UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Implementation of FPGA Based Smart Collision Avoidance Alert System Algorithm

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

By

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor Degree of Engineering Technology (Computer Systems) (Hons.). The member of the supervisory is as follow:

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EN. AIMAN ZAKWAN BIN JIDIN

ABSTRAK

Pada masa kini, kemalangan jalan raya menyumbang sejumlah besar kematian dan kecederaan. brek secara tiba-tiba dan memandu terlalu rapat dengan kenderaan depan adalah salah satu faktor yang menyebabkan kemalangan. kesilapan manusia adalah faktor utama yang menyebabkan kemalangan jalan raya. Banyak kes kemalangan jalan raya berlaku kerana ketaksedaran manusia. Oleh itu, kajian ini akan mencipta satu algoritma yang mampu untuk memberi amaran kepada pemandu dengan meggunakan sensor untuk mengesan jarak antara sensor tersebut dengan kenderaan atau objek depan untuk mengurangkan kejadian kemalangan jalan raya. Algoritma ini mengandungi 2 mod. Dalam mod memandu, ia mengesan kadar perubahan jarak antara sensor dengan kenderaan depan dan juga mengesan jarak selamat antara dua kenderaan. Dalam mod letak kereta, sensor juga akan mengesan jarak selamat antara sensor dengan kenderaan depan. Ini membantu untuk mencegah atau mengurangkan kerosakan yang disebabkan oleh perlanggaran. Komponen yang telah digunakan dalam projek ini adalah FPGA, buzzer dan led. Sensor ultrasonik telah digunakan untuk mengesan jarak. Bahasa pengaturcaraanasa yang telah digunakan dalam projek ini adalah Verilog dan software yang telah digunakan untuk projek ini adalah Altera Quartus II. Projek ini telah berjaya dilaksanakan dan objektif projek ini telah dicapai. Perbandingan antara sistem pencegah pelanggaran yang berdasarkan FPGA dan sistem pencegah pelanggaran yang berdasarkan Arduino telah menunjukkan bahawa sistem pencegah pelanggaran yang berdasarkan FPGA mempunyai prestasi yang lebih baik dan ia lebih dipercayai apabila berbanding dengan sistem pencegah pelanggaran yang berdasarkan Arduino.

ABSTRACT

Nowadays, road accidents accounts for a large number of deaths and injuries. Sudden braking and driving too closely are one of the reasons causing accidents. Human error is the main factor that causing road accident. Many cases of road accident occur because of human's unawareness. Therefore, this study was going to design an algorithm that able to alert driver by detecting the range from the detector to the vehicle or object ahead to reduce the occurrence of road accident. This project was focused only on the algorithm implementation and tested by using ultrasonic sensor. This algorithm contained 2 modes. In driving mode, it would detect the rate of change of range between the detector and the vehicle ahead and also detect the safe distance between two vehicles. In parking mode, the detector would detect the safe distance between the detector and the preceding vehicle as well. This helped the vehicle to prevent or to take reduced damage from collisions. The hardware components that have been used in this project were FPGA, a buzzer and a led. An ultrasonic sensor was used for distance detection. The language that has been used to configure FPGA was Verilog and the software that has been used for the configuration of FPGA was Altera Quartus II. It has been proved that the project could be successfully implemented and the objective of this project has been achieved. The comparison between FPGA based collision avoidance alert system and Arduino based collision avoidance alert system has shown that FPGA based collision avoidance alert system has better performance and it was more reliable to be used compared to Arduino based collision avoidance alert system.

DEDICATION

Special dedicated to my beloved parent, siblings and friends who give me encouragement and support to help me in completing my final year project successfully. My supervisor, En Aiman Zakwan Bin Jidin also gave me a lot of guidance throughout the project implementation. Thank you.

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ASIC	-	Application Specific Integrated Circuit
ASSP	-	Application-Specific Standard Parts
DC	-	Direct Current
DSP	-	Digital Signal Processing
ECM	-	Engine Control Module
FPGA	-	Field-Programmable Gate Array
GPS	-	Global Positioning System
GSM	-	Global System for Mobile Communication
HDL	-	Hardware Description Language
IF	-	Intermediate Frequency
LCD	-	Liquid Crystal Display
MPGA	-	Mask Programmed Gate Arrays
NRE	-	Non-Recurring Engineering
PLD	-	Programmable Logic Devices
UMC	-	United Microelectronics Corporation
VHDL	-	VHSIC Hardware Description Language
VLSI	-	Very large Scale Integration
V2V	-	Vehicle to Vehicle

CHAPTER 1
INTRODUCTION

1.0 Introduction

Transportation nowadays has become more and more convenient and safe; however, there are still a lot of people dying because of road accident. One of the factors that caused road accidents to occur are sudden braking and driving too closely with vehicle ahead. Majority of road accidents are caused by carelessness of driver, especially when they drive at midnight, the strong desire of reaching destination in a short time always cause them leave unnoticed to the surrounding vehicle. Therefore, a collision avoidance alert system is required to alert driver to avoid any crashes or minimize the impact of collision. A range detector could be used for this. A range detector is a detector that will detect the range between two vehicles on the road. It can be used to detect the safe distance between two vehicles. Therefore, this study was going to design an algorithm that was able to alert driver by detecting the range from the detector to the vehicle ahead. This algorithm contained 2 modes. In driving mode, it would detect the rate of change of range between the detector and the preceding vehicle and also detect the safe distance between two vehicles. In parking mode, the detector detects the safe distance between the detector and the preceding vehicle as well. Once the vehicle was not in the safe condition, the system would activate a signal to alert the driver to reduce the probability of collision.

1.1 Project Background

According to statistics produced by Bukit Aman Traffic Unit (2014), there were about 65,883 accident cases on Malaysian roads involving car drivers and motorcyclists which were at least 5.4 percent higher than the 62519 cases recorded in 2013. From this phenomena, it can be seen that road accidents account a large number of deaths and injuries, the number of road accident increasing year by year. According to Malaysia Institute of Road Safety Research (Miros) director general Professor Dr Wong Shaw Voon, there are several factors that cause road accidents increasing year by year which includes transportation, road constraint, driver behavior, attitude and human error, distracted driving and illegal racing. Among all of these factors, the most causative factor is human factor. Any road accidents that occurred because of human's behavior, human's unawareness of road condition, human's reaction speed and how human make a decision are included in human factor. After these years, it has been found that human factor always the main causes of vehicle collision. Since 1985, it has been found that there were 93% of vehicle collisions were caused by human factor based on British and American crash data. From the article written by Olivia Olarte (2011), Bob Joop Goos, chairman of the International Organization for Road Accident Prevention pointed that road accident is mainly caused by human factor where there were 90% of road accidents were caused by human factor. Jose Miguel, chairman of the Portuguese Society for Road Accidents Prevention, claimed that the quality of road transport system or a break system of a car and how the driver applies the car break system corresponding to the environmental demand is the condition of occurring road accident. Therefore, it is very important to make people to be conscious that the behavior of driver in driving is the main factor that causing accidents. In order to reduce this problem, the traffic safety program should be focusing on people by telling them the consequences of road accidents and the way that all of us can do to prevent road accidents. Besides that, an alert system can be used to alert driver when driver is in dangerous. Due to the behavior of the driver, they rather choose to ignore any risk that may cause accident. With an alert

system installed in a car, it can be used to alert driver so that he or she notice that they are not in the safe area.

It was reported (Free Malaysia Today, 2014) that in 3rd December 2014, a road accident that involved 13 vehicles had occurred in Kuala Pilah. It was an accident occurred because of driver unaware of road condition. Even though the driver had applied on the brakes but it still caused the road accident to occur. The distance between the vehicle and the object was too close to each other, therefore the driver unable to brake in time. 13 vehicles and 39 people were involved in that accident. Since the accident involved a tanker carrying palm oil, the leaking palm oil caused the road to become slippery.

Figure 1.1: Sudden braking causes 13 vehicles and 39 people involved in an accident

According to the statistic shown above, the main factor that causing road accident since 1985 remain unchanged, the danger on the road always cannot be apart from human's behavior. Other than organizing safety programmed, there are still ways of reducing probability of road accidents occur. One of the ways to attract driver's attention during driving is to build a smart collision avoidance alert system in the car to

alert driver. In this project, the implementation of FPGA based smart collision avoidance alert system algorithm has been done to alert driver when they were not aware of road condition while driving.

A field-programmable gate array (FPGA) is an integrated circuit. It was designed to be configured by using hardware description language (HDL). FPGA contains an array of programmable logic block which the logic blocks is used to be configured to perform simple logic gates and combinational functions. There are differences between FPGA and microcontroller. Microcontrollers are mini computers that built in an integrated circuit and perform specific task while FPGAs built up from logic blocks and can be reprogrammed and rewired electrically. FPGAs can run concurrently while microcontroller is always sequential, thus FPGA is faster than microcontroller.

There are two hardware description languages that can be used to configure FPGA which are Verilog and VHDL. Two of these hardware description languages are difference in both their concept and syntax. VHDL is more on ADA programing language while Verilog is more C programming language.

1.2 Problem Statement

Nowadays, car continues to become safer and more convenience, however, they are still a lot of traffic accidents occur. Traffic accidents occur for several reasons. Most of the traffic accidents are caused by driver's careless, especially when vehicle ahead brake suddenly and driver driving too close to the vehicle in front, this cause the driver unable to brake in time and accident occurred. Many accidents occur due to the driver's failure to recognize danger. Many people unable to estimate the safe distance between own vehicle and the vehicle ahead on the road so that when the vehicle in front make sudden braking, the driver still hit the vehicle ahead although they had applied the brakes. Drivers with stronger desire to arrive at their destination as soon as possible are more likely to take risk. Sometimes, when driver driving too long for the journey will

cause them cannot pay well attention on driving and leave unnoticed when the vehicle ahead change their speed. Therefore, an alert system is required to alert the driver with warning when the system determines that there is possibility of collision and allow the driver to keep a safe distance with the vehicle in front.

1.3 Objectives

1. To study on how to detect the rate of change of range between vehicles
2. To develop an algorithm to detect and alert occurrence of slowing or stalling vehicle ahead on FPGA.
3. To analyze the functionality and reliability of the alert system in the aspect of distance detection.

1.4 Work Scope

The aim of this project was to design an algorithm to detect the range between the detector and the vehicle or object ahead on the road by using FPGA to prevent or minimize the risk of road accidents. An ultrasonic sensor was used for testing the functionality of the system. The ultrasonic sensor was connected with an FPGA which was generally configured by using hardware description language. This project was focusing only on the algorithm implementation and testing by using ultrasonic sensor. The test was done in the following situation:

In driving mode:

- If vehicle ahead makes sudden braking, the system should alert the driver.
- If two vehicles are driving too close to each other and their gap is less than the safe distance, the system should alert the driver.

In parking mode:

- If the vehicle is not in the safe distance with vehicle ahead during parking, the system should alert the driver as well. Due to the speed of vehicle in driving and in parking are different, the safe distance in driving mode and in parking mode are also different.

To make an analysis on the overall performance of the alert system based on FPGA, a comparison with the existing system based on Arduino would be done.

1.5 Conclusion

This chapter mainly brief about introduction of this project. Nowadays road accidents account a large number of deaths and injuries. The main reason for a road accident to occur is never been apart from human behavior. Therefore, a FPGA based collision avoidance system is required to alert driver if there are possibilities of collision. The component in building the system included FPGA and the language used to configure FPGA could be either Verilog or VHDL. This chapter also discussed about the objectives and work scope of this project where the main objective of building this project was to detect and alert occurrence of slowing or stalling vehicle ahead on FPGA. This project would focus only on the algorithm implementation and testing by using ultrasonic sensor.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter will discuss the history of the detector and the application of field programmable gate array (FPGA). The comparison between FPGA and other microcontroller as well as the advantages and disadvantages of FPGA will also be discussed in this chapter. Besides that, this chapter will also discuss about two hardware description languages which are Verilog and VHDL, these two languages have their own applications and advantages as well as disadvantages.

2.1 A brief history of detector

Detectors or sensors have been around for a long time in different forms. According to the article written by Ken Smyers (2013), the first electric thermostat came to market in 1883. The inventor of this first thermostat was Warren S. Johnson, a professor at State Normal College in Whitewater. This thermostat has been considered as the first modern, manmade sensor. Based on a research conducted by A.Rogalski (2012), infrared sensors have been discovered in 1940. This sensor has been extensively developed since 1940's.

Other than thermostat and infrared sensor, Tuteja et al. (2014) stated from their article that the first motion sensor was invented by Samuel Bagno in the mid-1940. According to the article, the motion sensor was known as ultrasonic alarm where it sent ultrasonic waves throughout a room. From the ultrasonic wave that spread throughout the room, when the wave was disrupted by something, a return echo triggered the alarm.

Throughout the inventions of these sensors, people start to realize the importance and application of a sensor. The inventions of sensors and their applications had created a commercial demand for people. In 1970s, the principle of Bagno's ultrasonic technology continued to be used, the motion sensor turned into alarm system by using the same principle. The system transmitted an ultrasonic signal and detected changes in the response. If there was a changed occurred in the response, the detector notified the alarm system's control panel. But in 1970s, technologies were not so advanced, false alarms were common, a little sound like clock chiming could change the ultrasonic wave's echo.

Figure 2.1: The first manmade motion sensor

According to same article, in 1980s, infrared motion sensor began to replace radar sensor. These sensors became more and more widely in used. Initially, the prices of these devices were costly but with these devices became more and more widely in used, the prices became lower and could be afforded by most people. Bagno's device made use of ultrasonic frequencies as well as Doppler Effect.

2.2 Sensor in a vehicle

With sensor has been widely used in vehicle, vehicle continues to become safer and convenient. There are several parts of vehicle that required sensor. In a real world system, a vehicle needs to be well communicated with an outside world. Many conditions have to be considered during driving and there may have some unexpected situations to be occurred. A sensor can help to improve the performance of a vehicle and communicate accurately between vehicle operator and outside world. It also helps to guarantee the safety of drivers and passengers. Therefore, a vehicle needs a reliable, accurate and effective sensor. According to John Vetelino and Aravind Reghu (2010), sensor plays a very important role in a vehicle, the sensor functions may range from a simple sensing of water temperature, oil pressure, and fuel level to the control of the engine and transmission to optimize economy and performance while reducing the potentially dangerous emission effluents. It can be concluded that a vehicle will be unable to function without these sensor. Figure 2.2 shows the areas that sensors are in used.