

**MOTION ESTIMATION FOR 1-CHANNEL AROUND  
VIEW MONITORING IN ADVANCE DRIVER  
ASSISTANCE SYSTEM USING WIDE FISHEYE  
CAMERA**

**BY**

**SYAHIRAH BINTI HANIZAM**

**A thesis submitted in fulfilment of the requirement for the  
degree of Master of Science (Mechatronics Engineering)**

**Kulliyyah of Engineering  
International Islamic University Malaysia**

**MARCH 2022**

## ABSTRACT

Around View Monitoring (AVM) system uses multiple input cameras mounted on different vehicle positions to display 360° bird-eye-view around the vehicle that is not readily visible to the driver. The development of this system will reduce parking accidents by monitoring its surroundings, detecting lanes, and identifying obstacles. Even a short propel guidance can diminish the number of accidents, even minor ones. This project proposes developing one ultra-wide-angle camera on the rear vehicle integrated with the motion estimation (ME) algorithm to produce a parking bird-eye view. This algorithm will not depend on other sensors such as GPS, odometer, and steering. The AVM system must be fast enough to make the image as a bird's eye view and make it as close as possible compared to the real world. The algorithm will use information from ME to stitch image sequences captured from the front or rear of vehicles. Hence, it will create a synthetic image around the vehicle for the AVM system. With this solution, all kinds of vehicles will have AVM technology, even the old vehicles. Before applying ME in the AVM algorithm, the images will undergo pre-processing, which are dewarping, top-down view, and cropped. ME is needed to calculate vectors that show the motion of the vehicle. The studies show that the ME method that can be used for a homogeneous surface is indirect. From the indirect method, there are optical flow and block matching. After the analysis, optical flow is deemed unsuitable for a real-time ADAS system as it fails at least 25.5% of the time. This statistic means, out of 100 frames, the algorithm will fail at least for 25 frames. Usually, the real-time application is up to 30 frames per second. 25 frames are close to one second, and an error of one second is unacceptable. On the other hand, for block matching, the results for percentage fails are 6.76% and 18.24% for left and right segments of the images. The ME methods result are analyzed, and the block matching method fits the system with the highest accuracy and lowest processing time. Thus, the new algorithm for the AVM system is based on the Block Matching method. This project's algorithm is on par with CCORR\_NORMED with 14.86% and 18.98% fail percentages for left and right segments, respectively. CCORR\_NORMED processing speed is 4.323ms, while this project's ME is 4.655ms. PC platform produces 12.750 ms processing speed with 47 fps, 94.594 ms with 10 fps on Renesas, and 172.955 ms with 5 fps on Telechips.

## خلاصة البحث

يستخدم نظام مراقبة الرؤية المحيطة (AVM) كاميرات إدخال متعددة مثبتة على مواضع مختلفة للسيارة لعرض رؤية عين الطائر بزوايا 360 درجة حول السيارة والتي لا يمكن رؤيتها بسهولة للسائق. سيؤدي تطوير هذا النظام إلى تقليل حوادث وقوف السيارات من خلال مراقبة محيطه ، واكتشاف الممرات ، وتحديد العقبات. حتى التوجيه القصير للدفع يمكن أن يقلل من عدد الحوادث ، حتى الحوادث الصغيرة. يقترح هذا المشروع تطوير كاميرا واحدة فائقة الزاوية على السيارة الخلفية مدججة مع خوارزمية تقدير الحركة (ME) لإنتاج عرض عين طائر وقوف السيارات. لن تعتمد هذه الخوارزمية على أجهزة استشعار أخرى مثل GPS وعداد المسافات والتوجيه. يجب أن يكون نظام AVM سريعاً بما يكفي لجعل الصورة كمنظر عين الطائر وجعلها قريبة قدر الإمكان مقارنة بالعالم الحقيقي. ستستخدم الخوارزمية معلومات من ME لغرز تسلسل الصور المتقطعة من مقدمة أو خلف المركبات. وبالتالي ، ستنشئ صورة اصطناعية حول السيارة لنظام AVM. مع هذا الحل ، ستحتوي جميع أنواع المركبات على تقنية AVM ، حتى المركبات القديمة. قبل تطبيق ME في خوارزمية AVM ، ستخضع الصور للمعالجة المسبقة ، والتي يتم إزالتها ، وعرضها من أعلى لأسفل ، وقطعها. هناك حاجة إلى ME لحساب المتجهات التي تظهر حركة السيارة. تظهر الدراسات أن طريقة ME التي يمكن استخدامها لسطح متجانس غير مباشرة. من الطريقة غير المباشرة ، هناك تدفق بصري ومطابقة كتلة. بعد التحليل ، يعتبر التدفق البصري غير مناسب لنظام ADAS في الوقت الحقيقي لأنه يفشل على الأقل 25.5٪ من الوقت. تعني هذه الإحصائيات ، من بين 100 إطار ، ستفشل الخوارزمية على الأقل لـ 25 إطاراً. عادة ، يصل التطبيق في الوقت الفعلي إلى 30 إطاراً في الثانية. 25 إطاراً قريبة من ثانية واحدة ، وخطأ لمدة ثانية واحدة غير مقبول. من ناحية أخرى ، بالنسبة لمطابقة الكتلة ، فإن نتائج النسبة المئوية للفشل هي 6.76٪ و 18.24٪ للمقاطع اليسرى واليمينى من الصور. يتم تحليل نتيجة طرق ME ، وتناسب طريقة مطابقة الكتلة النظام بأعلى دقة وأقل وقت معالجة. وبالتالي ، تعتمد الخوارزمية الجديدة لنظام AVM على طريقة مطابقة الكتلة. خوارزمية هذا المشروع على قدم المساواة مع CCORR\_NORMED بنسبة 14.86٪ و 18.98٪ من حالات الفشل للقطاعات الأيسر والأيمن ، على التوالي. تبلغ سرعة معالجة CCORR\_NORMED 4.323 مللي ثانية ، بينما تبلغ سرعة هذا المشروع 4.655 مللي ثانية. تنتج منصة الكمبيوتر 12.750 مللي ثانية من المعالجة بـ 47 إطاراً في الثانية و 94.594 مللي ثانية مع 10 إطارات في الثانية على Renesas و 172.955 مللي ثانية مع 5 إطارات في الثانية على Telechips.

## APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Mechatronics Engineering).

.....  
Nik Nur Wahidah Nik Hashim  
Supervisor

.....  
Zulkifli Zainal Abidin  
Co-Supervisor

.....  
Hasan Firdaus Mohd Zaki  
Co-Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Mechatronics Engineering).

.....  
Abd Halim Embong  
Internal Examiner

.....  
Siti Anom Ahmad  
External Examiner

This thesis was submitted to the Department of Mechatronics Engineering and is accepted as a fulfillment of the requirement for the degree of Master of Science (Mechatronics Engineering).

.....  
Ali Sophian  
Head, Department of  
Mechatronics Engineering

This thesis was submitted to the Kulliyah of Engineering and is accepted as a fulfillment of the requirement for the degree of Master of Science (Mechatronics Engineering).

.....  
Sany Izan Ihsan  
Dean, Kulliyah of Engineering

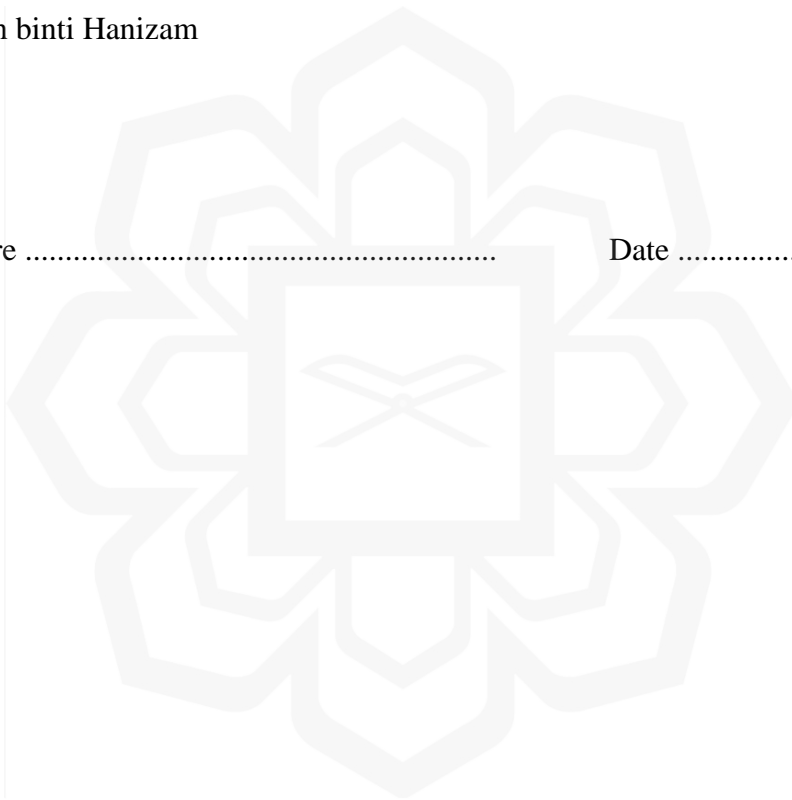
## DECLARATION

I hereby declare that this thesis results from my investigations, except otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Syahirah binti Hanizam

Signature .....

Date .....



**INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA**

**DECLARATION OF COPYRIGHT AND AFFIRMATION OF  
FAIR USE OF UNPUBLISHED RESEARCH**

**MOTION ESTIMATION FOR 1-CHANNEL AROUND VIEW  
MONITORING IN ADVANCE DRIVER ASSISTANCE SYSTEM  
USING WIDE FISHEYE CAMERA**

I declare that the copyright holders of this thesis are jointly owned by the student and IIUM.

Copyright © 2022 Syahirah binti Hanizam and International Islamic University Malaysia. All rights reserved.

No part of this unpublished research may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without prior written permission of the copyright holder except as provided below

1. Any material contained in or derived from this unpublished research may be used by others in their writing with due acknowledgement.
2. IIUM or its library will have the right to make and transmit copies (print or electronic) for institutional and academic purposes.
3. The IIUM library will have the right to make, store in a retrieved system and supply copies of this unpublished research if requested by other universities and research libraries.

By signing this form, I acknowledged that I have read and understand the IIUM Intellectual Property Right and Commercialization policy.

Affirmed by Syahirah binti Hanizam

.....

Signature

.....

Date

## ACKNOWLEDGEMENTS

*IN THE NAME OF ALLAH, THE MOST COMPASSIONATE AND THE MOST MERCIFUL*

I thank Allah S.W.T, Sustainer and the Creator of the universe and its inhabitant, for He has given me HIS blessings and making it possible for me to complete this thesis.

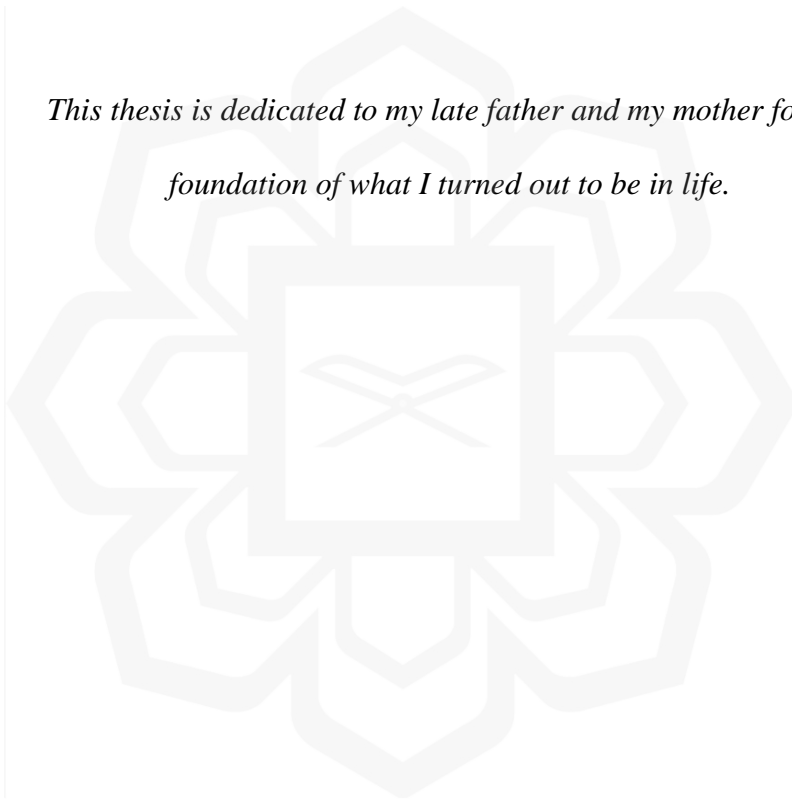
Firstly, it is my utmost pleasure to dedicate this work to my dear parents and my family, who granted me the gift of their unwavering belief in my ability to accomplish this goal: thank you for your support and patience.

I wish to express my appreciation and thanks to those who provided their time, effort, and support for this project. To the dissertation committee members, thank you for sticking with me.

Finally, a special thanks to Associate Professor Nik Nur Wahidah for his continuous support, encouragement, and leadership, and for that, I will be forever grateful.

This research is supported by International Islamic University Malaysia (IIUM) with Collaborative Research in Engineering, Science & Technology Center (CREST) and Delloyd R&D (M) Sdn. Bhd. (Project ID P11C2-17 & SP17-029-0291)

*This thesis is dedicated to my late father and my mother for laying the  
foundation of what I turned out to be in life.*





# TABLE OF CONTENTS

Abstract .....	ii
Abstract in Arabic .....	iii
Approval page .....	iv
Declaration .....	v
Acknowledgements .....	vii
Table of contents .....	ix
List of Tables .....	xi
List of Figures .....	xii
List of Abbreviations .....	xv
List of Symbols .....	xvi
<b>CHAPTER ONE: INTRODUCTION .....</b>	<b>1</b>
1.1 Background of The Study .....	1
1.2 Problem Statement .....	4
1.3 Research Objectives .....	6
1.4 Research Methodology .....	7
1.5 Research Scope .....	8
1.6 Publication .....	9
1.7 Outline .....	10
<b>CHAPTER TWO: LITERATURE REVIEW .....</b>	<b>11</b>
2.1 Introduction .....	11
2.2 Around View Monitoring .....	11
2.2.1 Camera .....	12
2.2.2 Calibration .....	13
2.2.3 Bird's Eye View .....	15
2.2.4 Stitching .....	15
2.2.5 Commercial Systems .....	16
2.3 Motion Estimation .....	17
2.3.1 Direct Method .....	20
2.3.1.1 Phase Correlation .....	20
2.3.1.2 Block Matching .....	21
2.3.1.3 Spatio-Temporal Gradient .....	23
2.3.1.3.1 Optical Flow .....	23
2.3.1.3.2 Pel-Recursive .....	26
2.3.2 Indirect Method .....	26
2.3.2.1 Feature Matching .....	27
2.4 Chapter Summary .....	27
<b>CHAPTER THREE: SYSTEM DEVELOPMENT .....</b>	<b>31</b>
3.1 Introduction .....	31
3.2 Proposed algorithm .....	31
3.3 Data Collection .....	32
3.3.1 Camera Setup .....	32
3.3.2 Video Collection .....	33

3.4	Stitching.....	34
3.5	Calibration .....	36
3.5.1	Camera Calibration .....	36
3.5.2	Top-Down Calibration .....	41
3.6	Ground Truth Configuration.....	45
3.7	Algorithm for Motion Estimation.....	45
3.7.1	Optical Flow.....	46
3.7.1.1	Farneback .....	71
3.7.2	Block Matching.....	46
3.7.3	Proposed Motion Estimation.....	47
3.8	Inertial Measurement Unit.....	49
3.8.1	Gyroscope .....	50
3.8.2	Accelerometer .....	54
3.8.3	IMU Conclusion.....	55
3.9	Embedded Board .....	56
3.10	Chapter Summary .....	57
<b>CHAPTER FOUR: RESULT AND DISCUSSION .....</b>		<b>58</b>
4.1	Introduction.....	58
4.2	Result Around View Monitoring System .....	58
4.2.1	Optical Flow by Farneback .....	59
4.2.1.1	Winsize .....	59
4.2.1.2	Poly_n.....	60
4.2.1.3	Poly_sigma .....	61
4.2.1.4	Optical Flow Conclusion.....	61
4.2.2	Block Matching.....	62
4.2.2.1	OpenCv Template Matching .....	62
4.2.2.2	Block Matching .....	65
4.3	Result on Embedded System .....	66
4.4	Chapter Summary .....	68
<b>CHAPTER FIVE: CONCLUSION .....</b>		<b>69</b>
5.1	Conclusion .....	69
5.2	Recommendation .....	70
<b>REFERENCES.....</b>		<b>71</b>

## LIST OF TABLES

Table 2.1 Number of cameras summary	28
Table 2.2 Summary for ME methods	29
Table 3.1 Camera specification	33
Table 3.2 Benchmark of AVM image from commercial vehicle brands	34
Table 3.3 Full-scale configuration test	52
Table 3.4 LPF and HPF configuration result	53
Table 4.1 Template Matching Percentage Fail on Day Time	62
Table 4.2 Template Matching Percentage Fail on Night-Time	63
Table 4.3 Fail Percentage on different ROI size	65
Table 4.4 Fail Percentage on different color methods	66
Table 4.5 Fail Percentage on luminance color method	66
Table 4.6 Processing time of benchmark block matching methods	67
Table 4.7 Processing time of block matching algorithm in different platform	67
Table 4.8 AVM algorithm speed in different platform	67

## LIST OF FIGURES

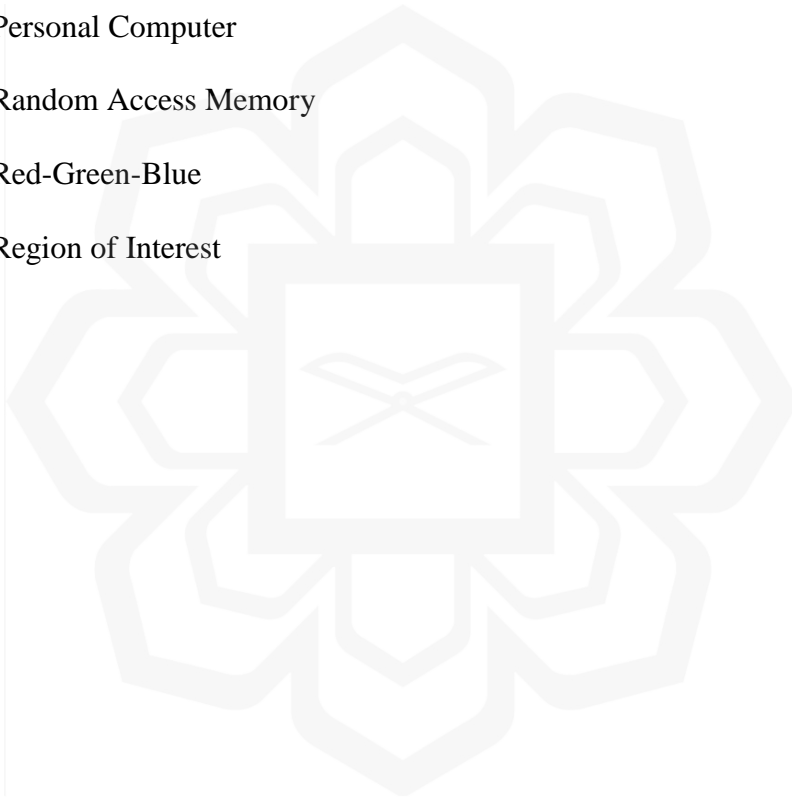
Figure 1.1 Overall features of ADAS ( <i>ADAS: Features of Advanced Driver Assistance Systems</i> , n.d.)	2
Figure 1.2 Example of Around View Monitoring from BMW ( <i>What Are Car Surround View Cameras, and Why Are They Better than They Need to Be? - ExtremeTech</i> , n.d.)	2
Figure 1.3 Classification of Motion Estimation	4
Figure 1.4 Malaysia Road Accident 2010 – 2019 ( <i>Portal Rasmi Kementerian Pengangkutan Malaysia Kemalangan Dan Kematian Jalan Raya Di Malaysia</i> , n.d.)	5
Figure 1.5 Flowchart of research methodology	7
Figure 2.1 Overall AVM Process	11
Figure 2.2 Example of commercial AVM system (a) source : (“BMW 7 Series Sedan : Driver Assistance,” n.d.) (b) source : (“Audi S8 360-degree View Camera - YouTube,” n.d.) (c) source : (“How does the Toyota Bird’s Eye View Monitor System work?,” n.d.)	17
Figure 2.3 Classification of Motion Estimation Algorithms according to (Baraskar et al., 2015)	19
Figure 2.4 Block Matching Algorithm by (Pesquet-popescu et al., n.d.-b)	22
Figure 2.5 Summary Step of (Farneback, 2002) Algorithm	24
Figure 2.6 Optical Flow Process by ( <i>Learning to Estimate Robot Motion and Find Unexpected Objects from Optical Flow   Hizook</i> , n.d.)	25
Figure 2.7 Catadioptric cameras positioned on camera side views in (Gandhi & Trivedi, 2006b)	29
Figure 3.1 Overall flowchart of project’s algorithm	31
Figure 3.2 Camera mounted on Range Rover toy car	33
Figure 3.3 Angle of the camera mounted on a Range Rover toy car	33
Figure 3.4 Dimension of Range Rover toy car (height and width)	35
Figure 3.5 Height and width for image stitching	35
Figure 3.6 Top-down height and width parameters	36

Figure 3.7 (a) Application provided for parameter extraction; (b) 9x6 chessboard	37
Figure 3.8 Example of several datasets collected using a fisheye camera	38
Figure 3.9 (a) original fisheye image (b) result of the image after dewarp	38
Figure 3.10 Results of using <code>getOptimalNewCameraMatrix</code> , <code>initUndistortRectifyMap</code> , remap with different alpha value	39
Figure 3.11 Results of using <code>getOptimalNewCameraMatrix</code> , <code>Undistort</code> with different alpha value	39
Figure 3.12 Results of using <code>Knew = camMat</code> , <code>initUndistortRectifyMap</code> , remap with different alpha value	39
Figure 3.13 Results of using <code>Knew = camMat</code> , <code>Undistort</code> with different alpha values	40
Figure 3.14 Results of using <code>Knew</code> , <code>omnidir::initUndistortRectifyMap</code> , remap with different alpha values	40
Figure 3.15 Example of markers positioned to use in application given	41
Figure 3.16 Example of ArUco marker used	42
Figure 3.17 Setup of ArUco marker	42
Figure 3.18 Visualization of camera position in terms of its Field of View (FOV)	43
Figure 3.19 Final result of top-down view (a) original (b) dewarp (c) top-down	44
Figure 3.20 Configuration measurement (a) Measurement of overall ground truth configuration (b) Measurement of each checkerboard used	45
Figure 3.21 Example optical flow algorithm applied on an asphalt surface	46
Figure 3.22 Steps of Proposed ME (a) <i>previous frame</i> with template (b) <i>current frame</i> with ROIs (c) right ROI and left ROI (d) searching region (e) delta x and delta y for both ROIs (f) final vector	48
Figure 3.23 Visual representation of roll, pitch, and yaw	49
Figure 3.24 Experimental board containing accelerometer and gyro-meter	50
Figure 3.25 Gyroscope reading when stationary with no filter	51
Figure 3.26 Gyroscope reading when rotating with no filter	51
Figure 3.27 Low Pass Filter (LPF) and High Pass Filter (HPF) configuration	53
Figure 3.28 Accelerometer reading while moving forward using Toy Car	54

Figure 3.29 Accelerometer reading while moving reverse using Toy Car	55
Figure 3.30 Embedded board (a) Renesas R-Car H2 (b) Telechips TCC 8971 board	56
Figure 4.1 AVM algorithm result image	58
Figure 4.2 False detection when winsize being manipulated	60
Figure 4.3 False detection when poly_n being manipulated	60
Figure 4.4 False detection when poly_sigma being manipulated	61
Figure 4.5 Reverse lighting condition (a) testing vehicle (b) Peugeot Traveler	64
Figure 4.6 Template matching during night condition	64
Figure A5.1 Farneback algorithm flowchart	71
Figure A5.2 Figure A2 Explanation of CV_32FC2 ( <i>Opencv - Convert a Matrix of Type "CV_32FC2" to Type "CV_32FC1" - Stack Overflow, n.d.</i> )	72
Figure A5.3 Example of image pyramid ( <i>Images – IPIImage, n.d.</i> )	72

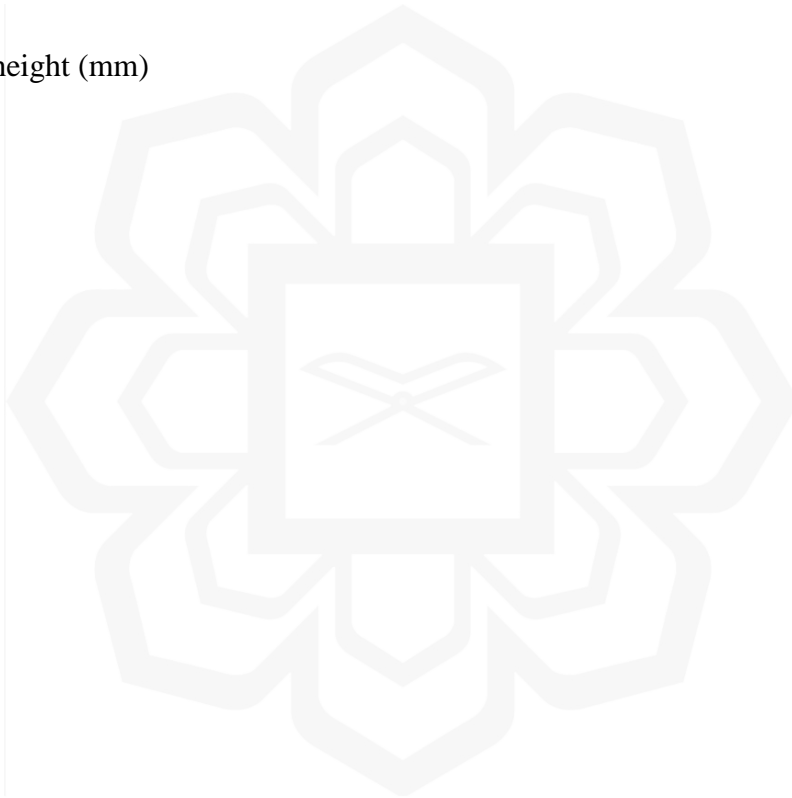
## LIST OF ABBREVIATIONS

AVM	Around View Monitoring
GPU	Graphical Processing Unit
IMU	Internal Measurement Unit
ME	Motion Estimation
OS	Operating System
PC	Personal Computer
RAM	Random Access Memory
RGB	Red-Green-Blue
ROI	Region of Interest



## LIST OF SYMBOLS

$K$	Camera Matrix
$D$	Distortion Coefficient
$x_i$	Len's Shape Parameter
$a$	width (mm)
$b$	height (mm)





# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 BACKGROUND OF THE STUDY**

Transportation is one of the most critical aspects of human civilization. People will use the transportation system every day, especially to work and during emergency events. Therefore, it is essential to ensure the safety of the passengers and drivers while they are using the transportation system. An advanced driver assistance system (ADAS) is a new technology currently being studied and developed focusing on the safety of drivers and passengers in the vehicle. An around view monitoring (AVM) system is one of the features designed under the ADAS spectrum, as illustrated in Figure 1.1. It is a system that can produce a top view of the vehicle's surrounding for the driver's view. At the same time, motion estimation (ME) is a technique that can be used in AVM image processing. The development of AVM will undoubtedly contribute to the increase of safety measures for road users using any transportation.

## ADAS: THE CIRCLE OF SAFETY

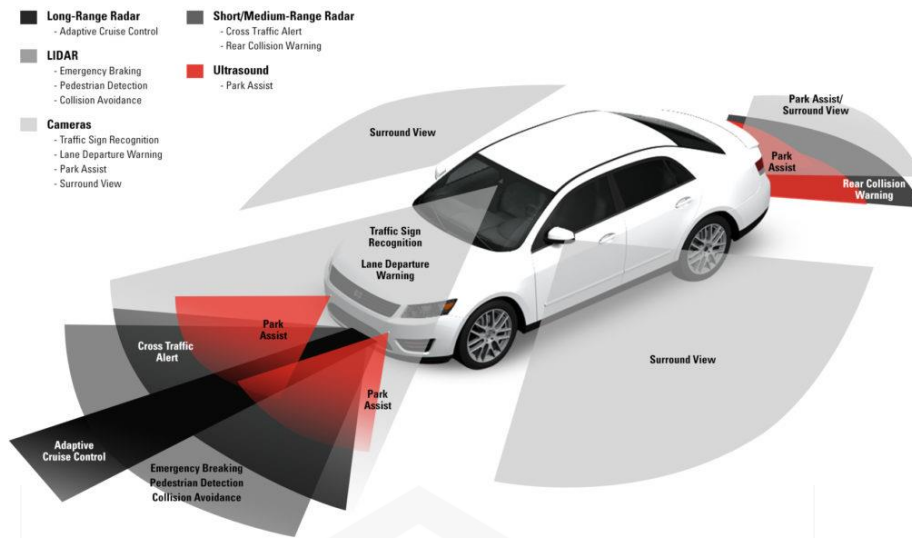


Figure 1.1 Overall features of ADAS (*ADAS: Features of Advanced Driver Assistance Systems, n.d.*)

As shown in Figure 1.1, AVM is one of the ADAS features using a camera. It is shown in light gray color and written as surround view. The commercial vehicle usually uses four cameras positioned outside the car; center at the front, under both side mirrors, and center at the rear, as indicated by red arrows in Figure 1.2. Some of them also use ultrasonic sensors to detect objects surrounding the car. Figure 1.2 also shows the example of the AVM final product.

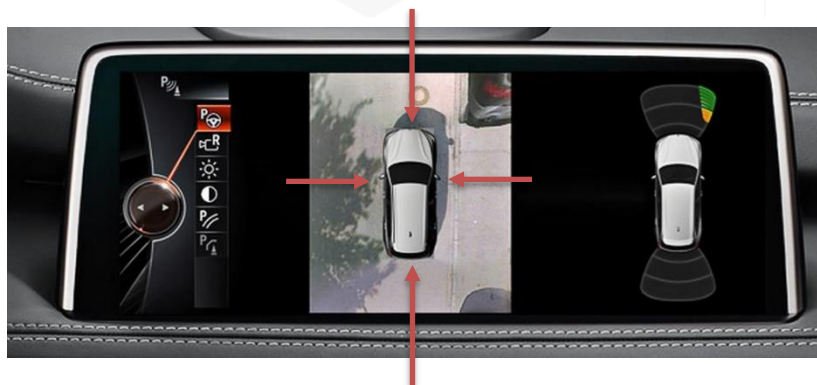


Figure 1.2 Example of Around View Monitoring from BMW (*What Are Car Surround View Cameras, and Why Are They Better than They Need to Be? - ExtremeTech, n.d.*)

Motion estimation (ME) is a process to find the same pixel size between frames to determine the motion vector. Motion is the crucial source of information in video sequences. Sequential frames may contain the same object, but the object is either still at the same place or moved to a new location due to the object's moving in the real world or camera motion. ME is primarily designed for video compression to make the output more stable. According to (Pesquet-popescu et al., n.d.-a), ME is essential for computer vision, image sequence analysis, and video communication. Therefore, it needs to be accurate and efficient.

In the real world, motion can be complicated. It may be a combination of rotation and translation, which will be challenging to estimate the motion, thus requiring high processing. However, in sequential frames, the motion can only be translated as the gap between frames is 0.1 seconds for ten frames per second (fps) or 0.033 seconds for 30 fps video. The interval between two frames is small so that motion can be estimated and used effectively for further processing, such as motion compensation.

According to (Pesquet-popescu et al., n.d.-b), there are several approaches for ME. These approaches are optical flow, pel-recursive, transform-domain, block matching, parametric ME, and multi-resolution methods. Among all these approaches, block matching algorithms (BMA) have been used the most due to their efficiency and simplicity, as claimed by (Baraskar et al., 2015). ME can be classified as shown in Figure 1.3.

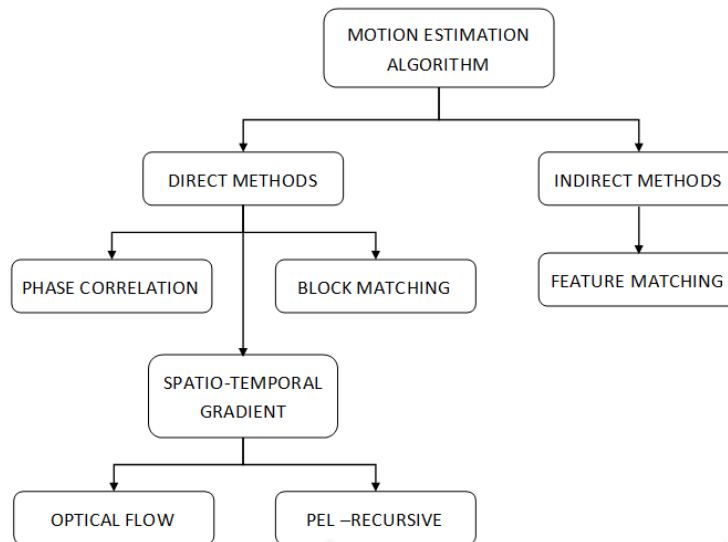


Figure 1.3 Classification of Motion Estimation

## 1.2 PROBLEM STATEMENT

In 2019 alone, there are 567,516 traffic/road accidents, which put Malaysia in the top rank of the road accident relative to its population (*Portal Rasmi Kementerian Pengangkutan Malaysia Kemalangan Dan Kematian Jalan Raya Di Malaysia*, n.d.). The accident rate has increased from 2010 to 2019, as shown in Figure 1.4. This statistic includes all the fender benders maneuvering in narrow spaces and parking spaces.

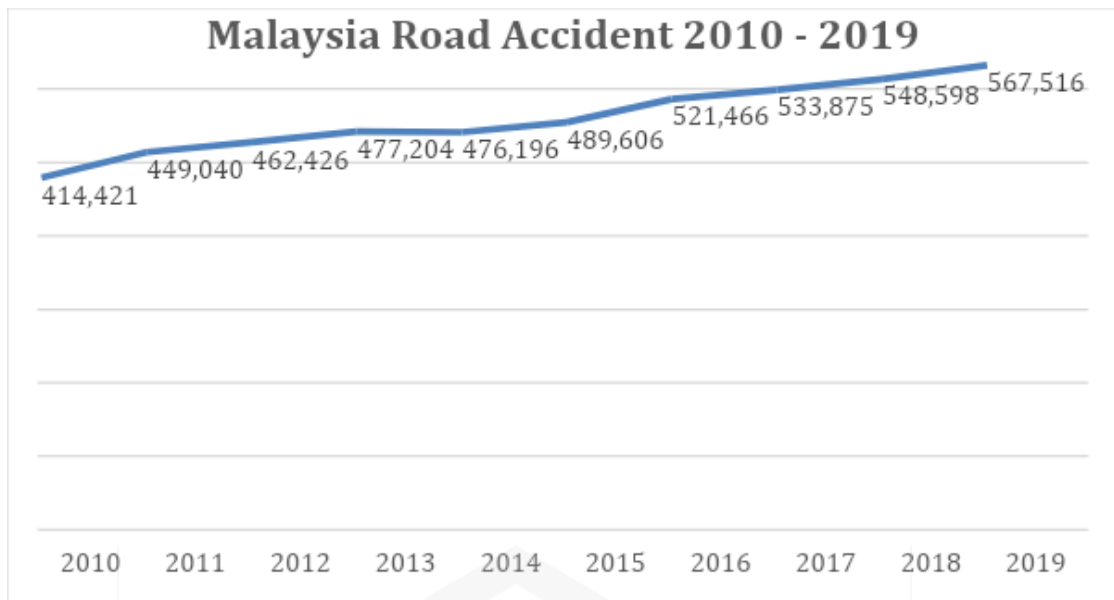


Figure 1.4 Malaysia Road Accident 2010 – 2019 (*Portal Rasmi Kementerian Pengangkutan Malaysia Kemalangan Dan Kematian Jalan Raya di Malaysia, n.d.*)

A technology called Around View Monitoring (AVM) is currently being developed to assist drivers during parking and maneuvering in tight spaces to reduce the number of casualties from accidents. AVM requires an accurate and efficient real-time bird's eye view with forward/backward trajectory lines. Current AVM uses parameters information from the odometer, a global positioning system (GPS), and a steering system to calculate the trajectory lines. Conventionally, there are two types of AVM systems:

1. Four-channel AVM system (using four cameras)
2. One-channel AVM system (using one camera)

One-channel AVM system requires fusing with other systems such as the odometer, the global positioning system (GPS), and the steering system to produce the bird's eye view. Each system has its flaws. The odometer and steering system cannot detect a slippage, thus creating a crooked bird's eye view. Moreover, GPS cannot be

used when the environment is cloudy and if the GPS is in a tall building. Another problem for AVM system manufacturers is that manufacturers for the odometer, GPS, and steering system are reluctant to have their systems being tampered with as it will affect their safety. As the AVM system is dependent on other systems, thus failure in any one of the systems may affect the validity and performance of the AVM output.

An after-market AVM system is sold in Malaysia using four cameras. However, fixing an AVM system in a car is expensive. Currently, AVM systems are built-in with the car. Not all vehicles are suitable to use the current AVM system. Furthermore, not all vehicles are currently being sold with the AVM system, thus limiting users' options.

Thus, developing a one-channel AVM system algorithm using ME will significantly contribute to ADAS technology. Because the motion vector between frames is small, ME will be suitable for capturing the motion. Therefore, it can stitch two conservative frames as the difference was insignificant.

This new algorithm will not require information from other systems such as odometer, GPS, and steering system. Thus, the algorithm will not depend on those systems' failures.

### **1.3 RESEARCH OBJECTIVES**

The research aims to achieve the following objectives:

1. To develop a new algorithm for AVM system using a single camera during parking.
2. To implement ME on the AVM system.
3. To evaluate the performance of the ME on the developed AVM system.
4. To validate and compare with other existing systems

## 1.4 RESEARCH METHODOLOGY

This project aims to use ME techniques on images to estimate the motion of ground vehicles, especially on homogenous surfaces. The research methodology is as described in Figure 1.5.

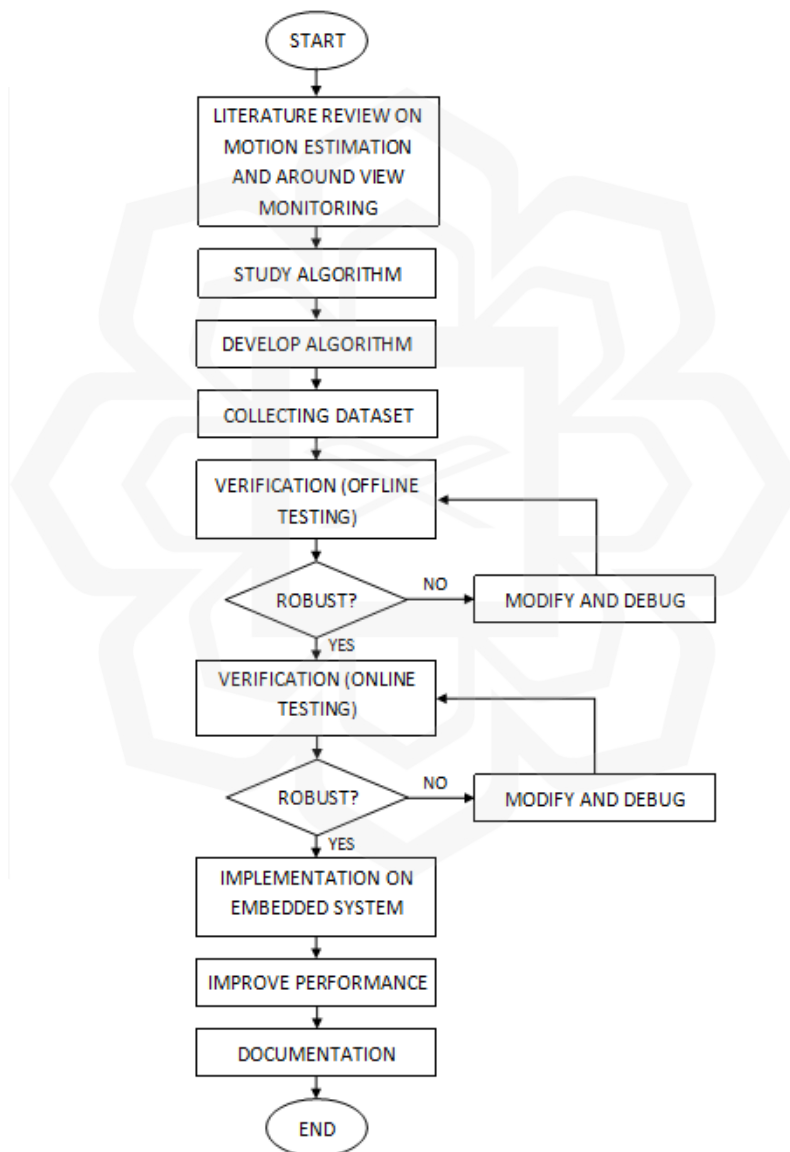


Figure 1.5 Flowchart of research methodology

Based on the flowchart in Figure 1.5, this project's methodology starts with a literature review on Around View Monitoring (AVM) and motion estimation (ME). This step ensures that the project aligns with the current technology and fills the research gap. This project also needs as much information as possible about the industrial demand and their requirements.

The next begins by reproducing results using existing ME algorithms on new videos to identify the best suitable method to achieve the objectives. The ME will be direct or indirect methods, and the selection will be explained in chapter 2. After that, we developed an algorithm for a one-channel AVM system using ME. This process will be presented in the next sub-chapter. At the same time, new datasets were collected to evaluate the performance of the developed algorithm when offline. There are two conditions for the algorithm to be tested: offline and online. Offline testing means the algorithm is tested on a video recorded, while online testing is tested in a real-time environment.

The algorithm must be constantly tested and modified accordingly until the algorithm is robust enough. Next, the algorithm will be tested in real-time. After the algorithm is considered robust during an online test, it will be integrated with an embedded system. The algorithm will require optimization until the embedded system can run in real-time.

## **1.5 RESEARCH SCOPE**

The research focuses mainly on:

- i. Developing a one-channel AVM system algorithm using ME uses less computing cost on the embedded system.