SMALL SCALE INTELLIGENT VEHICLES

IAN DIVINE HILLARY BAJAU

This report is submitted to
Faculty of Mechanical Engineering,
In partial fulfillment for Bachelor of Mechanical Engineering (Automotive)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

October 2008

“Saya/Kami akui bahawa telah membaca
karya ini dan pada pandangan saya/kami karya ini
adalah memadai dari segi skop dan kualiti untuk penganugerahan
Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)”

Tandatangan : ………………………
Nama Penyelia 1 : ..……………………..
Tarikh : ………………………

Tandatangan : ………………………
Nama Penyelia 2 : ..……………………..
Tarikh : ………………………

"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya telah jelaskan sumber"

Tandatangan : ……………..……………………
Nama Penulis : IAN DIVINE HILLARY BAJAU
Tarikh : …………..……………………….

“I would like to dedicate this to my beloved fiancé, Claudia Uray Sabestian, my parents and family”

ACKNOWLEDGEMENT

This project could not have been finished without Mr. Herdy Rusnandi who not only served as my supervisor but also encouraged and challenged me throughout my Projek Sarjana Muda (PSM). He patiently guided me through the project process, never accepting less than my best efforts. I would like thank him whole-heartedly.

I would like to thank my family who support me either in motivations or financially. Thanks to all my friends who help me throughout my PSM. Without them, this project may never have finish with flying colors. Thanks also to Claudia Uray Sabestian, who is my reason for trying to be the best that I can be, and who lights my way when it becomes dark.

Last but not least, I would like to thank each and everyone who involve either direly or indirectly in this project. Hopefully, this report will become a good reference and guideline to other students in the future.

ABSTRACT

Intelligent Vehicle (IV) is one of the technology that improving capabilities of a modern vehicles. Advanced sensing, communications, and computing promise to allow vehicles to operate automatically, to avoid collisions, and to prevent or deal with injuries when a crash does occur. Recently, there has been an increase in the practical application of ACC (adaptive cruise control), which measure the following distance to the preceding vehicle by radar and automatically maintain an appropriate following distance, and Lane Recognition systems, which recognize lane using vision sensors and keep the vehicle from deviating from the lane. Current systems are based on the premise of highway driving, but in the future, these systems will come to be used on regular roads as well, in pursuit of even greater safety and comfort. Just for this, this project will simulate the IV technology into a small scale IV model to understand more about the Intelligent Vehicle.

The purpose of this research was to develop a scale model platform for the rapid prototyping and testing of IV systems and technologies. Specifically, this body of work was concerned with the development of an automatic headway control system that utilized ultrasonic sensors. This control system was intended to automatically maintain headway distance in an effort to create an adaptive cruise control system for scale model vehicle. Implementation of such systems could conceivably reduce driver fatigue by removing the burden of maintaining safe following distance from the driver.

ABSTRAK

Intelligent Vehicle (IV) atau ‘Kenderaan Pintar’ adalah satu teknologi yang meningkatkan keupayaan sesebuah kenderaan moden. Penggunaan sistem pengesan atau sensor yang maju, komunikasi, dan juga komputer membenarkan kenderaan tersebut beroperasi secara automatik bagi mengelak atau mencegah kemalangan. Baru-baru ini, penggunaan sistem seperti ACC (adaptive cruise control) semakin meningkat. Sistem ini mengukur dan menganggar jarak kenderaan di hadapan dengan menggunakan radar dan secara automatik mengekalkan satu jarak yang sesuai dengan kenderaan dihadapannya. Penggunaan sistem Lane Recognition, yang mengenalpasti jalan dengan menggunakan sensor-sensor dan mengekalkan kenderaan daripada menyeleweng daripada jalan raya. Sistem-sistem IV semasa adalah berdasarkan premis pemanduan di lebuh raya, tetapi pada masa depan, sistem-sistem ini akan digunakan di jalan-jalan biasa. Ini akan meningkatkan lagi keselamatan dan keselesaan pengguna jalan raya. Oleh itu, projek ini akan membuat simulasi teknologi IV ke model berskala kecil supaya lebih memahami lagi tentang Intelligent Vehicle.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

l = length of the car body

è = orientation of the vehicle x-axis

ö = angle of the front wheels

e_h = headway error

h = headway distance

ù(t) = estimated velocity of the lead vehicle in terms of arc length at the current sample time

$f(c)$ = dynamics of the follower

v_1 = driving velocity

$\hat{\omega}(t)$ = estimate of the distance between the two vehicles, obtained from the ultrasonic sensor

LIST OF ATTACHMENT

CHAPTER I

INTRODUCTION

In order to complete the Bachelor in Mechanical Engineering in Automotive, student required to implement a final year project (Projek Sarjana Muda, PSM). My project title is “Small Scale Intelligent Vehicles” which is I have to develop a simulation of a small scale intelligent vehicle as a scale model platform. Small scale Intelligent Vehicle also called Robotic Car. This project will refer to the robotic car of Flexible Low-cost Automated Scaled Highway (FLASH) project for its hardware platforms as there will no fabricating of the small scale in this project.

1.1 Project Background

This project is concerned with research work on small-scale model vehicles. It has been shown in other similar studies that such work is often directly applicable to full scale transportation systems. The primary focus of this study is to provide automatic headway control for a 1/10 scale autonomous vehicle by using closed loop control systems and ultrasonic sensors to increase the vehicle’s ability to automatically maneuver. This project covers the simulation of adaptive cruise control and also a little bit of lane recognition (line follower).

Adaptive cruise control allows a user to input a desired vehicle velocity, the same way one would set cruise control in a modern vehicle. Adaptive cruise control also allows the driver to set a desired following distance for objects that may be in front of the vehicle. As long as the adaptive cruise control system does not detect any obstacles in the vehicle’s path, the maximum velocity as entered by the driver will be maintained.

When an object is in the vehicle’s path, the adaptive cruise control system will adjust the vehicle’s velocity accordingly to maintain the desired, safe, distance from the obstacle. It is easy to see how adaptive cruise control can be further enhanced to provide lane changing mechanisms for automatic passing of slower traffic, and to provide collision avoidance mechanisms that allow vehicles to not only maintain a specific distance, but to go around, or even halt in the presence of an accident or other nonmoving obstacle in the road.

Development of control systems for scaled, as well as full sized, vehicles should be concerned at all times with the safety of the vehicle’s occupants, and with the stability of the system as a whole. Automatic headway control allows a driver another degree of freedom in controlling a vehicle as mentioned earlier.

The project is also concerned with the development of future technologies, and with helping the public adapt to the rapid changes that are being made in the automotive industry. People are naturally reluctant to allow technology become as prevalent in automobiles as they feel a loss of control in their daily activities. As such, a major responsibility of the project is to provide interaction with these new and emerging technologies and to provide as much information as possible so that the public can make their own informed decisions as to whether this use of technology is appropriate. In dealing with other aspects of Intelligent Transportation System (ITS), such as road surface materials and current traffic management technologies, the project is concerned with providing a look into what the public might expect to become common place in the future.

1.2 Objective

The objective of this project is to develop a simulation of a small scale intelligent vehicle as a scale model platform. By developing simulation in a small scale Intelligent Vehicle, we can simulate and understand how the electronic control system applied in automotive field.

1.3 Scope

The scopes of this project are stated as below:-

1. Use 1/10 scale vehicle as Intelligent Vehicle model for the simulation; and
2. Use closed loop control systems and headway error control system.

1.5 Problems statement

Consider some of the implications of cars are Intelligent Vehicle.

- We might eliminate the more than ninety percent of traffic crashes that are caused by human errors such as misjudgments and inattention.
- We might reduce antisocial driving behavior such as road rage, rubbernecking delays, and unsafe speeds, thereby significantly reducing the stress of driving.
- The entire population, including the young, the old, and the infirm, might enjoy a higher level of mobility without requiring advanced driving skills.
- The luxury of being chauffeured to your destination might be enjoyed by the general populace, not just the wealthiest individuals, so we might all do whatever we like, at work or leisure, while traveling in safety.
- Fuel consumption and polluting emissions might be reduced by smoothing traffic flow and running vehicles close enough to each other to benefit from aerodynamic drafting.
- Traffic-management decisions might be based on firm knowledge of vehicle responses to instructions, rather than on guesses about the choices that drivers might make.
- The capacity of a freeway lane might be doubled or tripled, making it possible to accommodate growing demands for travel without major new construction, or, equivalently, today’s level of congestion might be reduced, enabling travelers to save a lot of time.

CHAPTER II

LITERATURE REVIEW

2.1 Intelligent Vehicles (IV) : Adaptive Cruise Control

The mission of the IV is to accelerate the development and availability of advanced safety and information systems applied to all types of vehicles. Driver error is cited as the primary cause in about 90 percent of all police-reported crashes involving passenger vehicles, trucks, and buses; therefore, this is exactly where new technologies that allow the implementation of ideas like cruise control, adaptive cruise control, and platooning come into play. IV's primary goal is to help drivers operate vehicles more safely and effectively with technologies integrated to create a fully intelligent vehicle that works cooperatively with the driver. IV advocates the creation of smart vehicles that fully consider the driver's requirements, capabilities, and limitations.

Most people today are familiar with cruise control. One simply presses a button to set the speed they wish the automobile to maintain, and then the driver only need be concerned with steering the vehicle. Figure 1.1 illustrates a basic cruise control system as it appears in most vehicles today.

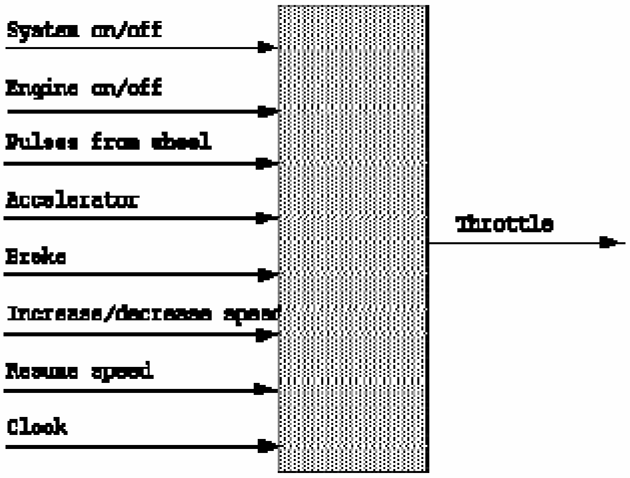


Figure 2.0 Block Diagram of a cruise control system

When the driver approaches a vehicle in front of their own, he must decide whether to go around the obstacle, set the cruise control to match the speed of the blocking vehicle, or disengage the cruise control entirely.

In an effort to make cruise control more advanced, engineers and scientists posed the idea that forward looking system, like ultrasound, radar, and laser range finding technologies could be used to determine distance from vehicles and obstacles in front of the automobile, and then maintain a set distance from these obstacles.

Automatic headway control, also known as adaptive cruise control, is an area that has been under research for some time. Adaptive cruise control reduces driver strain by reducing the need to constantly monitor the vehicle’s speed. It can also be coupled with other driver convenience systems to provide control for lane changing, obstacle detection, and collision avoidance to further reduce driver fatigue when traveling long distances.

Automatic headway control is one of the topics that readers would be likely to find in literature concerning Intelligent Transportation System (ITS) today. Cruise control, anti-lock braking systems, collision warning, air bags, and other driver safety systems all fall into this area of research.

2.2 Hardware Environment

In this subtopic we discuss the hardware used to create the test platform. The hardware environment for this experiment is shown in the block diagram in Figure 2.1. Major components of this architecture include the model vehicle platform, the Digital Signal Processor (DSP), the Microcontroller, and the sensor arrays including ultrasound, infrared, Hall Effect, and vision control systems.

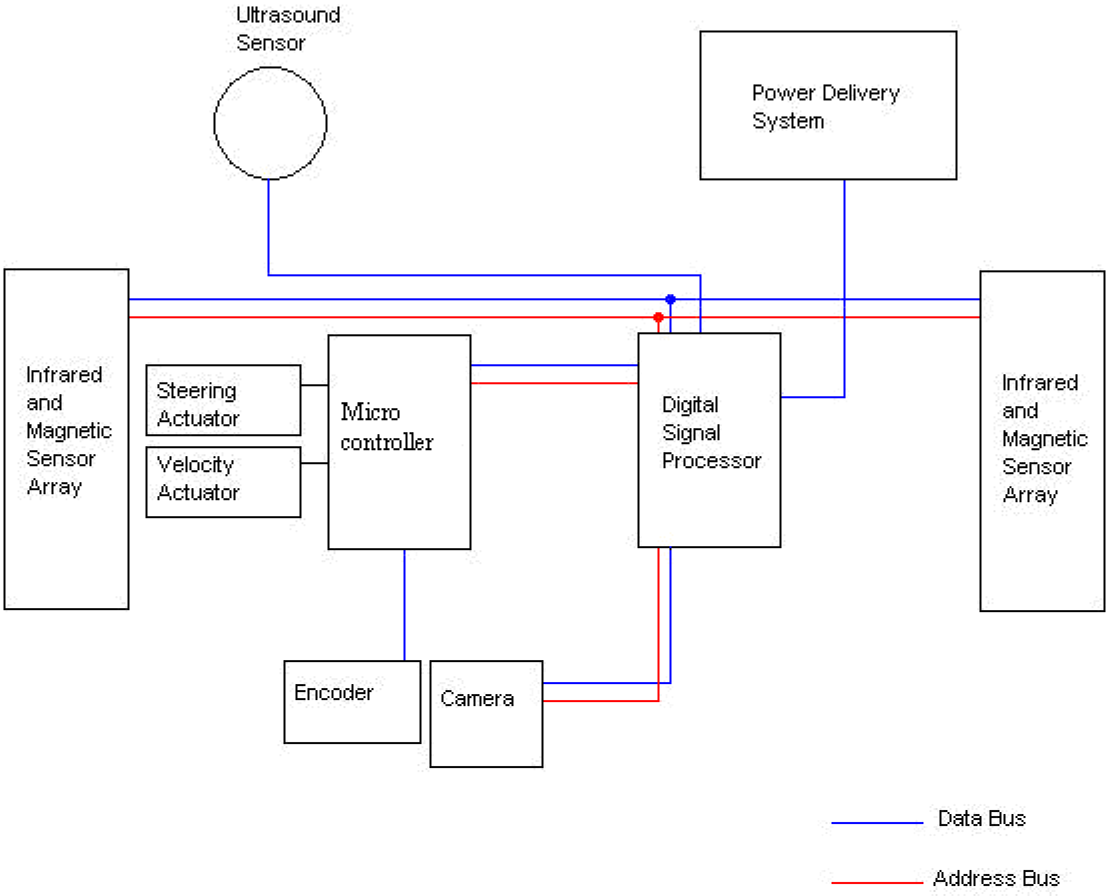
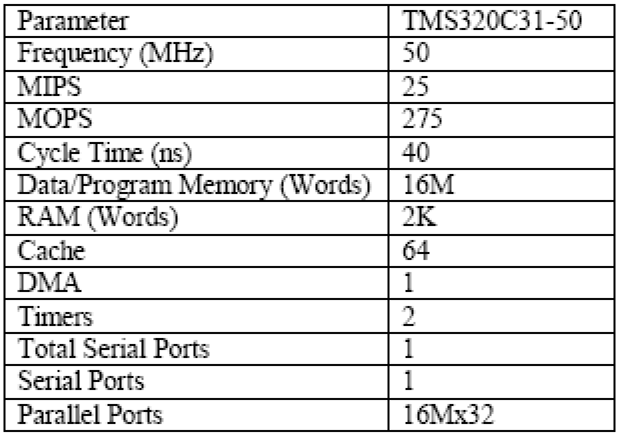


Figure 2.1 High-level architecture block diagram of the vehicle hardware platform

2.3 Digital Signal Processor Platform

The choice of a digital signal processor as the high level processor for the automated vehicle was made primarily for the ability to perform image processing. However, due to the inexpensive nature of today’s DSP platforms, the project was able to incorporate a DSP that could meet the project’s needs for image processing and that still had enough power to process the rest of the sensor data for the control of the vehicle. Table 2.0 lists the statistics for the Texas Instruments TMS320C31 DSP used by the FLASH project.



Parameter	TMS320C31-50
Frequency (MHz)	50
MIPS	25
MOPS	275
Cycle Time (ns)	40
Data/Program Memory (Words)	16M
RAM (Words)	2K
Cache	64
DMA	1
Timers	2
Total Serial Ports	1
Serial Ports	1
Parallel Ports	16Mx32

Table 2.0 Texas Instruments Model TMS230C31 DSP

The DSP is seated in a development kit that grants easy access to control signals, and external interface hardware that is critical to the development of the vehicle’s control structure. Functioning as the driver of the vehicle, the DSP performs most of the data processing required to interpret the data received from the individual sensor arrays. The exception to this rule is the optical encoder used to determine the vehicle’s actual speed, which is interfaced to the PIC processor. Each sensor is treated as a slave device on the memory bus, and during a sensor processing cycle, each device is read, and the data from that sensor is processed to determine what adjustments are to be made to the steering and velocity controls. This is accomplished by making ample use of the 24 bit addressable 32 bit data bus. The infrared and Hall Effect sensors are thus located in memory-mapped space in the DSP while the ultrasound data is read separately via the analog-to-digital conversion unit provided on the DSP development board. The PIC processor is also treated as a slave device by the DSP, and once the sensor data has been processed and the appropriate drive commands have been determined, the commands are sent to the PIC processor, which is the direct interface to the system's velocity and steering control.

Another feature of the DSP that the vehicle makes heavy use of is the boot loader capability. Upon resetting the vehicle, the processor is triggered by an external interrupt that indicates that the vehicle's control code is loaded from one of three addresses in memory. In the case of the project vehicle, external interrupt 1, INT1, is de-asserted to indicate that the processor should begin loading code from address 0x400000. At this address resides an EEPROM that contains the operating program for the vehicle. The EEPROM is an ATMEL 24HC64B 8-bit wide memory device, and so the 32-bit DSP must read in the program code four bytes at a time, and reassemble by placing them correctly into one word in the internal RAM of the processor. Once the code has been reassembled in memory, the boot loader program transfers control of the processor to a pre-determined address, at which point the control code is executed.

Difficulties in converting the program to boot table format arose early in the development of the vehicle. While the control program could easily be compiled and loaded onto the DSP via a parallel interface with a host computer, the same code could not successfully be translated into a boot table and loaded from the EEPROM. As the code could be loaded and run from a host computer, the development of the EEPROM was tabled until such time as it was necessary to further the development of the vehicle.

The infrared and Hall Effect sensors are each addressed via the addressing structure. Each of these two sensors uses tri-state buffers, which keeps them from transmitting data to the bus when they are not active. As each device is addressed, they supply their data to the 32-bit data bus. Two infrared sensors, each with 12 bits, are read in during one cycle with the front sensor supplying the lower 12 bits on the data bus, and the rear sensor supplying the upper 12 bits on the data bus. The Hall Effect sensors each supply 8 bits on the data bus, with the front sensor array supplying the lower nibble, and the rear sensor supplying the upper nibble.