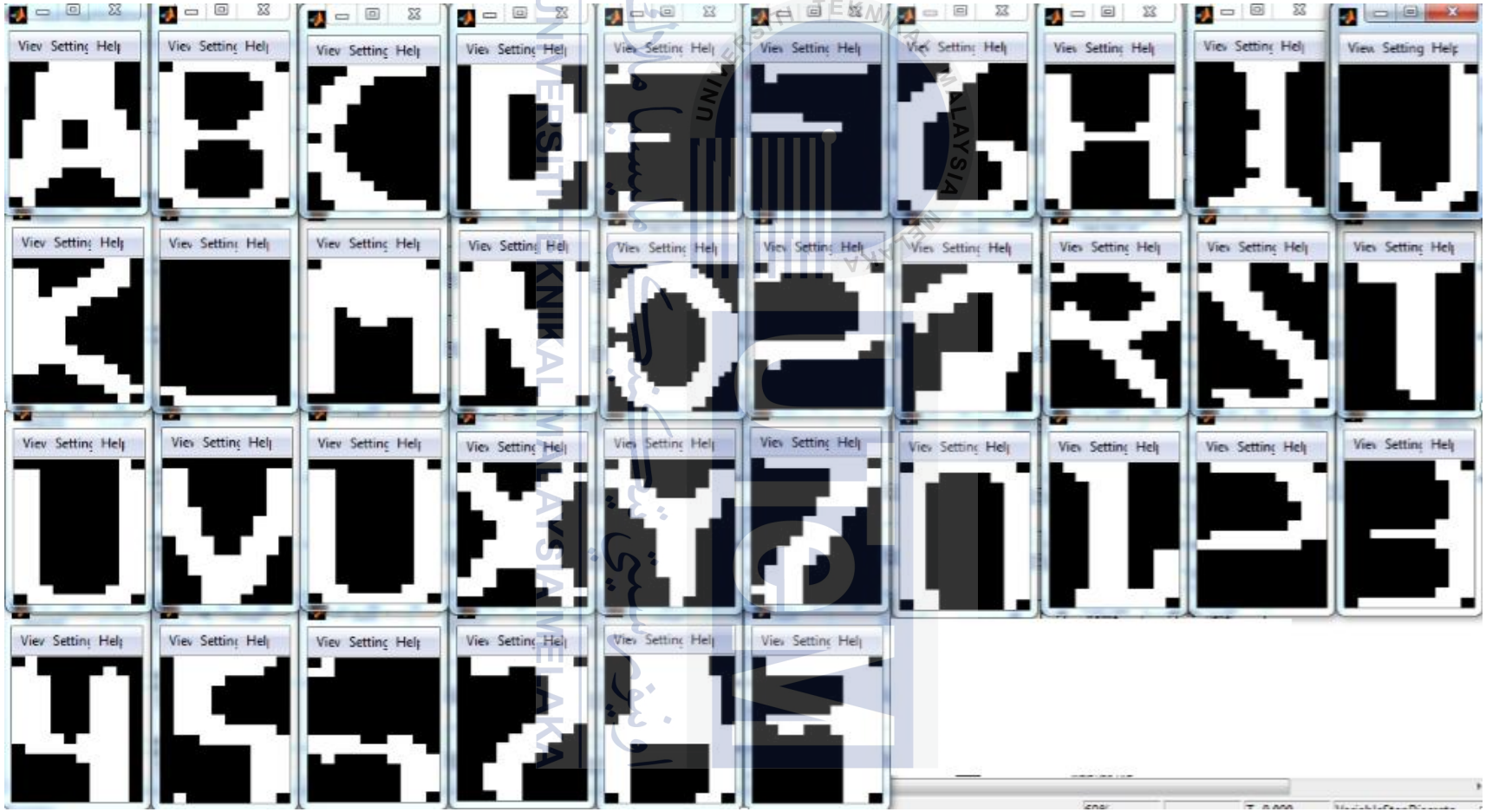


The template with 3x3 of median filter and 40x25 of image size.

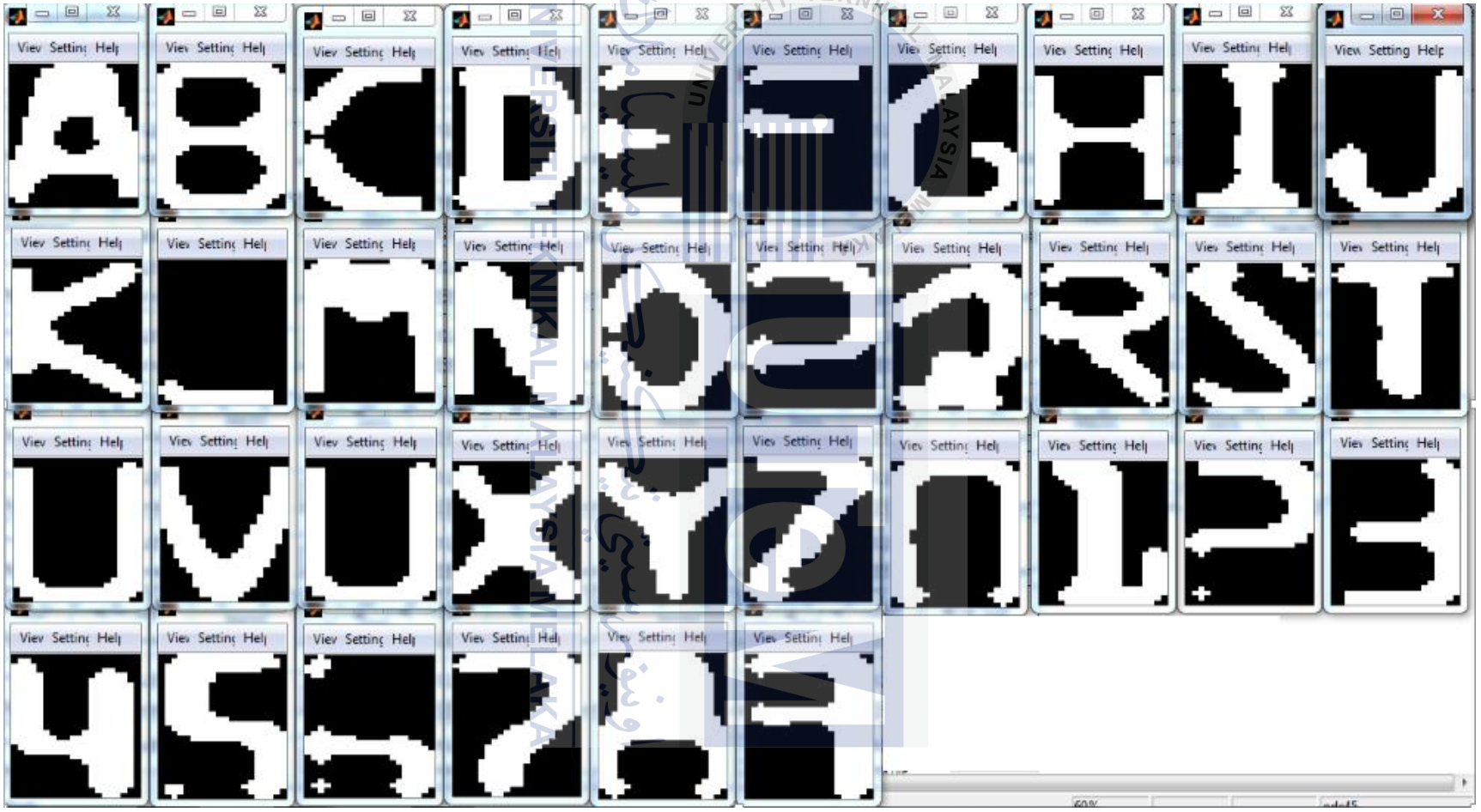
The template with 5x5 of median filter and 10x7 of image size.



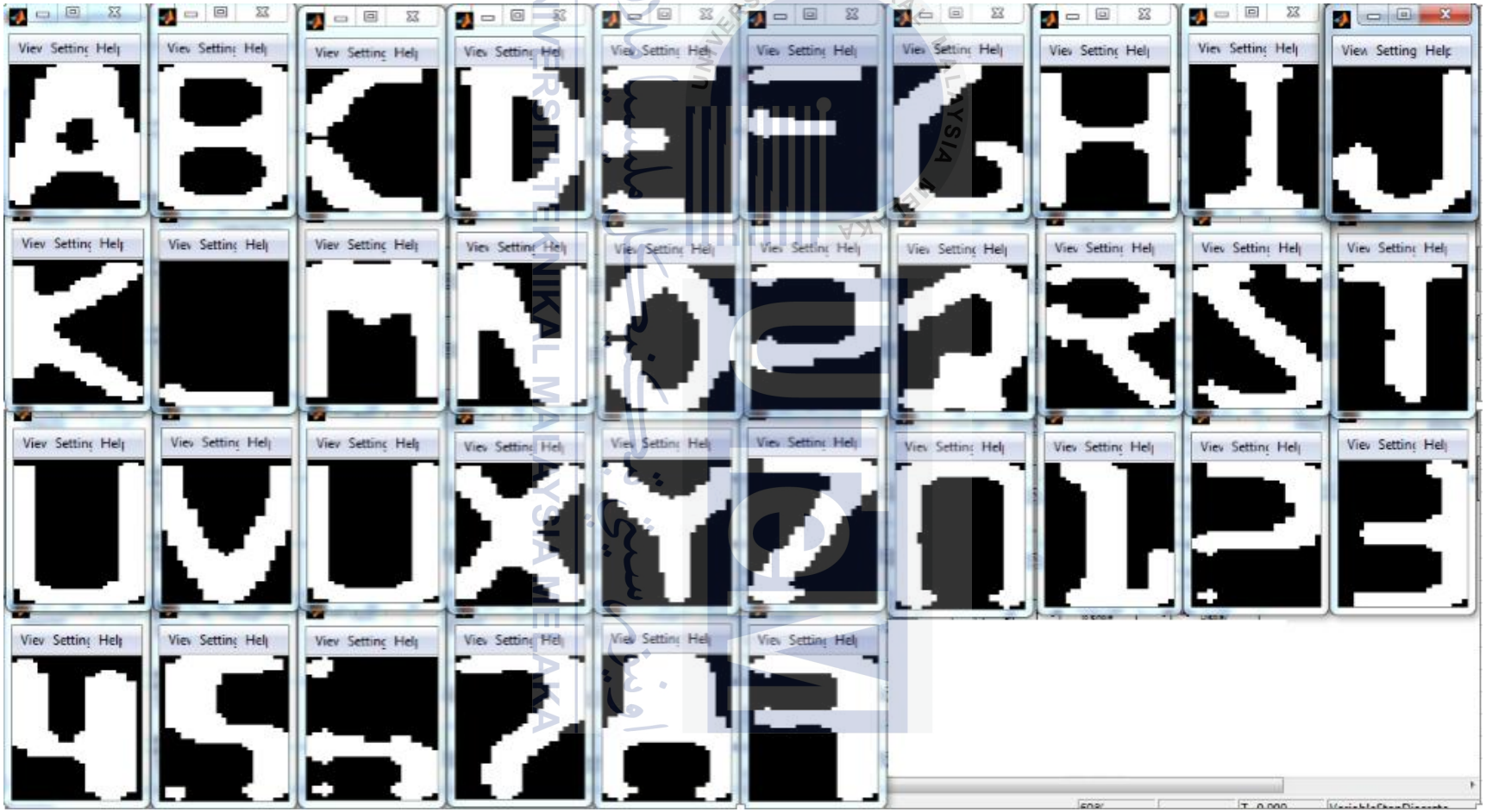
The template with 5x5 of median filter and 15x10 of image size.



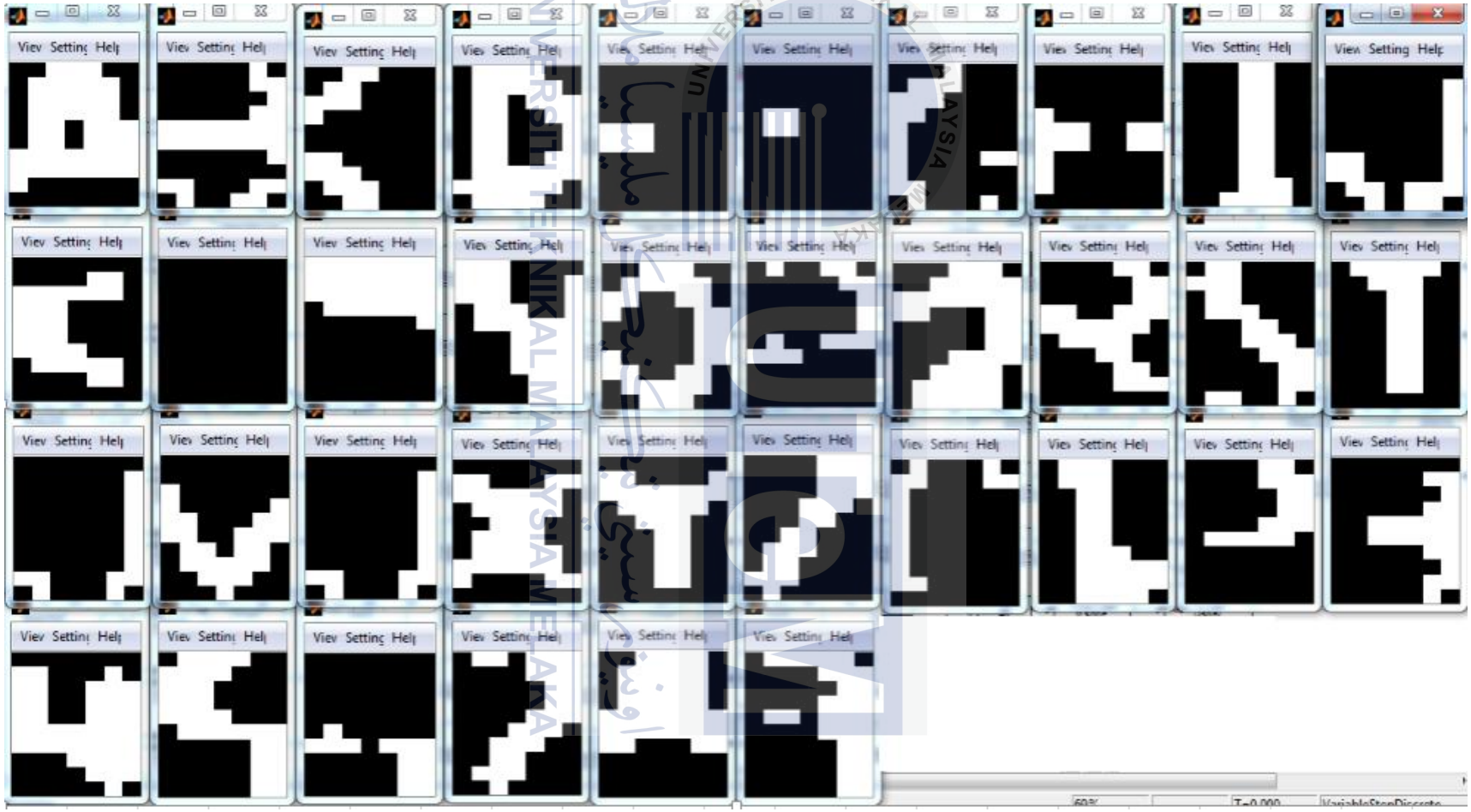
The template with 5x5 of median filter and 30x20 of image size.



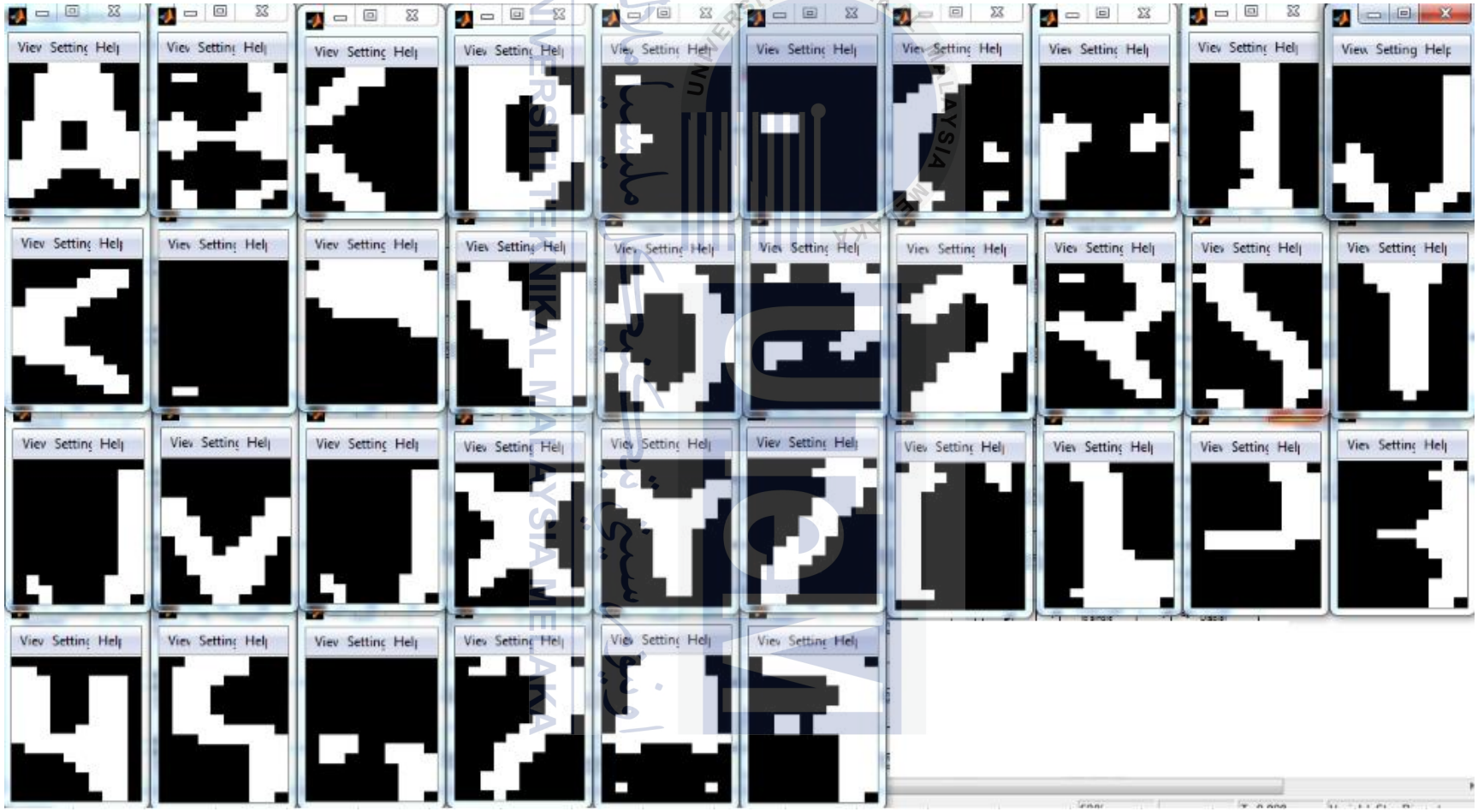
The template with 5x5 of median filter and 40x25 of image size.



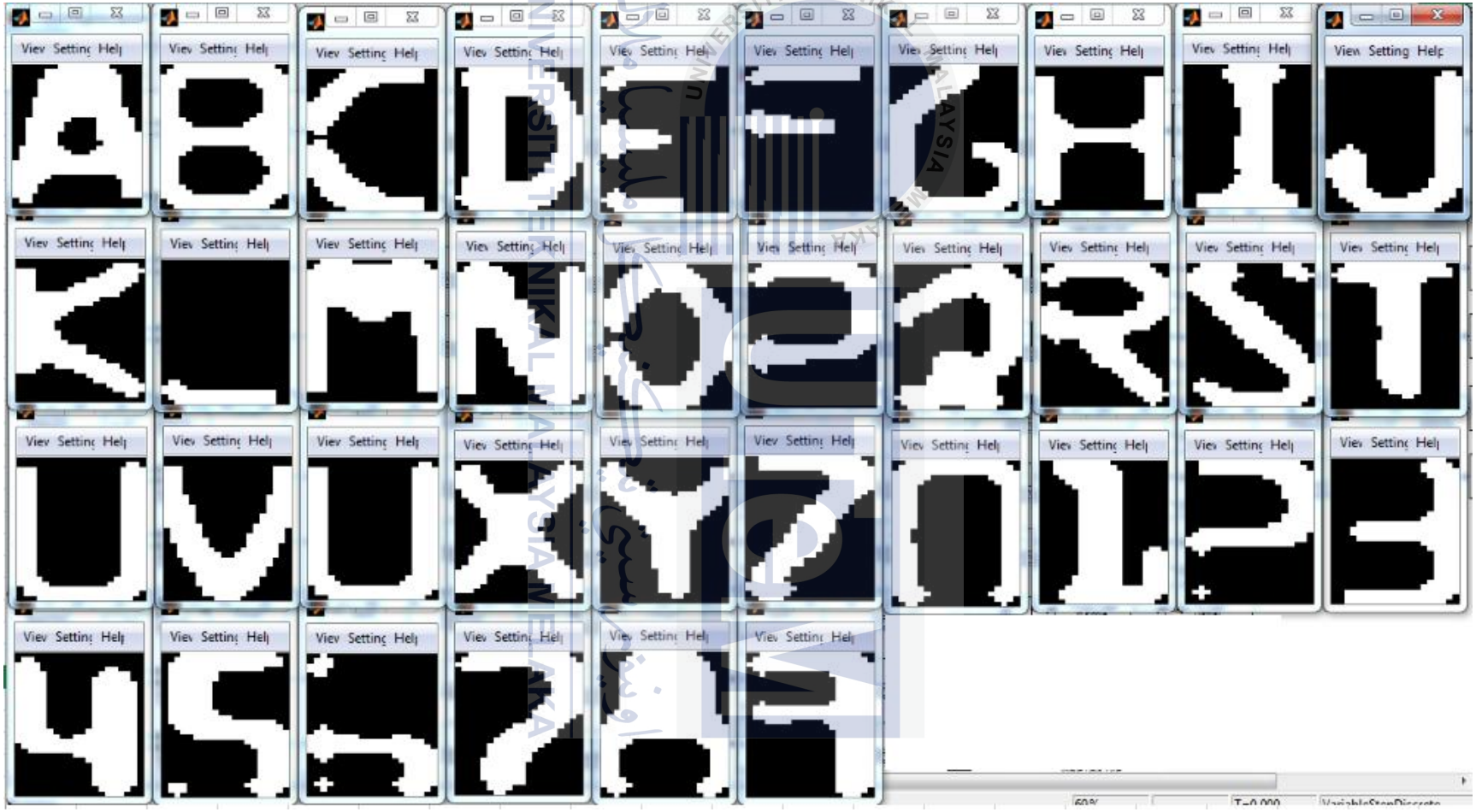
The template with 7x7 of median filter and 10x7 of image size.



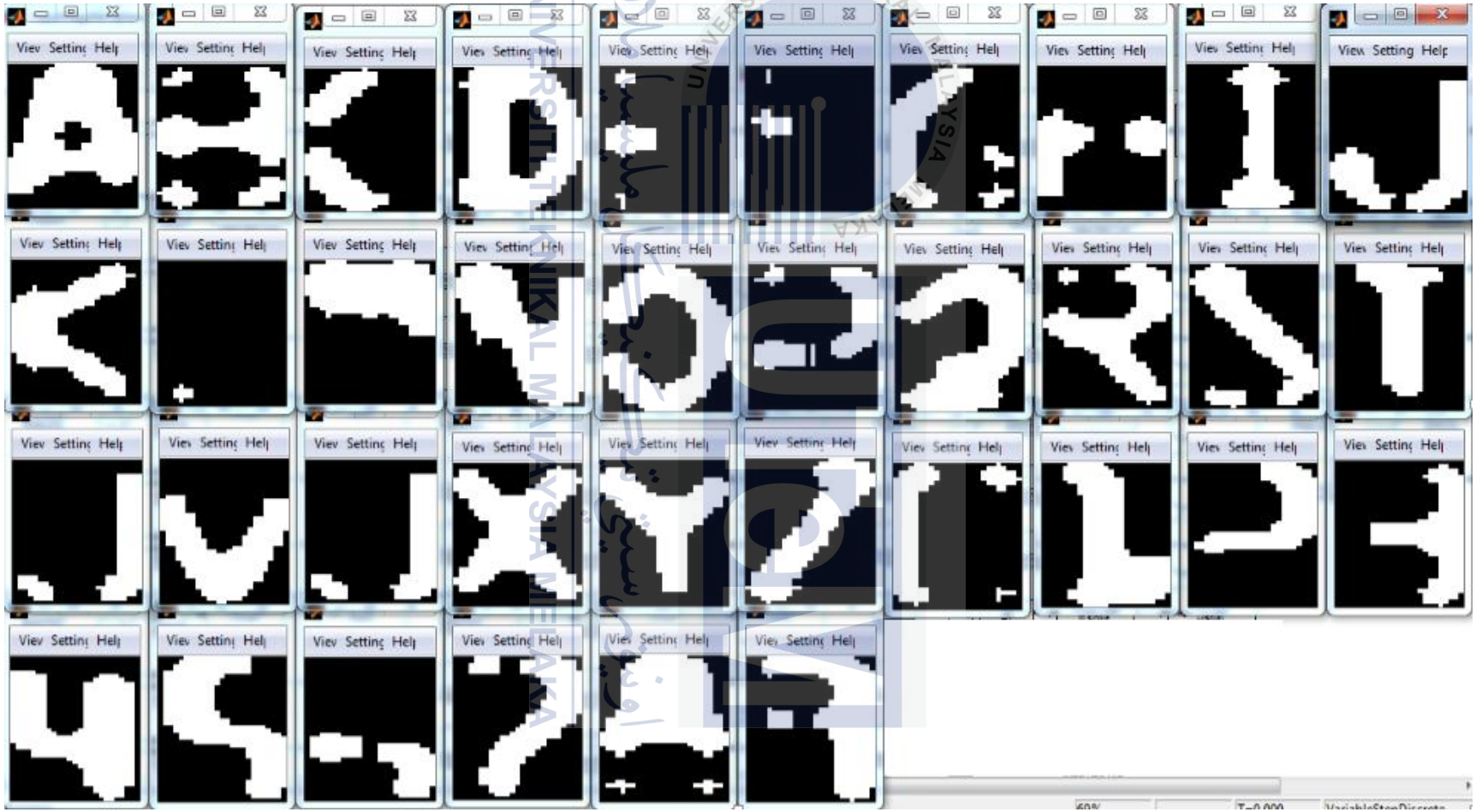
The template with 7x7 of median filter and 15x10 of image size.



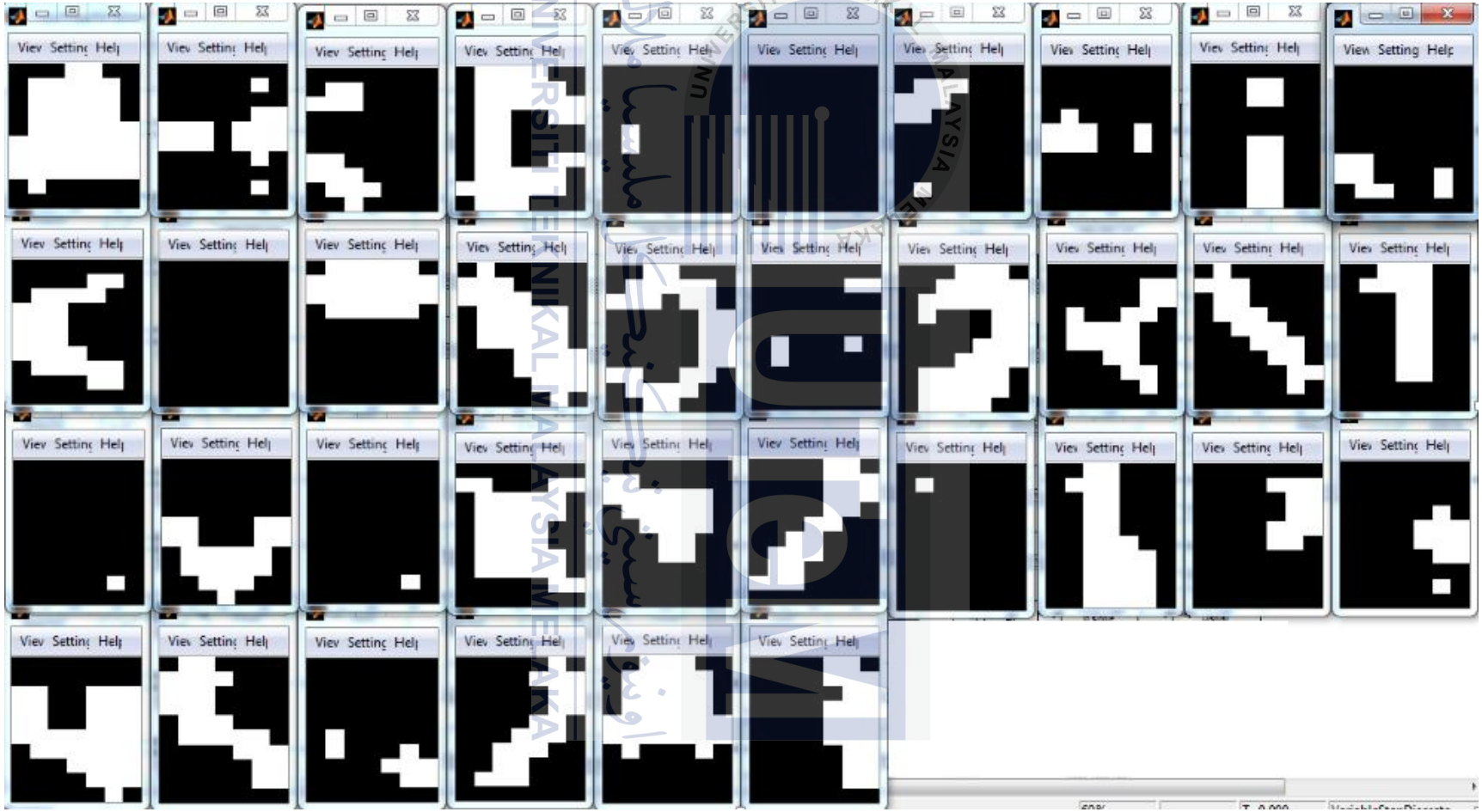
The template with 7x7 of median filter and 30x20 of image size.



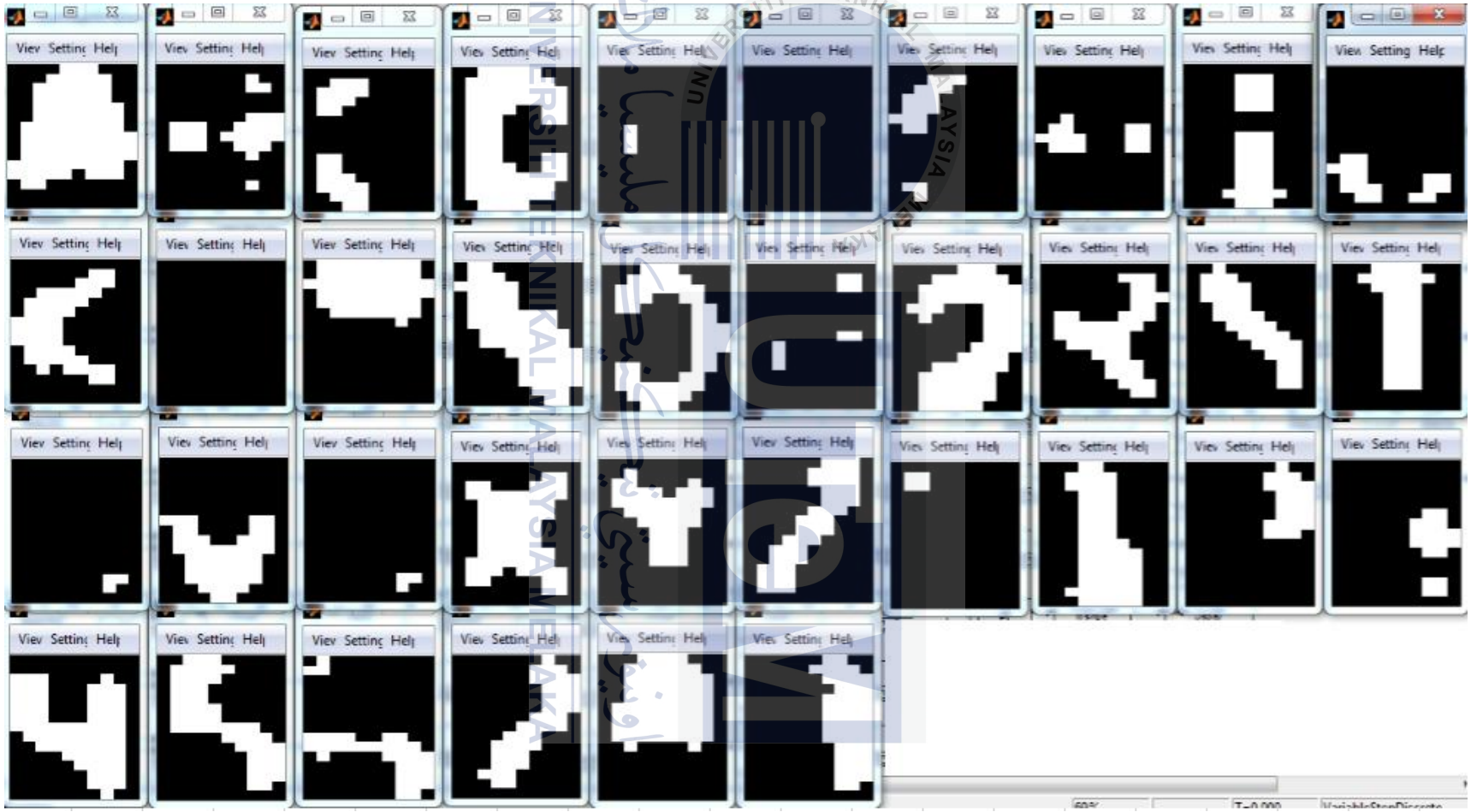
The template with 7x7 of median filter and 40x25 of image size.



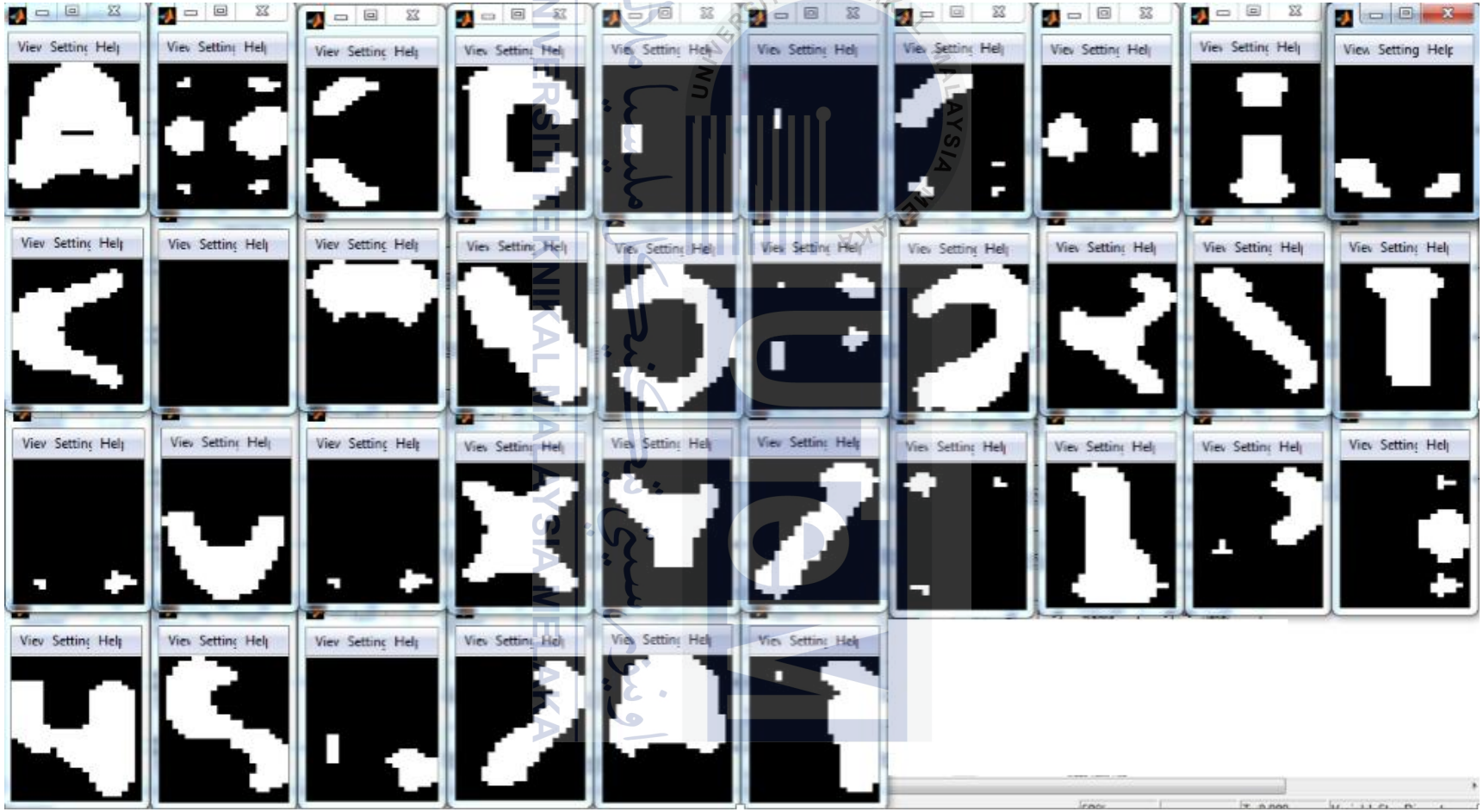
The template with 9x9 of median filter and 10x7 of image size.



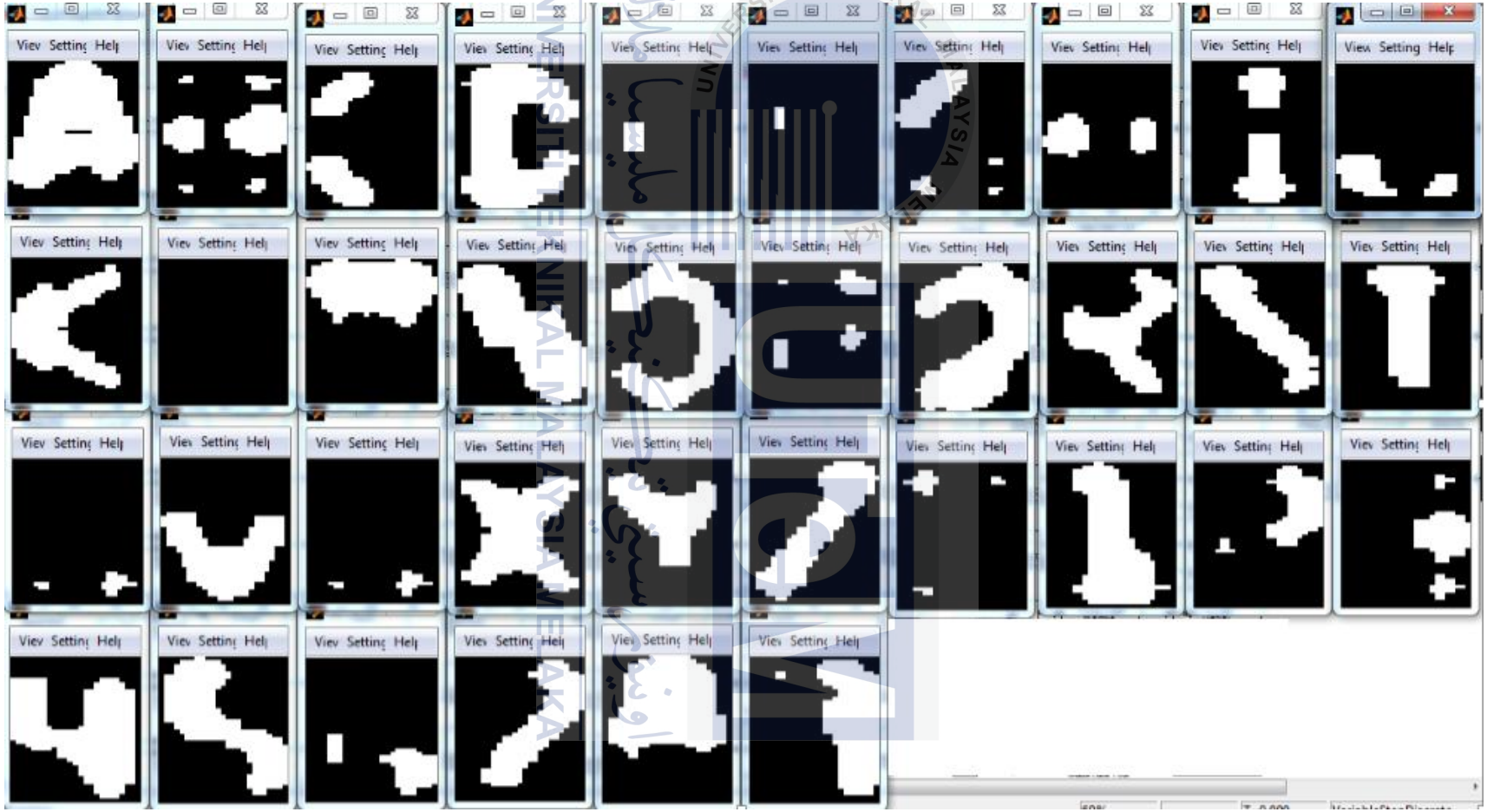
The template with 9x9 of median filter and 15x10 of image size.



The template with 9x9 of median filter and 30x20 of image size.



The template with 9x9 of median filter and 40x25 of image size.



APPENDIX C

White pixel value left after match for all the character and alphabet.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	0	1	2	3	4	5	6	7	8	9
A	55	321	342	213	361	340	265	320	379	395	291	385	282	365	293	321	317	354	361	356	371	375	431	299	401	311	335	322	334	305	361	277	340	381	194	341
B	358	67	264	315	165	272	215	108	343	209	341	219	236	225	273	207	301	272	247	268	135	267	165	377	359	285	119	354	146	153	165	237	196	265	236	221
C	347	286	53	276	178	207	148	301	276	252	298	158	297	336	156	256	300	323	236	313	202	260	288	354	326	256	246	291	271	316	178	218	199	292	319	260
D	224	293	270	63	331	336	283	356	267	259	355	361	322	361	161	325	265	352	329	396	311	273	375	355	383	299	307	306	302	283	331	277	310	357	276	357
E	379	206	169	316	44	143	194	243	222	272	290	230	303	332	268	210	306	247	220	269	186	266	252	358	296	216	176	277	171	232	314	208	173	232	309	246
F	351	292	193	368	150	55	260	265	248	312	256	150	257	320	286	190	350	199	234	213	252	282	314	300	228	240	224	307	243	292	296	246	253	220	343	138
G	272	213	138	313	173	234	38	246	297	249	301	179	230	271	235	245	263	336	219	330	175	335	247	355	363	291	183	314	260	257	295	210	164	333	252	255
H	325	120	297	376	200	263	254	79	402	232	272	212	191	182	296	202	332	291	312	371	124	228	162	306	340	174	397	201	218	180	286	207	274	293	202	258
I	387	350	247	354	208	203	288	391	81	360	340	224	339	352	342	302	278	259	232	130	342	344	266	342	228	198	294	193	249	272	432	242	311	196	313	304
J	316	223	226	267	249	270	221	226	337	73	317	177	300	301	199	229	251	316	273	370	165	233	243	313	323	265	179	322	218	195	255	265	212	269	312	273
K	290	337	286	359	243	248	301	282	319	319	47	217	258	301	337	257	301	292	363	280	277	257	299	299	279	315	309	336	330	387	301	379	264	319	348	303
L	374	261	172	355	117	162	213	236	239	235	271	6	298	325	263	221	283	282	245	282	177	257	235	309	253	227	187	280	198	259	301	233	172	241	346	249
M	270	219	276	321	267	276	249	214	355	301	257	293	57	183	269	219	289	326	311	300	207	351	263	319	345	305	179	374	282	303	275	301	292	355	232	185
N	246	245	332	355	313	340	271	192	351	317	281	309	168	81	315	277	313	290	249	326	205	331	183	263	319	383	247	318	326	313	245	295	264	359	290	247
O	278	279	160	155	289	296	199	312	365	191	345	261	282	323	83	281	227	338	331	392	225	253	301	385	373	329	243	340	294	287	267	285	276	343	296	287
P	341	172	225	324	172	201	246	181	344	258	268	224	195	234	262	74	286	251	302	285	190	230	226	322	324	262	153	399	185	248	228	342	185	214	371	200
Q	319	294	275	264	318	373	244	333	284	252	296	268	277	272	218	282	84	329	356	329	256	266	224	392	338	366	232	331	291	316	330	316	315	278	321	338
R	371	214	305	402	202	183	346	247	292	336	264	274	291	222	338	192	312	8	278	255	294	308	258	258	256	276	212	343	209	238	244	332	313	246	325	216
S	346	253	248	327	213	216	239	310	243	315	353	257	308	249	245	283	351	246	79	244	281	257	293	215	249	233	225	236	252	205	299	169	272	275	286	215
T	376	369	300	385	253	192	361	380	125	411	305	307	294	319	383	271	315	226	241	42	397	339	309	283	179	217	333	206	282	313	407	281	374	165	342	285
U	368	149	210	319	193	278	165	114	375	171	269	143	190	205	229	213	285	334	269	408	82	229	123	335	329	309	123	370	234	241	217	275	116	307	304	183
V	363	290	305	254	288	287	334	247	256	248	260	254	349	306	260	236	240	321	340	339	218	70	240	366	288	386	280	335	307	292	218	372	247	212	477	268
W	436	191	286	377	243	332	251	156	267	231	295	193	252	165	291	253	243	308	283	318	115	235	80	323	247	329	191	302	262	277	279	307	188	243	348	263
X	309	392	369	362	364	323	400	323	328	340	238	338	323	254	396	348	398	247	242	293	356	366	330	32	188	224	382	291	371	360	292	338	329	340	339	314
Y	399	376	335	376	312	239	388	325	228	360	296	270	329	260	362	318	344	237	210	195	326	284	268	182	36	294	356	281	313	246	306	294	339	204	373	264
Z	349	284	241	310	198	217	328	341	206	290	340	252	335	394	328	272	346	229	244	233	322	368	324	208	262	55	260	267	195	238	396	268	299	274	273	296
0	327	141	253	310	162	243	222	199	346	156	326	192	207	240	228	154	234	249	258	363	156	276	218	256	366	272	74	251	149	124	210	262	229	256	281	172
1	339	362	327	326	302	301	302	393	162	364	350	294	341	292	368	388	324	307	238	173	350	388	272	302	278	260	316	54	339	274	398	226	303	296	297	328
2	342	119	240	315	115	216	281	206	275	229	349	203	286	323	273	181	279	210	279	294	235	279	273	359	311	201	139	342	48	107	273	247	284	197	232	251
3	306	121	314	287	199	250	267	230	297	191	397	277	312	307	287	247	291	206	235	330	249	295	287	341	345	251	141	296	114	61	207	231	286	229	250	223
4	282	229	344	299	319	310	283	204	449	255	275	299	266	243	271	215	321	258	311	416	217	235	287	279	319	395	233	376	286	215	58	345	202	301	342	211
5	265	246	235	300	218	225	210	281	244	312	374	274	279	286	320	332	338	299	168	249	302	416	334	320	312	248	242	213	237	206	346	69	313	314	169	236
6	349	202	241	342	178	273	164	199	320	230	254	128	267	234	286	200	330	327	242	363	132	270	174	302	340	294	174	293	271	250	212	302	55	318	359	268
7	378	265	292	357	247	192	361	292	211	295	351	279	338	331	329	173	251	204	273	152	311	213	259	335	213	279	239	304	182	209	293	305	342	70	406	229
8	187	206	285	262	248	303	204	275	310	324	350	314	249	302	284	364	348	315	262	351	308	458	344	332	354	272	258	305	231	238	312	158	305	410	72	298
9	327	172	285	332	248	141	292	197	346	242	326	280	209	236	278	190	308	171	244	301	208	276	262	320	282	300	112	347	243	178	198	246	297	244	309	82

APPENDIX D

The result for the comparison between the percentages of recognition after matching to the template with difference image size when the 3x3 median filter and 86% of matching percentage is fixed and in white light condition.

10X7						
	C1	C2	C3	C4	C5	C6
ABC123						
DEF456						
GHI789						NA
JKL245						
YUI876						
HUI976		NA		NA		
GYU678			NA			
UIP945	NA			NA		
KIY890				NA		
YRT543						
SER421						
JUO964		NA	NA			
TYU765			NA			
OPJ876	NA					
GTR432						
NJU765	NA		NA			
LOP654		NA				
NBV543						
CDS345						
LPI754						
HYR541						
CGR475						
BYI865						
FRE567						
MIO965		NA	NA			
SCE327						
MXY543						
PAC698						
ZYO963			NA	NA		
TDW370						
HUO975		NA	NA	NA		
SDR541						
TYU890			NA			
CSE579						
VYT371						
NIO047	NA		NA			
ZWQ356						
BUO746		NA				
CTQ479			NA			
BYA490					NA	
BYO853						
MNA960						
ATO521			NA			
LIX763						
PXT496						
SUO836		NA				
XOP042						
ZUO490		NA	NA			NA

15x10						
	C1	C2	C3	C4	C5	C6
ABC123						
DEF456						
GHI789						
JKL245						
YUI876		NA	NA			
HUI976		NA	NA			
GYU678						
UIP945						
KIY890						
YRT543						
SER421						
JUO964		NA		NA		
TYU765						
OPJ876						
GTR432						
NJU765						
LOP654						
NBV543			NA			
CDS345						
LPI754						
HYR541						
CGR475						
BYI865						
FRE567						
MIO965				NA		
SCE327						
MXY543						
PAC698						
ZYO963						
TDW370						
HUO975						
SDR541						
TYU890			NA		NA	
CSE579						
VYT371	NA					
NIO047						
ZWQ356						
BUO746		NA	NA			
CTQ479						
BYA490						
BYO853						
MNA960						
ATO521			NA			
LIX763						
PXT496						
SUO836						
XOP042						
ZUO490						

30X20						
	C1	C2	C3	C4	C5	C6
ABC123						
DEF456						
GHI789						NA
JKL245						
YUI876		NA				
HUI976		NA		NA		
GYU678						
UIP945	NA			NA		
KIY890						
YRT543						
SER421						
JUO964		NA	NA	NA		
TYU765						
OPJ876						
GTR432						
NJU765	NA		NA			
LOP654						
NBV543						
CDS345						
LPI754						
HYR541						
CGR475						
BYI865						
FRE567						
MIO965			NA	NA		
SCE327						
MXY543						
PAC698						
ZYO963						
TDW370						
HUO975						
SDR541						
TYU890						
CSE579						
VYT371						
NIO047						
ZWQ356						
BUO746						
CTQ479			NA			NA
BYA490						
BYO853						
MNA960						
ATO521						
LIX763						
PXT496						
SUO836						
XOP042						
ZUO490		NA	NA			

40X25						
	C1	C2	C3	C4	C5	C6
ABC123						
DEF456						
GHI789						
JKL245						
YUI876		NA				
HUI976	NA	NA		NA		
GYU678						
UIP945	NA			NA		
KIY890					NA	NA
YRT543						
SER421						
JUO964		NA	NA	NA		
TYU765						
OPJ876						
GTR432						
NJU765	NA		NA			
LOP654						
NBV543						
CDS345						
LPI754						
HYR541						
CGR475						
BYI865						
FRE567						
MIO965						
SCE327						
MXY543						
PAC698						
ZYO963						
TDW370						
HUO975		NA		NA		
SDR541						
TYU890			NA		NA	NA
CSE579						
VYT371						
NIO047						
ZWQ356						
BUO746		NA	NA			
CTQ479						
BYA490					NA	NA
BYO853						
MNA960						
ATO521						
LIX763						
PXT496						
SUO836		NA	NA			
XOP042						
ZUO490		NA	NA		NA	

AOP692						
HTS381						
QYE375	NA					
PDY720						
FOE830						
SUE934		NA		NA		
LYK853						
BYW917						
MOS579		NA				
WEE922						
TTA428						
VCC555						
QQQ456	NA	NA	NA			
GUR560		NA				
TIS533						
KPY780						
CRW431						
JAS880						
RR3561						
NIT553						
LPR589						
BIT532						
HHH666						
PPO995			NA	NA	NA	
DDR423						
KUT765		NA				
CRT321						
MOI998						
BUY664		NA				
OOO756	NA	NA	NA			
VYR532						
MNB098						
FFF456						
KOU864		NA	NA			
POE466						
LIA122						
NUY665						
POU889		NA	NA			
BNY664						
MIY643						
PRG754						
MOO874		NA	NA			
III064						
THY623						
LOP998		NA				
VRW954						
LTE964						
BTE000						
MUE412		NA				
HHH634						
NUI476		NA				
PRE479						NA
63%						
After analysis U,9,O,N,I,0,Q						

AOP692						
HTS381						
QYE375	NA					
PDY720						
FOE830						
SUE934		NA		NA		
LYK853						
BYW917						
MOS579		NA				NA
WEE922						
TTA428						
VCC555	NA					
QQQ456	NA	NA	NA			
GUR560		NA				
TIS533						
KPY780						
CRW431						
JAS880						
RR3561						
NIT553		NA				
LPR589						
BIT532						
HHH666						
PPO995			NA	NA	NA	
DDR423						
KUT765						
CRT321						
MOI998		NA		NA	NA	
BUY664						
OOO756	NA	NA	NA			
VYR532	NA					
MNB098						
FFF456						
KOU864		NA	NA			
POE466		NA				
LIA122						
NUY665						
POU889		NA	NA			NA
BNY664						
MIY643						
PRG754						
MOO874		NA	NA			
III064						
THY623						
LOP998		NA		NA	NA	
VRW954	NA					
LTE964						
BTE000						
MUE412		NA				
HHH634						
NUI476	NA					
PRE479						NA
72%						
After analysis U,I,9,Q,V,O						

AOP692						
HTS381						
QYE375	NA					
PDY720						
FOE830						
SUE934						
LYK853						
BYW917				NA		
MOS579						
WEE922						
TTA428						
VCC555						
QQQ456	NA	NA	NA			
GUR560						
TIS533						
KPY780						
CRW431						
JAS880						
RR3561						
NIT553						
LPR589						
BIT532						
HHH666						
PPO995						
DDR423						
KUT765						
CRT321						
MOI998		NA				
BUY664						
OOO756	NA	NA	NA			
VYR532						
MNB098						
FFF456						
KOU864		NA	NA			
POE466						
LIA122						
NUY665	NA	NA				
POU889						
BNY664						
MIY643						
PRG754						
MOO874		NA	NA			
III064						
THY623						
LOP998		NA		NA	NA	
VRW954						
LTE964						
BTE000						
MUE412						
HHH634						
NUI476	NA	NA				
PRE479						
81%						
After analysis N,U,O,Q,9						

AOP692						
HTS381						
QYE375						
PDY720						
FOE830		NA				
SUE934						
LYK853						
BYW917						
MOS579						
WEE922						
TTA428						
VCC555						
QQQ456	NA	NA	NA			
GUR560						
TIS533						
KPY780						
CRW431						
JAS880						
RR3561						
NIT553						
LPR589						NA
BIT532						
HHH666						
PPO995			NA	NA	NA	
DDR423						
KUT765						
CRT321						
MOI998				NA	NA	
BUY664						
OOO756						
VYR532						
MNB098		NA			NA	NA
FFF456						
KOU864						
POE466						
LIA122						
NUY665						
POU889		NA	NA			NA
BNY664						
MIY643						
PRG754						
MOO874		NA	NA			
III064						
THY623						
LOP998						
VRW954						
LTE964						
BTE000				NA	NA	NA
MUE412						
HHH634						
NUI476	NA	NA				
PRE479						
78%						
After analysis N,U,0,O,9,Q						

APPENDIX E

The result for the comparison between the percentages of recognition after matching with 100 good(G) sample to the template with difference matrix of median filter when the 30x20 of image size and 86% of matching percentage is fixed and in white light condition.

3X3							5X5							7X7							9X9						
	C1	C2	C3	C4	C5	C6		C1	C2	C3	C4	C5	C6		C1	C2	C3	C4	C5	C6		C1	C2	C3	C4	C5	C6
ABC123							ABC123							ABC123					NA		ABC123		NA	NA	NA	NA	
DEF456							DEF456					NA		DEF456		L,E	E,F				DEF456	NA	NA	E,9,F	NA	NA	NA
GHI789						NA	GHI789		NA	NA			NA	GHI789				NA	NA	NA	GHI789		NA		NA	NA	NA
JKL245							JKL245	NA					NA	JKL245			F,U,L			NA	JKL245			L,E,F,9	NA		NA
YUI876							YUI876		NA	NA		NA		YUI876				NA	NA		YUI876	NA	J,3,U		NA	NA	NA
HUI976		NA		NA			HUI976	NA	NA	NA	NA			HUI976				NA	NA		HUI976	NA	J,3,U		NA	NA	NA
GYU678							GYU678							GYU678					NA	NA	GYU678		NA	J,3,U	NA	NA	NA
UIP945							UIP945	NA	NA		NA		NA	UIP945			NA	NA			UIP945	J,U		NA	NA		NA
KIY890							KIY890		NA					KIY890				NA	NA		KIY890	NA		NA	NA	NA	NA
YRT543							YRT543				NA			YRT543		NA		NA			YRT543	NA	NA		NA		NA
SER421							SER421	NA						SER421	NA	L,E					SER421	NA	NA	NA		NA	NA
JUO964		NA	NA	NA			JUO964	NA						JUO964			NA	NA			JUO964		J,3,U	NA	NA	NA	
TYU765							TYU765			NA	NA		NA	TYU765				NA		NA	TYU765		NA	J,3,U	NA	NA	NA
OPJ876							OPJ876		NA	NA		NA		OPJ876	NA	NA		NA	NA		OPJ876	NA	NA		NA	NA	NA
GTR432							GTR432							GTR432							GTR432			NA			NA
NJU765							NJU765	NA	NA	NA	NA			NJU765	NA			NA		NA	NJU765	NA		J,3,U	NA	NA	NA
LOP654		NA					LOP654			NA		NA		LOP654	F,U,L	NA	NA		NA		LOP654	L,E,F,6,9	NA	NA	NA	NA	
NBV543							NBV543				NA			NBV543	NA			NA			NBV543	NA	NA	NA	NA		
CDS345							CDS345			NA			NA	CDS345			NA			NA	CDS345	NA	NA	NA			NA
LPI754							LPI754			NA	NA			LPI754	F,L	NA		NA	NA		LPI754	L,E,F,6,9	NA		NA	NA	
HYR541							HYR541	NA			NA			HYR541				NA			HYR541	NA	NA	NA	NA		NA
CGR475							CGR475					NA	NA	CGR475					NA	NA	CGR475	NA		NA		NA	NA
BYI865							BYI865			NA				BYI865				NA		NA	BYI865	NA	NA	NA	NA	NA	NA
FRE567							FRE567							FRE567			L,E	NA		NA	FRE567	E,9,F	NA	NA	NA	NA	NA
MIO965			NA	NA			MIO965		NA	NA	NA			MIO965	NA		NA	NA		NA	MIO965	NA		NA	NA	NA	NA
SCE327							SCE327							SCE327	NA		L,E,F			NA	SCE327	NA	NA	NA		NA	NA
MXY543							MXY543				NA			MXY543	NA			NA			MXY543	NA		NA	NA	NA	
PAC698							PAC698							PAC698	NA				NA	NA	PAC698	NA		NA	NA	NA	NA
ZYO963							ZYO963							ZYO963				NA			ZYO963		NA	NA	NA	NA	
TDW370							TDW370					NA		TDW370					NA		TDW370		NA	NA		NA	NA
HUO975		NA	NA	NA			HUO975	NA	NA	NA	NA			HUO975				NA	NA	NA	HUO975	NA	J,3,U	NA	NA	NA	NA
SDR541							SDR541							SDR541	NA			NA			SDR541	NA	NA	NA	NA		NA
TYU890							TYU890			NA		NA		TYU890				NA	NA		TYU890		NA	J,3,U	NA	NA	NA
CSE579							CSE579							CSE579		NA	L,E		NA	NA	CSE579	NA	NA	NA	NA	NA	NA
VYT371							VYT371							VYT371					NA		VYT371	NA	NA			NA	NA
NIO047							NIO047		NA	NA				NIO047	NA					NA	NIO047	NA	NA	NA	NA		NA
ZWQ356							ZWQ356							ZWQ356			NA		NA		ZWQ356		NA	NA		NA	NA
BUO746							BUO746							BUO746			NA	NA			BUO746	NA	J,3,U	NA	NA		NA
CTQ479			NA			NA	CTQ479			NA		NA	NA	CTQ479			NA		NA	NA	CTQ479	NA		NA		NA	NA
BYA490							BYA490							BYA490					NA		BYA490	NA	NA			NA	NA
BYO853							BYO853							BYO853			NA	NA	NA		BYO853	NA	NA	NA	NA	NA	
MNA960							MNA960				NA			MNA960	NA	NA		NA			MNA960	NA	NA		NA	NA	NA
ATO521							ATO521							ATO521			NA	NA			ATO521		NA	NA	NA	NA	NA
LIX763							LIX763		NA					LIX763	F,U,L			NA			LIX763	L,E,F,6,9	NA		NA	NA	
PXT496							PXT496							PXT496	NA				NA		PXT496	NA			NA	NA	NA
SUO836							SUO836	NA	NA					SUO836	NA		NA	NA			SUO836	NA	J,3,U	NA	NA		NA
XOP042							XOP042							XOP042		NA	NA				XOP042	NA	NA	NA	NA		NA
ZUO490							ZUO490		NA			NA		ZUO490		NA	NA		NA		ZUO490		J,3,U	NA		NA	NA
AOP692							AOP692							AOP692		NA	NA		NA		AOP692		NA	NA	NA	NA	NA
HTS381							HTS381	NA						HTS381			NA		NA		HTS381	NA		NA		NA	NA
QYE375	NA						QYE375	NA				NA		QYE375	NA		L,E		NA	NA	QYE375	NA	NA	NA		NA	NA

PDY720						
FOE830						
SUE934		NA		NA		
LYK853						
BYW917				NA		
MOS579						
WEE922						
TTA428						
VCC555						
QQQ456	NA	NA	NA			
GUR560						
TIS533						
KPY780						
CRW431						
JAS880						
RR3561						
NIT553	NA					
LPR589						
BIT532						
HHH666						
PPO995			NA	NA	NA	
DDR423						
KUT765						
CRT321						
MOI998		NA		NA	NA	
BUY664						
OOO756						
VYR532						
MNB098						
FFF456						
KOU864						
POE466						
LIA122						
NUY665	NA	NA				
POU889		NA	NA			NA
BNY664						
MIY643						
PRG754						
MOO874						
III064						
THY623						
LOP998						
VRW954						
LTE964						
BTE000						
MUE412						
HHH634						
NUI476	NA	NA				
PRE479						
83%						
After analysis N,U,O,Q,9						

PDY720						
FOE830						
SUE934	NA	NA		NA		
LYK853						
BYW917				NA		
MOS579						
WEE922				NA		
TTA428						
VCC555						
QQQ456	NA	NA	NA		NA	
GUR560						
TIS533		NA	NA			
KPY780		NA		NA		
CRW431						
JAS880	NA					
RR3561						
NIT553		NA		NA		
LPR589						
BIT532		NA				
HHH666	NA	NA	NA			
PPO995						
DDR423						
KUT765		NA		NA		
CRT321						
MOI998		NA	NA	NA		
BUY664		NA				
OOO756	NA	NA	NA			
VYR532				NA		
MNB098					NA	
FFF456					NA	
KOU864		NA	NA			
POE466		NA				
LIA122						
NUY665						
POU889						
BNY664						
MIY643		NA				
PRG754						
MOO874						
III064	NA	NA				
THY623		NA				
LOP998						
VRW954				NA	NA	
LTE964						
BTE000						
MUE412		NA				
HHH634						
NUI476		NA	NA			
PRE479	NA				NA	NA
41%						
After analysis HIJPQSUW0579						

PDY720	NA			NA		
FOE830	E,U	NA	L,E	NA		
SUE934	NA	NA	L,E,F	NA		
LYK853	L,F,U			NA	NA	
BYW917				NA		NA
MOS579		NA	NA	NA	NA	NA
WEE922		L,E	L,E	NA		
TTA428						NA
VCC555				NA	NA	NA
QQQ456	NA	NA	NA		NA	
GUR560				NA		
TIS533			NA	NA		
KPY780		NA		NA	NA	
CRW431						
JAS880			NA	NA	NA	
RR3561				NA		
NIT553	NA			NA	NA	
LPR589	L,F,U			NA	NA	NA
BIT532				NA		
HHH666						
PPO995	NA	NA	NA	NA	NA	NA
DDR423						
KUT765				NA		NA
CRT321						
MOI998		NA		NA	NA	NA
BUY664		NA				
OOO756				NA	NA	
VYR532				NA		
MNB098		NA			NA	NA
FFF456	F,E,U				NA	
KOU864		NA	NA	NA		
POE466	NA	NA	E,L			
LIA122	L,F,U					
NUY665		NA				NA
POU889		NA	NA	NA	NA	NA
BNY664		NA				
MIY643						
PRG754				NA	NA	
MOO874		NA	NA	NA	NA	
III064						
THY623						
LOP998	L,F,U	NA	NA	NA	NA	NA
VRW954				NA	NA	
LTE964	L,F		E,L	NA		
BTE000						
MUE412		NA				
HHH634						
NUI476	NA	NA			NA	
PRE479			E,L		NA	NA
11%						
After analysis EwL,FwEU,LwFU BHMNOPQSUV						

PDY720	NA	NA	NA	NA	NA	NA
FOE830	E,9,F	NA	NA	NA		NA
SUE934	NA	J,U	NA	NA		
LYK853	L,E,F,6,9	NA		NA	NA	NA
BYW917	NA	NA	NA	NA	NA	NA
MOS579	NA	NA	NA	NA	NA	NA
WEE922	NA	NA	NA	NA	NA	NA
TTA428	NA	NA			NA	NA
VCC555	NA	NA	NA	NA	NA	NA
QQQ456	NA	NA	NA		NA	NA
GUR560		J,3,U	NA	NA	NA	NA
TIS533		NA	NA	NA		
KPY780		NA	NA	NA	NA	NA
CRW431	NA	NA	NA			NA
JAS880	NA		NA	NA	NA	NA
RR3561	NA	NA		NA	NA	NA
NIT553	NA	NA		NA	NA	
LPR589	L,E,F,6,9	NA	NA	NA	NA	NA
BIT532	NA	NA		NA		NA
HHH666	NA	NA	NA	NA	NA	NA
PPO995	NA	NA	NA	NA	NA	NA
DDR423	NA	NA	NA	NA	NA	
KUT765		J,3,U	NA	NA	NA	NA
CRT321	NA	NA		NA	NA	NA
MOI998	NA	NA		NA	NA	NA
BUY664	NA	3,U	NA	NA	NA	
OOO756	NA	NA	NA	NA	NA	NA
VYR532	NA	NA	NA	NA		NA
MNB098	NA	NA	NA	NA	NA	NA
FFF456	E,9,F	E,9,F	E,9,F		NA	NA
KOU864		NA	J,3,U	NA	NA	
POE466	NA	NA			NA	NA
LIA122	L,E,F,6,9	NA	NA	NA	NA	NA
NUY665	NA	J,3,U	NA	NA	NA	NA
POU889	NA	NA	J,3,U	NA	NA	NA
BNY664	NA	NA	NA	NA	NA	
MIY643	NA	NA	NA	NA		
PRG754	NA	NA	NA	NA	NA	
MOO874	NA	NA	NA	NA	NA	NA
III064				NA	NA	NA
THY623	NA	NA	NA	NA	NA	
LOP998	L,E,F,6	NA	NA	NA	NA	NA
VRW954	NA	NA	NA	NA	NA	
LTE964	L,E,F,6,9		NA	NA	NA	
BTE000	NA		NA	NA	NA	NA
MUE412	NA	U,J	NA		NA	NA
HHH634	NA	NA	NA	NA	NA	
NUI476	NA	U,J,3	NA	NA	NA	NA
PRE479	NA	NA	NA		NA	NA
0%						
After analysis BCDEHMNOPQRSUV WY1256789 FwE9,LwEF69,UwJ2						

APPENDIX F1

The result for the comparison between the percentages of recognition after matching with 100 good(G) sample to the template with difference matching percentage when the 30x20 of image size and 3x3 of median filter is fixed and in white light condition.

80%							85%							90%						
	C1	C2	C3	C4	C5	C6		C1	C2	C3	C4	C5	C6		C1	C2	C3	C4	C5	C6
ABC123							ABC123							ABC123	NA	NA			NA	NA
DEF456		E,L	F,E,L				DEF456							DEF456	NA			NA	NA	NA
GHI789		H,B	I,T				GHI789							GHI789				NA	NA	NA
JKL245			L,E				JKL245							JKL245				NA	NA	NA
YUI876			I,T				YUI876							YUI876				NA	NA	NA
HUI976	H,B		I,T				HUI976							HUI976				NA	NA	NA
GYU678							GYU678							GYU678				NA	NA	NA
UIP945							UIP945							UIP945				NA	NA	NA
KIY890		I,T				0,B,U	KIY890							KIY890				NA	NA	NA
YRT543			I,T				YRT543							YRT543			NA	NA	NA	NA
SER421		E,L					SER421							SER421	NA		NA	NA	NA	
JUO964							JUO964							JUO964			NA	NA	NA	NA
TYU765	I,T						TYU765							TYU765	NA			NA	NA	NA
OPJ876							OPJ876							OPJ876	NA			NA	NA	NA
GTR432		I,T					GTR432							GTR432		NA		NA	NA	NA
NJU765							NJU765							NJU765				NA	NA	NA
LOP654	L,E						LOP654							LOP654		NA		NA	NA	NA
NBV543							NBV543							NBV543	NA	NA	NA	NA	NA	NA
CDS345							CDS345							CDS345		NA	NA	NA	NA	NA
LPI754	L,E		I,T				LPI754							LPI754				NA	NA	NA
HYR541	H,B						HYR541							HYR541			NA	NA	NA	
CGR475							CGR475							CGR475			NA	NA	NA	NA
BYI865			I,T				BYI865							BYI865	NA			NA	NA	NA
FRE567	F,E		E,L				FRE567							FRE567		NA		NA	NA	NA
MIO965		I,T					MIO965							MIO965			NA	NA	NA	NA
SCE327			E,L				SCE327							SCE327	NA			NA	NA	NA
MXY543							MXY543							MXY543				NA	NA	NA
PAC698							PAC698							PAC698				NA	NA	NA
ZYO963							ZYO963							ZYO963	NA		NA	NA	NA	NA
TDW370	I,T					0,B,U	TDW370							TDW370	NA	NA	NA	NA	NA	NA
HUO975	H,B						HUO975							HUO975			NA	NA	NA	NA
SDR541							SDR541							SDR541	NA	NA	NA	NA	NA	
TYU890	I,T					0,B,U	TYU890							TYU890	NA			NA	NA	NA
CSE579			E,L				CSE579							CSE579		NA		NA	NA	NA
VYT371			I,T				VYT371							VYT371	NA		NA	NA	NA	
NIO047		I,T					NIO047							NIO047	NA		NA	NA	NA	NA
ZWQ356							ZWQ356							ZWQ356	NA	NA	NA	NA	NA	NA
BUO746							BUO746							BUO746	NA		NA	NA	NA	NA
CTQ479		I,T					CTQ479							CTQ479		NA	NA	NA	NA	NA
BYA490						0,B,U	BYA490							BYA490	NA			NA	NA	NA
BYO853							BYO853							BYO853	NA		NA	NA	NA	NA
MNA960						0,B,U	MNA960							MNA960		NA		NA	NA	NA
ATO521		I,T					ATO521							ATO521		NA	NA	NA	NA	
LIX763	L,E	I,T					LIX763							LIX763				NA	NA	NA
PXT496			I,T				PXT496							PXT496			NA	NA	NA	NA
SUO836							SUO836							SUO836	NA		NA	NA	NA	NA
XOP042							XOP042							XOP042		NA		NA	NA	NA
ZUO490						0,B,U	ZUO490							ZUO490	NA		NA	NA	NA	NA
AOP692							AOP692							AOP692		NA		NA	NA	NA
HTS381	H,B	I,T					HTS381							HTS381		NA	NA	NA	NA	
QYE375			E,L				QYE375							QYE375	NA			NA	NA	NA

PDY720						0,B,U	PDY720							PDY720		NA		NA	NA	NA
FOE830	F,E		E,L			0,B,U	FOE830							FOE830		NA		NA	NA	NA
SUE934			E,L,F				SUE934							SUE934	NA			NA	NA	NA
LYK853	L,E						LYK853							LYK853				NA	NA	NA
BYW917							BYW917							BYW917	NA		NA	NA		NA
MOS579							MOS579							MOS579		NA	NA	NA	NA	NA
WEE922		E,L	E,L				WEE922							WEE922	NA			NA	NA	NA
TTA428	I,T	I,T					TTA428							TTA428	NA	NA		NA	NA	NA
VCC555							VCC555							VCC555	NA			NA	NA	NA
QQQ456							QQQ456							QQQ456	NA	NA	NA	NA	NA	NA
GUR560						0,B,U	GUR560							GUR560			NA	NA	NA	NA
TIS533	I,T	I,T					TIS533							TIS533	NA		NA	NA	NA	NA
KPY780						0,B,U	KPY780							KPY780				NA	NA	NA
CRW431							CRW431							CRW431		NA	NA	NA	NA	
JAS880						0,B,U	JAS880							JAS880			NA	NA	NA	NA
RR3561							RR3561							RR3561	NA	NA		NA	NA	
NIT553		I,T	I,T				NIT553							NIT553	NA		NA	NA	NA	NA
LPR589	L,E						LPR589							LPR589			NA	NA	NA	NA
BIT532		I,T	I,T				BIT532							BIT532	NA		NA	NA	NA	NA
HHH666	H,B	H,B	H,B				HHH666							HHH666				NA	NA	NA
PPO995							PPO995							PPO995			NA	NA	NA	NA
DDR423							DDR423							DDR423	NA	NA	NA	NA	NA	NA
KUT765			I,T				KUT765							KUT765			NA	NA	NA	NA
CRT321			I,T				CRT321							CRT321		NA	NA	NA	NA	
MOI998			I,T				MOI998							MOI998		NA		NA	NA	NA
BUY664							BUY664							BUY664	NA			NA	NA	NA
OOO756							OOO756							OOO756	NA	NA	NA	NA	NA	NA
VYR532							VYR532							VYR532	NA		NA	NA	NA	NA
MNB098							MNB098							MNB098		NA	NA	NA	NA	NA
FFF456	F,E	F,E	F,E				FFF456							FFF456				NA	NA	NA
KOU864							KOU864							KOU864		NA		NA	NA	NA
POE466			E,L				POE466							POE466		NA		NA	NA	NA
LIA122	L,E	I,T					LIA122							LIA122					NA	NA
NUY665							NUY665							NUY665	NA			NA	NA	NA
POU889							POU889							POU889		NA		NA	NA	NA
BNY664							BNY664							BNY664	NA	NA		NA	NA	NA
MIY643		I,T					MIY643							MIY643				NA	NA	NA
PRG754							PRG754							PRG754		NA		NA	NA	NA
MOO874							MOO874							MOO874		NA	NA	NA	NA	NA
III064	I,T	I,T	I,T				III064							III064				NA	NA	NA
THY623	I,T	H,B					THY623							THY623	NA			NA	NA	NA
LOP998	L,E						LOP998							LOP998		NA		NA	NA	NA
VRW954							VRW954							VRW954	NA	NA	NA	NA	NA	NA
LTE964	L,E	I,T	E,L				LTE964							LTE964		NA		NA	NA	NA
BTE000		I,T	E,L	0,B,U	0,B,U	0,B,U	BTE000							BTE000	NA	NA		NA	NA	NA
MUE412			E,L				MUE412							MUE412				NA		NA
HHH634	H,B	H,B	H,B				HHH634							HHH634				NA	NA	NA
NUI476			I,T				NUI476							NUI476	NA			NA	NA	NA
PRE479			E,L				PRE479							PRE479		NA		NA	NA	NA
38%							100%							0%						
After analysis		EwL,FwE,HwB,IwT,LwE, TwI,0wBU					After analysis	NA						After analysis		ABDNOQRSTVWZ02345679				

APPENDIX F2

The result for the comparison between the percentages of recognition after matching with 100 not good(NG) sample to the template with difference matching percentage when the 30x20 of image size and 3x3 of median filter is fixed and in white light condition.

			80%							85%									90%					
	C1	C2	C3	C4	C5	C6		C1	C2	C3	C4	C5	C6		C1	C2	C3	C4	C5	C6
ABC123	NA	NA	NA		2,E	3,C	ABC123			C			3	ABC123						
DEF456		NA	NA	NA	NA	NA	DEF456			F				DEF456			F			
GHI789			I,E	7,Z		NA	GHI789							GHI789						
JKL245			NA	2,E	NA	NA	JKL245							JKL245						
YUI876			I,E		7,Z	NA	YUI876							YUI876						
HUI976			I,E	NA	7,Z	NA	HUI976							HUI976						
GYU678				NA	7,Z		GYU678							GYU678						
UIP945		I,E		NA	NA	NA	UIP945							UIP945						
KIY890					NA		KIY890							KIY890						
YRT543				NA	NA	3,C	YRT543						3	YRT543						
SER421		NA		NA	2,E		SER421							SER421						
JUO964				NA	NA		JUO964							JUO964						
TYU765				7,Z	NA	NA	TYU765							TYU765						
OPJ876					7,Z	NA	OPJ876							OPJ876						
GTR432				NA		2,E	GTR432							GTR432						
NJU765				7,Z	NA	NA	NJU765							NJU765						
LOP654	NA			NA	NA	NA	LOP654							LOP654						
NBV543		NA		NA	NA	3,C	NBV543						3	NBV543						
CDS345	NA			3,C	NA	NA	CDS345	C						CDS345						
LPI754	NA		I,E	7,Z	NA	NA	LPI754							LPI754						
HYR541					NA		HYR541							HYR541						
CGR475	NA			NA	7,Z	NA	CGR475	C						CGR475						
BYI865	NA		I,E		NA	NA	BYI865							BYI865						
FRE567	NA		NA	NA	NA	7,Z	FRE567	F						FRE567	F					
MIO965		I,E		NA	NA	NA	MIO965							MIO965						
SCE327			NA	3,C	2,E	7,Z	SCE327							SCE327						
MXY543				NA	NA	3,C	MXY543						3	MXY543						
PAC698		NA	NA	NA	NA		PAC698			C				PAC698						
ZYO963	Z,E			NA	NA	3,C	ZYO963						3	ZYO963						
TDW370				3,C	7,Z		TDW370							TDW370						
HUO975				NA	7,Z	NA	HUO975							HUO975						
SDR541				NA	NA		SDR541							SDR541						
TYU890					NA		TYU890							TYU890						
CSE579	NA		NA	NA	7,Z	NA	CSE579	C						CSE579						
VYT371				3,C	7,Z		VYT371							VYT371						
NIO047		I,E			NA	7,Z	NIO047							NIO047						
ZWQ356	Z,E			3,C	NA	NA	ZWQ356							ZWQ356						
BUO746	NA			7,Z	NA	NA	BUO746							BUO746						
CTQ479	NA			NA	7,Z	NA	CTQ479	C						CTQ479						
BYA490	NA		NA	NA	NA		BYA490							BYA490						
BYO853	NA				NA	3,C	BYO853						3	BYO853						
MNA960			NA	NA	NA		MNA960							MNA960						
ATO521	NA			NA	2,E		ATO521							ATO521						
LIX763	NA	I,E		7,Z	NA	3,C	LIX763						3	LIX763						
PXT496				NA	NA	NA	PXT496							PXT496						
SUO836					3,C	NA	SUO836							SUO836						
XOP042					NA	2,E	XOP042							XOP042						
ZUO490				NA	NA		ZUO490							ZUO490						
AOP692	NA			NA	NA	2,E	AOP692							AOP692						
HTS381				3,C			HTS381							HTS381						
QYE375			NA		7,F	5,G	QYE375							QYE375						

PDY720					2,E		PDY720							PDY720								
FOE830			NA		3,C		FOE830	F				3		FOE830	F							
SUE934			NA		3,C	NA	SUE934							SUE934								
LYK853	NA				5,G	NA	LYK853						3	LYK853								
BYW917	B,0			NA		7,F	BYW917							BYW917								
MOS579					7,F	NA	MOS579							MOS579								
WEE922		E,L,6	E,L,6	NA	NA	NA	WEE922							WEE922								
TTA428			NA	NA			TTA428							TTA428								
VCC555		NA	NA	5,G	5,G	5,G	VCC555		C	C				VCC555								
QQQ456				NA	5,G		QQQ456							QQQ456								
GUR560				5,G	NA		GUR560							GUR560								
TIS533		I,T			NA	NA	TIS533					3	3	TIS533								
KPY780				7,F			KPY780							KPY780								
CRW431				NA	NA		CRW431	C				3		CRW431								
JAS880		NA					JAS880							JAS880								
RR3561			NA	5,G	NA		RR3561			3				RR3561								
NIT553		I,T		5,G	5,G	NA	NIT553						3	NIT553								
LPR589	NA			5,G		NA	LPR589							LPR589								
BIT532	B,0			5,G	NA	NA	BIT532					3		BIT532								
HHH666				NA	NA	NA	HHH666							HHH666								
PPO995				NA	NA		PPO995							PPO995								
DDR423	D,0	D,0		NA	NA	NA	DDR423						3	DDR423								
KUT765				7,F	NA	5,G	KUT765							KUT765								
CRT321	NA			NA	NA		CRT321	C			3			CRT321								
MOI998				NA	NA		MOI998							MOI998								
BUY664	B,0			NA	NA	NA	BUY664							BUY664								
OOO756				7,F	5,G	NA	OOO756							OOO756								
VYR532				5,G	NA	NA	VYR532					3		VYR532								
MNB098		B,0			NA		MNB098							MNB098								
FFF456	NA	NA	NA	NA	5,G	NA	FFF456	F	F	F				FFF456	F	F	F					
KOU864					NA	NA	KOU864							KOU864								
POE466			E,L,6	NA	NA	NA	POE466							POE466								
LIA122	NA	I,T	NA		NA	NA	LIA122							LIA122								
NUY665				NA	NA		NUY665							NUY665								
POU889						NA	POU889							POU889								
BNY664	B,0			NA	NA	NA	BNY664							BNY664								
MIY643				NA	NA	NA	MIY643						3	MIY643								
PRG754				7,F	5,G	NA	PRG754							PRG754								
MOO874					7,F	NA	MOO874							MOO874								
III064	I,T	I,T	I,T		NA	NA	III064							III064								
THY623				NA	NA	NA	THY623						3	THY623								
LOP998	NA			NA	NA		LOP998							LOP998								
VRW954				NA	5,G	NA	VRW954							VRW954								
LTE964			E,L,6	NA		NA	LTE964							LTE964								
BTE000	B,0		E,L,6				BTE000							BTE000								
MUE412			E,L,6	NA		NA	MUE412							MUE412								
HHH634				NA	NA	NA	HHH634							HHH634								
NUI476			I,T	NA	7,F	NA	NUI476							NUI476								
PRE479			E,L,6	NA	7,F	NA	PRE479							PRE479								
100%							28%							4%								

After analysis	A,C,B,Bw0,2,2wE,7wZ,7wF,D,Dw0, F,6,L, 5wG,3,EwL6,IwT,IwE,Z,ZwE,3wC,E,4,9
After analysis	C,F,3
After analysis	F

APPENDIX G1

The comparison between the percentages of recognition after adjustment of white pixel value left at character C, F, and 3 in **white light condition** with the three best parameter for 100 good(G) and 100 not good(NG) testing sample.

Good sample with white light						
	C1	C2	C3	C4	C5	C6
ABC123						
DEF456						
GHI789						
JKL245						
YUI876						
HUI976						
GYU678						
UIP945						
KIY890						
YRT543						
SER421						
JUO964						
TYU765						
OPJ876						
GTR432						
NJU765						
LOP654						
NBV543						
CDS345						
LPI754						
HYR541						
CGR475						
BYI865						
FRE567						
MIO965						
SCE327						
MXY543						
PAC698						
ZYO963						
TDW370						
HUO975						
SDR541						
TYU890						
CSE579						
VYT371						
NIO047						
ZWQ356						
BUO746						
CTQ479						
BYA490						
BYO853						
MNA960						
ATO521						
LIX763						
PXT496						
SUO836						
XOP042						
ZUO490						
AOP692						
HTS381						

Not Good sample with white light						
	C1	C2	C3	C4	C5	C6
ABC123	NA	NA	NA	NA	NA	NA
DEF456	NA	NA	NA	NA	NA	NA
GHI789	NA	NA	NA	NA	NA	NA
JKL245	NA	NA	NA	NA	NA	NA
YUI876	NA	NA	NA	NA	NA	NA
HUI976	NA	NA	NA	NA	NA	NA
GYU678	NA	NA	NA	NA	NA	NA
UIP945	NA	NA	NA	NA	NA	NA
KIY890	NA	NA	NA	NA	NA	NA
YRT543	NA	NA	NA	NA	NA	NA
SER421	NA	NA	NA	NA	NA	NA
JUO964	NA	NA	NA	NA	NA	NA
TYU765	NA	NA	NA	NA	NA	NA
OPJ876	NA	NA	NA	NA	NA	NA
GTR432	NA	NA	NA	NA	NA	NA
NJU765	NA	NA	NA	NA	NA	NA
LOP654	NA	NA	NA	NA	NA	NA
NBV543	NA	NA	NA	NA	NA	NA
CDS345	NA	NA	NA	NA	NA	NA
LPI754	NA	NA	NA	NA	NA	NA
HYR541	NA	NA	NA	NA	NA	NA
CGR475	NA	NA	NA	NA	NA	NA
BYI865	NA	NA	NA	NA	NA	NA
FRE567	NA	NA	NA	NA	NA	NA
MIO965	NA	NA	NA	NA	NA	NA
SCE327	NA	NA	NA	NA	NA	NA
MXY543	NA	NA	NA	NA	NA	NA
PAC698	NA	NA	NA	NA	NA	NA
ZYO963	NA	NA	NA	NA	NA	NA
TDW370	NA	NA	NA	NA	NA	NA
HUO975	NA	NA	NA	NA	NA	NA
SDR541	NA	NA	NA	NA	NA	NA
TYU890	NA	NA	NA	NA	NA	NA
CSE579	NA	NA	NA	NA	NA	NA
VYT371	NA	NA	NA	NA	NA	NA
NIO047	NA	NA	NA	NA	NA	NA
ZWQ356	NA	NA	NA	NA	NA	NA
BUO746	NA	NA	NA	NA	NA	NA
CTQ479	NA	NA	NA	NA	NA	NA
BYA490	NA	NA	NA	NA	NA	NA
BYO853	NA	NA	NA	NA	NA	NA
MNA960	NA	NA	NA	NA	NA	NA
ATO521	NA	NA	NA	NA	NA	NA
LIX763	NA	NA	NA	NA	NA	NA
PXT496	NA	NA	NA	NA	NA	NA
SUO836	NA	NA	NA	NA	NA	NA
XOP042	NA	NA	NA	NA	NA	NA
ZUO490	NA	NA	NA	NA	NA	NA
AOP692	NA	NA	NA	NA	NA	NA
HTS381	NA	NA	NA	NA	NA	NA

QYE375							QYE375	NA	NA	NA	NA	NA	NA
PDY720							PDY720	NA	NA	NA	NA	NA	NA
FOE830							FOE830	NA	NA	NA	NA	NA	NA
SUE934							SUE934	NA	NA	NA	NA	NA	NA
LYK853							LYK853	NA	NA	NA	NA	NA	NA
BYW917							BYW917	NA	NA	NA	NA	NA	NA
MOS579							MOS579	NA	NA	NA	NA	NA	NA
WEE922							WEE922	NA	NA	NA	NA	NA	NA
TTA428							TTA428	NA	NA	NA	NA	NA	NA
VCC555							VCC555	NA	NA	NA	NA	NA	NA
QQQ456							QQQ456	NA	NA	NA	NA	NA	NA
GUR560							GUR560	NA	NA	NA	NA	NA	NA
TIS533							TIS533	NA	NA	NA	NA	NA	NA
KPY780							KPY780	NA	NA	NA	NA	NA	NA
CRW431							CRW431	NA	NA	NA	NA	NA	NA
JAS880							JAS880	NA	NA	NA	NA	NA	NA
RR3561							RR3561	NA	NA	NA	NA	NA	NA
NIT553							NIT553	NA	NA	NA	NA	NA	NA
LPR589							LPR589	NA	NA	NA	NA	NA	NA
BIT532							BIT532	NA	NA	NA	NA	NA	NA
HHH666							HHH666	NA	NA	NA	NA	NA	NA
PPO995							PPO995	NA	NA	NA	NA	NA	NA
DDR423							DDR423	NA	NA	NA	NA	NA	NA
KUT765							KUT765	NA	NA	NA	NA	NA	NA
CRT321							CRT321	NA	NA	NA	NA	NA	NA
MOI998							MOI998	NA	NA	NA	NA	NA	NA
BUY664							BUY664	NA	NA	NA	NA	NA	NA
OOO756							OOO756	NA	NA	NA	NA	NA	NA
VYR532							VYR532	NA	NA	NA	NA	NA	NA
MNB098							MNB098	NA	NA	NA	NA	NA	NA
FFF456							FFF456	NA	NA	NA	NA	NA	NA
KOU864							KOU864	NA	NA	NA	NA	NA	NA
POE466							POE466	NA	NA	NA	NA	NA	NA
LIA122							LIA122	NA	NA	NA	NA	NA	NA
NUY665							NUY665	NA	NA	NA	NA	NA	NA
POU889							POU889	NA	NA	NA	NA	NA	NA
BNY664							BNY664	NA	NA	NA	NA	NA	NA
MIY643							MIY643	NA	NA	NA	NA	NA	NA
PRG754							PRG754	NA	NA	NA	NA	NA	NA
MOO874							MOO874	NA	NA	NA	NA	NA	NA
III064							III064	NA	NA	NA	NA	NA	NA
THY623							THY623	NA	NA	NA	NA	NA	NA
LOP998							LOP998	NA	NA	NA	NA	NA	NA
VRW954							VRW954	NA	NA	NA	NA	NA	NA
LTE964							LTE964	NA	NA	NA	NA	NA	NA
BTE000							BTE000	NA	NA	NA	NA	NA	NA
MUE412							MUE412	NA	NA	NA	NA	NA	NA
HHH634							HHH634	NA	NA	NA	NA	NA	NA
NUI476							NUI476	NA	NA	NA	NA	NA	NA
PRE479							PRE479	NA	NA	NA	NA	NA	NA
100%							0%						
After analysis NA							After analysis NA						

APPENDIX G2

The comparison between the percentages of recognition after adjustment of white pixel value left at character C, F, and 3 in **yellow light condition** with the three best parameter for 100 good(G) and 100 not good(NG) testing sample.

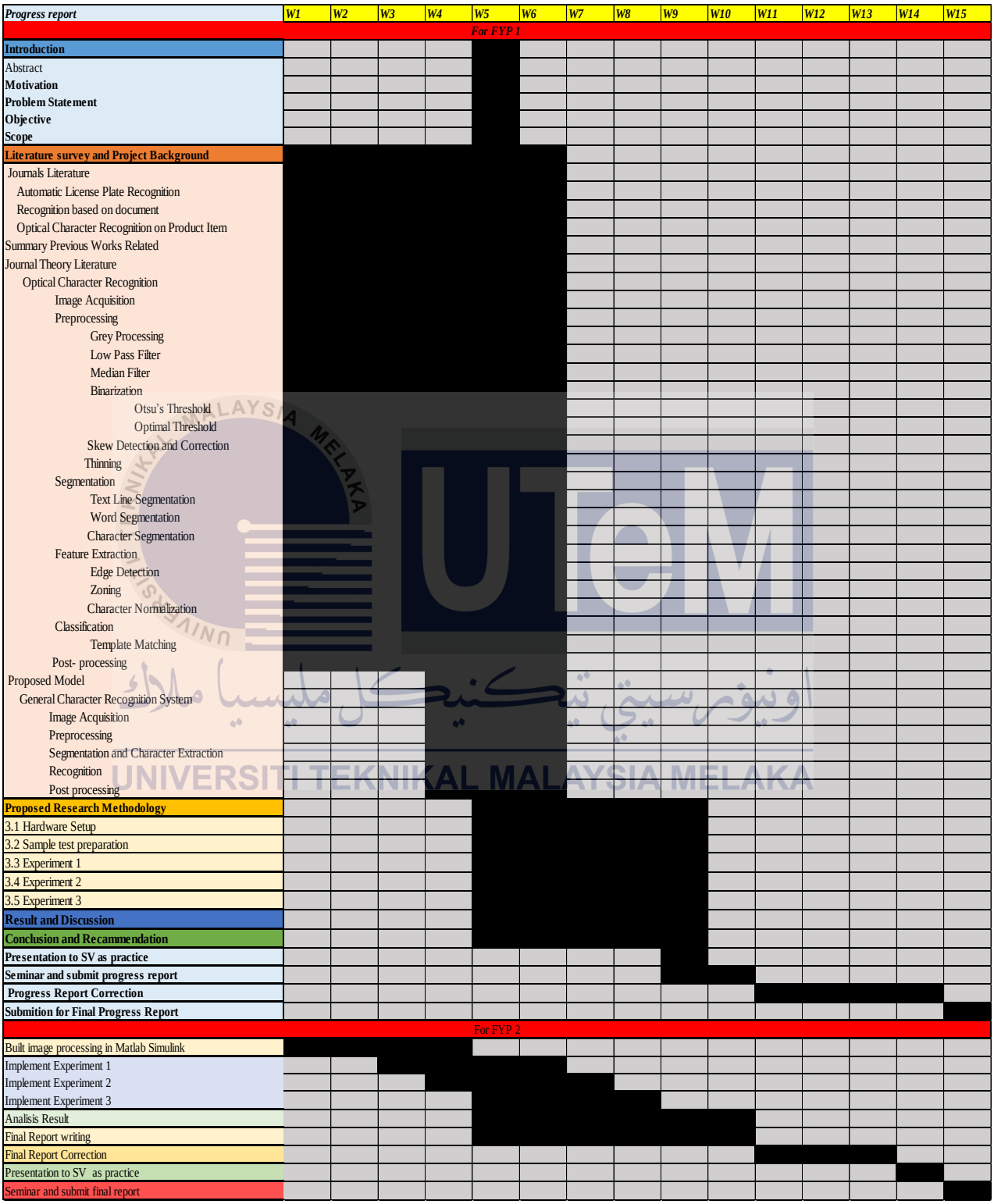
Good sample with yellow light						
	C1	C2	C3	C4	C5	C6
ABC123						
DEF456						
GHI789						
JKL245						
YUI876						
HUI976						
GYU678						
UIP945						
KIY890						
YRT543						
SER421						
JUO964						
TYU765						
OPJ876						
GTR432						
NJU765						
LOP654						
NBV543						
CDS345						
LPI754						
HYR541						
CGR475						
BYI865						
FRE567						
MIO965						
SCE327						
MXY543						
PAC698						
ZYO963						
TDW370						
HUO975						
SDR541						
TYU890						
CSE579						
VYT371						
NIO047						
ZWQ356						
BUO746						
CTQ479						
BYA490						
BYO853						
MNA960						
ATO521						
LIX763						
PXT496						
SUO836						
XOP042						
ZUO490						
AOP692						
HTS381						

Not Good sample with yellow light						
	C1	C2	C3	C4	C5	C6
ABC123	NA	NA	NA	NA	NA	NA
DEF456	NA	NA	NA	NA	NA	NA
GHI789	NA	NA	NA	NA	NA	NA
JKL245	NA	NA	NA	NA	NA	NA
YUI876	NA	NA	NA	NA	NA	NA
HUI976	NA	NA	NA	NA	NA	NA
GYU678	NA	NA	NA	NA	NA	NA
UIP945	NA	NA	NA	NA	NA	NA
KIY890	NA	NA	NA	NA	NA	NA
YRT543	NA	NA	NA	NA	NA	NA
SER421	NA	NA	NA	NA	NA	NA
JUO964	NA	NA	NA	NA	NA	NA
TYU765	NA	NA	NA	NA	NA	NA
OPJ876	NA	NA	NA	NA	NA	NA
GTR432	NA	NA	NA	NA	NA	NA
NJU765	NA	NA	NA	NA	NA	NA
LOP654	NA	NA	NA	NA	NA	NA
NBV543	NA	NA	NA	NA	NA	NA
CDS345	NA	NA	NA	NA	NA	NA
LPI754	NA	NA	NA	NA	NA	NA
HYR541	NA	NA	NA	NA	NA	NA
CGR475	NA	NA	NA	NA	NA	NA
BYI865	NA	NA	NA	NA	NA	NA
FRE567	NA	NA	NA	NA	NA	NA
MIO965	NA	NA	NA	NA	NA	NA
SCE327	NA	NA	NA	NA	NA	NA
MXY543	NA	NA	NA	NA	NA	NA
PAC698	NA	NA	NA	NA	NA	NA
ZYO963	NA	NA	NA	NA	NA	NA
TDW370	NA	NA	NA	NA	NA	NA
HUO975	NA	NA	NA	NA	NA	NA
SDR541	NA	NA	NA	NA	NA	NA
TYU890	NA	NA	NA	NA	NA	NA
CSE579	NA	NA	NA	NA	NA	NA
VYT371	NA	NA	NA	NA	NA	NA
NIO047	NA	NA	NA	NA	NA	NA
ZWQ356	NA	NA	NA	NA	NA	NA
BUO746	NA	NA	NA	NA	NA	NA
CTQ479	NA	NA	NA	NA	NA	NA
BYA490	NA	NA	NA	NA	NA	NA
BYO853	NA	NA	NA	NA	NA	NA
MNA960	NA	NA	NA	NA	NA	NA
ATO521	NA	NA	NA	NA	NA	NA
LIX763	NA	NA	NA	NA	NA	NA
PXT496	NA	NA	NA	NA	NA	NA
SUO836	NA	NA	NA	NA	NA	NA
XOP042	NA	NA	NA	NA	NA	NA
ZUO490	NA	NA	NA	NA	NA	NA
AOP692	NA	NA	NA	NA	NA	NA
HTS381	NA	NA	NA	NA	NA	NA

QYE375						
PDY720						
FOE830						
SUE934						
LYK853						
BYW917						
MOS579						
WEE922						
TTA428						
VCC555						
QQQ456						
GUR560						
TIS533						
KPY780						
CRW431						
JAS880						
RR3561						
NIT553						
LPR589						
BIT532						
HHH666						
PPO995						
DDR423						
KUT765						
CRT321						
MOI998						
BUY664						
OOO756						
VYR532						
MNB098						
FFF456						
KOU864						
POE466						
LIA122						
NUY665						
POU889						
BNY664						
MIY643						
PRG754						
MOO874						
III064						
THY623						
LOP998						
VRW954						
LTE964						
BTE000						
MUE412						
HHH634						
NUI476						
PRE479						
100%						
After analysis	NA					

QYE375	NA	NA	NA	NA	NA	NA
PDY720	NA	NA	NA	NA	NA	NA
FOE830	NA	NA	NA	NA	NA	NA
SUE934	NA	NA	NA	NA	NA	NA
LYK853	NA	NA	NA	NA	NA	NA
BYW917	NA	NA	NA	NA	NA	NA
MOS579	NA	NA	NA	NA	NA	NA
WEE922	NA	NA	NA	NA	NA	NA
TTA428	NA	NA	NA	NA	NA	NA
VCC555	NA	NA	NA	NA	NA	NA
QQQ456	NA	NA	NA	NA	NA	NA
GUR560	NA	NA	NA	NA	NA	NA
TIS533	NA	NA	NA	NA	NA	NA
KPY780	NA	NA	NA	NA	NA	NA
CRW431	NA	NA	NA	NA	NA	NA
JAS880	NA	NA	NA	NA	NA	NA
RR3561	NA	NA	NA	NA	NA	NA
NIT553	NA	NA	NA	NA	NA	NA
LPR589	NA	NA	NA	NA	NA	NA
BIT532	NA	NA	NA	NA	NA	NA
HHH666	NA	NA	NA	NA	NA	NA
PPO995	NA	NA	NA	NA	NA	NA
DDR423	NA	NA	NA	NA	NA	NA
KUT765	NA	NA	NA	NA	NA	NA
CRT321	NA	NA	NA	NA	NA	NA
MOI998	NA	NA	NA	NA	NA	NA
BUY664	NA	NA	NA	NA	NA	NA
OOO756	NA	NA	NA	NA	NA	NA
VYR532	NA	NA	NA	NA	NA	NA
MNB098	NA	NA	NA	NA	NA	NA
FFF456	NA	NA	NA	NA	NA	NA
KOU864	NA	NA	NA	NA	NA	NA
POE466	NA	NA	NA	NA	NA	NA
LIA122	NA	NA	NA	NA	NA	NA
NUY665	NA	NA	NA	NA	NA	NA
POU889	NA	NA	NA	NA	NA	NA
BNY664	NA	NA	NA	NA	NA	NA
MIY643	NA	NA	NA	NA	NA	NA
PRG754	NA	NA	NA	NA	NA	NA
MOO874	NA	NA	NA	NA	NA	NA
III064	NA	NA	NA	NA	NA	NA
THY623	NA	NA	NA	NA	NA	NA
LOP998	NA	NA	NA	NA	NA	NA
VRW954	NA	NA	NA	NA	NA	NA
LTE964	NA	NA	NA	NA	NA	NA
BTE000	NA	NA	NA	NA	NA	NA
MUE412	NA	NA	NA	NA	NA	NA
HHH634	NA	NA	NA	NA	NA	NA
NUI476	NA	NA	NA	NA	NA	NA
PRE479	NA	NA	NA	NA	NA	NA
0%						
After analysis	NA					

APPENDIX H
Gantt Chart



APPENDIX I

Photo visiting Silterra Company