

**NIGHT-TIME ANIMAL RECOGNITION SYSTEM USING DIGITAL IMAGE
PROCESSING**

By

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FINAL PROJECT REPORT

Submitted to the Department of Electrical & Electronic Engineering
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronic Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Department of Electrical & Electronic Engineering
Universiti Teknologi PETRONAS
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Approved:

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TRONOH, PERAK

September 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

TAN FENG JIE

ABSTRACT

Animal-related accidents always haunted the road users in Malaysia. Victims and animals involved in animal-related accidents are either injured or lost their lives. This project proposes to develop a buffalo detection system to alert drivers by using the image processing technique during night-time. With this system, drivers will be able to have sufficient time to avoid collision with the animals. Various MATLAB image processing techniques are used to perform the buffalo recognition in this project.

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LIST OF ABBREVIATIONS

MIROS	Malaysian Institute of Road Safety Research
IR	Infrared
USA	United States of America
ROI	Region of Interest

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Since the first modern automobile car was invented by Karl Benz in 1886 [1], automotive industry has rapidly grown responded to the high demand. Car has become a daily necessity for travelling. However, high population of road users also bring about 1.2 million death each year as result of road accident [2].

Road accident is one of the major causes of death and injuries. According to Malaysian Institute of Road Safety Research (MIROS), some common factors caused the road accident are fatigue, overloading, risky driving, speeding, conspicuousness, driving under influence of alcohol, brake defect, road defect, tyre defect and etc [3]. Table 1 shows the statistic of road accidents happened in Malaysia in 2008, 2009 and 2010. From the tabulated data, the total of road accidents within these three years is up to 1,184,822 cases and the road deaths can be rounded up to 20,000 cases. Based on the table, the amount of road accidents is increasing every year. Statistics also shows the road accidents has resulted RM 7.8 billion losses which is equivalent to 1.5 percent of the Gross Domestic Product (GDP) [4].

Year	Population	Vehicles Registered	Vehicle Involved	Road Length	Road Accidents	Road Casualties	Road Deaths	Vehicle Ownership (<i>Person per vehicle</i>)
2008	27,730,000	17,971,901	671,078	73,419	373,071	32,274	6,527	1.5
2009	28,730,000	19,016,782	705,623	100,002	397,330	31,417	6,745	1.5
2010	28,910,000	20,188,565	760,433	111,378	414,421	28,269	6,872	1.4

Table 1: General Road Accident Data in Malaysia (2008-2010) [5]

Among the reasons of road accident, animal-related road accident is the cause of traffic crash which is unavoidable with human effort. Animals always appear on the road and resulted road accident. According to Natural Resources and Environment Ministry, Malaysia currently maintains more than 50 percent of the lands under forest cover [6]. Figure 1 shows the road coverage in Malaysia. The yellow boxes in the map indicate the important town in each state. Referring to the map, the road network which is away from the towns is comprised of rural and forest areas.



Figure 1: Major Road Network of Peninsular Malaysia [7]

Malaysia is a country with high population of stray animals appears on the roadway [8]. The common stray animals often seen on the roads include cows, water buffalos, tapirs, wild boars, dogs, monkeys and goats [9]. In the vast majority of the accidents are involved of livestock and household pets without the surveillance of owners or the attention of the road users.

Among of all, cows and buffalos are the most potential animals that impose the dangerous driving condition to the road users due to its large size, dark colour, and also the high frequency it appearance on the Malaysia roadway [10] as shown in figure 2 and 3. For those drives who did not realize the existence of animals on the road will eventually hit the animals or perform emergency turn or brake to avoid the animals.



Figure 2: Ambulance was crashed after hitting cow at Labok [11]



Figure 3: Young man is dead after hitting a buffalo in Terengganu [12]

Not only in Malaysia, countries like United States of America (USA) and Australia also facing animal-related accident issues. Table 2 and 3 show the statistics of road accident caused by animal in USA and Australia, respectively. Only in two years period, USA has suffered the losses up to \$4 billion. On the other hand, Queensland of Australia has total loss of around \$0.14 billion in five years. Those losses in terms of life and money are definitely not good for the growth of country.

Country	Time Period	Casualty Type	Number	Category	Total Loss
USA	2011-2012	Fatal Crash	200	Hit animal	\$4 billion

Table 2: United States of America (USA) Road Accident Statistics [13]

State, Country	Time Period	Casualty Type	Number	Category	Total Loss
Queensland, Australia	2001-2005	Fatal Crash	16	Hit animal	\$142,524,000
		Serious injury	649		
		Slight injury	981		
		Property damage	1551		

Table 3: Queensland, Australia Road Accident Statistics [14]

1.2 Problem Statement

Problem Identification

The rapid development of road without taking consideration of animal traffic is one of the main factors that causing animal-related accidents. It's animal behavior to move from one place to another place to searching for food and shelter. Therefore, animal like buffalo is frequently found crossing road in Malaysia. Besides, irresponsible buffalo owners allowing their buffalo wandering at the traffic area due to the scarcity of grass, grazing land, lack of cost and insufficient of manpower has imposed the risk to drivers to involve in animal-related accident.

Human factor is undeniable another main factor causes the animal-related accident. The fact is most of the times drivers have insufficient time to react or stop the vehicle when they realized the existence of animal on the road. Due to the limited street light and dark colour appearance of animals, drivers are usually unable to discover the existence of animals earlier during night-time. In order to prevent the losses of life of drivers and animals, a system to assist the driver to detect the far distance animal is needed.

Key Statements:

- Road users have vision limitation to discover the far distance animal in front of car during night-time.
- Imperfection of Animal Road Sign:
 - Hardly to be noticed during night-time
 - Not all wildlife crossing location has animal road sign.
 - Lack of maintenance
- No cost effective solution to keep wild/stray animals away from road.

Significant of the Project

Since there is no proper enforcement or solution to prevent animal crossing road, animal recognition system can assist drivers to discover the far distance animal earlier during night-time so that driver have enough time to take proper action to avoid the collision with the animal. The project aims to initiate an animal recognition system

by applying image processing techniques to identify, extract and perform pattern recognition of animal on night-time images.

1.3 Objectives

In this project, buffalo is chosen as the animal to develop the animal recognition system. Buffalo has characteristics that make it always involved in serious animal-related accidents in Malaysia like dark appearance, big in size and active rate of road crossing. This system will not be restricted by just detecting buffalo. By enriching the image library, the animal recognition system is able to detect any kind of animal.

There are three (3) objectives to be achieved in the end of this project:

- To perform buffalo recognition on night-time images.
- Detect the animal presence to reduce the requirement of animal signs on road.
- To determine the percentage of matching and time-efficiency of the animal recognition system on various patterns of buffalo.

1.4 Scope of Study

This project will focus on the following topics:

- I. Apply image processing techniques to perform buffalo recognition on static images. The required techniques are:
 - i. Noise Filtering (Image Enhancement)
 - ii. Edge Extraction
 - iii. Features Extraction
 - iv. Pattern Recognition
 - v. Selection of region of interest (ROI)
 - vi. Template Matching

- II. Initiate the animal recognition system by developing MATLAB code that can perform the buffalo recognition on static images.

1.5 The Relevancy of the Project

The disadvantages brought by the animal-related accident is discussed earlier in the background of the study. Thus, this project is executed with the purpose to reduce the road accident caused by stray and wild animals in Malaysia. To overcome this problem, the solution is to implement an animal detection system with an alarm to alert the driver by using the image processing technique to analyze the existence of animals during night time. An animal detection system with an alarm will be designed to assist the poor visibility of drivers during the night period so that the driver has sufficient time to take proper action to avoid an accident. Precisely, this project is the preliminary stage of the overall design. In this project, the focus is to perform buffalo recognition on night-time images. The design will be carried out stage by stage in the future to realize the animal detection system with an alarm. Above all, this project is relevant to achieve the goal and solve the animal-related accident issue.

1.4 Feasibility of the Project within the Scope and Time Frame

Final Year Project 2 (FYP 2) is a course of 14 weeks. In the end of the project, a MATLAB code to perform the buffalo recognition shall be completed. Up until now, the project is still on track with the schedule and expecting to be finished on time. Project activities timeline of FYP 2 is shown in figure 4.

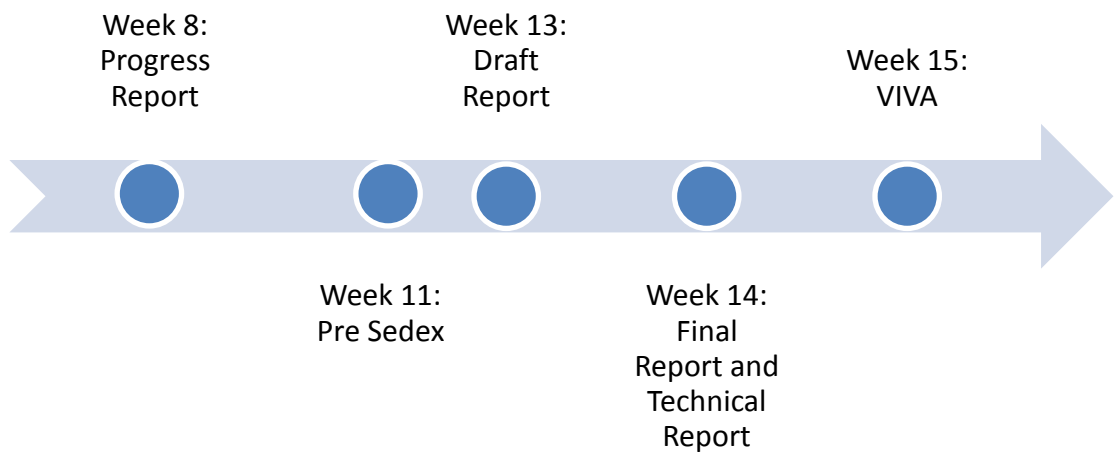


Figure 4: Final Year Project 2 (FYP 2) Timeline

CHAPTER 2

LITERATURE REVIEW

2.1 Existing Methods to Reduce Animal-Related Accident

In Malaysia, there are two methods being used to decrease the rate of animal-related road accidents. The first method is set up the animal road sign at habitat or region where impose a danger of collision with animals [15]. Animal road signs alert road users to be more aware because they are approaching active animal crossing area. However, the sign may not be very effective because road users always overlook the sign when they are driving especially during night period [16]. If the maintenance on the animal road sign is not efficient, it can cause the animal-related accident increases [16].

The second method is to isolate the animals from the roadways using fence [17]. Fence can block the animals from wandering at the roadway. Malaysia East Coast Expressway (LTP) spends million Ringgit every year on the maintenance to repair fencing along the highway [17]. The disadvantage of the fencing is that it does not solve the animal traffic. Animals have to struggle with the limited source of food and shelter because they are being isolated to moving from one side of road to another side. [17]

In USA, animal road sign is collaborated with detection system is used to improve the efficiency of the animal road sign. Basically, two detection systems are used to collaborate with animal road sign which are area coverage sensor and break-the-beam sensor [18]. Area coverage sensor detects large animals within the range of the sensor. It sends a signal over an area and measures its reflection using microwave. From the receiving signals, the system use algorithms to distinguish between moving vehicles and movement of large animals.

Break-the-beam sensor detects large animals when their bodies block or interrupt the beam of infrared sent between a transmitter and receiver [18]. The example of break-the-beam sensor is as shown in figure 5. When the sensors sense the existence of

animals, it will send a signal to the indication light of animal road sign. Therefore, road users can acknowledge the road condition as indication from the road sign. However, the costs of the integration with sensors are comparatively more expensive than animal road sign alone.



Figure 5: Break-the-beam Sensor [18]

2.2 Real-Time Object Recognition Technologies

2.2.1 Bike Alert Technology

According to the United Kingdom (UK) Transport Department, 6040 pedestrians, 3270 cyclists and 5440 motorcyclists were killed or severe injured on the UK roads between October 2011 and September 2012 [19]. This has brought an idea to Volvo to release a cyclist detection facility on Volvo car to prevent road accident. This system can detect and measure the distance of the object like cyclist in front of the car using the car's grille and a camera located in between of windscreen and back view mirror as shown in figure 6. Moreover, this bike technology is able to detect multiple pedestrians and cyclists at the same time as shown in figure 7.

"A Volvo Car UK spokesman told the BBC that the firm's engineers were now working on a fresh version as part of its 2020 programme which would also detect animals....."The aim is to avoid collisions with horses and deer for example," said Chris Mullord. "But there's no firm release date yet."

- BBC News, 2013 [19]



Figure 6: Extracted Image from Cyclist-and-brake Car System [19]

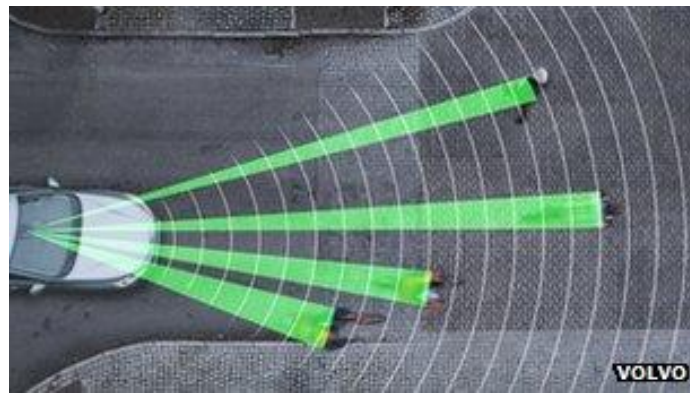


Figure 7: Handle Multiple Targets at the Same Time [19]

2.2.2 *Animal Night-Time Detecting System*

“In future, Autoliv hopes to bring down these numbers drastically and has announced that the technology will be made available as early as next year. These enhanced night vision systems will also be found in future models of Mercedes, Audi and BMW vehicles, the LATimes report said. ”

-Los Angeles Times, 2012 [20]

Autoliv Company standout in L.A. Auto Show with its new technology that will help to detect animals on the road while driving at night. This system uses various algorithms and thermal imagery infrared cameras to see and detect animals on the road that are beyond vehicle headlights’ field of vision. Furthermore, the system has an in-car display, audible notification and alert on a heads-up display to warn drivers of animals that are on the road ahead [20].

2.3 Project Relevant Technique

2.3.1 Camera Setup

Camera calibration is important to determine the parameters of transformation between the real world coordinate and image coordinate [21]. According the research paper from Taiwan University, the analysis to measure the most suitable position of the camera in the car needs to be conducted to ensure that the image captured has good coordinate to be process. In this project, the detection of the camera on the existence of animal must be fast in order for the system to alert the driver earlier before hitting. Therefore, camera position and angle must be in the right place to identify the animal that far in front so that it able to capture a meaningful image coordinate. The focus length and the pan need to be adjusted at right position so the camera only captures the road condition with the minimum of unwanted information.

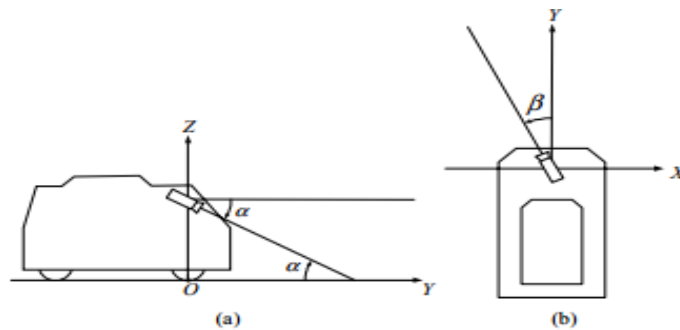


Figure 8: Example of Vehicle Coordinate System. (a) Side View (b) Bird's eye view

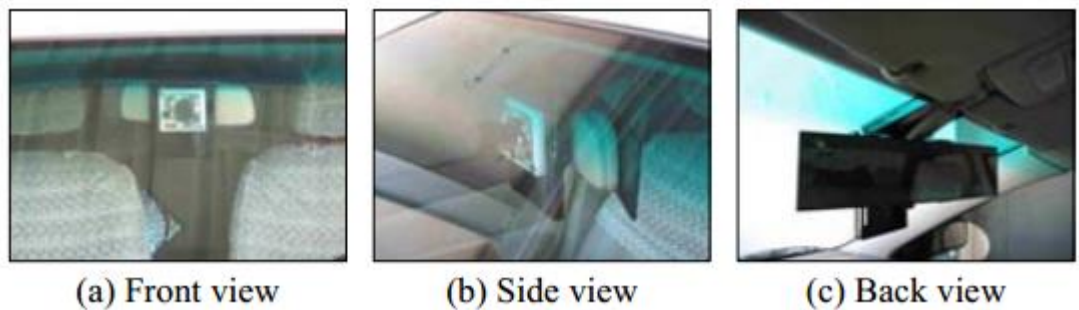


Figure 9: Example of Camera Setup

2.4 Image Processing Techniques

2.4.1 Colour-Based Recognition

Colour contributes huge information for object recognition. Colour histogram is one of the simplest and effective ways to represent and match images. However, in the colour-based recognition, the colour models always have following characteristics:

- i. Sturdiness to a change in viewing direction
- ii. Sturdiness to a change in object geometry
- iii. Sturdiness to a change in the direction of the illumination
- iv. Sturdiness to a change in the intensity of the illumination
- v. Sturdiness to a change in the spectral power distribution of the illumination
- vi. High discriminative power
- vii. Sturdiness to object occlusion and cluttering
- viii. Sturdiness to noise in the images

In a research article, the recognition of multi-coloured objects invariant is negatively affected to a substantial change in viewpoint, object geometry and illumination [22]. Therefore, this method is not very suitable for this project as the illumination and geometry is vary due to low light condition and animal movement.



Figure 10: Multi-coloured Object with Varying Geometry [22]



Figure 11: Multi-coloured Object with Varying Illumination [22]

2.4.2 Image Restoration

Image restoration is the process to filter the noise and estimating the clean original image. Images that captured using a camera is basically have noises because of the

image's transmission over a noisy channel [23]. It's been proved; image resolution is limited by the atmosphere condition [24]. Therefore, it is necessary to perform the image enhancement by filtering the noise before conducting image processing procedures [24].

Two-dimensional median filter technique (square $M \times M$) is one of the suggested methods by a research paper [24]. Below figures represented the example of median filter technique:

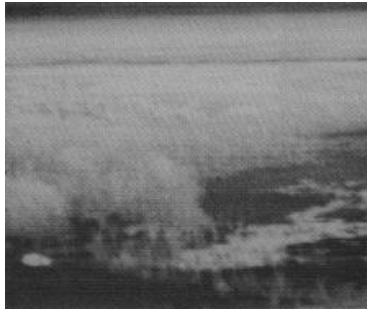


Figure 12: Original Image [24]

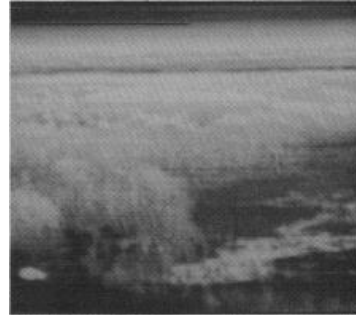


Figure 13: 3x 3 Two-dimensional Median Filter [24]

2.4.3 Image Segmentation and Shape Analysis

Segmentation subdivides an image into its constituent regions or objects [25]. Besides, segmentation accuracy determines the eventual success or failure of computerized analysis procedures [25]. This project will use the image segmentation technique to extract the animal features from the captured image.

Grayscale

Grayscale is to remove the colour values of an image and simplifies computation drastically compared to a colour RGB image [26]. According to the research paper [27], the night-time image is easier for the processing in MATLAB after it is converted into grayscale. In this project, the image taken from infrared camera is in grayscale; therefore the reference image needs to convert into grayscale for the better result of correlation.

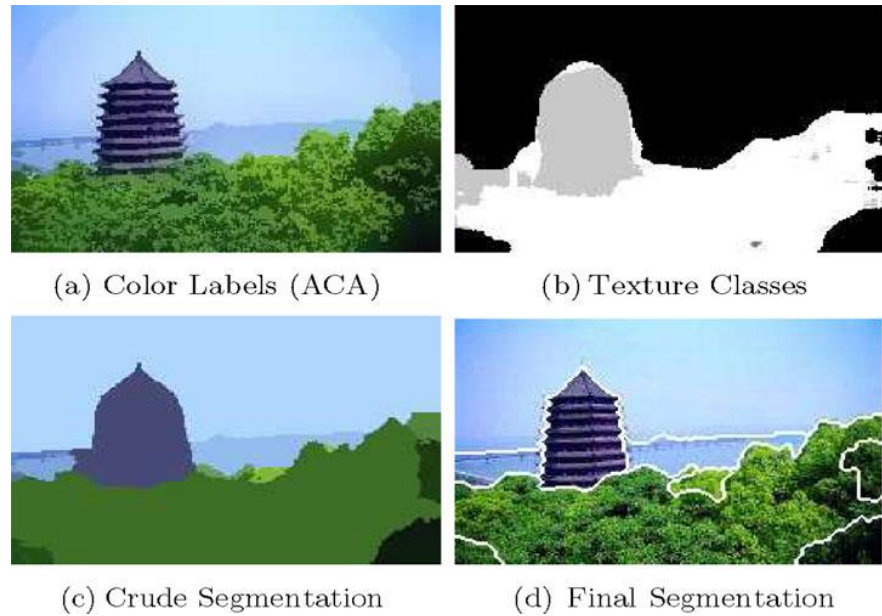


Figure 14: Example of Image Segmentation

Point Detection

Point detection is the detection of isolated points embedded in areas of constant or nearly constant intensity in an image is straightforward in principle [28]. The isolated point can be detected at the mask which is centered. In this case, $|R| \geq T$ where T is a nonnegative threshold. The mask for point detection is as shown in figure 15.

-1	-1	-1
-1	8	-1
-1	-1	-1

Figure 15: Mask for Point Detection [28]

Line Detection

Line detection is higher complexity of point detection [28]. When a mask moving constantly in a direction of an image, the mask will most likely responded to the line that oriented in the same direction. As stated in the research, the slope for a line segment is the same and the top or the bottom point of a line segment will locate precisely on the extended line [28].

-1	-1	-1	-1	-1	2	-1	2	-1	2	-1	-1
2	2	2	-1	2	-1	-1	2	-1	-1	2	-1
-1	-1	-1	2	-1	-1	-1	2	-1	-1	-1	2

Figure 16: Line Detector Masks [28]

Edge Detection

Edge detection is the most common approach for detecting meaningful discontinuities in intensity values [28]. Edge detection can be used for the detection of various shapes of road signs as mentioned in the research paper [29]. Therefore, it is possible to apply the edge detection to analyse the animal's image in this project. There are three techniques of edge detection can be used for dark region [30]:

1. Sobel Edge Detector- Sobel approximation is used.
2. Prewitt edge Detector- Prewitt approximation is used.
3. Laplacian of a Gaussian (LoG) Detector- looking for zero crossings with Gaussian filter.
4. Canny edge detector- uses a multi-stage algorithm to detect a wide range of edges in images [31].

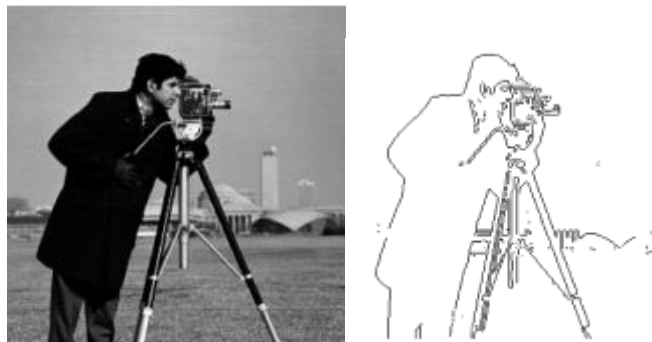


Figure 17: Comparison between Original Image and Sobel Edge Detection [30]

2.4.4 Object Recognition

“In some applications, pattern characteristics are best described by structural relationships. For example, fingerprint recognition is based on the interrelationships of print features called minutiae. Together with their relative sizes and locations, these features are primitive components that describe fingerprint ridge properties, such as abrupt endings, branching, merging, and disconnected segments.” [28]

Object detection is demonstrates a number of challenges. The object may have different size and slightly different size in colour. Correlation is a basic operation in pattern recognition to extract desired feature from an image. This method is effective, useful and easy to implement. The identification of object can be carried out by a normalized correlation-based pattern matching technique using object sample image database [29]. Correlation requires great amount of storage, therefore it naturally to pursue dimensionality reduction schemes [32].

Illumination cones were used in the face recognition. A small number of a fixed pose face illuminated by limited light source can provides sufficient information to generate representation of the face for the recognition under variable pose and illumination. Besides, shadows casted in the illumination cones improve recognition rates. The idea of illumination cones is relevant and suitable for the dark region as required in this project.

CHAPTER 3 METHODOLOGY

3.1 Research Methodology

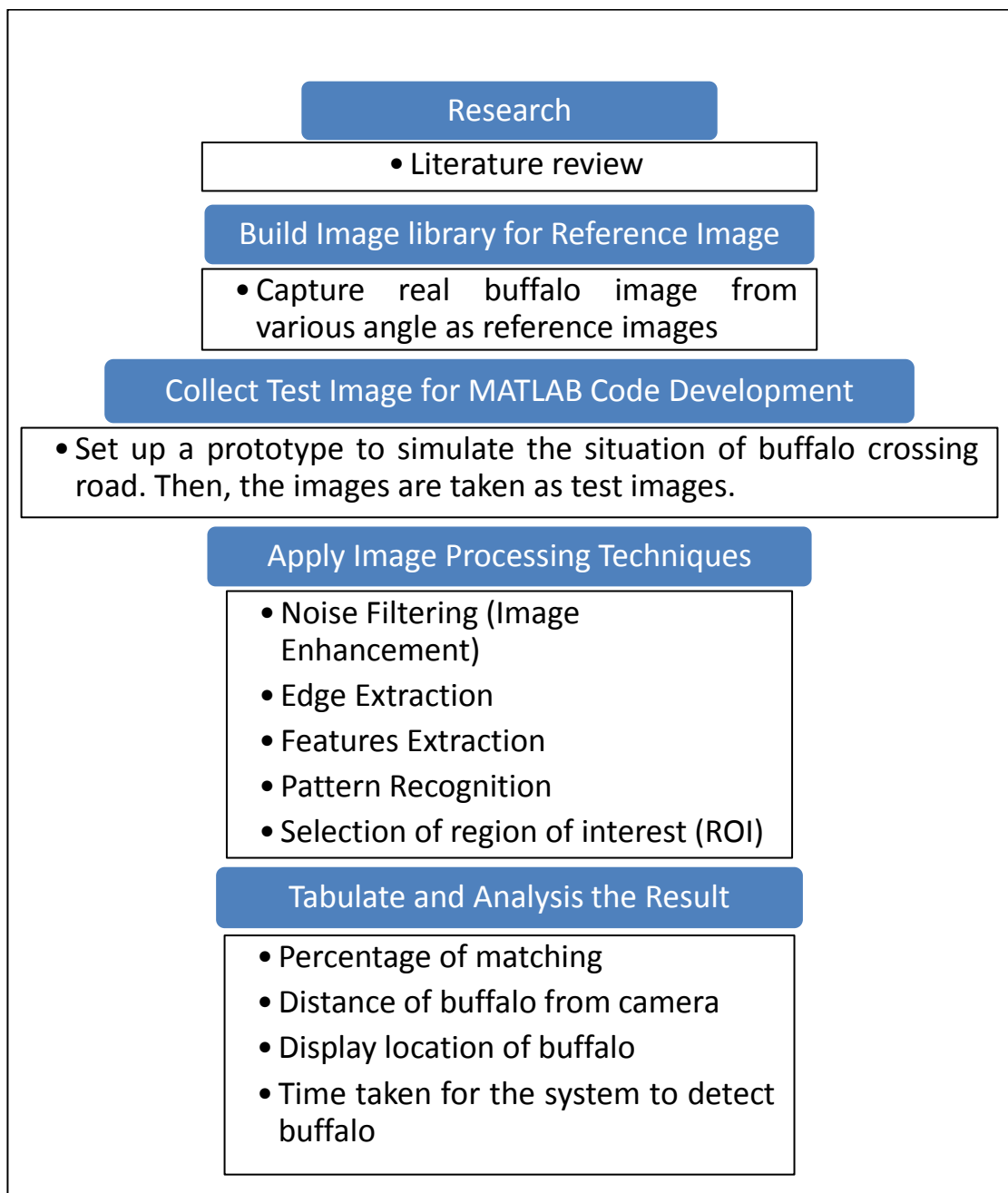


Figure 18: Research Methodology

First of all, literature review is carried out to study the research papers which are related to this project, for example object recognition using image processing techniques.

The second stage of the project is to prepare an image library for reference image. Reference images consist of various features of buffalo to perform the correlation in order to recognize the buffalo from the test image.

Third stage is to capture and collect the test images. Test images are comprised of night-time buffalo images to check the capability of the system to recognize the buffalo in the low light condition. A prototype is set up to simulate the situation of buffalo crossing road. Hence, the images are taken as test images.

After the database is ready, the project will proceed to stage to apply suitable image processing techniques to perform the buffalo recognition. Those techniques included noise filtering (image enhancement), edge extraction, features extraction, pattern recognition and etc. Trials will be executed repeatedly to identify the most effective algorithm to perform the buffalo recognition.

The final stage of this project is the tabulation and analysis of the results. The outcomes of this project are included percentage of matching, distance of buffalo from camera, display location of buffalo and time taken for the system to detect buffalo.

3.1.1 Logic Flow of the Animal Recognition System

Figure 19 shows the logic flow of animal recognition system. The logic flow can basically divided into three major parts, image input, image processing and validate the detection. Image input is the step to collect the reference images of various patterns of buffalo and save it in the image library. On the other hand, the night-time images of buffalo crossing road is also capture using IR camera to use as test image for the animal recognition system.

In image processing step, the collected reference and test images will be go through several image segmentations to extract the buffalo features and minimize the unwanted information and noise content in the image. Then, the program will applied template matching to identity the buffalo location and pattern in the test image by matching the reference images to the particular test image.

In the final step, the percentage of matching will be calculated and compared with the set value that was found during the experiment stage. If the percentage is higher than the set value, the system will assume the buffalo is existing in the image. The location of the buffalo will then be displayed in the MATLAB GUI.

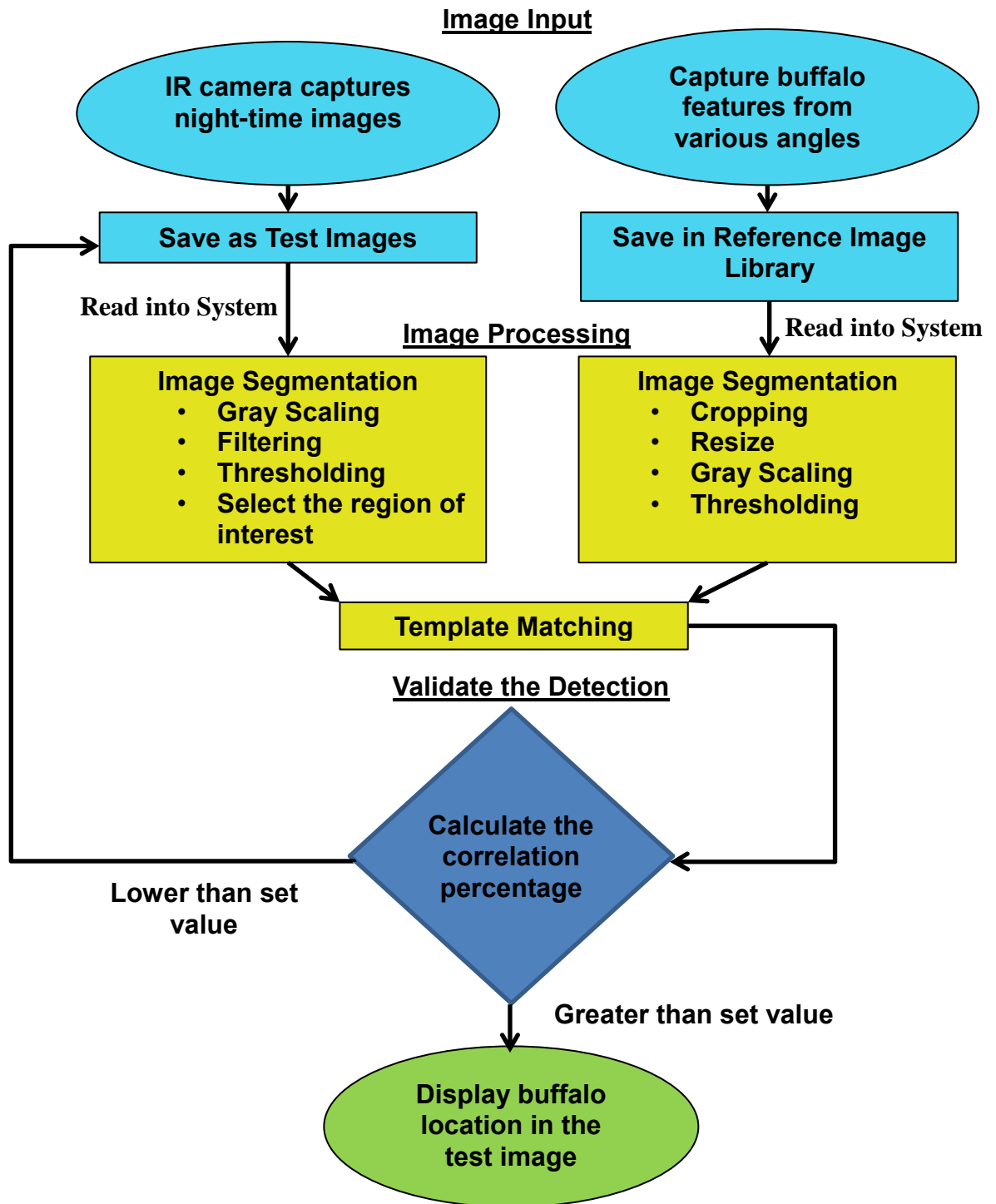


Figure 19: Logic Flow of Animal Recognition System

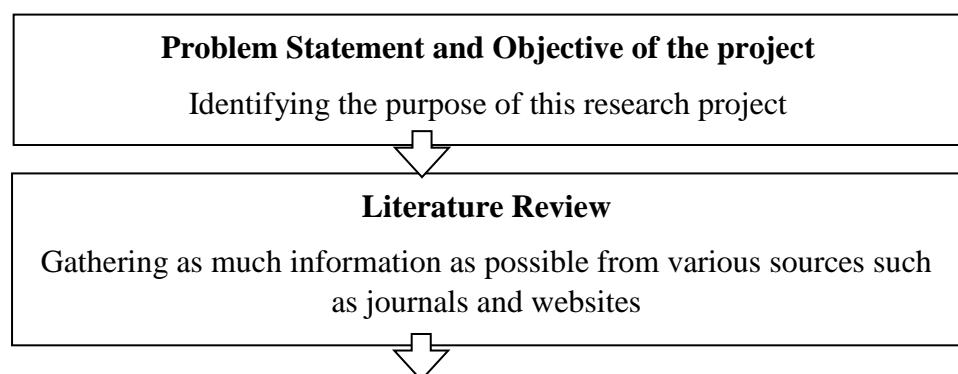
3.2 Project Activities

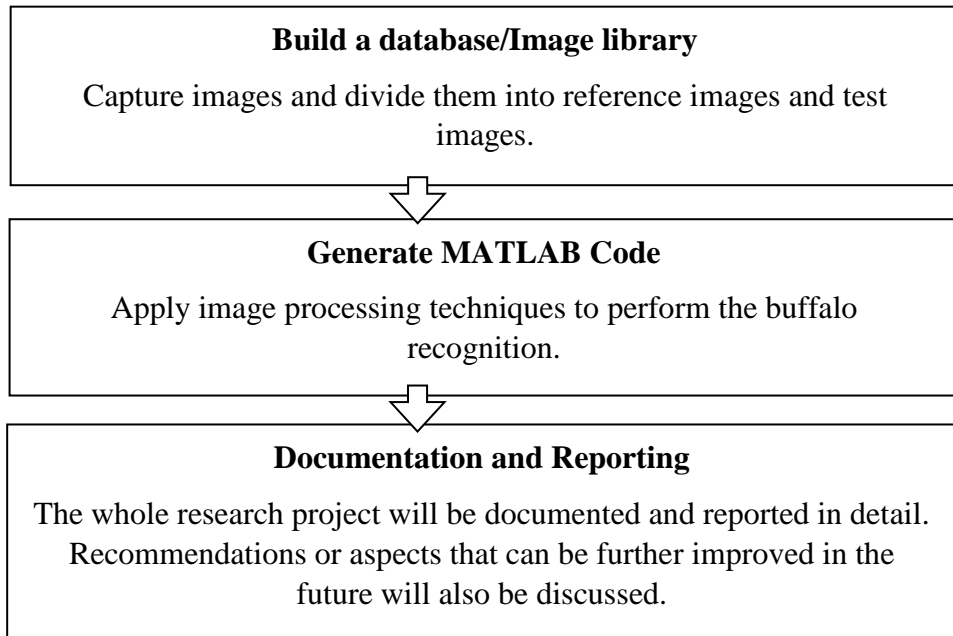
Tasks to be completed in Final Year Project:

- 1) Identify the active spot of buffalo.
- 2) Capture and collect real buffalo images as reference images.
- 3) Compile the reference images in an image library.
- 4) Build a buffalo model to represent real buffalo.
- 5) Set up the prototype, do the simulation of buffalo crossing road and capture the static images as test images.
- 6) Research the suitable image processing techniques for buffalo recognition.
- 7) Apply the image processing techniques and generate the MATLAB code.
- 8) Debug the MATLAB code to improve the percentage of matching and shorten the time taken of the system perform the detection.
- 9) In Final Year Project 2, there are three project papers and 2 presentations need to be completed:
 - Progress Report
 - Final Report and Technical Report
 - Pre-Sedex Presentation
 - Viva (Final Presentation)

3.3 Key Milestones

Several key milestones for this research project must be achieved in order to meet the objective of this project:





3.4 Tools

Software	Hardware
<ul style="list-style-type: none"> MATLAB R2010a 	<ul style="list-style-type: none"> Samsung SCC-B9270 (IR LED Camera)-<i>specifications refer to Appendix C</i> Buffalo model Materials required to build prototype for simulation.

3.5 Gantt Chart

NO	DETAIL WEEK															
		1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Find a suitable buffalo model to capture test image and reference image	■	■	■												
2	Generate and Troubleshoot the MATLAB Code		■	■	■	■	■	■								
3	Submission of Progress Report							■	●							
4	Pre-SEDEX											●				
5	Hardware Implementation								■	■	■	■	■	■		
6	Submission of Draft Report										■	■		●		
7	Submission of Final Report			■	■	■	■	■					■		●	
8	VIVA											■	■	■	■	●

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Preparation Works

Based on the study did by Cranfield University, the stopping distance needed by a car is equal to the sum of thinking time and braking distance [33].

$$\text{Stopping Distance} = \text{Thinking Distance} + \text{Braking Distance}$$

For example, if a car travels in speed of 30 miles per hour (48.2 km/h), the expecting thinking distance is 9m and the braking distance is 14m. Therefore, the total braking distance = 9m+14m=23m.

Table 4 shows the typical stopping distances included in the Highway Code. The data given are only typical because in reality the thinking distance and braking distance might be influenced different circumstances like human factors and car specifications.

Speed (miles per hour)	20 (~32.2 km/h)	30 (~48.3 km/h)	40 (~64.4 km/h)	50 (~80.5 km/h)	60 (~96.6 km/h)	70 (~112.7 km/h)	80 (~128.5 km/h)
Thinking Distance (m)	6	9	12	15	18	21	24
Braking Distance (m)	6	14	24	38	54	75	96
Total Stopping Distance (m)	12	23	36	53	72	96	120

Table 4: Typical Stopping Distances of the Highway Code

In this project, 80km/h and 64.4km/h are selected as the speed to develop animal recognition system because driver cannot drive over 90km/h in rural area. Therefore, the total stopping distance is estimated to be 53m. According to the police research, a normal low beam headlight can reach 260 feet (48. 5m) [34]. In order to detect the buffalo earlier than driver so that he can have more time to take proper action, the camera must be able to capture the road condition farther than headlight and total stopping distance. Thus, the distances that used to capture the test images are 60m and 50m.

Originally, the plan was planned to capture the real buffalo as the reference and test image to save in image library. However, it was found that difficult to find a power supply to power up Samsung SCC-B9270 at palm oil tree farm. Besides, uncertain dangerous is imposed to individual when searching for buffalo at palm oil tree farm during night time. Summing up all the problem, buffalo model is finally decided to be used in this project as substitution of real buffalo.

The buffalo model is made in size 0.08m height x 0.13m long versus the average size of real buffalo which is about 1.7m height x 2.7m long. By dividing the size of real buffalo with the size of buffalo model, the calculation showed the ratio of buffalo model to real buffalo is 1:21. Besides, Malaysia road must have width more than 4.5m per lane. Based on this ratio and statistics, the simulation of capturing the image of buffalo from 60m and 50m is plotted. Figure 21 shows the arrangement of simulation to show the buffalo is 60m away.

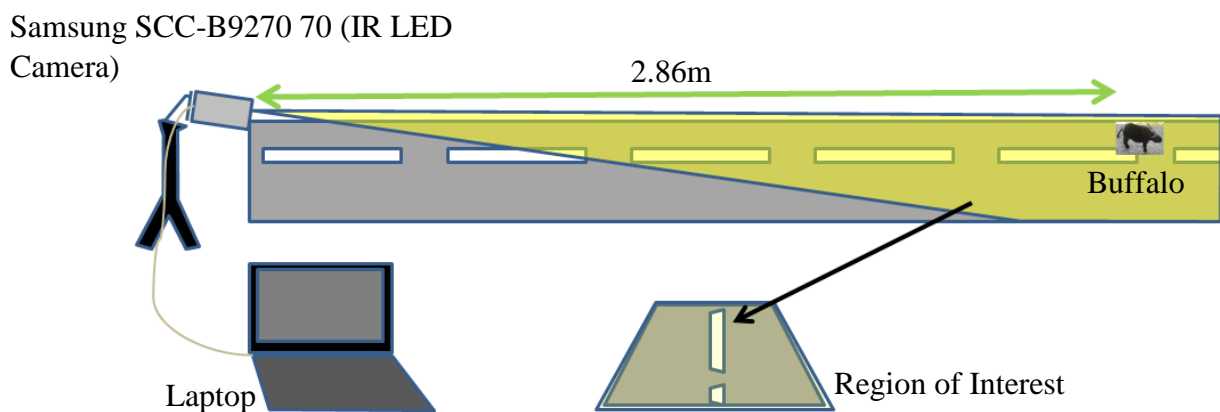

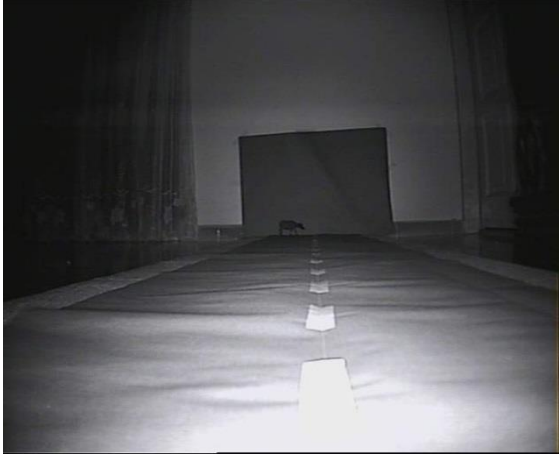

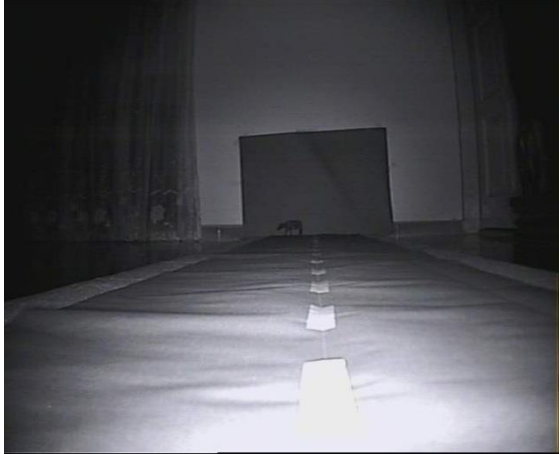

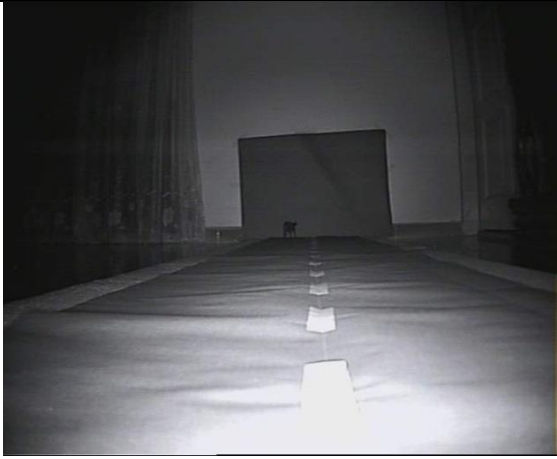

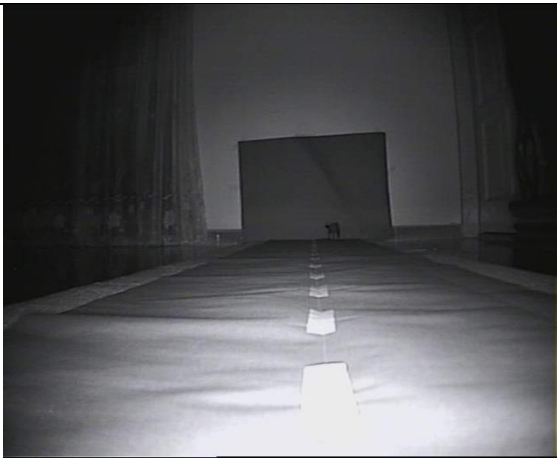

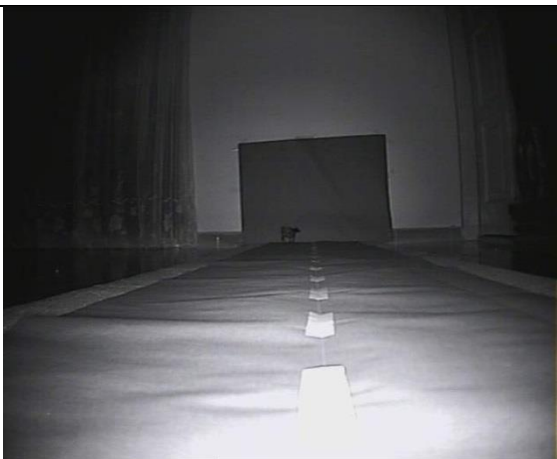


Figure 20: Arrangement of Simulation

4.1.2 Image Library

For each 60m and 50m, 16 test images (2 images for one angle) with various angles of buffalo are captured. 8 reference images captured are using to perform matching with the test image to recognize the buffalo inside the test image. The reference and test images of 60m are shown in the table below:

Angle	Reference Image	Test Image
Horizontal (face to right)		
Horizontal (face to left)		

<p>45° (face to right)</p>	 A water buffalo standing on a white background, facing towards the right side of the frame.	 A dark, long room with a white dashed line on the floor leading to a large screen at the far end. A small figure is visible on the screen.
<p>45° (face to left)</p>	 A water buffalo standing on a white background, facing towards the left side of the frame.	 A dark, long room with a white dashed line on the floor leading to a large screen at the far end. A small figure is visible on the screen.
<p>135° (face to right)</p>	 A water buffalo standing on a white background, facing towards the right side of the frame.	 A dark, long room with a white dashed line on the floor leading to a large screen at the far end. A small figure is visible on the screen.


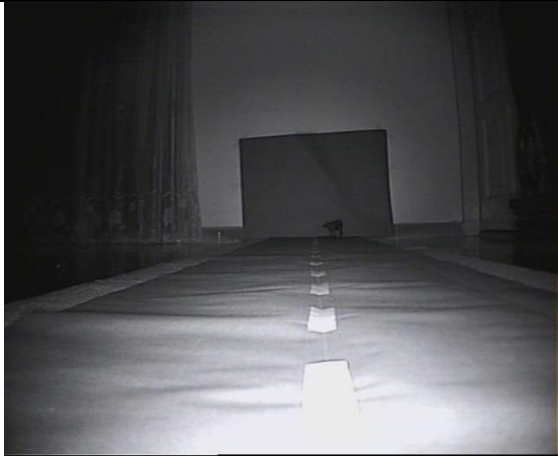

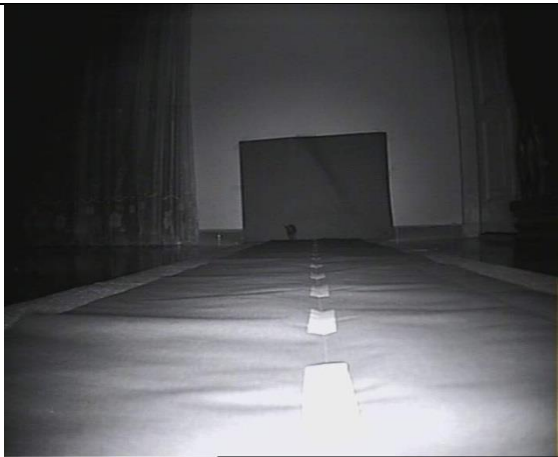

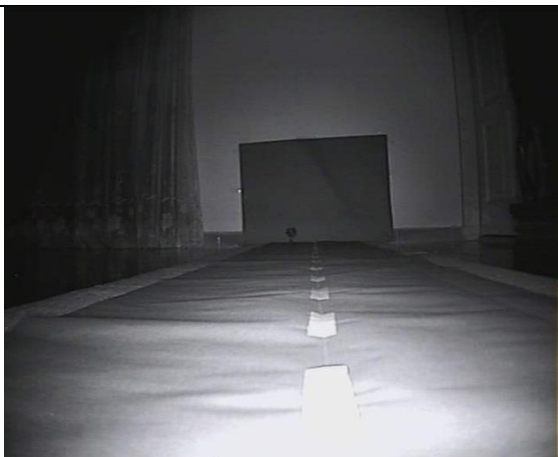
<p>135° (face to left)</p>		
<p>Front (face)</p>		
<p>Back</p>		

Table 5: Reference and Test Images when buffalo is 60m Away

4.1.3 MATLAB Result

The following are the image result of animal recognition system (Generated in MATLAB).

Processing of Reference Images:

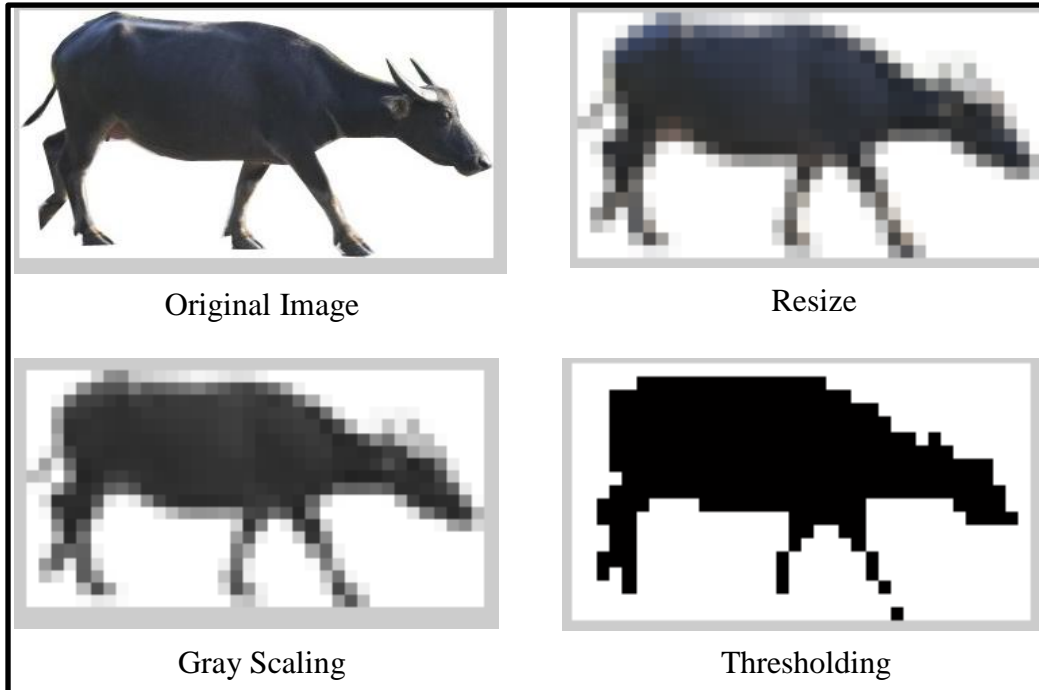
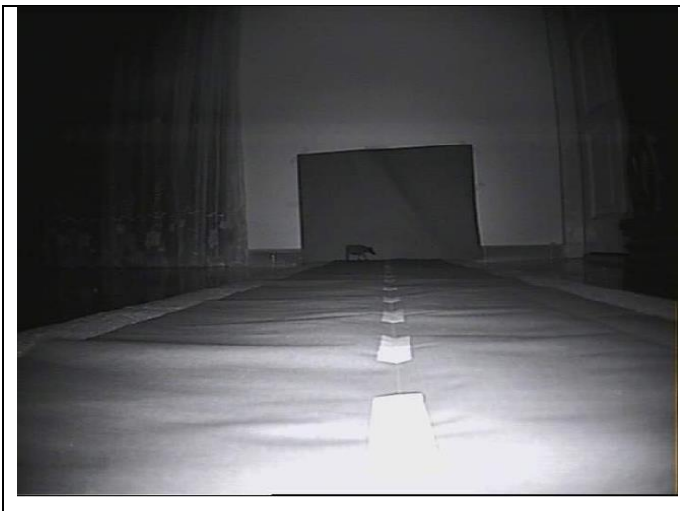
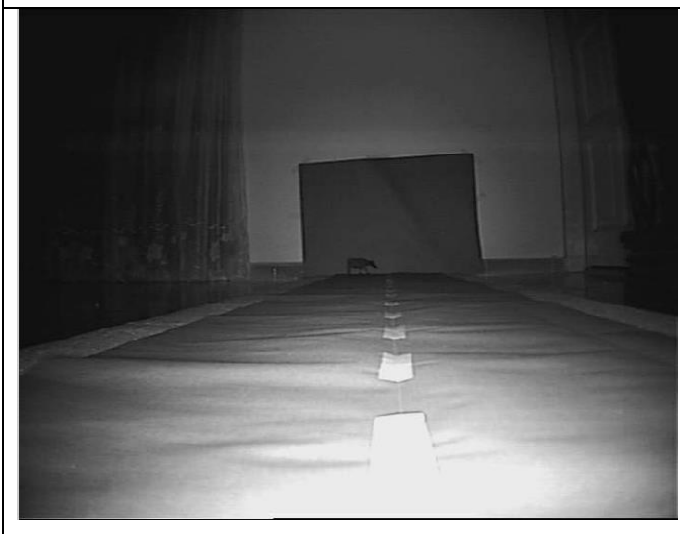
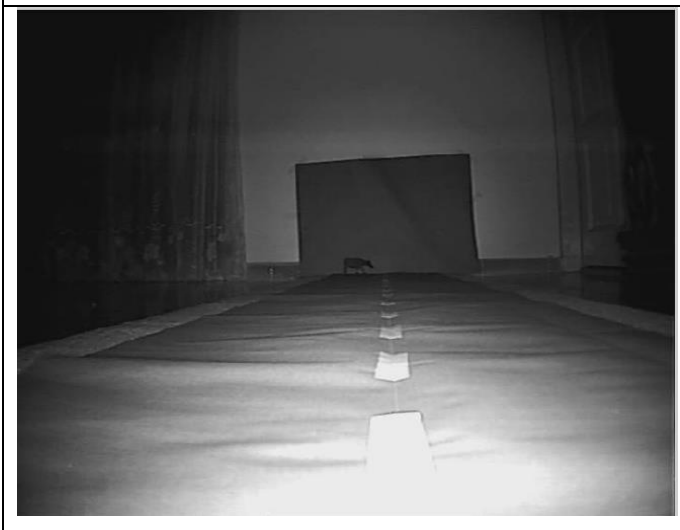


Figure 21: Reference Image Processing

First of all, animal recognition system reads the reference image from image library. In order to obtain accurate matching result, the reference image is resized to about the same size of buffalo when it is 60m away from camera. Then, the reference image is converted into grayscale (black and white colour) because the target image is night-time image that has no colour content. This step can make the dynamic range of the reference image much closer to the test image as both of them are in black and white colour only. Before matching the reference image with test image to find out the buffalo, thresholding is applied to eliminate the noise and extract the buffalo feature to make the recognition easier and faster.

Processing of Test Image:

	<p><u>Original Test Image</u></p> <p>This is the night-time image captured by IR camera.</p>
	<p><u>Gray Scaling</u></p> <p>Test image is converted to grayscale to ensure it has similar dynamic range with reference image. This is essential to make the matching result more accurate.</p>
	<p><u>Filtering</u></p> <p>The filtering processing can remove the unwanted tiny noise that might influence the matching result.</p>

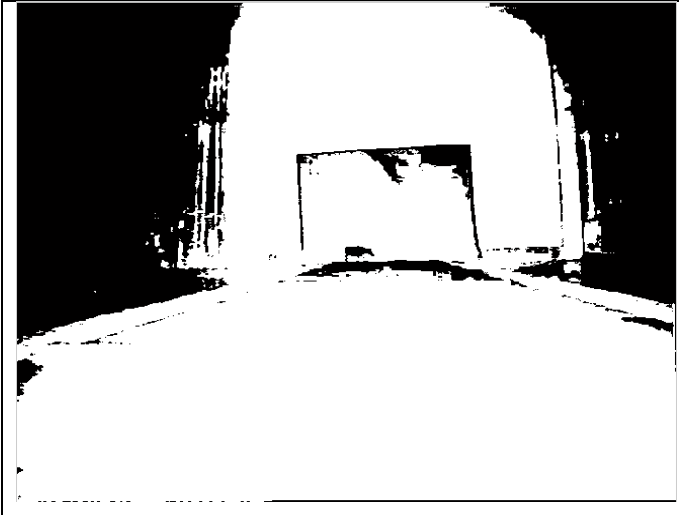
	<p><u>Thresholding</u></p> <p>The final step before template matching is threshold the test image to extract the darker object in the test image. The buffalo already can be seen from the image because it is darker than surrounding.</p>
---	---

Table 6: Test Image Processing

Template Matching Result:

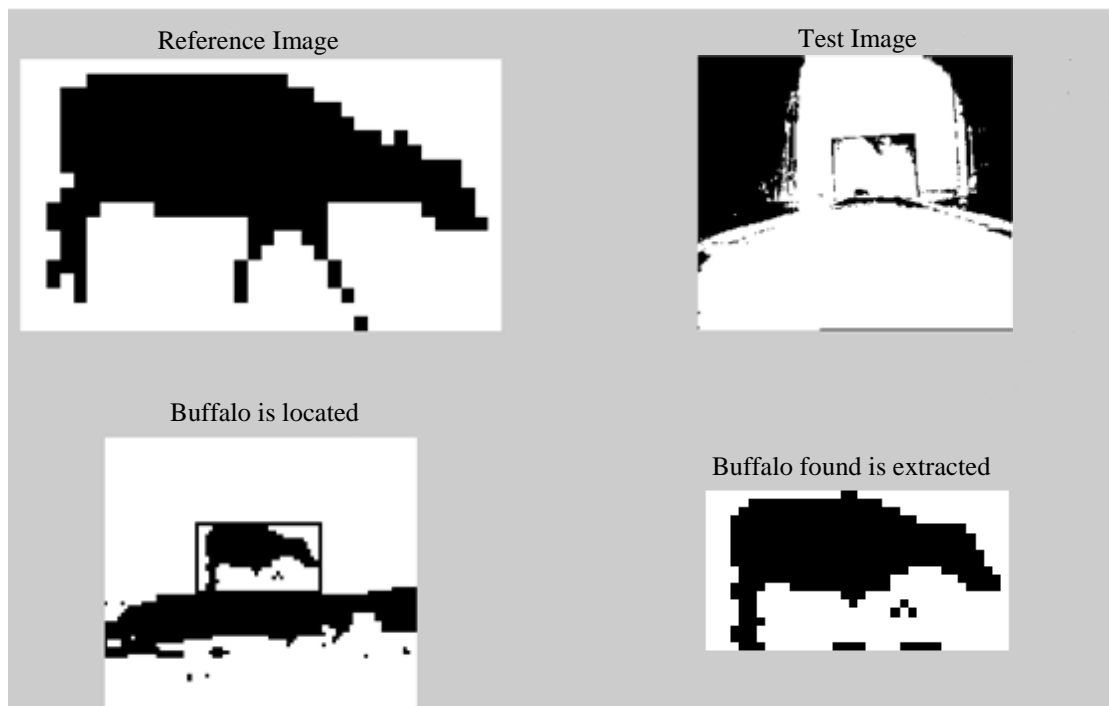


Figure 22: Template Matching Result

Template matching is a technique that can find small parts of an image which match a template image. In this case, reference image is use to find the buffalo in the test image. From figure 22, the buffalo is located and a small black box is plotted around it. This shows the system is successfully detect and recognize the buffalo from the test image.

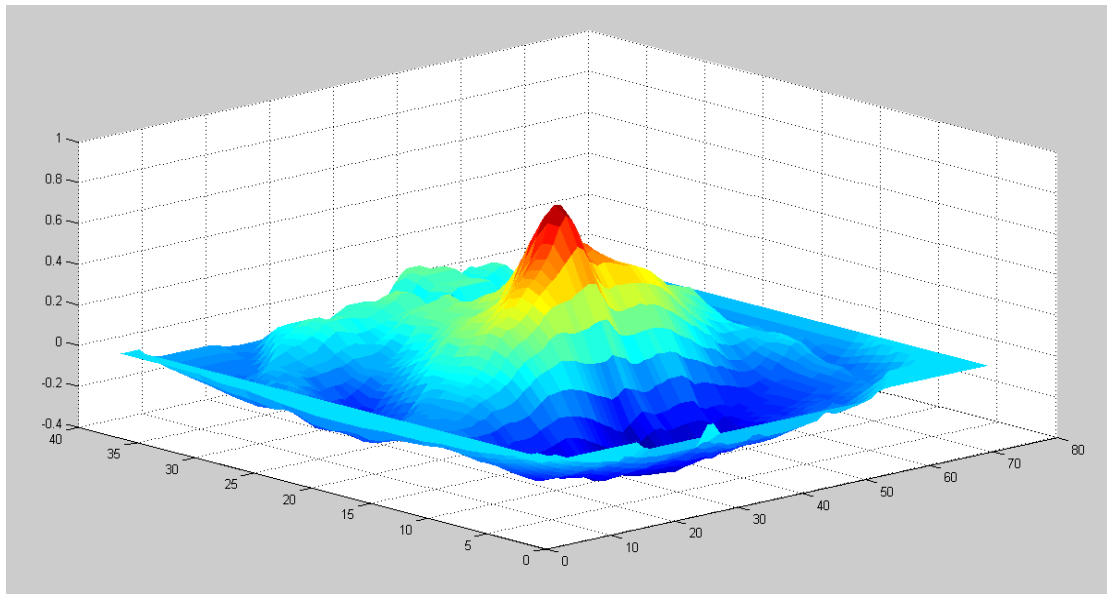


Figure 23: Graph plotted the Normalized 2D Cross Correlation Between Reference and Extracted Buffalo from Test Image

Figure 23 shows the normalized 2D cross correlation between reference image and extracted buffalo from test image. The red peak indicates the high similarity of reference image with the test image at that particular area. The correlation value will be then used to determine the percentage of matching.

Animal Recognition System Graphical User Interface (GUI):

Figure 24 shows the GUI of animal recognition system in MATLAB. The green button is function key to import test image into the system. After the test image is imported, the system will start the reference and test images processing. The 8 reference images will be matching one by one with the test image until the pattern of buffalo is matched with the buffalo inside the test image. The percentage of matching and time taken for the system to recognize the buffalo will be displayed on the right corner of GUI. If no reference image is matched with test image, the system will indicate no buffalo on the display.

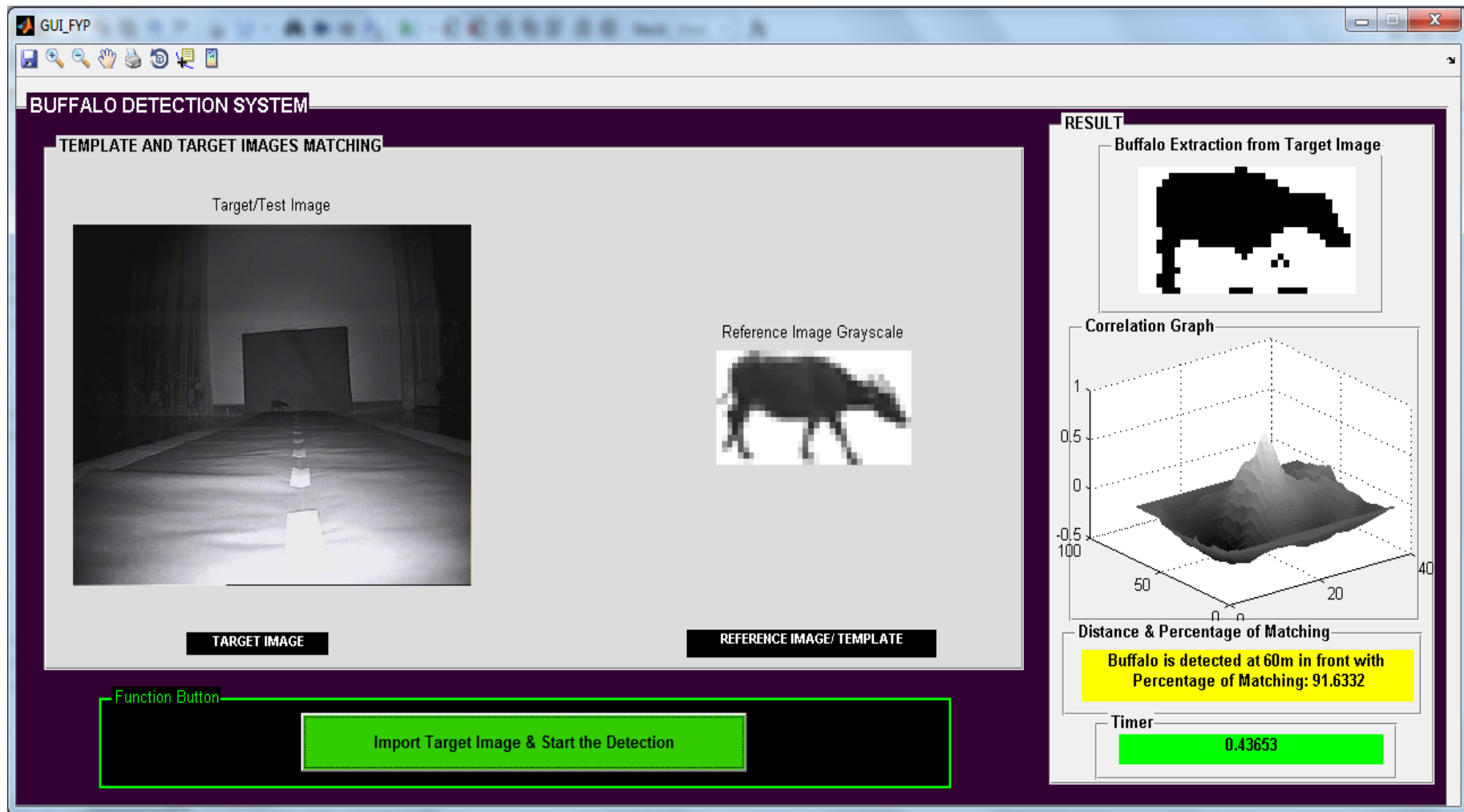


Figure 24: Animal Recognition System GUI

Animal Recognitions System Overall Results:

60m	Percentage Matching of 1 st Set of Test Images (%)	Percentage Matching of 2 nd Set of Test Images (%)	Average Percentage (%)	Time Taken of 1 st Set of Test Images (s)	Time Taken of 2 nd Set of Test Images (s)	Average Time Taken (s)
Horizontal_1	91.63%	93.63%	92.63%	0.48	0.48	0.48
Horizontal_2	93.11%	88.88%	91.00%	0.55	0.58	0.57
45°_1	89.21%	88.35%	88.78%	0.72	0.71	0.72
45°_2	89.27%	88.15%	88.71%	0.85	0.83	0.84
135°_1	94.74%	86.98%	90.86%	0.99	0.99	0.99
135°_2	92.26%	93.32%	92.79%	1.11	1.11	1.11
Face	91.52%	91.73%	91.63%	1.20	1.20	1.20
Back	94.63%	93.99%	94.31%	1.23	1.29	1.26

Table 7: Result of 60m Test Images

50m	Percentage Matching of 1 st Set of Test Images (%)	Percentage Matching of 2 nd Set of Test Images (%)	Average Percentage (%)	Time Taken of 1 st Set of Test Images (s)	Time Taken of 2 nd Set of Test Images (s)	Average Time Taken (s)
Horizontal_1	93.16%	96.50%	94.83%	0.47	0.49	0.48
Horizontal_2	88.83%	96.37%	92.60%	0.55	0.59	0.57
45°_1	86.82%	82.25%	84.54%	0.73	0.74	0.74
45°_2	88.03%	92.88%	90.46%	0.81	0.86	0.84
135°_1	92.74%	91.39%	92.07%	0.97	0.97	0.97
135°_2	90.22%	88.67%	89.45%	1.09	1.08	1.09
Face	85.10%	88.96%	87.03%	1.18	1.17	1.18
Back	92.59%	92.47%	92.53%	1.30	1.28	1.29

Table 8: Result of 50m Test Images

4.2 Discussion

Overall result of animal recognition system is recorded in table 7 and 8. Two sets of test images for both 60m and 50m are tested using the system. 1st set of test images consists of various patterns of buffalo on the left lane and 2nd set of test images consists of various patterns of buffalo on the right lane. Both sets of the test images are used to test the animal recognition system to check the reliability and the flexibility of the system to detect the buffalo while the location of buffalo is different on the road.

The percentage of matching is calculated based on the normalized correlation coefficients. By collecting two sets of percentage of matching, the average percentage of matching is also calculated as shown in the table 7 and 8. Both percentage results of 60m and 50m have small range of difference is due to two factors. First is the distance between 60m and 50m is not very far, thus the size of buffalo in the both images do not have very big and significant difference. Second is when the buffalo is getting closer to the camera, the more IR light emitted by IR LED is reflected by the buffalo. Therefore, it causes some region of the buffalo body has higher luminance than usual, and that will affect the performance of the system to extract the feature of buffalo from the test image. Due to this reason, some the of percentage of matching of 50m are slightly lower than 60m's percentage of matching even though the distance of buffalo has become nearer. Overall the percentages of matching for 60m and 50m are more than 80 %, and can be classified as good matching. Basically, the matching percentage is depending on how good the buffalo feature is being extracted from the test image before doing the template matching with reference images.

The time taken for the animal recognition system to recognize and identify the existence of buffalo in the test image also recorded in table 7 and 8. The longest time taken for both 60m and 50m are 1.26 and 1.29 seconds respectively. Time taken can be further reducing by removing the figures display and using a thermal IR Camera. Thermal IR camera can detect the heat source immediately unlike normal IR camera cannot detect the buffalo location but have to depend on template matching technique to match across the region pixel by pixel to find out the buffalo. However, a thermal IR camera is cost about RM 15,000 to RM30,000 [35]. Thus, it is no very cost

effective compare to normal IR camera which just cost few thousands to install in car to detect animal.

The system is able to generate the expecting outcome which is to detect the buffalo in the test image using the template matching technique. The correlation between the reference image and the whole area of test image is being calculated by matching from one area to another area. The area with highest percentage of matching is being selected as the most possible area where the buffalo is present.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Night-time animal recognition system is only the preliminary stage of animal detection system with alarm that can assist and alert driver when there is existence of animal in front of car. The objectives of this project are achieved because the designed system can perform the buffalo recognition with high percentage of matching and short time taken. The studies, techniques and results obtained in this project have provided a good platform for future development of the night-time animal detection system with alarm.

5.2 Recommendation

Throughout the implementation of this project, it is found that there are some limitations in current design. Samsung SCC-B9270 (IR LED Camera) lacks if in terms of detecting the night-time image of animal and the distance it can reach is not ideally far enough. Besides, thermal IR camera can directly detect the heat source which means the system no longer need to spend a lot of time to identify the location of buffalo and do the matching. Therefore, in future recommendation thermal infrared camera is suggested to be used in developing the current design to improve animal recognition system in term of accuracy and animal recognizing spend. Besides, display can also add into the hardware design for the driver to monitor the road condition in front to make the system more user-friendly. In future design, other large animals like horse, deer, wild boar, and dog can be added into image library so that the system can recognize more animals.

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APPENDICES

APPENDIX A

MATLAB CODE

```
%Input the Test/Target Image
[filename pathname]= uigetfile ('*.jpg'), 'Import Target/Test
Image')
fullpathname25=strcat(pathname, filename);
image25=imread (fullpathname25);
axes(handles.axes1)
imshow (image25), title ('Target/Test Image')

result1= FYP_Main2 (image25,handles);

function result1= FYP_Main2 (image25,handles)
%Import Reference image 1 (Hori_1)
image1= imread ('C:\Users\Asus\Desktop\lembu that i
want\hori_1.jpg');
%[filename pathname]= uigetfile ('*.jpg'), 'Import Reference Image
1')
%fullpathname1=strcat(pathname, filename);
%image1=imread (fullpathname1);

%Import Reference image 2 (Hori_2)
image2= imread ('C:\Users\Asus\Desktop\lembu that i
want\hori_2.jpg');
%[filename pathname]= uigetfile ('*.jpg'), 'Import Reference Image
2')
%fullpathname2=strcat(pathname, filename);
%image2=imread (fullpathname2);

%Import Reference image 3 (45 right)
image3= imread ('C:\Users\Asus\Desktop\lembu that i want\45_1.jpg');
%[filename pathname]= uigetfile ('*.jpg'), 'Import Reference Image
3')
%fullpathname3=strcat(pathname, filename);
%image3=imread (fullpathname3);

%Import Reference image 4 (45 left)
image4= imread ('C:\Users\Asus\Desktop\lembu that i want\45_2.jpg');
%[filename pathname]= uigetfile ('*.jpg'), 'Import Reference Image
4')
%fullpathname4=strcat(pathname, filename);
%image4=imread (fullpathname4);

%Import Reference Image 5 (135 right)
image5= imread ('C:\Users\Asus\Desktop\lembu that i want\135_1.jpg');
%[filename pathname]= uigetfile ('*.jpg'), 'Import Reference Image
5')
%fullpathname5=strcat(pathname, filename);
%image5=imread (fullpathname5);

%Import Reference Image 6 (135 left)
image6= imread ('C:\Users\Asus\Desktop\lembu that i want\135_2.jpg');
%[filename pathname]= uigetfile ('*.jpg'), 'Import Reference Image
6')
%fullpathname6=strcat(pathname, filename);
%image6=imread (fullpathname6);
```

```

%Import Reference Image 7 (face)
image7= imread ('C:\Users\Asus\Desktop\lembu that i want\front.jpg');
%[filename pathname]= uigetfile (*.jpg), 'Import Reference Image
7')
%fullpathname7=strcat(pathname, filename);
%image7=imread (fullpathname7);

%Import Reference Image 8 (back)
image8= imread ('C:\Users\Asus\Desktop\lembu that i want\back.jpg');
%[filename pathname]= uigetfile (*.jpg), 'Import Reference Image
8')
%fullpathname8=strcat(pathname, filename);
%image8=imread (fullpathname8);

%% Loop Function
number= 0;
tic; %Timer start
while number<8
    number=number+1

    %% 60 meters
    %% Case 1
    for number = 1;
        Read1=imager1;
        Read1= imresize(Read1, [19 36]);

        %convert into grayscale
        GS=rgb2gray(Read1);
        axes(handles.axes2)
        imshow (GS), title ('Reference Image Grayscale')

        % filter the noise using adaptive spatial filter
        f1=medfilt2(GS, [7 7], 'symmetric');
        J=adpmedian (GS, 7);

        %apply canny edge detector
        %W= edge (J, 'canny');
        %xes(handles.axes3)
        %mshow (BW), title ('Reference Image Canny Edge')

        %apply thresholding
        redBand= J(:, :, 1);
        redthreshold= 130;
        redMask= (redBand>redthreshold);
        %axes(handles.axes4)
        %imshow (redMask), title ('Reference Image Threshold')

        % read reference image
        im1=redMask;
        %figure, imshow(im1);
        %Test Image Processing
        Test=imcrop(image25, [337 275 108 27]);
        %im2=imcrop(image2);

        % grayscale target image
        Test=rgb2gray(Test);
        %axes(handles.axes6)
        %imshow (im2), title ('Target/Test Image Grayscale')

```

```

%filter the noise using adaptive spatial filter
f2=medfilt2(Test, [7 7], 'symmetric');
Test=adpmedian (Test, 7);

%apply canny edge detector
%BW2= edge (im2, 'canny');
%axes(handles.axes7)
%imshow (BW2), title ('Target/Test Image Canny Edge')

%apply colour extraction
redBand= Test(:,:,1);
redthreshold= 40;
redMask2= (redBand>redthreshold);
%axes(handles.axes8)
%imshow (redMask2), title ('Target/Test Image Threshold')
im2=redMask2;
%figure,imshow (im2);
%im2=BW2;

%Reduce the region of interest by doing pixel detection
across the
%region
Test=imcomplement(im2);
foregroundcol = any(Test);
    firstforegroundcol = find(foregroundcol, 1);
    lastforegroundcol = find(foregroundcol, 1, 'last');
foregroundrow = any(Test,2);
    firstforegroundrow = find(foregroundrow, 1);
    lastforegroundrow = find(foregroundrow, 1, 'last');

    firstforegroundcol = firstforegroundcol;
    lastforegroundcol = lastforegroundcol;
    firstforegroundrow = firstforegroundrow;
    lastforegroundrow = lastforegroundrow;

    im2 = im2(firstforegroundrow:lastforegroundrow,
firstforegroundcol:lastforegroundcol);

%Template Matching
if size(im1)>size(im2)
    Target=im1;
    Template=im2;
else
    Target=im2;
    Template=im1;
end
% read both images sizes
[r1,c1]=size(Target);
[r2,c2]=size(Template);

% mean of the template
image22=Template-mean(mean(Template));

%corrolate both images
corrMat=[];

```

```

for i=1:(r1-r2+1)
    for j=1:(c1-c2+1)
        Nimage=Target(i:i+r2-1,j:j+c2-1);
        Nimage=Nimage-mean(mean(Nimage)); % mean of image
part under mask
        corr=sum(sum(Nimage.*image22));
        corrMat(i,j)=corr;
    end
end

[r1,c1]=size(Target);
[r2,c2]=size(Template);

[r,c]=max(corrMat);
[r3,c3]=max(max(corrMat));

i=c(c3);
j=c3;

ybegin = i;
yend   = i+r2-1;
xbegin = j;
xend   = j+c2-1;

%Percentage Algorithm, calculate the percentage
Template_Complement=imcomplement(Template);
%figure,imshow(Template_Complement)
Target_Complement=Target(ybegin:yend,xbegin:xend);
a=imcomplement(Target_Complement);
%figure, imshow(a)
d=mean(double(Template_Complement));
e=mean(double(a));
c = normxcorr2(d,e);
f = normxcorr2(Template_Complement(:,:,1), a(:,:,1));
%L=Template_Complement-a;
%figure,imshow(L);

%Display the results
if max(c(:)) > 0.90
    %disp(['Buffalo is detected at 50m in front with Percentage
of Matching: ',num2str((max(c(:))/1)*100)]);
    set(handles.text4,'string',['Buffalo is detected at 60m in
front with Percentage of Matching: ',num2str((max(c(:))/1)*100)])
    figure, surf(f), shading flat
    axes(handles.axes4),surf(f),shading flat
    sub_Target=Target(ybegin:yend,xbegin:xend);
    axes(handles.axes3)
    imshow(sub_Target), title('Buffalo is Detected')

result=Target;
for x=i:i+r2-1
    for y=j
        result(x,y)=255-255;
    end
end
for x=i:i+r2-1
    for y=j+c2-1
        result(x,y)=255-255;
    end
end

```

```

for x=i
    for y=j:j+c2-1
        result(x,y)=255-255;
    end
end
for x=i+r2-1
    for y=j:j+c2-1
        result(x,y)=255-255;
    end
end

%Plot the result of Template Matching
figure,
subplot(2,2,1),imshow(im1);title('Template');
subplot(2,2,2),imshow(im2);title('Target');
subplot(2,2,3),imshow(result);title('Matching Result using
Template Matching');
t1=toc %timer stop
set(handles.text5,'string',t1)
throw (b);

else
    disp(['No buffalo, Percentage of Matching:
',num2str((max(c(:))/1)*100)]);
    %throw (sub_Target);

end
break
end

```


Appendix B
Samsung SCC-B9270 (IR LED Camera)

ITEM	PAL
Image Sensor	1/3" Interline transfer type Color CCD (SONY)
Effective Pixels	500H x 582V (290K pixels)
Scanning System	625 Lines 2:1 Interlace
Scanning Frequency	15.625KHz (H), 50Hz (V)
Resolution	350TVL
Shutter Speed	1/50~1/100,000 sec.
S/N Ratio	More than 48dB (AGC Off)
Sync. System	Internal
Min. Illumination	0 Lux (IR LED On)
White Balance	AWC
Video Output	VBS 1.0 Vp-p (75Ω Load)
Lens	4.3mm DC Fixed IRIS F2.0 Day&Night Lens
Power Supply(*)	DC12V ± 10%
Power Consumption	1.3W(LED Off)/5.4W(LED On)
Operating Temp.	-10°C~50°C (14F~122F)
Operational Humidity	Max. 90% RH
Dimensions	70mm (Ø) × 102mm (L)