UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND IMPLEMENTATION OF VEHICLE FRONT SENSING SYSTEM USING FPGA FOR LOW-SPEED FOLLOWING FEATURE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Computer Engineering Technology (Computer Systems) with Honours.

by

MUHAMMAD HAKIM BIN RAZALUDIN

B071510491

960918-01-6179

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY

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Taman Pasir Putih,
81700 Pasir Gudang, Johor.
Tarikh:

Disahkan oleh penyelia:

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Author : Muhammad Hakim Bin Razaludin

Date:

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Computer Systems) with Honours. The member of the supervisory is as follow:

Signature: …….

Supervisor: En. Aiman Zakwan Bin Jidin

Signature: …….

Co-supervisor: En. Noor Mohd Ariff Bin Brahin

ABSTRAK

Pada masa kini, kesesakan jalan raya merupakan satu yang utama di kebanyakkan negara. Antara faktor yang membawa kepada kesesakkan jalan raya adalah terdapat banyak jalan raya yang bersambung dan bilangan lampu trafik yang banyak. Kesesakan yang berpanjangan akan memberi kesan yang negatif kepada setiap pemandu seperti ketidakselesaan, dimana tempoh masa perjalanan mereka menjadi lebih lama. Jalan penyelesaian masalah ini perlu dikenalpasti untuk membantu pemandu untuk menghadapi kesesakkan jalan raya dengan selesa. Oleh itu, projek yang dicadangkan ini bertujuan untuk membangunkan dan melakasanakan sebuah algoritma yang akan dipasangkan pada kenderaaan dimana fungsinya sangat berkesan untuk membantu pemandu menghadapi situati tersebut tanpa tertekan. Algoritma tersebut akan mempunyai kawalan sensor untuk mengesan jarak kenderaan di hadapan, dimana jarak itu akan diproses untuk menentukan pergerakkan kenderaan samada bergerak ataupun berhenti. Algoritma in hanya beroperasi apabila suis ditekan, dimana pemandu perlu hidupkan hanya ketika di dalam kesesakkan jalan raya ataupun menunggu lampu trafik. Komponen yang telah digunakan dalam projek ini adalah FPGA board, motor driver dan sensor ultrasonik. Motor driver berfungsi untuk mengawal arah pergerakan motor manakala sensor ultrasonik digunakan untuk mengesan jarak. Verilog adalah bahasa pengaturcaraan yang telah digunakan dalam projek ini dan perisian Altera Quartus II digunakan sebagai platform reka bentuk. Projek ini telah berjaya dilaksanakan dan objektif telah dicapai

.

ABSTRACT

Nowadays, traffic congestion has become the main problem in many countries. Factor that leads to the traffic congestion was due to the combined road or numerous of traffic light presence. Prolonged traffic congestion causes negative impact such as discomfort to all driver as their jouney time travel extended. Therefore, this proposed project aims to develop and to implement an algorithm to be utilized for a vehicle which could be useful to ease driver having the situation without stressed. The algorithm consisted of the sensor controller to detect the distance of car ahead. Then, the distance will be proceessed to indicate movement of the car either move or stop. The algorithm only operates when enabled, whereby the driver need to activeted it only when having traffic jam or waiting for traffic light. Components that have been used in this project were an FPGA board, a motor driver and two ultrasonic sensor. Motor driver was used to control and indicate direction of motor movement, while ultrsonic sensor was used for distance detection. Verilog is the programming languange that has been used in this project and Altera Quartus II used as the design platform. It has been proved that the project has been successfully implemented and the objectives has been achieved.

DEDICATION

To my beloved parents, I acknowledge my sincere indebtedness and gratitude to them for their love, dream and sacrifice throughout my life. I am really thankful for their sacrifice, patience, and understanding that were inevitable to make this work possible. Their sacrifice had inspired me from the day I learned how to read and write until what I have become now. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve my dreams. Lastly, I would like to send my gratitude to any person that contributes to my final year project whether it is directly or indirectly. I would like to acknowledge their comments and suggestions, which are key for the successful completion of this study

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CHAPTER 1

INTRODUCTION

1.0 Introduction

In this chapter, an introduction of the most important topics that involve background, problems statement, objectives and scope of the project are provided. The background of the study describes the most important subtopics such as about vehicle front sensing system. The structure of this report for the project is briefly explained to ensure a better visualization of the sequence of the entire project.

1.1 Background

Lee *et al.* (2008) state that traffic congestion has become the main problem in many countries. Congestion happens when the number of traffic is much higher compared to the capacity of existing highway facilities according to Hashim and Ibrahim (2009). One of the main causes of traffic congestion is due to road combined or to many traffic lights. Vehicles tend to move slower when they reach the merging point. The congestion has possibilities to affect the comfortability of driver as they experience reduced speed, longer travel time, or longer travel time or longer waiting time on the road. Thus, a solution must be figured out to solve or reduce the traffic congestion.

Figure 1.1: Traffic congestion on the highway

Nowadays, fully automated driving is a very important research as there is well-known development due to issues of traffic congestion. Autonomous vehicles are vehicles embedded with a system that allows automatic driving which includes the suitable sensing technology according to Singh *et al.* (2017). This technology helps in development varies safety features into the vehicles. Furthermore, it also able to provide the comfortability and safety to the driver for facing any situation or condition on the road.

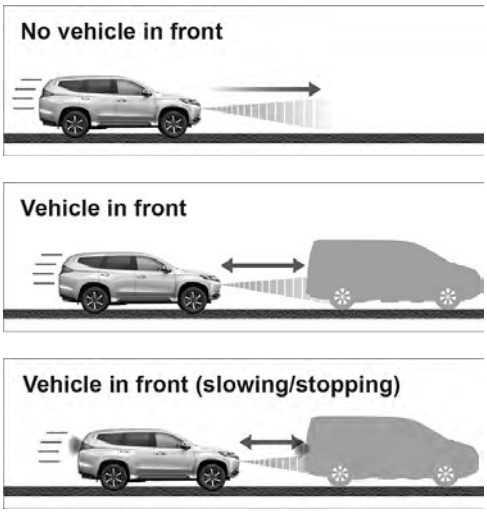

Figure 1. 2: Adaptive Cruise Control (ACC)

(Sources: <https://www.mitsubishimotors.com/en/showroom/pajero_sport/safety/>)

ACC is a feature of the autonomous vehicle which maintains a selected distance between own vehicle and the car ahead via the sensor to offer driving assistance and improve driving comfort. Figure 1.1 illustrates the ACC functionality where the car movement is dependent on the distance of the front car. The car will move when the distance is far from the front car until the distance becomes nearest or at the limit of safe distance. The feature especially able to reduces driver stress during slow traffic jams on highways such as Figure 1.2.

Besides, the revolution in digital image processing embedded technologies like radar, LiDAR, GPS, etc. helps in detecting the object in the surrounding. The sensor technology in autonomous vehicle system plays an important role in the accuracy and precision of the data obtained from the sensor will be used for any Advance Driving Assistance System (ADAS). The Advance control systems have the ability to analyze data obtained from sensors and recognize the detected object even the distance from the object.

In this project, the implementation of FPGA based vehicle front sensing system algorithm has been done to ease the driver while having the traffic jams on the highway.

1.2 Problem Statement

Most of the ACC feature is provided in the expensive vehicle. The feature has a capability of automatic follow the front car with safe speed and safe distance. Traffic jam and waiting for traffic light are the event that usually happened on the road especially on peak hour or season. The event causes displeasure to the driver for having a journey. Therefore, the system is introduced to ease driver facing the situation.

However, there is a certain problem with the normal cruise control technology that not aware of another vehicle movement. Hence, the driver must be always aware of the possible collision with the leading car. In addition, the cruise control does not slow down when there is possibility collision.

In this research, the main design parameter is the area detection by the sensor and the motor movement controlled by the system. The performance of the system is determined by motor responses according to the data obtained from the sensor.

1.3 Objectives

The objectives of this project are:

1) To study the method of detecting and movement feature of the system in FPGA.
2) To develop an algorithm of vehicle front sensing system using FPGA with low-speed following feature.
3) To analysis the performance and reliability of the system in term of range detection of the sensor and rate movement of the motor.

1.4 Scope

The scopes of work are defined in order to achieve the objective of this project. This current project is consisting of four work scope. First work scope is about hardware which is Field-Programmable Gate Array (FPGA). Cyclone III FPGA DE0 Board device will be used in this project. The board consists programmable IC which allow the development of the sophisticated digital system. FPGA needs to be connected to the computer using a USB cable for programming process.

The second work scope is the software which Altera Quartus II Design Software where the system algorithm developed using Verilog HDL languages. The simulation of the system algorithm done using ModelSim for a better observation compared to embedded simulation in Quartus software. Then, SignalTap II used for observation when the FPGA programmed with the system algorithm to check if the system works same as the simulation.

The third work scope is the parallel position of two ultrasonic sensor HC-SR04. Both sensors placed with parallel purposed to have wider area detection for the front vehicle. It is considered for the situation if there are two vehicles in front and both have different distance. Thus, the two sensors placed as mentioned for detecting two different distance by each sensor.

The last work scope is the laboratory as the area of the experiment. The purposed project will be on prototype model and not a real vehicle. The parameter for

system test only uses in the range of sensor capable. Thus, the purposed project can be tested in the laboratory.

Once finished developing the project, several tests conducted on a simple test event. Then, an analysis was performed based on the result obtained to ensure if the project meets the requirements and objectives as stated. Any error found was identified and corrected. The project also proceeds adjustment and improvement if there is an error detected to produce the best result. Once all the objectives achieved, the project is a success.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In order to make this project successful, some studies and research have been consulted to find the applicable information about the development of vehicle front sensing system using FPGA for low-speed following feature. The information was collected from many sources such as books, articles, journals, and internet. The concepts and findings from previous studies are reviewed and described to ensure the project can be completed successfully.

2.1 Advance Driving Assistance System (ADAS)

The research of Jiménez *et al.* (2016), Advanced Driving Assistance System (ADAS) are the smart system implemented inside the car purposed to help or assist the driver while on the road. The system capable to detect and estimate the status of the car to the surrounding and perform a certain task according to the corresponded status. The system will have the ability to control the car due to evaluated car status and operates task such automatic brake, adaptive cruise control, collision alert etc.

Intel (2016) state that ADAS system is known as small part of DAS system with the amplified use of complex processing algorithms to detect and assess the vehicle environment based on data collected through many types of sensor inputs.

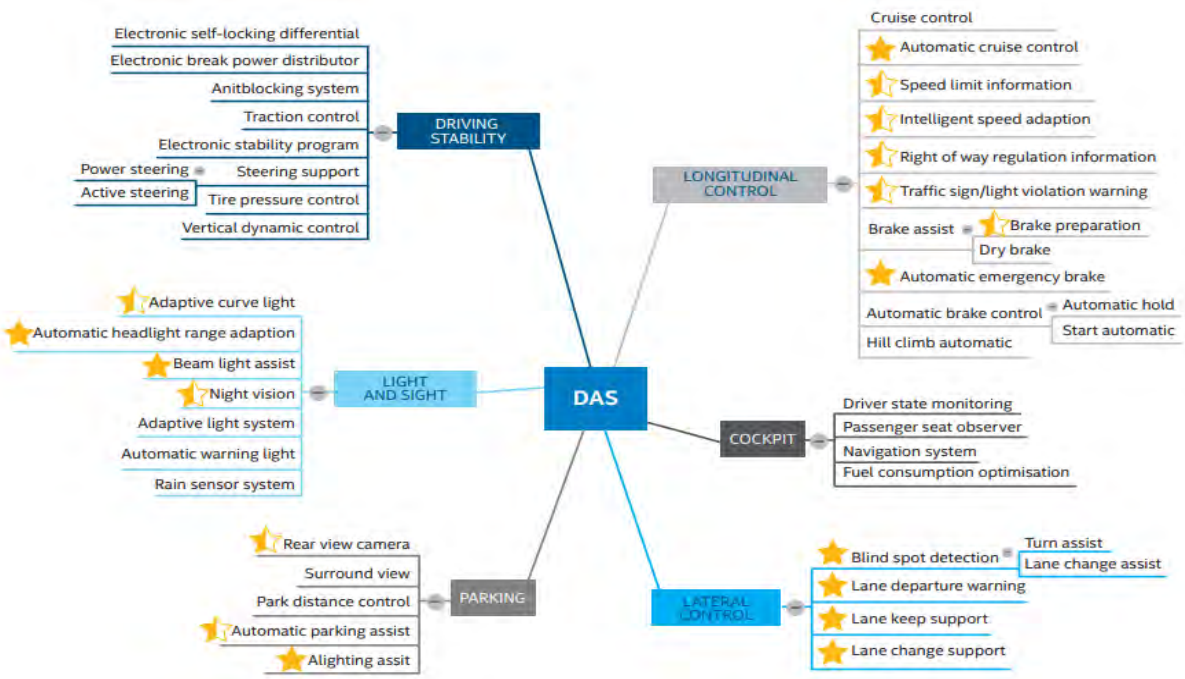

Figure 2. 1: Spectrum of DAS and ADAS Functions (Intel 2016)

Figure 2.1 illustrates the spectrum of DAS capabilities available in production today. The ADAS usage cases with the highlighted star are the capabilities of ADAS.

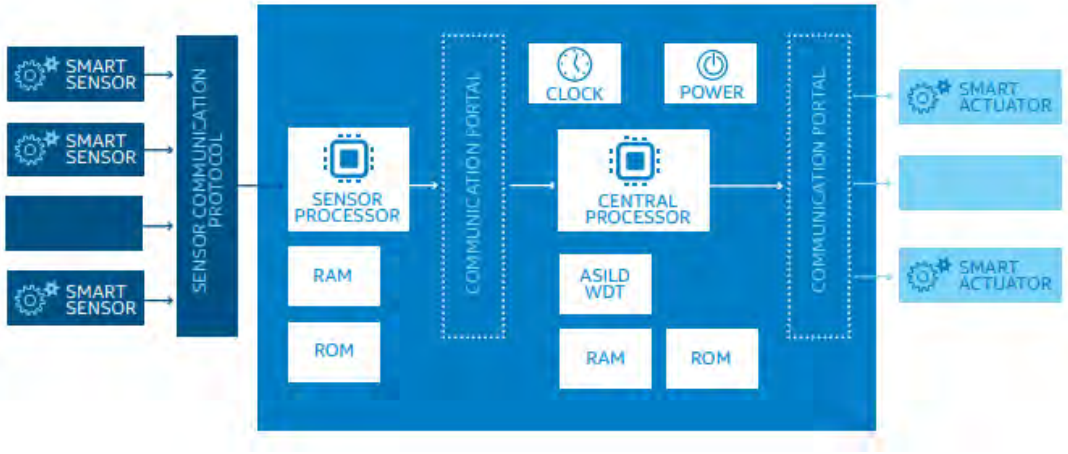

Figure 2.3: Conceptual Hardware Block Diagram for ADAS System (Intel 2016)

Figure 2.2 shows the general view of ADAS system looks like. The overall system is the combination many types of sensors, a CPU-GPU to operate the sensor data processing; Central Processor for executing sensor synthesis from different sensor block. The system is a closed-loop control system where the vehicle control actuation is only dependence on the received data from sensors. The output product of control actuation will be reused in the loop as sensor input.