CAR LICENSE PLATE NUMBER RECOGNITION USING MEDIAN FILTERING, FREQUENCY DOMAIN FILTERING AND MORPHOLOGICAL FILTERING

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DECLARATION

I hereby declare that this project report entitled

CAR LICENSE PLATE NUMBER RECOGNITION USING MORPHOLOGICAL FILTERING, FREQUENCY DOMAIN FILTERING AND IMAGE FILTERING TECHNIQUES

is written by me and is my own effort and that no part has been plagiarized

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STUDENT : _____ Date : 09/09/2021

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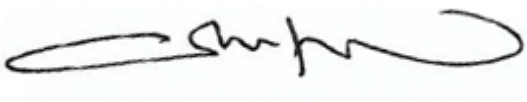
I hereby declare that I have read this project report and found

this project report is sufficient in term of the scope and quality for the award of

Bachelor of Computer Science (Computer Security) with Honours.



SUPERVISOR : _____ Date : 09/09/2021

(DR OTHMAN BIN MOHD)

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This report is submitted in partial fulfilment of the requirements for the Bachelor of Computer Science (Computer Security) with Honours.

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DEDICATION

I dedicated this project for my mother who single handedly taking care of three daughters. My beloved sisters and my grandparents.

To my friend Nurul Aiman Asyiqin Binti Nor Azrin

To my close friend Fehed Wasti

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Fistly, I would like to thank Allah S.W.T for blessing me with additional knowledge and giving me guidance and strength to proceed with my final year project. I would like to thank my supervisor, Dr Othman Mohd, who has helped me through all aspects of the project whether it be relating to the final implementation of the analysis or academic writing as well as helping me get through the struggles faced during the pandemic throughout my final year project at UTeM.

Furthermore, I'd like to thank my mother for endless support, giving me motivation to continue with my final year project and reassure me when I am feeling like giving up. Teaching me the basics needed in a final year report and being the backbone of my life.

Finally, I would like to thank my friends who helped me on my project. Giving me feedbacks and opinions, supported me mentally throughout the pandemic, in particular F.W who was there to encourage me.

ABSTRACT

The project focused on the recognising the plate numbers image using MATLAB platform. The image will undergo few images processing for a better read on the image characters. The images used are in various kinds of condition. There are several techniques will be applied as a filtering technique such as median filter, frequency domain filter and morphological filtering. Image will then be converted into binary image, the value will be based on 1s and 0s or black and white only. Afterwards, the image will undergo edge-detection to detect the plate number's characters location and then characters found will be segmented. Finally, the recognition step is done using template matching technique which the characters will be scanned using the template and the most matching pattern will be identified. The result of the plate number recognition will be based on how many characters are identified correctly in the image after character recognition. The best filtering technique between median filtering, frequency domain filtering and morphological filtering will be chosen.

ABSTRAK

Projek ini memfokuskan pada mengenali gambar nombor plat menggunakan platform MATLAB. Imej akan dijalani beberapa pemprosesan gambar untuk membaca abjad gambar dengan lebih baik. Gambar yang digunakan akan berada dalam pelbagai jenis keadaan. Terdapat beberapa teknik yang akan diterapkan sebagai teknik penyaringan seperti *median filter, frekuensi domain filter* dan *morphological filtering*. Imej kemudian akan ditukar menjadi gambar binary, nilai gambar akan berdasarkan hanya 1 dan 0 atau hitam dan putih. Selepas itu, gambar akan menjalani pengesanan tepi untuk mengesan lokasi abjad nombor plat dan kemudian lokasi yang dijumpai akan disegmentasikan. Akhirnya, langkah pengecaman dilakukan dengan menggunakan teknik pencocokan templat yang mana abjad akan diimbas menggunakan templat dan corak yang paling sesuai akan dikenal pasti. Hasil pengecaman nombor plat akan didasarkan pada berapa banyak watak yang dikenal pasti dengan betul dalam gambar selepas pengecaman watak. Teknik penapisan terbaik antara penapisan median, penapisan domain frekuensi dan penapisan morfologi akan dipilih.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Car license plate number recognition is a project to identify vehicles' their plate number in MATLAB. Plate number recognition is a technology with pattern recognition technology that collects a type of plate number and compare it with to predefined collection of samples in a file. The deliverable of this is the comparison between the actual plate number and the predefined samples. The issues of plate number recognition are the human error and behaviour such as maintenance of the plate number. Low resolution of plate number image and non-uniform plate number model. Techniques used for this project is based on MATLAB only and there are various techniques has been used to recognize the characters of the images.

1.2 Problem Statement

The problem statement of the project is the quality of the image is low or it is too small to be able to recognize the characters. Next, the vehicle's plate number has gone through poor maintenance, the characters are damaged by natural disaster. The summary of the project statement is as in Table 1.1.

Table 1.1 Summary of problem statement

PS	Problem Statement
PS_1	Difficulties on recognising the plate numbers that is in certain damaged condition or has small images

1.3 Project Question (PQ)

Based on the problem statement discussed in 1.2, there are some questions arises from it. The summary of the project question as shown in Table 1.2.

Table 1.2 Summary of Project Question

PS	PQ	Project Question
PS_1	PQ_1	What are the three techniques to improve readability of the plate numbers?
		Which of the techniques has the best output of the plate number recognition based on the three techniques?

1.4 Project Objective

Based on the problem statement and project question discussed above, the objectives of this project were summarized and as shown in Table 1.3.

Table 1.3 Summary of Project Objectives

PS	PQ	PO	Project Objective
PS_1	PQ_1	PO_1	To identify the techniques of plate number recognition
		PO_2	To implement three techniques of plate number recognition using morphological filtering, frequency domain filtering and image filtering techniques.
	PQ_2	PO_3	To evaluate the best techniques of the plate number recognition based on those three techniques

1.5 Project Scope

In this project, the simulation will be conducted using MATLAB. There are Python that has in-built library, but MATLAB has it better with matrix computations. Also, some of the MATLAB toolboxes is inequivalent to the Python libraries. Still images of the plate numbers from various situation will be used such as unmaintained plate numbers, small images to help deduce the better technique. The image will undergo three different technique of image processing that is median filtering, frequency domain filtering and morphological filtering. After removing unwanted details in the image, all numbers and alphabets will be segmented by using bounding box method. Afterwards, template matching approach is used to recognize the numbers and characters.

1.6 Project Contribution (PC)

This project beneficial for other recognition process such as fingerprint, facial recognition that can be used for security purposes. The project provides three different techniques that can be applied for image processing, one of those three could be used for further applications.

Table 1.4 Summary of Project Contribution

PS	PQ	PO	PC	Project Contribution
PS_1	PQ_1	PO_1	PC_1	Classify the methods that can be used for image filtering
		PO_2	PC_2	Proposed the general way of the three images filtering technique
	PQ_2	PO_3	PC_3	Identify the best technique to recognize the plate numbers

1.7 Report Organisation

Report organisation contains the outline of the chapters of the final year project report. Chapter 1 of this report discussed the overall summary of this project, including the problem statement, project questions, project objectives, the scope of the project, how the project can contribute and the organization of this report.

In Chapter 2 is the literature review where it encapsulates the recent research and scholarly sources relevant on the topic and theory in this project. This chapter also summarizes the particular of theory on simulation approach that connected with this project.

In Chapter 3 is the methodology part which summarize about the method that will be used in this project to obtain the result. In this project the method that will be used in recognizing the license plate character is image processing approach using different image filtering techniques simulation using MATLAB.

Chapter 4 explains the results of the analysis of the beginning of design and the result of detailed design. The result is represented in the form of performance table, the network simulation result from the network training and the discussion on recognition result.

Chapter 5 explains the implementation of the project. The techniques used are listed and explained.

Chapter 6 describe the activity involved in the implementation phase during the simulation/testbed project. It has critical analysis on the results.

Chapter 7 consist of the overall summary of the project, what contribution that has been made in this project, the limitation found when conducting the project and future works that consist of suggestions from the limitation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the related work of this project was discussed and similar project that has been conducted by previous researchers. This project mainly focused on analysing which image processing is better for recognition of the plate numbers. Therefore, localization of the car plate is not included. Based on that, reviewed the current problem faced by previous work and proposed solution of the problem.

2.2 Related Work

Since the 1960s, image processing has been used to increase the quality of individual images. MacDonald (2013), stated that, image processing is a necessary step since human eye does not perceive images in the same way that digital imaging technologies do. Meanwhile, image pre-processing was more concerned with preparing images for efficient use. Filtering, colour transformation, brightness correction, and other image pre-processing techniques are examples. It is possible to achieve good image quality by processing the data (images).

Image processing filtering is used to suppress either the high frequencies (low-pass filtering) in the image which leads to smoothing of the image or the low frequencies (high-pass filtering) that is for sharpening of the images. The image can be filtered in both frequency domain and in spatial domain. When smoothen or blurred filter are applied, it will eliminate noises which is an unwanted information of image that complicates the desired information. Gonzalez R. C. et al (2020), stated that, this technique of filtering is called linear filtering where they used a Fourier multiplication. Linear operations multiply each pixel in the neighbourhood by corresponding coefficient and summing the results to obtain the response at each point.

As for nonlinear filtering, they also based on neighbourhood operations where they slide the centre point through an image are the same. However, rather than

computing sum of products as linear operations, nonlinear let the response at each centre point be equal to the maximum pixel value in its neighbourhood. Balafar M. (2012), although linear filters tend to be simple in concept, they degrade image details and edges of the image. Padzil F. M. (2016), nonlinear filter simply replaces each pixel with the middle value which makes it help preserving edges.

There is another technique can be used as filtering called morphological filtering. The main morphological operations are called dilation and erosion. Raid A. M. et al. (2014), for dilation operation, the objects are expanded making the small holes filled and objects to be connected. Meanwhile, for erosion operation, the objects are diminished with etching away their boundaries.

Image segmentation is the part where the object in the image is separated into parts or regions. There are two different techniques that co-exist for it, region-based segmentation, and edge detection segmentation. As for region-based algorithm, it separates the objects into different regions based on some threshold value. Edge detections algorithm, focus more on discontinuation local features of an image.

2.3 Critical review of current problem and justification

There are various solutions of relevant problem. The main issues in plate number recognition are climate condition, environmental interference, the maintenance of the car plate and accuracy of number plate localization.

A similar project done where they focused on Malaysia's plate numbers using a horizontal density vector method to locate the plate numbers (Omran Khalifa et al, 2007). Due varieties of number characters and some old plate number designed as a square shape with the characters written in two lines. The plate extraction process that is successfully located the plate numbers are 92.1%. This technique of locating the plate numbers is good for detecting plate numbers from different angles and distances. However, the general error during this process is due to bad quality of input image. By applying a useful pre-processing technique to enhance the image quality mitigate the errors based on the condition of the image.

One of the techniques conducted by Ragini Bhat and Bijender Mehandar (2014), where they used the morphological operations on the images and Sobel edge detection following by template matching for character recognition. However, this

technique could not recognize the unmaintained car plates, blurry images, and low resolution of the characters. It may be due to pre-processing phase which is not thorough for these situations of images.

An automatic vehicle number plate recognition system proposed by using structured elements. After undergoing pre-processing techniques, they used canny detection algorithm to detect the edges of the plate number and morphological operation applied to remove unnecessary objects in the image. After acquiring the desired plate number, the image segmentation is applied to separate the characters. By selecting correct threshold values, the characters are enhanced therefore only the alpha-numeric characters in the image is shown. With vertical blank areas between two different characters are used to separate them, each row and column data are stored. Characters are compared by the similarity of object or element. The proposed technique has the recognition rate of 92% for 150 different plate number images. Some failures are said to be the cause of abnormal size of the number plate or image of the car is too far (Islam et al, 2015).

R.Radha and C.P.Sumathi (2012), conducted a research for number plates written with contrast background and foreground. The extracted objects obtained after going through pre-processing step that requires the image to be converted into grey scale, they include median filtering to remove unwanted noise. All the objects are drawn bounding boxes around them and only characters in the connected objects are extracted. The test was conducted on 100 images and 95% of the images' number plates localized properly and 5% of it are rejected due to damages in the number plates.

Sarbjit Kaur and Sukhvir Kaur (2014) developed an efficient approach for number plate extraction. The approach that is used is noise removal by iterative bilateral filter, which is a nonlinear filter, contrast enhancement by using adaptive histogram equalization and morphological opening and image subtraction operation. The plate number then is enhanced by morphological dilation, erosion, and opening and closing operation. The extraction process of plate numbers is said to work well for low resolution, noisy and low contrast images with the success rate of 97.14%.

Enhancement can be made for the median filter. In a survey, there are several approaches on how to manipulate the median filtering method (George Ginu et al, 2018). The comparison study showed that threshold median filter is the better method for removal of noise from images. As the process only the noisy pixel thus helps to retain the features and edge of an image.

In addition, we have morphological filtering that is frequently used in plate number recognition system by the researchers. The dilation and erosion able to eliminate unnecessary detail in the image meanwhile opening and closing act as a noise filter that comes afterwards to reconnect the lines that has been separated by dilation and erosion operation. Another operation that can be used for shape detection is the hit-or-miss transformation. Morphological filtering can be applied to manipulate grey-scale such as smoothing, gradient, top-hat transformation, and textural segmentation. Morphological considered a powerful tool for extracting features of interest in an image (Srisombut, 2004).

There are other techniques that can be applied as a filter rather than just median filter and morphological filter. Frequency domain is another technique of filtering for image processing. Fast Fourier Transform developed by Jean Baptiste Joseph Fourier played an influential role in image processing. It consists of lowpass and high pass filter that can act as both noise-removal and edge preservation process, respectively (Makandar and Halalli, 2015). Lowpass will produce a Gaussian smoothing blur image meanwhile high pass filter will increase the contrast to sharpen the image.

Following that, various applications or tools are developed for image processing. They are MATLAB, GNU Octave, OpenCV, Scikit-Image and Scilab. Pattnaik (2018), MATLAB is the most of flexible software to perform image processing. The name MATLAB comes from "Matrix Laboratory", a fourth-generation high-level programming language developed by MathWorks(U.S). Every aspect of computational mathematics can be handled in MATLAB. Ragini Bhat and Bijender Mehandia uses this software to conduct their research. They exported the data into a text file for further analysis of the output. Although MATLAB is popular, it is not open source. License will be needed to use MATLAB and to acquire such license you would have to pay.

Rather than using a computer to do the plate number recognition, they also used mobile platform (Mutholib A. et al, 2012). Image was acquired using the camera available with the mobile, and it undergoes image processing such as contrast enhancement, filtering and in the end optical character recognition (OCR) for recognizing the plate numbers. On the other hand, another team that used a mobile device with OpenCV imported into the android program (Hung Ngoc et al, 2016).

The other software that is available for plate number recognition is OpenCV. It is an Open-Source programming library geared mostly at real-time computer vision.

It is written in the C++ programming language. Sweta Kumari, Leeza Gupta and Prena Gupta used this software for their automatic license plate recognition research on the computer. Under the open-source BSD licence, the library is cross-platform and free to use. System such as face recognition, gesture recognition, human-computer interaction, mobile robots, segmentation, and other uses of OpenCV.

2.4 Proposed Solution/ further project

Based on the previous system on plate number recognition, image filtering can help increase the readability of the plate numbers. Image filtering techniques on morphology filtering were used has helped improve the plate number to be recognized (Kaur Sarbjit and Sukhvir Kaur, 2014). According to Chandel and Gupta, image filtering allows for a variety of helpful image processing tasks. The project will be focused on the various technique of image filtering that is somewhat similar to each other in terms of its objective. Analysis will be conducted to get which technique produce the best result. The methodology on this project is image acquired will undergo several image processing before recognition phase such as converting RGB to grey scale, image filtering for three techniques, character segmentation and template matching for character recognition.

2.5 Conclusion

The chapter includes a profound understanding of how researchers tweak the plate number recognition system. Few software and hardware used are discussed and justification on the plan of this project. Plate number recognition will help understand the concept of image processing techniques and could be applied for other types of recognition such as fingerprint recognition, face recognition and so on. Next chapter will be talking about how the project will be done.

CHAPTER 3

PROJECT METHODOLOGY

3.1 Introduction

This chapter emphasis on the methodology of the project that was conducted. The analysis was based on the percentage of the characters that are correctly been recognized by the algorithm. Manually blurred plate number images were collected and used. The same collected images waas processed on all three different filtering techniques to find out which technique has the best recognition percentage.

3.2 Methodology

The project consist of 5 phases, converting image to grey scale, image filtering, image binarizing, detecting edges of image, character segmentation and character recognition. Figure 3.1 shown is the general approach to process the image in this project for plate number recognition.

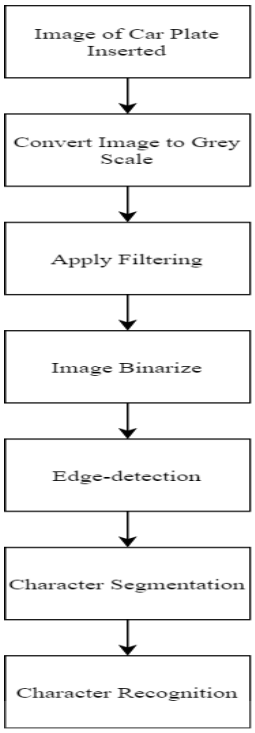

Figure 3.1 Phases of Image Processing

3.2.1 Converting RGB to Grey Scale:

The loaded image was checked to see if it is already in greyscale. If the output indicates that the image is RGB, then it converted to a grey level image. In MATLAB, a function called rgb2gray() can be called for grey level image conversion.

3.2.2 Applying Filtering:

At this phase, three different techniques were used which are median filtering, frequency domain filtering and morphological filtering. Figure 3.2 shows the three technique that was used under apply filtering step. These filters have a similar goal, but they take a different technique to achieve it. By filtering the image can help image to reduce the noise for better object detection (smoothing). This step also includes the manipulation of the image to become distorted. The technique used to revert the image back to normal is called Deconvolution-Lucy and Edge Taper which is an additional

technique added specially for manually blurred images. Figure 3.3 shows the flow of the technique for blurry images.

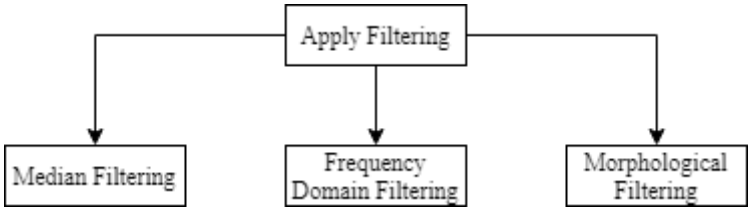

Figure 3.2 Three techniques used under apply filtering method

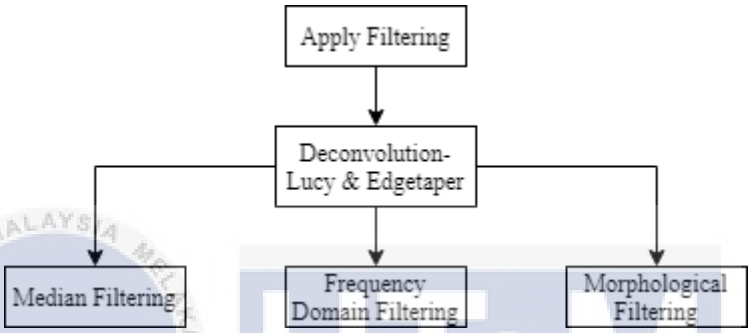

Figure 3.3 Deconvolution-Lucy and Edgetaper technique

3.2.3 Edge-detection:

Edge detectors technique used was Canny. There are other kinds of edge detector technique can be used. Each of them is used in a variety of situations and issues. In this project, Canny were chosen to help detect the plate number's edges.

3.2.4 Image Binarization:

As for binary image, it contains only two colours such as black and white. There are variety of threshold approaches for binary image. Working with a binary image is more convenient. For this project, Otsu’s method will be used to convert the grey image into binary image.

3.2.5 Character Segmentation:

After knowing each character edges, character segmentation will be done by bounding box technique. Because all subsequent phases rely on segmentation, it is one of the most crucial stages in number plate recognition. Following the creation of a bounding box over each character and number exhibited on the number plate, each character and number is separated out for number plate identification.

3.2.6 Character Recognition:

The last step is to recognize the characters that is in the image. Template matching consist of images of each character which is already in the database. The validity of the correct characters recognized was also checked based on the database consisting of the car plates matched with their car plate image. A matching process will be carried out by each character. It transfers the template picture to every conceivable point in a bigger source image and calculates a number index that shows how well the template matches the image in that spot. Pixel-by-pixel matching is carried out in template matching technique.

3.2.7 Analysis:

Based on the past's project, performances of the recognition were calculated by calculating how many correct characters has been recognized divided by the total number of characters in the image. As the number of characters recognized correctly increases, the percentage and performance of the technique increases.

3.3 Project Milestones

The project planning and milestone of this project is shown in Table 3.1. The milestones are prepared to make sure the project runs smoothly and on time.

Table 3.1 Project Gantt Chart

Activity\Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Proposal Assessment & Verification															
Proposal Submission and Approval															
Proposal presentation															
Introduction of project															
Literature Review															
Project methodology															
Implementation & Analysis															
Project Demo															
Final Presentation															

The 1st to 3rd week of project, a proposal was sent out to supervisor for their approval of topic and scope of the project. The supervisor has overseen and rectify the project's objectives, and the supervisor has sign off on them as approved. Afterwards, the supervisor's accepted proposal was presented to the final year project committee, who has decided whether to pursue the proposed topic or request a change of topic.

Subsequently, the project development must be started by 4th week. The introduction of the project stated clearly on the objective of the project as well as the project's contribution. A review of previous works and other relevant topics was conducted to aid the project. After done reviewing, project methodology was thought as a draft for upcoming project implementation. Logbook was used to keep track of any changes or remarks. Finally, a project demo was presented to the supervisor for further improvements.

3.4 Conclusion

Finally, project milestones are critical for this project. Keeping track of the project's development could aid in meeting the project's deadline. Following that, the methods were laid out in Chapter 4.

CHAPTER 4

IMPLEMENTATION

4.1 Introduction

In this chapter, the execution of the project was done by following the methodology stated in Chapter 3. Algorithm applied on each filtering technique was shown as well as its source code. Median filtering, Frequency Domain Filtering and Morphological Filtering technique analysis were done in a simulation environment.

4.2 Environment Setup

The analysis was conducted on MATLAB R2020b version. Images was manually blurred in this project. The images are collected from the internet which is from platerecognizer.com that was free to use and a few from previous research The simulation will be done in a laptop. The laptop specification is as Figure 4.1.

Figure 4.1 Snippets of Laptop's specifications

4.3 Implementation

In this part, each step said in Chapter 3 source code were shown. The three filtering technique was adjusted based on the image's requirements.

4.3.1 Convert to Grey Scale source code

The Figure 4.2 is the source code during the 'Convert to Grey Scale' phase which change the image contains only black, white, and grey colours in which grey has multiple levels. The source code reads the image and check if the image is in RGB and convert it.

```
im = imread('Number Plate Images/img3.jpg');
imgsize = size(im);
%im = imresize(im, [570 NaN]);
%imgsize = imresize(im,0.5);
subplot(2, 3, 1);imshow(im);title('Resize image');
[rows, columns, numberOfColorBands] = size(im);
if numberOfColorBands > 1
    imgray = rgb2gray(im);
else imgray = im;
end
%only uncomment this when ur plate number is white
%imgray = uint8(255) - imgray;
subplot(2, 3, 2);imshow(imgray);title('Image grayscale');
```

Figure 4.2 Snippets of conversion of RGB to Grey Scale Level

4.3.2 Deblurring Image Sample

The Figure 4.3 shows the snippet of source code used to revert the blurred images back to normal. The technique used in this project is Deconvolution-Lucy with the help of edgetaper() technique to reduce the 'ringing' of the images

```
blurrnoisy = edgetaper(blurrnoisy,PSF);

%---Using Lucy Deblurring techniques---%
luc1 = deconvlucy(blurrnoisy,PSF,it);
%figure(2);subplot(2,2,1);imshow(luc1);title('Restored Image using Lucy')
```

Figure 4.3 Snippet of Deconvolution-Lucy and Edgetaper

In this project, the image was manually distorted indicate a bad car plate image such as motion that needs to be processed. Figure 4.4 shows the example of distorted car plate image that will be used. Additional technique used to improve the image is Deconvolution-Lucy to reduce the image distortion. Figure 4.5 shows the sample after undergoing Deconvolution-Lucy.

Figure 4.4 Image sample after undergoing manual distortion

Figure 4.5 Sample after undergoing Deconvolution-Lucy technique

4.3.3 Morphological Filtering

The Figure 4.6 shows the morphological filtering technique. There are few approaches can be used. By using the imopen() function from Image Processing

Toolbox, the image will go through erosion followed by dilation. The function uses the same structuring elements for both operations.

```
% se=strel('disk',1);
% g = imdilate(g,se);
% subplot(2,4,3);imshow(g);title('Dilate morphological');
%
% se2=strel('disk',1);
% g = imerode(g,se2);
% subplot(2,4,4);imshow(g);title('Erode morphological');

 se=strel('disk',1);
g = imopen(g,se);
 subplot(2,4,4);imshow(g);title('Open morphological');
```

Figure 4.6 Snippets of Morphological Filtering code

4.3.4 Frequency Domain Filtering

Figure 4.7 shows the source code for the frequency domain filtering. The code is referenced from the Digital Image Processing Using MATLAB book. The function fft2() returns the 2D Fourier transform using a fast Fourier transform algorithm. The function lpfilter() is the lowpass filtering function.


```
%#############Image Filtering#################%
PQ = paddedsize(size(im));
F = fft2(im, PQ(1),PQ(2));
H = lpfilter('gaussian',PQ(1),PQ(2),1*PQ(2),0);
%H2 = lpfilter('gaussian',PQ(1),PQ(2),0.03*PQ(2),0);
g = dftfilt(im,H);
%g2 = dftfilt(im,H2);

figure(1), imshow(fftshift(H),[ ]);
figure(2), imshow(log(1 + abs(fftshift(F))),[ ]);
imgray=cast(g,'uint8');
subplot(2, 3, 1);imshow(imgray);title('Image grayscale');
subplot(2,3,2);imshow(imgray);title('Image after apply FD blurr');
```

Figure 4.7 Snippets of Frequency Domain Filtering code

4.3.5 Median Filtering

Figure 4.8 shows source code used for the median filtering in this project. The function used is called medfilt().

```
%#############---Applying Filter (Nonlinear)---################

imblurr = medfilt2(imgray,[3 3]);
subplot(2, 3, 3);imshow(imblurr);title('Image blurr to reduce noise');
```

Figure 4.8 Snippets of Median Filtering code

4.3.6 Image Binarization

Meanwhile, Figure 4.9 is the source code on conversion of image to binary. The function used is called imbinarize(). The parameters used is adaptive, foregroundPolarity, dark and Sensitivity which in this case 0.4.

```
%############Image Binarization#################%

imbin = imbinarize(l,'adaptive','ForegroundPolarity','dark','Sensitivity',0.4);
```

Figure 4.9 Snippets of Image Binarization code

4.3.7 Edge Detection

Figure 4 10 is the edge-detection source code used in this project. The function used is edge(). The parameters used is 0.3 for the threshold of the edge and 4 for the sigma.

```
%#############---Edge-detection---#############
%use highpass here for edge detection
im = edge(luc1, 'canny',0.3,4);
```

Figure 4.10 Snippets of Edge-detection using Canny.

4.3.8 Character Segmentation

Next, Figure 4.11 is the source code of the character segmentation where after detecting the edges of the characters, unwanted part was cut out of the image.

```
%#############---Find the characters---#############
%Below steps are to find location of number plate
Iprops=regionprops(im,'BoundingBox','Area', 'Image');
area = Iprops.Area;
count = numel(Iprops);
maxa= area;
boundingBox = Iprops.BoundingBox;
for i=1:count
   if maxa<Iprops(i).Area
       maxa=Iprops(i).Area;
       boundingBox=Iprops(i).BoundingBox;
   end
end

im = imcrop(imbin, boundingBox);%crop the number plate area
subplot(2, 3, 6);imshow(im);title('After cropping number plate area');
im = bwareafilt(~im,500);
%im = bwareaopen(~im, 500); %remove some object if it width is too long or too small than 500
figure(1);imshow(im);
```

Figure 4.11 Snippets of Character segmentation

4.3.9 Character Recognition

Figure 4.12 is the source code of on for character recognition where template matching function is called to match the characters patterns for identification.

```
for n=1:Ne
    [r,c] = find(L==n);
    n1 = imbin2(min(r):max(r),min(c):max(c));
    n1 = imresize(n1,[42 24]);
    %imshow(n1);
    letter=Letter_detection(n1); % Reading the letter corresponding the binary image 'N'.
    noPlate=[noPlate letter] % Appending every subsequent character in noPlate variable.
    pause(0.2)
    x =[ ];
end
```

Figure 4.12 Snippets of Character Recognition using Template Matching

Lastly, Figure 4.13 is the phase of collection of data after recognition for further analysis on how many percentages of the correctly recognized characters. The data is saved as a CSV file as shown in Figure 4.14.

```
for i=1:row
    for j=1:col
     if isequal(asciiknown(i,j),asciitest(i,j))
         similarity = similarity + 1;
     else
        similarity = similarity;
     end
    end
end

percentage = (similarity / col) * 100;
  end
perc2 = string(percentage);
output = msgbox('Successfully recognized rate: '+ perc2  +'%','Percentage of recognization');

  platecell = cellstr(noPlate);
  perccell = cellstr(perc2);
  data =[platecell perc2];
  filename = 'D:\FYP\fyp-plate-number-recognition\platenumberMorph.csv';
  writematrix(data,filename,'WriteMode','append')
```

Figure 4.13 Snippets of counting characters recognized code and saved as CSV file

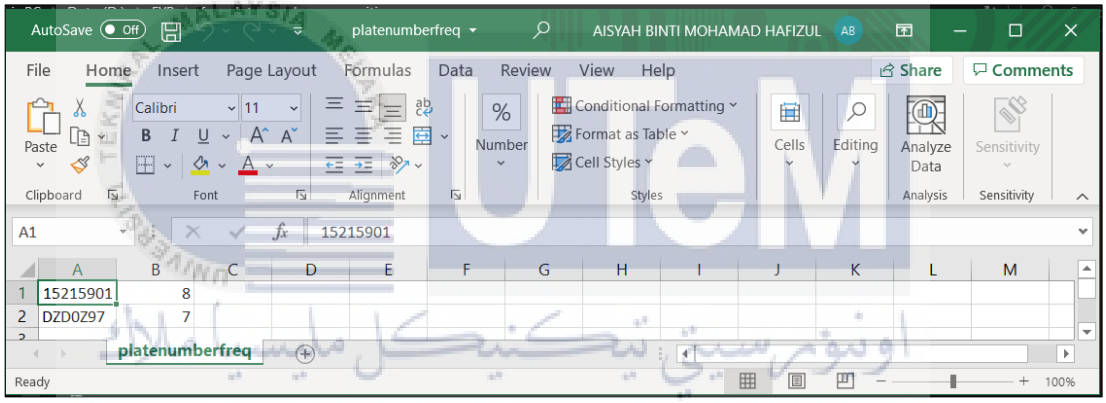

Figure 4.14 Snippets of example of CSV file with data

Figure 4.15 and Figure 4.16 is one of the plate number image samples. Figure 4.17 is one of image sample that has been distorted.

Figure 4.15 Snippets of Image Sample 1

Figure 4.16 Snippets of Image Sample 2

Figure 4.17 Snippets of Image Sample distorted.

Figure 4.18 until Figure 4.20 is example of each phases' image of the car license plate number recognition.

Figure 4.18 The output for each process on Morphological Filtering

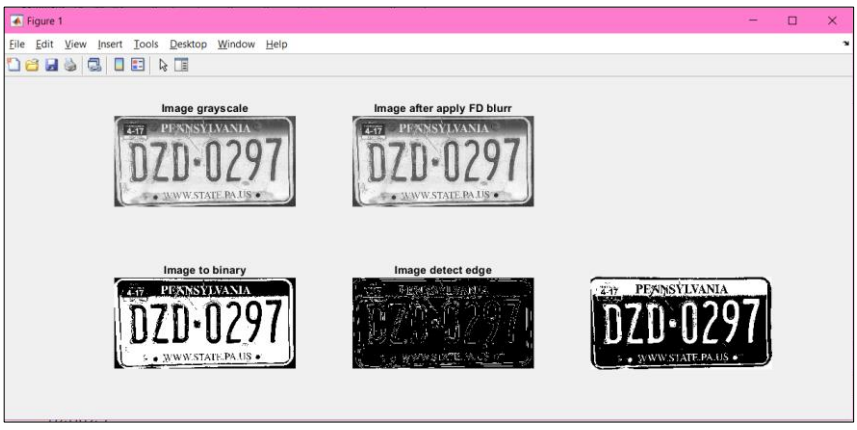

Figure 4.19 The output for each process on Frequency Domain Filtering

Figure 4.20 The output for each process of the image on Median Filtering

Lastly, a message box popped out showing the characters recognized by the algorithm is shown in Figure 4.21. Figure 4.22 is the example of message box popped out showing the recognition rate of image

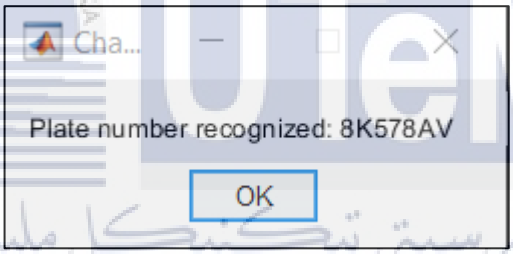

Figure 4.21 Example of characters recognized

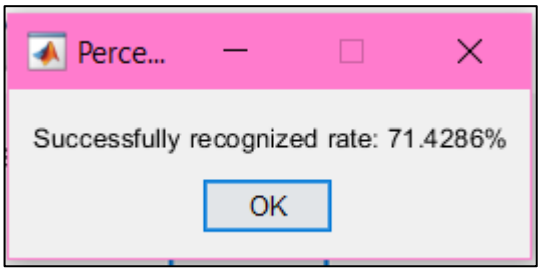

Figure 4.22 Example of Recognition rate

To check the validity of the object, we use MATLAB in-built database that holds the file path of the image linked with its characters. The data was first saved in excel and imported into MATLAB. The sample of data can be found in Appendix. The recognition percentage is calculated as below:

$$Percentage = \frac{total\ correct\ characters\ recognized}{total\ characters\ in\ the\ car\ plate}\ x\ 100$$

4.4 Conclusion

The implemented techniques for this project are showed in this chapter by using MATLAB R2020b. Three filtering technique consist of median filtering, frequency domain filtering and morphological filtering. The result of the image was shown in the MATLAB and recognized characters are recorded and saved into CSV file. In the next chapter, the result data will be analysed, discussed, and calculated.

CHAPTER 5

RESULTS AND ANALYSIS

5.1 Introduction

This chapter is a discussion on how the results was captured, the activity done to achieve the objectives. The test plan on conducting the research is explained in this chapter including the classes of test, design of the test, the test data, and the result with analysis. The analysis was based on 30 still and blurred images of plate numbers to be used on each three different techniques. The condition of each image was kept the same throughout the three techniques to acquire consistency of the result.

5.2 Test Plan

The plan to conduct the research is crucial to keep the accuracy and consistency of the research output. The test plan shows the personnel involved conducting the research, the environment, and the schedule of the testing.

5.2.1 Test Organization

The research is conducted by Aisyah Binti Mohamad Hafizul and is supervised by Dr Othman Mohd.

5.2.2 Test Environment

Test environment is the components that helps with executing the research such as the software and the hardware. The testing was done using personal laptop and MATLAB application. The database for template matching is done in ready-made

MATLAB database consist of alphabets and numbers of samples for recognition. The data set used to conduct the research is taken from platerecognizer.com and some of researcher's personal car plate numbers. Table 5.1 presents the hardware specification that is used during the testing phase. Meanwhile, Table 5.2 shows the software used to conduct the research.

Table 5.1 Test Environment of Hardware Components

Environment Specification	Description
Model	Illegear
Processor	AMD Ryzen 7
Display	15 inch (1920 x1080)
Storage	500GB
Random Access Memory (RAM)	16GB

Table 5.2 Test Environment of Software

Environment Specification	Description
Database	Internal MATLAB & Microsoft Excel
Operating System	Windows 10
Development Tool	MATLAB
Documentation	Microsoft Word

5.2.3 Test Schedule

Test schedule is timetable of the testing being conducted to achieve the output of the project based on the objectives. The objective of the project is to find which is the best technique for car plate number recognition. There are three different techniques will be conducted. Table 5.3 shows the test schedule for the research.

Table 5.3 Test Schedule in Car Plate Recognition

Technique	Description	Start Date	End Date
Median Filtering Technique	The test for 30 images will be conducted using Median Filtering techniques to achieve the best possible outcome of the plate number recognition rate	25 July 2021	18 August
Frequency Domain Filtering Technique	The test for 30 images will be conducted using Frequency Domain Filtering techniques to achieve the best possible outcome of the plate number recognition rate	2 August 2021	18 August 2021
Morphological Filtering Technique	The test for 30 images will be conducted using Morphological techniques to achieve the best possible outcome of the plate number recognition rate	2 August 2021	18 August 2021

5.3 Test Strategy

Test strategy used in this project is analytical strategy where the best method for car plate recognition was clarified. Each image recognition rate was saved and the total percentage for each technique with 30 image samples was calculated to get the average percentage. The average percentage of the recognized characters taken notes. The condition of the images was based on known blurred images and normal non-blurred image. The illumination of the image was also be considered in the test. The strategy of the test is white-box classes of test.

5.3.1 Classes of Test

There are two types of test class that is implemented for this testing process in Car Plate Recognition.

i. Accuracy of Recognition
   a. This testing will see the correctness of the characters recognized after detecting the car plate and provide the percentage of the recognition.

ii. Detection of Plate Number
   a. This testing will check the discovery of the plate number position in each method.

5.4 Test Implementation

In conducting this testing, there are a few testings has conducted. The test implementation consists of test description and test data.

5.4.1 Test Description

The project needs MATLAB R2020b version to conduct the analysis. In the MATLAB, Image Processing Toolbox is required. It can be installed after installing MATLAB. The image is saved into Number Plate Images folder meanwhile the image sample of characters are in Alpha folder.

5.4.2 Test Data

The data of this research is the still images of the car plate number. There were 30 still images used. Between the images, only 15 of them was manipulated to be blurry or distort the images. The image went through extra technique to restore the state of the image (Deconvolution-Lucy). The Figure 5.1 is normal state of the image to be processed using the three different filtering techniques.

Figure 5.1 Sample Image Data

Meanwhile, Figure 5.2 is one of the samples that is used to blur (distort) the image as shown in Figure 5.3.

Figure 5.2 Sample Image Data 2

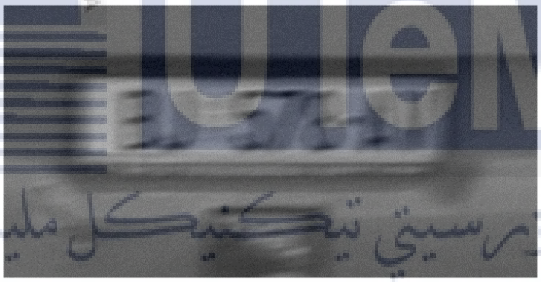

Figure 5.3 Sample Image Data 3 (Blurred Image)

The blurred image was reverted to normal by using Deconvolution-Lucy and Edgetaper technique as said in Chapter 4 to deblur the image and move on to using three different techniques to recognize the car plate numbers.

5.5 Test Results and Analysis

In this chapter, the data collected was analysed and compared to conclude the best technique between Median Filtering, Frequency Domain Filtering and Morphological Filtering. The three different techniques, 30 images of the car plate number recognition percentage are shown in the histogram graph provided. Figure 5.4

is the histogram graph of Median Filtering technique. Each image's recognition rate and the average of the result was noted. The three histograms are the percentage of recognition for each image tested.

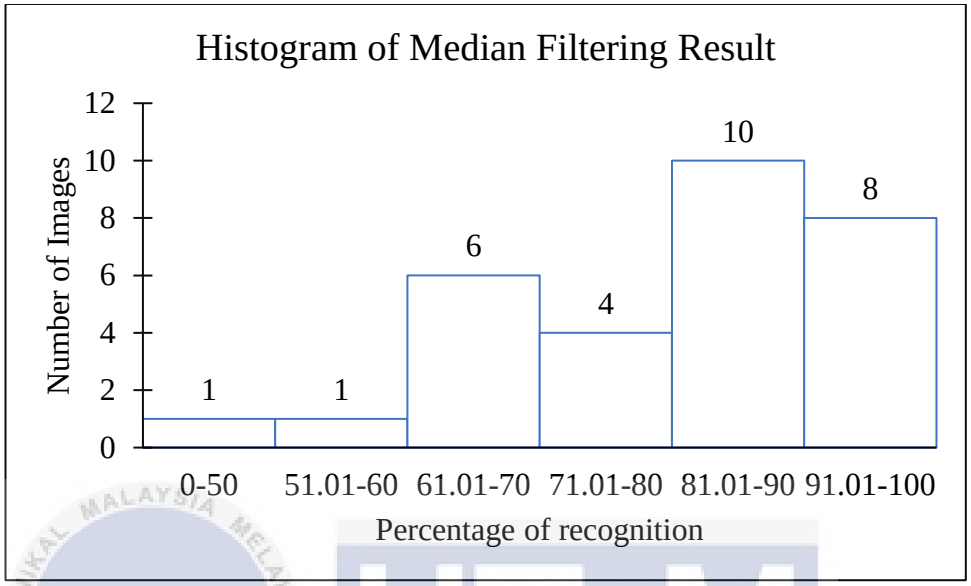

Figure 5.4 Histogram Graph of Median Filtering Result

The result coming from the median filtering technique shows that 8 out of 30 images recognized between 91.01 to 100% of the characters' correctly. Other than that, between 81.01 to 90% of the characters that correctly recognized is 10 out of 30 images. 4 out 30 images were recognized 71.01 to 80% of the characters and 6 out of 30. Meanwhile, both 0 to 50% and 51.01 to 60% has 1 out of 30 images recognized correctly. Hence, by using median filtering technique the outcome of the recognized characters is most likely to be between 80 percent and above.

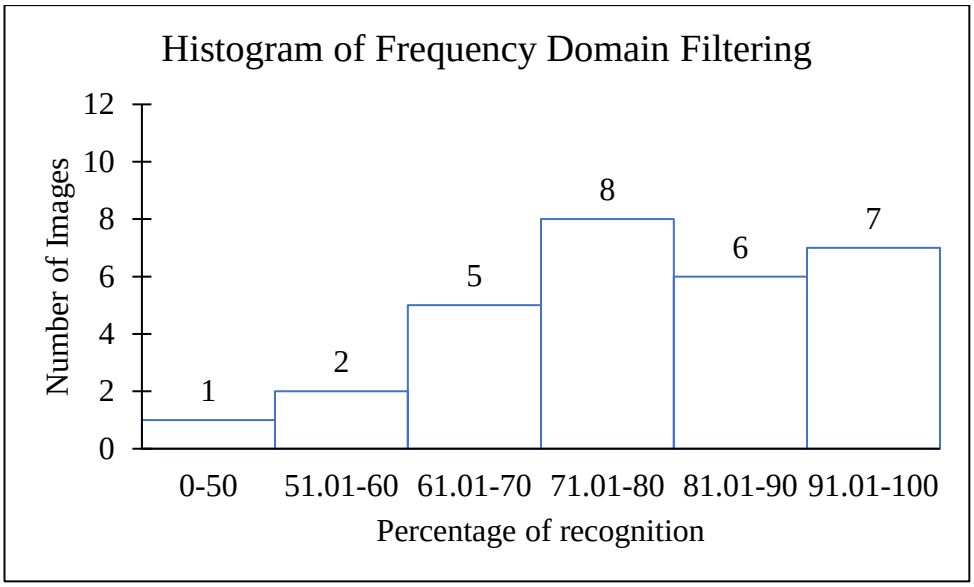

Figure 5.5 Histogram Graph of Frequency Domain Filtering Result

As for result of frequency domain filtering technique, the number of images' character recognized is between 71.01 to 80% with 8 out of 30 images. With only 1 difference from it, correctly recognized characters with 91.01 to 100% with 7 out of 30 the image samples. Next, 6 of the images returned with the result of 81.01 to 90% of recognition and 5 of the images results are between 61.01-70%. By using this filtering technique, 2 of the image sample returned between 51.01 to 60% of recognition rate and only 1 image returned between 0 to 50%. Therefore, the highest rate of recognition for frequency domain filtering technique is with 8 of the images is between 71.01 to 80% of correctly recognized characters.

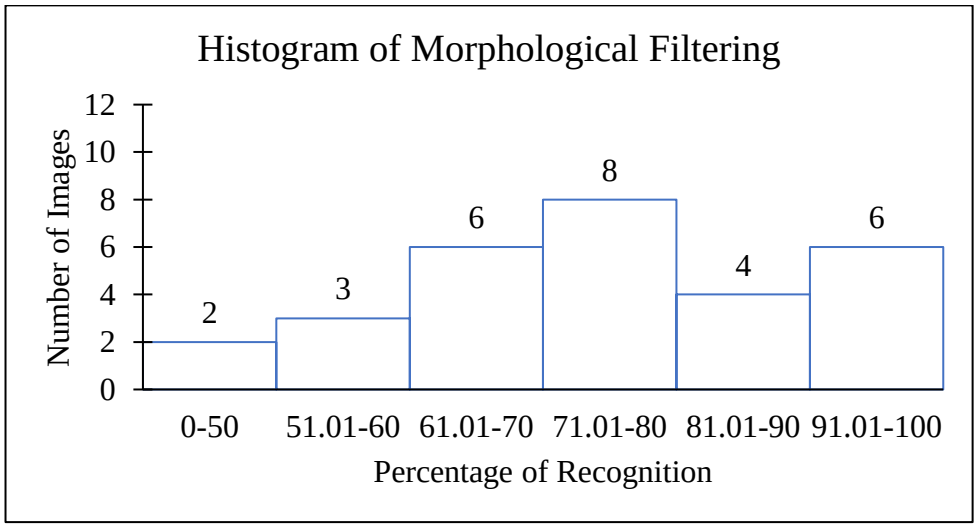

Figure 5.6 Histogram Graph of Morphological Filtering Result

Results of morphological filtering is as shown in the Figure 5.6. The number of image samples is between 71.01 to 80% with 8 images. Other than that, the result was tied with 6 images for 61.01 to 70% and 91.01 to 100%. As for 81.01 to 90% of recognition of characters has 4 out of 30 images. The morphological technique has 3 images with 51.01 to 60% of correctly recognized characters meanwhile the lowest average percentage of 0 to 50% recognition is 2 of the image sample. Thus, the highest average percentage of number of images recognized is 71.01 to 80%.

Table 5.4 Total Average Percentage of All Image Sample

Techniques	Median Filtering	Frequency Domain Filtering	Morphological Filtering
Average %	81.7	79.4	75.3

The average percentage was calculated by the sum of each image sample's average recognition percentage. Based on Table 5.4, median filtering technique is on the lead with only 0.2% difference from frequency domain filtering technique. Morphological filtering's result with 75.3%, placed last meanwhile median filtering and frequency domain filtering's result are 81.7% and 79.4 respectively.

$$Average\ Percentage = \frac{total\ percentage}{total\ image\ sample}\ x\ 100$$

During the testing phase, frequency domain's technique most likely to diminish the character's edges. Therefore, some characters were recognized incorrectly. Some of the car plate numbers are hard to discover due to frequency domain's technique. Based on Makanda and Hallali (2015), the technique both can be used for edge preservation and blur it can reduce the number of unwanted objects. However, there are certain condition whereby the images could lose more than wanted.

Meanwhile, morphological filtering technique which was said by Srisombut (2004) that morphological considered a powerful tool for extracting features of interest in an image. The technique is considered has the least average percentage of recognition between the other two techniques in this research. The morphological technique used in this research is for smoothing the images, but it still holds unwanted

information. There was a chance that car plate was not detected due to similar edges of others

Next, median filtering which has the highest average percentage of recognition managed to get the most out of the three. Median filtering retains the edges of the car plate number and the edges of the characters which make the recognition increases but also smooth the images. There are few images which was hard to distinguish the car plate number's edges. Therefore, the characters could not be recognized due to incorrectly detection of car plate numbers. Median filtering was said to have different ways to manipulate the median filtering technique (George Ginu et al, 2018).

5.6 Conclusion

In conclusion, after analysing and running the simulation to achieve the objectives, median filtering has the highest average percentage, frequency domain filtering is placed second and morphological filtering is placed last. Even though there are few flaws in the research, it will be considered for the future research. The next chapter will discuss the limitation of the project and overall conclusion of this project.

CHAPTER 6

CONCLUSION

6.1 Introduction

This chapter bring both the project and the project report to a close. The synopsis of the project and its contribution will also be included. Aside from that, the limitations of what this undertaking entails will be discussed. Future system upgrades were discussed, as well as suggestions for future improvements. The chapter finally come to a close.

6.2 Project Summarization

In this project we had three objectives. These objectives provide solutions to the respective problem statements drawn from the project's questions. The first project's goals are to identify the techniques of plate number recognition. After doing several readings on past researchers, the basic technique to create a plate number recognition is to convert the image to grayscale, we would apply filtering to the image depending on the need of the situation of the image then be converted into binary image which represents the 1s and 0s or black and white. From there identifying the car plates and character recognition.

The second objective of the project is to implement three techniques of plate number recognition using morphological filtering, frequency domain filtering and image filtering techniques. There are various ways of filtering the image and this project will evaluate between three chosen filters that is used. Different filters have different output of the image after being manipulated. Thus, each technique will be analysed.

The third objective is to evaluate the best techniques of the plate number recognition based on those three techniques. The analysis started with 30 of still images of car plates undergoing three different techniques as mentioned. The number

of characters correctly recognized was shown in percentage. Afterwards, the average percentage of the whole image output was calculated and thus the highest average percentage of the three technique is considered the best technique out of the three.

6.3 Project Contribution

A study of the methodologies utilised for car plate recognition is the project's main contribution. This involves presenting MATLAB approaches for learning about car plate recognition techniques. The project considers the fundamental technique in order to make sure the car plate recognition work as it usually would.

Aside from that, going through three strategies that have been discovered through previous research literature evaluations. Other strategies that can be utilised to perform a similar process to established car plate recognition algorithms are included. The median filtering technique, frequency domain technique, and morphological filtering technique are the three techniques.

The project's other contribution is the identification of the best techniques between three techniques. Following the execution of the three procedures, a judgement will be drawn as to which methodology produces the best output of the three. The analysis' outcome is shown. Each technique was described in detail, including its advantages and disadvantages.

6.4 Project Limitation

Every project is bound by its own set of restrictions. Only static photographs and images that have been manually blurred are being examined for this research. Aside from that, due to the project's short deadline and pandemic, the project sample is rather limited. Next, the character database is tiny, resulting in erroneous character recognition due to the many types of car plate fonts. It's difficult to distinguish between characters who are similar such as D and 0. Other than that, the image that is too dark or has slight sunlight on the car license plate was hindering the recognition of the characters

6.5 Future Works

In the near future, we will capture the image of moving autos utilising real-time video rather than static images. Identifying the best strategy for recognising characters in non-still images. Aside from that, a range of fonts, such as different types of cursives, bold, or small letters, are utilised as car plate numbers and improve the readings of similar characters. Then, employ a larger sample size to make the research statistically significant.

6.6 Conclusion

To sum it up, the project's goals were met satisfactorily. The investigation of car plate recognition techniques is known and documented in the project paper. We discovered that different types of filtering strategies can generate distinct outputs of the automobile plate identification. With the intention of expanding the studies of car plate recognition in the future.

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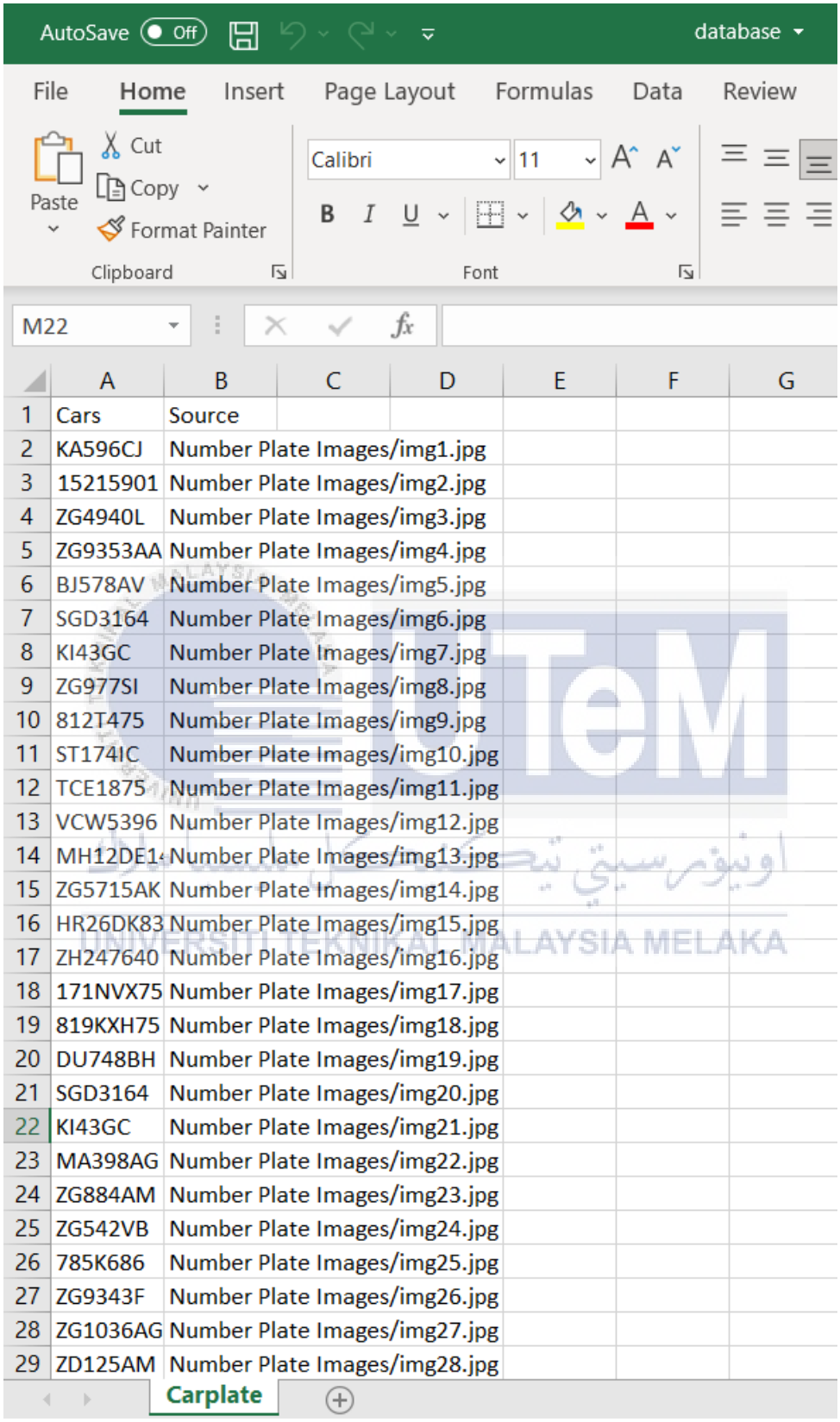
Appendix



AutoSave Off database

File Home Insert Page Layout Formulas Data Review

Paste Cut Copy Format Painter Clipboard

Calibri 11 Font

M22

	A	B	C	D	E	F	G
1	Cars	Source					
2	KA596CJ	Number Plate Images/img1.jpg					
3	15215901	Number Plate Images/img2.jpg					
4	ZG4940L	Number Plate Images/img3.jpg					
5	ZG9353AA	Number Plate Images/img4.jpg					
6	BJ578AV	Number Plate Images/img5.jpg					
7	SGD3164	Number Plate Images/img6.jpg					
8	KI43GC	Number Plate Images/img7.jpg					
9	ZG977SI	Number Plate Images/img8.jpg					
10	812T475	Number Plate Images/img9.jpg					
11	ST174IC	Number Plate Images/img10.jpg					
12	TCE1875	Number Plate Images/img11.jpg					
13	VCW5396	Number Plate Images/img12.jpg					
14	MH12DE1	Number Plate Images/img13.jpg					
15	ZG5715AK	Number Plate Images/img14.jpg					
16	HR26DK83	Number Plate Images/img15.jpg					
17	ZH247640	Number Plate Images/img16.jpg					
18	171NVX75	Number Plate Images/img17.jpg					
19	819KXH75	Number Plate Images/img18.jpg					
20	DU748BH	Number Plate Images/img19.jpg					
21	SGD3164	Number Plate Images/img20.jpg					
22	KI43GC	Number Plate Images/img21.jpg					
23	MA398AG	Number Plate Images/img22.jpg					
24	ZG884AM	Number Plate Images/img23.jpg					
25	ZG542VB	Number Plate Images/img24.jpg					
26	785K686	Number Plate Images/img25.jpg					
27	ZG9343F	Number Plate Images/img26.jpg					
28	ZG1036AG	Number Plate Images/img27.jpg					
29	ZD125AM	Number Plate Images/img28.jpg					

Carplate