

ULTRASONIC SYSTEM FOR AVOIDING CAR COLLISION

MOHD ZAMANI BIN ABDUL RAHMAN

UNIVERSITI TEKNOLOGI MALAYSIA

ULTRASONIC SYSTEM FOR AVOIDING CAR COLLISION

MOHD ZAMANI BIN ABDUL RAHMAN

A project report submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering
(Electrical - Mechatronic and Automatic Control)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JANUARY 2013

ACKNOWLEDGEMENT

In the Name of Allah the Most Gracious and the Most Merciful, all praises and gratefulness to Him for giving me the strength to complete my final year project on Ultrasonic System for Avoiding Car Collision. This project had given valuable experiences to me and will absolutely be a great value for me in the future, Insya Allah.

It is my pleasure to dedicate my sincerest gratitude to Assoc Professor Dr Sallehuddin Bin Ibrahim, my project supervisor for his vital contribution, advice, encouragement, and effort in helping me to complete this project and report.

I would like to extend my deepest appreciation to my parents and family members for their guidance and support to make me a better person in my life.

Last but not least, thank you to all my lecturers and my friends for their support and may Allah bless you.

ABSTRACT

This research project is about design of avoiding car collision using ultrasonic transducer. The ultrasonic sensor has been choosing due to the huge advantages compare to the other available sensors in the market. The transmitted signal and received signal from the sensor have been evaluated and compared with the environmental noise to provide correct information for the avoiding collision system. A software system has been designed to analyze the signals and to develop a reliable signal processing algorithm for the avoiding collision system. The actual data have been compared with the data from the designed system. The results from this project demonstrate that the system could supply correct information and reduce the number of false information to driver.

ABSTRAK

Projek penyelidikan ini adalah mengenai reka bentuk transduser ultrasonik yang digunakan untuk mengelakkan perlanggaran kereta. Sensor ultrasonik ini telah dipilih berdasarkan kelebihan yang besar berbanding dengan sensor lain yang terdapat di pasaran. Isyarat yang dipancarkan dan isyarat yang diterima daripada sensor telah dinilai dan dibandingkan dengan bunyi alam sekitar untuk memberikan maklumat yang betul untuk sistem mengelakkan perlanggaran ini. Satu sistem perisian telah direka untuk menganalisis isyarat dan untuk membangunkan algoritma pemprosesan isyarat berkesan untuk sistem mengelakkan perlanggaran ini. Data sebenar yang telah dibandingkan dengan data dari sistem yang direka. Hasil keputusan daripada projek ini menunjukkan bahawa sistem ini boleh membekalkan maklumat yang betul dan mengurangkan bilangan maklumat palsu kepada pemandu.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	ACKNOWLEDGEMENTS	iii
	ABSTRACT	iv
	ABSTRAK	v
	TABLE OF CONTENT	vii
	LIST OF TABLES	viii
	LIST OF FIGURES	ix
	LIST OF SYMBOLS	xi
1	INTRODUCTION	1
	1.1 Overview	1
	1.2 Research Objective	3
	1.3 Problem Statement	3
	1.4 Research Methodology	4
2	LITERATURE REVIEW	6
	2.1 Development of Ultrasonic Sensor in Industry	6
	2.2 Comparison of Sensor	11
	2.3 Collision Avoidance Method	12
	2.4 Doppler Effect	14
3	EXPERIMENTAL SETUP	15
	3.1 Preliminaries Setup	15

	3.2 Experimental Procedure	17
4	RESULTS AND DISCUSSION	22
	4.1 Case Study 1	22
	4.2 Case Study 2	24
	4.3 Case Study 3	26
5	CONCLUSIONS AND RECOMMENDATION	29
	5.1 Conclusion	29
	5.2 Recommendations for Future Work	29
	REFERENCES	31
	APPENDICES A-C	33-121

LIST OF TABLES

TABLE NO	TITLE	PAGE
1	Comparison of sensors	12
2	Analysis of result when sensor move toward static obstacles	24
3	Analysis of result when obstacle move toward static sensors	26
4	Analysis of result when sensor and obstacle move toward each other	28

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
1	An example of transmitted wave and reflected wave for ultrasonic sensor	2
2	Example of reverse sensor	2
3	Accident occur at car park	4
4	Driving stage designed for ProWave 400WB160 transducer	7
5	Hardware circuit of receiving part of the collision avoidance device	8
6	Hardware circuit of launch and display part of the collision avoidance device	8
7	Ultrasonic transmitter circuit by Song. Li and Xiaokui Ren, 2010	9
8	Automatic gain circuit by Song. Li and Xiaokui. Ren, 2010	10
9	A set of sensor with three different beam-width	13
10	Experimental setup for the avoidance car collision system	16
11	Serial monitor for distance display from microcontroller	16
12	Microcontroller board for the controller and data acquisition	17
13	Position of distance setting range between sensors and static obstacle	18

14	Graph of obstacle distance detected by sensor when sensor move to object	18
15	Graph of obstacle detected by sensor when obstacle move to sensor	19
16	Position of distance setting range between static sensors and obstacle	19
17	Position of a RC car at 100 cm position and the obstacle at 250 cm position	20
18	Position of distance setting range between moving sensors and moving obstacle	20
19	Position of a RC car before 200 cm position and the obstacle passed 200 cm position	20
20	Flow chart of the avoidance collision system	21
21	Graph of obstacle distance detected by sensors when sensors move to object	23
22	Graph of obstacle detected by sensor when obstacle move to sensor	25
23	Graph of obstacle distance detected by sensor when sensors and obstacle move to each other	27

LIST OF SYMBOLS

S	-	distance between the sensors and obstacle
ΔT	-	spent time of ultrasonic propagation
v	-	velocity of ultrasonic
C	-	environmental temperature ($^{\circ}\text{C}$)
c	-	ultrasonic propagation velocity (m/s)
T	-	ambient temperature
τ	-	time between two pulses
v	-	relative speed between sensor and target
v_s	-	speed of sound
2	-	factor because wave are being transmitted and received

LIST OF APPENDICES

APPENDIX	-TITLE	PAGE
A	-PROGRAMMING	33
B	-DISTANCE BETWEEN SENSOR AND OBSTACLE	37
C	-SENSOR DATASHEET	118

CHAPTER 1

INTRODUCTION

1.1 Overview

Nowadays, there are many types of sensors have been used in the automotive industry. These sensors have many functions to users such as to provide a comfortable handling to driver, to detect problems which might arise in the vehicle system and to offer safety precaution to driver. Sensor is a device to convert non electrical parameters into electrical signals which are proportional to the value of the physical parameter being measured. A sensor also known as detector is a converter that measures a physical quantity and converts it into a signal which can be read by an instrument [Wikipedia].

In this report, an ultrasonic sensor was used as a sensing system for avoiding car collision when reversing the car. Basically, ultrasound is a sound wave which is transmitted into a specific area and will be reflected if there is any obstacle. From the travelling wave, the time difference for transmit wave and received wave will be calculated and by using the speed of the ultrasonic waves, the distance measurement can be obtained [Song Li and Xiaokui Ren, 2010].

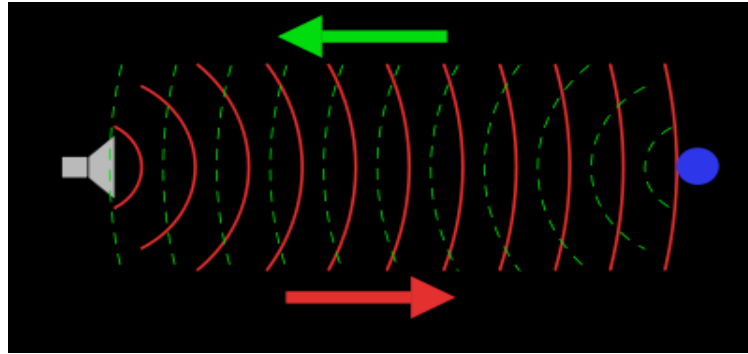


Figure 1: An example of transmitted wave and reflected wave for ultrasonic sensor

When a driver wants to reverse the car, they will look into the back mirror to see any obstacle behind the car before hit the accelerator. However, there were some blind spot that couldn't be seen by driver through the back mirror. With the development of ultrasonic sensors technology in the industry, driver now can avoid collision during reversing by using the ultrasonic sensor to act as an assistant to driver. Ultrasonic sensor ability to detect object in wide ranges have made it as the common sensor used for collision avoidance



Figure 2 : Example of reverse sensor

1.2 Research Objectives

The main objective of this research is to design an avoiding car collision system using ultrasonic transducer. This system will focus on to improve the functionality of ultrasonic sensor by eliminate a disturbance to the signal and increase the information value from the received signal. A software system will be developed to evaluate the ultrasonic emitted signal, received signal and noise from environment. The signal will be processed and analyzed to minimize the error in the ultrasonic system. After that, a signal processing algorithm for the system will be developed to produce a good system for the ultrasonic sensor.

1.3 Problem Statements

Currently, all the new vehicles in the market are build in with the reversing sensor at the back of the vehicle. For examples, luxury vehicle like Toyota Harrier have been built in with the reverse camera sensor to avoid collision during reversing the vehicle. This kind of technology are really good but need a higher cost in order to install it. Due to that, this kind of system only be installed in the high end or luxury vehicles. For the middle and low end car, the cheaper system will be used to cut of the cost in order to penetrate the market with a reasonable price.

As a result, most of the automobile companies have used the ultrasonic sensor in the reversing system for avoiding collision. Two units of ultrasonic sensor are commonly installed at the back of the car to detect obstacle. However, even all the new cars have been built with this system, many accidents still occur during reversing the vehicle. For example, in the figure 3 below, a signal cover for a car is broken after been hit by a car which came out from a car park. This accident may be looked as a small matter since it not cause any injury. However, it might be a bigger damage to the owner if the car moving faster toward the reversing car.



Figure 3: Accident occur at car park

There are also cases where driver have hit a pedestrian who cross over at the back of the car which has cause the leg of the pedestrian broken. In the Metro paper on the 9th February 2012, there is a sad story happen where a father have lost his beloved son after he accidentally hit his son during reversing his car at their house. Even the car are built in with the reverse sensor, the sensor could not detect the children came to the back of the car because of the blind spot area that cannot be covered by the sensor and the less realibility of the sensor ddetection. This was really a huge lost to the family which cannot be replaced by anything in this world.

In order to avoid this kind of accident and lost happen in the future, this project had been proposed to improve the ultrasonic system reliability in the car avoiding collision system especially to supply correct information to driver for the area that couldn't been seen during reversing the car.

1.4 Research Methodology

For this project, there are several methodology to be tag along. Firstly, to do the literature review on the past similar project that has been done. A deep read and analysis have to be done in order to have a good knowledge and information for this project. From the literature review, the basic knowledge about ultrasonic sensor have been gained. The characteristic of ultrasonic sensor have been differentiate with the

other sensor in the market. Common problems in the ultrasonic sensor have been identified through the later stage of the literature review.

After done with the literature review, the hardware of the system will be designed and implemented for the system testing. The programming for the microcontroller will be designed to cater with the requirement of this project. The hardware system and the microcontroller will be integrated to acquire data from the experiment. The result from experiment will play a vital role to improve the avoiding car collision system. All signals will be processed and the data will be collected for data analysis. Lastly, the outcome from the data analysis will be used to produce a better system for avoiding car collision.

REFERENCES

- Alvaro Hernandez, Fernando J. Alvarez, Jean P. Derutin and Ana Jimenez (2007). *Ultrasonic Sensory System for Mobile Robots and Autonomous Vehicles*. 2007 *IEEE*.
- A. Hernandez, J. Urena, J. J. GarciaJ., M. Mazo, D. Herranz, J. P. Derutin and J. Serot.(2004) *Ultrasonic ranging sensor using simultaneous emissions from different transducer,” IEEE Trans. On Ultrasonics, Ferroelectrics and Frequency Control*, vol. 51, no. 12, pp. 1660-1670, 2004.
- B.Q Han.(2006) *The research of Parking Distance Control System*. China: Harbin Institute of Technology, 2006.
- Chan Yet Wong and Uvais Qidwai.(2004) *Vehicle Collision Avoidance System*, EECS department, Tulane University, New Orleans, Louisiana, USA, *IEEE*. 2004. 316-319.
- C. C. Zhang.(2005) *Research on the Freeway Automotive Anti-collision Radar*.China, Chongqing University, 2005.
- C. G. Ruan, L. Z. Hui, and S. Chen,(2004) “*The Ultrasonic Measuring Distance System Based on Single-chip*”, Applied Science and Technology, China, Vol. 31, no.7, pp. 22-24, 2004.
- Fuquan Pan, Lixia Zhang, Gang Sun and Jiyou Li.(2009) *Design of vehicle reversing collision avoidance device based on single chip computer*, *Power Electronics and Intelligent Transportation System (PEITS)*, 2009 2nd International Conference on, vol.1, no., pp.223-226, 19-20 Dec. 2009.
- H. J.Miao, S. Tang and B. X. Tan,(2005) “*The design and manufacturer of backing car annunciator*,” *Journal of Shandong University of Technology*. China, vol. 19, no.4, pp. 6-9, 2005.

- Kai-Tai Song, Chih-Hao Chen and Cheng-Hsien Chiu Huang.(2004) *Design and experimental Study of an Ultrasonic Sensor System for Lateral Collision Avoidance at Low Speeds, Proceeding of the 2004 IEEE Intelligent Vehicles Symposium. June 14-17, 2004. University of Parma, Italy.* 647-652.
- Kalmegh, S.K., Samra, D.H., Rasegaonkar, N.M.(2010), “*Obstacle avoidance for a mobile exploration robot using a single ultrasonic range sensor,*”*Emerging Trends in Robotics and Communication Technologies (INTERACT), 2010 International Conference on*, vol., no., pp.8-11, 3-5 Dec. 2010. Doi: 10.1109/INTERACT.2010.5706156.
- Luciano Alonso, Vicente Milanés, Carlos Torre-Ferrero, Jorge Godoy, Juan P.Oria and Teresa de Pedro.(2011) *Ultrasonic Sensors in Urban Traffic Driving-Aid Systems, Sensor 2011*,11,661-673,doi:10.3390/s110100661.
- M.H. Zhao, J.C Wang and X.H. Huang.(2005) *Automatic gain circuits in the research on the application of ultrasonic ranging system, [J]. Measurement and Control Technology, 2005, 24(7), pp.69-71.*
- Prowave Ltd.(2006), *Air Ultrasonic Ceramic Transducer 400WB160*, 2006.
- Song Li and Xiaokui Ren.(2010) *Design of warning system for vehicle collision avoidance, Computational Problem-Solving (ICCP), 2010 International Conference on*, vol., no., pp.199-202, 3-5 Dec. 2010.
- Wikipedia, Sensor retrieved from <http://en.m.wikipedia.org/wiki/sensor>
- Z.Q. Wang and J. C. Chang(2004), “*The Ultrasonic Distance Measuring System Based on Microprocessor*”, *Journal of Sichuan University of Science and Technology, China*, Vol. 23, no.3, pp 72-90, 2004