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JUDUL: **FUZZY LOGIC CONTROLLER FOR AN AUTOMATIC CAR GEARBOX SHIFTING**

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FUZZY LOGIC CONTROLLER FOR AN AUTOMATIC CAR GEARBOX SHIFTING

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Control & Instrumentation)

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Date : <u>NOVEMBER 2009</u>

Specially dedicated to my beloved family.
To My Beloved Late Mom, My Parents, My Grandmother and My Lovely Sisters

Semiah Binti Mat Nor

Mohd Hassim Bin Mohd Pilus
Halijah Bt Zamzam

Selamah Binti Said

Norazura Aila Binti Mohd Hassim
Norazuin Binti Mohd Hassim

And to those who have guided and inspired me throughout my journey of education

Thank's For Everything...

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Thank You.

ABSTRACT

Now a days, most of the car accident happened because of the malfunctioning and the bad performance of the gearbox system. To overcome this situation, a fuzzy logic controller application has been implemented to enhance the performance and the ability to contribute to a smart gearbox system. This was done by using the Microsoft Visual C# software where the Graphical User Interface (GUI) and the Fuzzy Logic algorithms were created. It used the brake, speed and the oil pedal as the input membership and the gear knob shifting as the output for the project. The Fuzzy Logic components that were implemented included the fuzzification, knowledge base, inference engines and defuzzification. As a result, the GUI gives the correct gear selection based on the fuzzy logic algorithms that has been implemented in the programming part before. As a conclusion, using this Fuzzy Logic Controller application, the system will be simpler yet easy to understand and can operates smoothly rather than other controller. Hence, this automatic gearbox system will contribute to the smart and enhance the ability and the performance of the automatic gearbox system.

ABSTRAK

Pada masa kini, kebanyakan kemalangan kenderaan di seluruh dunia berlaku kerana disebabkan kekurangan kecekapan dan prestasi sistem penukaran gear pada setiap kenderaan yang kurang memberangsangkan. Jadi, untuk mengatasi masalah ini, sistem ini telah dicipta untuk menambahkan dan memperbaikkan kecekapan sistem gear yang akan membawa kepada kepintaran sistem gear kenderaan tersebut. Ia merupakan sebuah aplikasi 'Fuzzy Logic' yang di aplikasikan pada sistem gear automatik kenderaan. Sistem ini dijalankan menggunakan perisian Microsoft Visual C# di mana 'Graphical User Interface(GUI)' dan peraturan "Fuzzy Logic" di cipta. Projek ini menggunakan sistem brek, pedal minyak dan kelajuan kenderaan sebagai input keahlian dan penukaran sistem gear sebagai output. Komponen "Fuzzy Logic" yang telah diimplimentasikan di dalam projek ini ialah "fuzzification", knowledge base", "inferensing mechanism" dan "defuzzification". Sebagai keputusan, GUI memberikan bacaan pemilihan sistem gear yang tepat berdasarkan algoritma "Fuzzy Logic" yang telah diimplementasikan di dalam bahagian program sebelum ini. Kesimpulannya, dengan menggunakan sistem kawalan "Fuzzy Logic" tersebut, sistem kawalan akan menjadi lebih mudah difahami dan boleh beroperasi dengan lebih lancar berbanding sistem kawalan yang lain. Maka, ini akan menjadikan sistem penukaran gear automatik lebih pintar dan dapat meningkatkan kecekapan sistem gear tersebut.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Now a days, most of the car accident happened because of the malfunctioning and the bad performance of the gearbox system. To overcome this situation, this project has been created to enhance the performance and the ability to contribute to a smart gearbox system. This final year project is about the application of fuzzy logic implemented in an automatic car gearbox system. Using this information and an advanced control strategy based on fuzzy logic application will be design. This is a method of programming control systems using human-type reasoning.

Furthermore, this electronically controlled transmission can do things like downshift the car gearbox automatically when going downhill to control speed and reduce wear on the brakes and also make the gearshift changing more smoothly under the driver situation. But if you were driving a manual transmission car, you would probably leave the car in the same gear the whole time. Some automatic transmissions with advanced control systems can detect this situation after you have gone around a couple of the curve, and learn not to up-shift again.

This project was done by using the Microsoft Visual C# software where the Graphical User Interface (GUI) and the C# programming are created. This project used the brake, speed and the pedal as the input membership and the gear knob shifting as the output for the project. The fuzzy logic rules were implemented in the C# programming. Normally this fuzzy logic rules use the IF...THEN rules so that the GUI will run accordingly to the fuzzy logic rule that has been develop that will adapt to the drivers condition. The equation of the membership function was implemented in the C# programming so that when the GUI is running, it will give the value of the membership when any number is fill in the membership reading box. Finally, the combination of rules and the value of the input will determined whether the gearbox will be shift to gear 1 or gear 2 or gear 3.

1.2 PROBLEM STATEMENT

The statistic rate of road accident had been increasing nowadays. At present, there are five deaths per 10,000 vehicles. Generally, a car gearbox system operated manually as the driver shift the gearbox themselves. In such many cases, the cause of the accident is due to the distraction and failure to react in time. An electronically controlled transmissions which appears on some newer cars, still use hydraulics to actuate the clutches and bands, but each hydraulic circuit is controlled by an electric solenoid.

This simplifies the plumbing on the transmission and follows for more advanced control schemes. In addition to monitoring vehicle speed and throttle position, the transmission controller can monitor the engine speed if the brake pedal is being pressed. Therefore, to overcome this problem, an automated gear shifting for car gearbox system with the application of fuzzy logic controller will be created to avoid such accident.

1.2 OBJECTIVES

The objectives of this project are:

i) To develop a smart car gearbox system using fuzzy logic controller application.

ii) To develop and analyze the performance of the system by using Microsoft Visual C# software.

iii) To help reduce car accidents due to ineffective car gearbox system.

1.3 SCOPE OF PROJECT

The scope of this project are:

i) This project is about to create a smart automatic gearbox system using the fuzzy logic application. . This is a method of programming control systems using human-type reasoning that this fuzzy logic automatic gearbox will change the gearshift according to the driver situation.

ii) This project will run using the Microsoft Visual C#. This is where the Graphical User Interface (GUI) and the Fuzzy Logic algorithms will be implemented. The result will be shown using this software.

iii) This project also will help to reduce the car accident because this smart fuzzy logic automatic gearbox system will depends on the human type reasoning whether to up-shift or downshift. This project will also contribute to better performances due to ineffective car gearbox system.

CHAPTER 2

LITERATURE REVIEW

2.1 AN OVERVIEW OF FUZZY LOGIC

2.1.1 FUZZY LOGIC

Fuzzy logic is a form of multi-valued logic derived from fuzzy set theory to deal with reasoning that is approximate rather than precise. In binary sets with binary logic, in contrast to fuzzy logic known as crisp logic, the variables may have a membership value of only 0 or 1. Just as in fuzzy set theory with fuzzy logic the set membership values can range (inclusively) between 0 and 1, in fuzzy logic the degree of truth of a statement can range between 0 and 1 and is not constrained to the two truth values {true (1), false (0)} as in classic predicate logic. When linguistic variables are used, these degrees may be managed by specific functions, as discussed below.

The term "fuzzy logic" emerged as a consequence of the development of the theory of fuzzy sets by Lotfi Zadeh. A paper introducing the concept without using the term was published by R.H. Wilkinson in 1963 and thus preceded fuzzy set theory. Wilkinson was the first one to redefine and generalize the earlier multivalued logics in terms of set theory. The main purpose of his paper, following his first proposals in his 1961 Electrical Engineering master thesis, was to show how any mathematical function could be simulated using hardwired analog electronic circuits. He did this by first creating various linear voltage ramps which were then selected in a "logic block" using diodes and resistor circuits which implemented the maximum and minimum Fuzzy Logic rules of the INCLUSIVE OR and the AND operations respectively. He called his logic "analog logic" [1].

In 1965 Lotfi Zadeh axiomatized fuzzy set theory, thereby creating the set-theoretical equivalent of the "analog logic" of Wilkinson (without recourse to electrical circuits), not giving Wilkinson any credit. Fuzzy logic has been applied to diverse fields, from control theory to artificial intelligence, yet still remains controversial among most statisticians, who prefer Bayesian logic and some control engineers, who prefer traditional two-valued logic.

Figure 2.1 below shows the conventional control block diagram for the overall process. Meanwhile the Figure 2.2 shows the Fuzzy Logic Control System where the four fuzzy logic components were implemented in the block diagram.

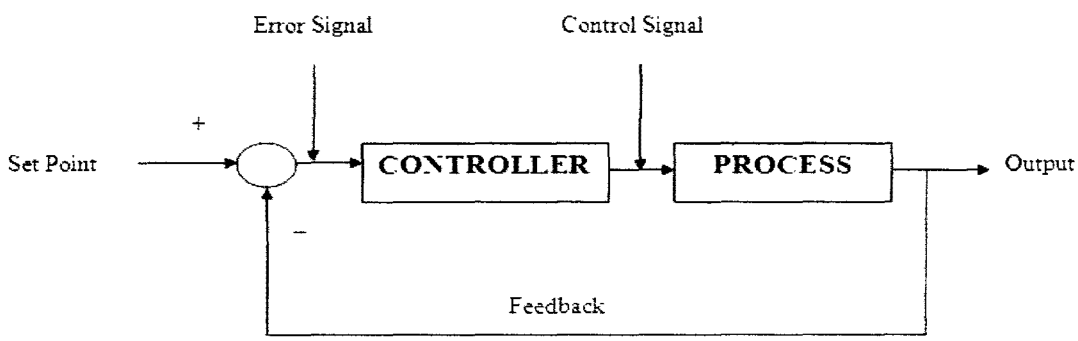


Figure 2.1 : A Conventional Control Block Diagram

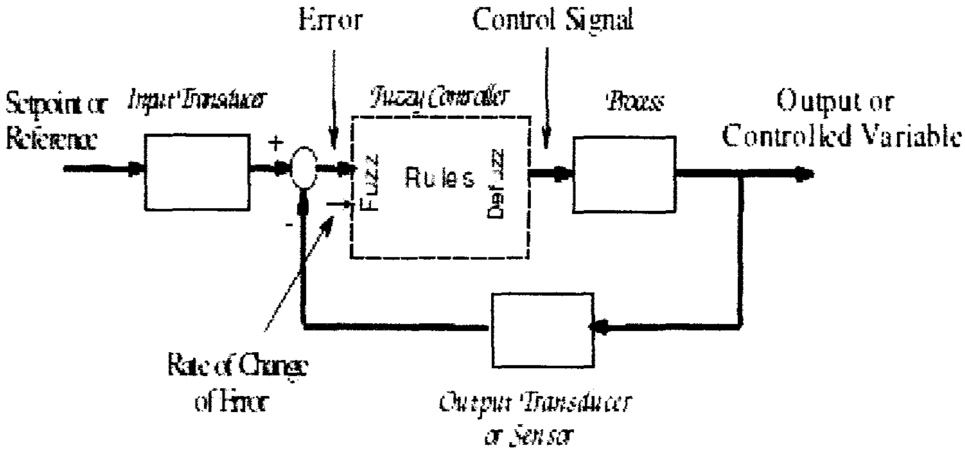


Figure 2.2 : A Fuzzy Logic Control System

2.1.2 DIFFERENCES BETWEEN FUZZY LOGIC AND CRISP LOGIC

Table 2.1 below shows the differentiation between Crisp Logic and Fuzzy Logic.

Table 2.1 : Differentiation Between Crisp Logic and Fuzzy Logic

CRISP	FUZZY
Precise	Imprecise
Properties	Properties
Full Membership • Yes Or No • True Or False • 1 Or 0	Partial Membership • Yes ----- No • True ------ False • 1------ 0
Crisp Sets • Girls Age 13 Years • People 1.5m Tall	Fuzzy Sets • Girls About 13 Years • People About 1.5m Tall
Crisp Models	Fuzzy Model
Crisp Relations	Fuzzy Relations

2.1.3 COMPONENTS OF FUZZY LOGIC CONTROLLER

It generally comprises four principal components:

i) Fuzzification

ii) Knowledge Base

iii) Inference Engine

iv) Defuzzification

If the output from the defuzzification is not a control action for a process, then the system is a fuzzy logic decision support system. The fuzzy controller itself is normally a two-input and a single output component. It is usually a Multiple Input Single Output (MISO) system.

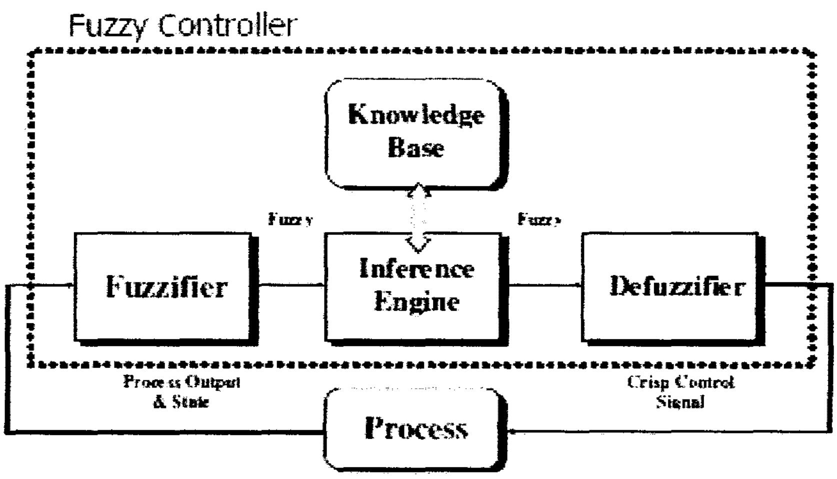


Figure 2.3 : The Components of Fuzzy Logic Controller

2.1.4 COMPONENTS OVERVIEW

2.1.4.1 Fuzzification

It involves the conversion of the input/output signals into a number of fuzzy represented values (fuzzy sets). Next, choose an appropriate Membership Function to represent each Fuzzy Set. After that, label the Fuzzy Sets appropriately such that they reflect the problem to be solved. Finally, set up the Fuzzy Sets on appropriate Universes of Discourse and adjust / tune the widths and center points of membership functions judiciously. Usually fuzzy sets are overlapped by about 25%. It can be observed that in fuzzy logic control the transition from one fuzzy set to another provides a smooth transition from one control action to another. If there is no overlapping in the fuzzy sets then the control action would resemble bivalent control (transition from one error region to another is rather abrupt). On the other hand if there is too much overlap in the fuzzy sets, there would be a lot of fuzziness and this blurs the distinction in the control action. For simplicity we can choose the same (triangular) membership functions for each of the fuzzy subsets of all the fuzzy variables. The example below shows membership functions chosen for 3 fuzzy input variables for controlling a gear shift knob of gearbox.

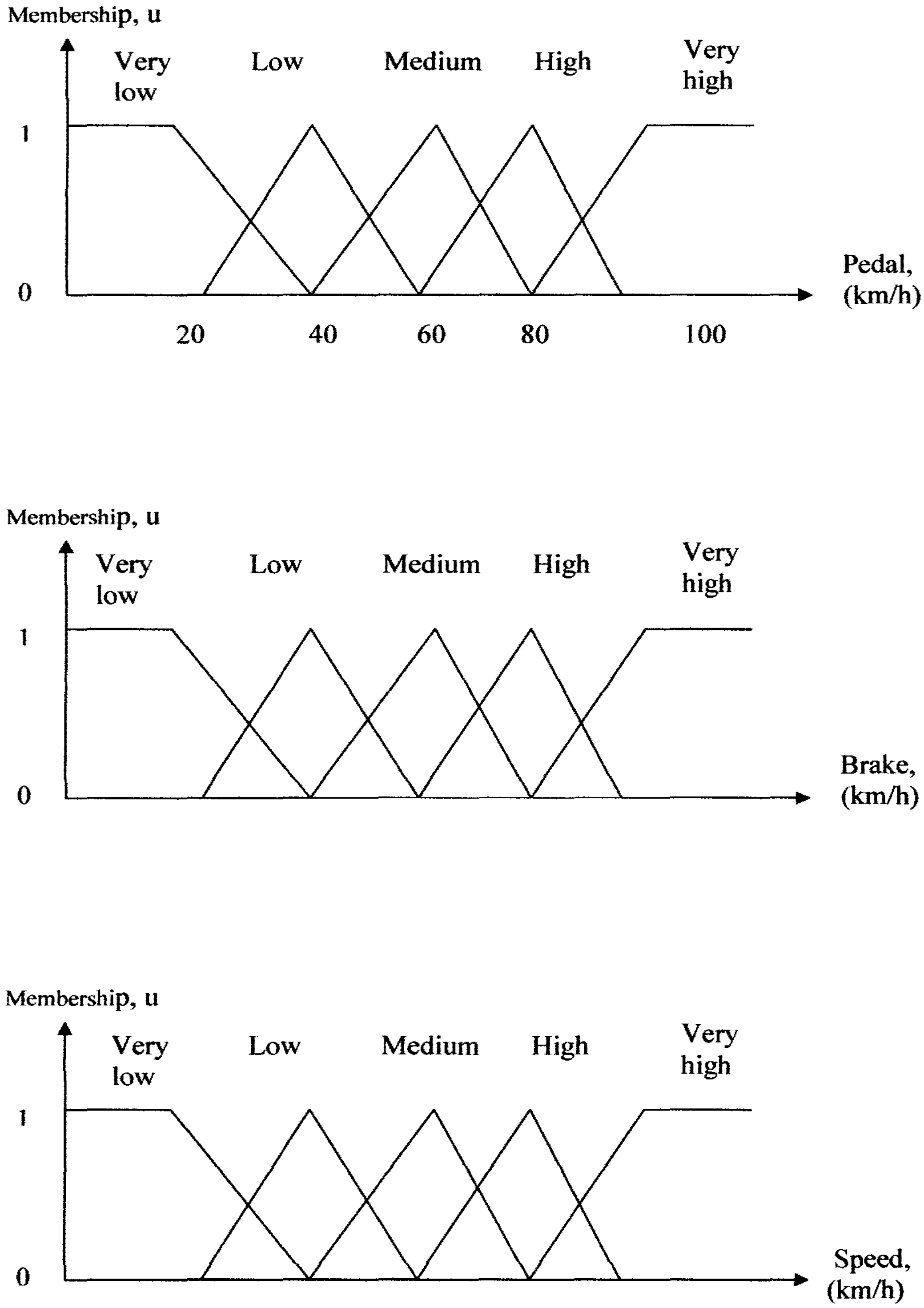


Figure 2.4 : An Example of Fuzzification For Car Gearbox Shifting

Table 2.2 : An Examples of Standard Labels used for Quantization into 5 Fuzzy Sets

Very Low	VL
Low	L
Medium	M
High	H
Very High	VH

2.1.4.2 Knowledge Base

The knowledge base of a fuzzy logic controller consists of a data base and a rule base. The basic function of the data base is to provide the necessary information for the proper functioning of the fuzzification module, the rule base and the defuzzification module. This information includes the meaning of the linguistic values of the membership functions of the process state and the control output variables, physical domains and their normalized counterparts together with the normalization, denormalization and scaling factors, the type of the membership function of a fuzzy set and the quantization look-up tables defining the discretization policy.

For Fuzzy Control Rules, the basic function of the rule base is to represent the expert knowledge in a form of if-then rule structure. There are four methods of deriving the rule base can be described such as expert experience and control engineering knowledge, based on operator's control actions, based on fuzzy model of a process and based on learning. For the expert experience and control engineering knowledge, this method is the least structured of the four methods and yet it is one of the most widely used today. It is based on the derivation of rules from the experience based knowledge of the process operator and/or control engineer.

Next, for the based on operator's control actions, this method tries to model an operator's skilled actions or control behavior in terms of fuzzy implications using the input output data connected with his control actions. The idea behind this technique is that it is easier to model an operator's actions than to model a process, since the input variables of the model are likely found by asking the operator the kind of information he uses in his control actions.

Furthermore, based on fuzzy model of a process, in the linguistic approach, the linguistic description of the dynamic characteristics of a controlled process may be viewed as a fuzzy model of the process. Based on the fuzzy model, we can generate a set of fuzzy control rules for attaining optimal performance of a dynamic system. The set of fuzzy control rules forms the rule base of the fuzzy logic controller. Although this approach is somewhat more complicated, it yields better performance and reliability and provides a more tractable structure for dealing theoretically with the fuzzy logic controller.

Lastly, based on learning, many fuzzy logic controllers have been built to emulate human decision making behavior. Currently, many research efforts are focused on emulating human learning, mainly on the ability to create fuzzy control rules and to modify them based on experience. There are now many examples of fuzzy controllers which have the capability to learn and to compose the rules involving neural networks and genetic algorithm. Table 2.3 below are an example of the Fuzzy Control Rule.

IF Road is Too Winding
AND the Brake is applied Many Times
THEN Gear is Low

For simplification a matrix can be used for presenting the rules which is called fuzzy rule matrix. Many control rules are written in the form below:

(Antecedents) (Consequent)
IF X AND Y **THEN Z**

Below are an example for gear knob shifting process.

Table 2.3 : An Example of Fuzzy Rules Matrix

Antecedents

Antecedents		VL	L	M	H	VH
	VL					
	L					
	M					
	H					
	VH					

2.1.4.3 An Inference Mechanism

The Inference Mechanism provides the mechanism for invoking or referring to the rule base such that the appropriate rules are fired. The two most common methods used in fuzzy logic control are the max-min composition and the max-(algebraic) product composition. The inference or firing with this fuzzy relation is performed via the operations between the fuzzified crisp input and the fuzzy relation representing the meaning of the overall set of rules. As a result of the composition, one obtains the fuzzy set describing the fuzzy value of the overall control output.

There are several inference procedure that can be used in Fuzzy Logic Control Systems such as the Max-Drastic Product, Max-bounded Product, Max-bounded sum, Max-algebraic sum, Max-Max, Min-Max, Max-Min and Max Algebraic Product. The most commonly used are the Max-Min and the Max Algebraic Product.

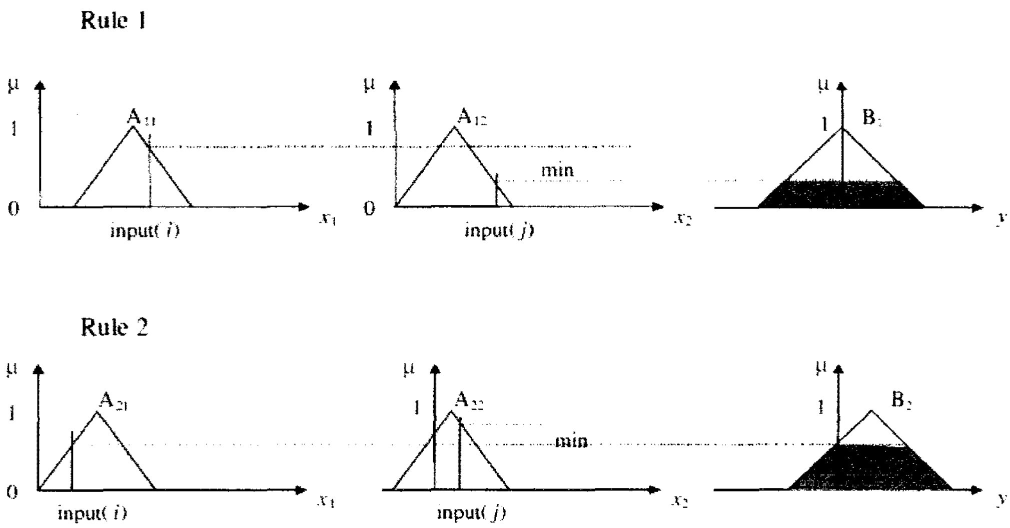


Figure 2.5 : Example of Fuzzy Inferencing Using Mamdani's Max-Min Compositional Operator

The Figure 2.5 above illustrates the graphical analysis of two rules, where the symbols A11 and A12 refer to the first and second fuzzy antecedents of the first rule, respectively, and the symbol B1 refers to the fuzzy consequent of the first rule. The symbols A21 and A22 refer to the first and second fuzzy antecedents, respectively, of the second rule, and the symbol B2 refers to the fuzzy consequent of the second rule. The minimum function arises because the antecedent pairs given in the general rule structure for this system are connected by a logical "and" connective. The minimum membership value for the antecedents propagates through to the consequent and truncates the membership function for the consequent of each rule.

This graphical inference is done for each rule. Then the truncated membership functions for each rule are aggregated. The aggregation operation "*max*" results in an aggregated membership function comprised of the outer envelope of the individual truncated membership forms from each rule. Then, a crisp value for the aggregated output y^* can be obtained through the defuzzification technique.

2.1.4.4 Defuzzification

A Defuzzification is a mapping from a space of fuzzy control actions defined over an output universe of discourse into a space of non-fuzzy (crisp) control action. This process is necessary because in many practical applications crisp control action is required to actuate the plant. The defuzzification also performs an output denormalization if a normalization is performed in the fuzzification module. There are many methods of defuzzification that have been proposed in recent years. Unfortunately, there is no systematic procedure for choosing a defuzzification strategy. There are four most common defuzzification method that are the max membership method, center of gravity method, weight average method and the mean-max membership method. The centre of gravity method (COG) in Figure 2.6 below are the procedure that the most prevalent and physically appealing of all the defuzzification methods. It is given by the algebraic expression.

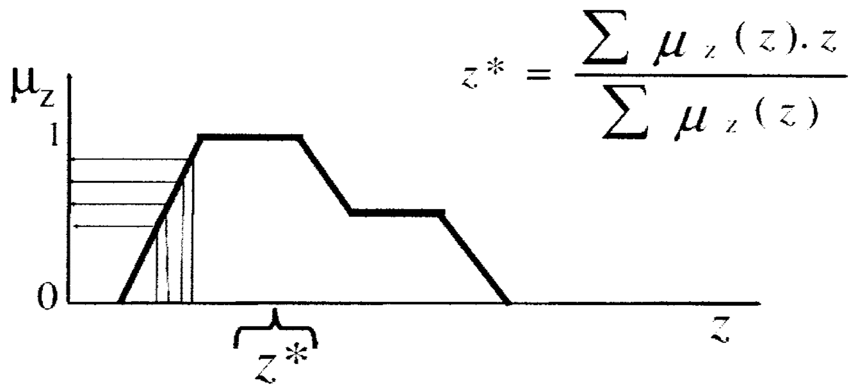


Figure 2.6 : Centre Of Gravity Method(COG)

2.1.5 BENEFITS OF USING FUZZY LOGIC

i) Fuzzy Logic reduces the design development cycle

With a fuzzy logic design methodology some time consuming steps are eliminated. Moreover, during the debugging and tuning cycle you can change your system by simply modifying rules, instead of redesigning the controller. In addition, since fuzzy is rule based, you do not need to be an expert in a high or low level language which helps you focus more on your application instead of programming. As a result, Fuzzy Logic substantially reduces the overall development cycle [3].

ii) Fuzzy Logic simplifies design complexity

Fuzzy logic lets you describe complex systems using your knowledge and experience in simple English-like rules. It does not require any system modeling or complex math equations governing the relationship between inputs and outputs. Fuzzy rules are very easy to learn and use, even by non-experts. It typically takes only a few rules to describe systems that may require several of lines of conventional software. As a result, Fuzzy Logic significantly simplifies design complexity.

iii) Fuzzy Logic improves time to market

Commercial applications in embedded control require a significant development effort a majority of which is spent on the software portion of the project. Development time is a function of design complexity, and the number of iterations required in a debugging and tuning cycle. As we explained above, a fuzzy based design methodology addresses both issues very effectively. Moreover, due to its simplicity the description of a fuzzy controller not only is transportable across design teams, but also provides a superior media to preserve, maintain, and upgrade intellectual property. As a result, Fuzzy Logic can dramatically improve time to market.

iv) Fuzzy Logic improves control performance

In many applications Fuzzy Logic can result in better control performance than linear, piecewise linear, or lookup table techniques. For instance, a typical problem associated with traditional techniques is trading-off the controller's response time versus overshoot.

v) Fuzzy Logic helps to simplifies performances

The one input temperature controller presented so far has helped us illustrate some fundamental concepts, however real life control is much more complex in nature. Most control applications have multiple inputs and require modeling and tuning of a large number of parameters which makes implementation very tedious and time consuming. Fuzzy rules can help you simplify implementation by combining multiple inputs into single if-then statements while still handling non-linearity [1].

vi) Fuzzy Logic reduces hardware costs

A conventional technique in most real life applications require complex mathematical analysis and modeling, floating point algorithms, and complex branching. This typically yields a substantial size of object code which requires a high end DSP chip to run. Fuzzy Logic enables you to use a simple rule based approach which offers significant cost savings, both in memory and processor class.

2.2 AN OVERVIEW OF AUTOMATIC GEARBOX

2.2.1 AN AUTOMATIC GEARBOX

Figure 2.7 is an automatic transmission for the gear knob selection (commonly "AT" or "Auto") is an automobile gearbox that can change gear ratios automatically as the vehicle moves, freeing the driver from having to shift gears manually. Similar but larger devices are also used for heavy-duty commercial and industrial vehicles and equipment.

Most automatic transmissions have a set selection of possible gear ranges, often with a parking pawl feature that will lock the output shaft of the transmission. Continuously variable transmissions (CVTs) can change the ratios over a range rather than between set gear ratios. CVTs have been used for decades in two-wheeled scooters but have seen limited use in a few automobile models. Recently, however, CVT technology has gained greater acceptance among manufacturers and customers, especially in Nissan automobiles.

Some machines with limited speed ranges or fixed engine speeds, such as some forklift trucks and lawn mowers, only use a torque converter to provide a variable gearing of the engine to the wheels [4].

Automatic car gearboxes are less common than manual gearboxes in Great Britain and as a result drivers are often uncertain in which position the gear shift lever should be in any given set of circumstances.

It is designed to assist the driver to decide the optimal position and explains the workings of the components to facilitate understanding. Because of the variety of systems in use you should abide by the guidance given in the vehicles owners handbook.

Modern automatics now have 5 gears and electronics to alter the shift characteristics to suit the driver although the majority of gear selection positions are marked as Table 2.4 below :

Table 2.4 : References of the gear shifting representation

P	Park	Must never be engaged whilst the vehicle is in motion as it locks the transmission and prevents the car from moving.
R	Reverse	
N	Neutral	
D	Automatic use of 1st, 2nd, 3rd, 4th & 5th gears.	
4	Automatic use of 1st, 2nd, 3rd & 4th gears.	
3	Automatic use of 1st, 2nd & 3rd gears.	
2	Automatic use of 1st & 2nd gears.	
1	1st gear hold.	

For normal driving the lever may be placed in D and the transmission will automatically change up or down according to road speed and accelerator position. If it is necessary to manually change down to a lower gear, this may be done by moving the gear lever to the required position, but only if the vehicle is travelling at a speed which is within the range of the gear chosen. This facility must not be used excessively [2].

When maximum acceleration is required, the accelerator should be pushed to the full throttle position, overcoming the built-in resistance. This brings into operation the "kick down" that causes an immediate downshift into the correct gear for maximum acceleration, provided that the road speed is within the speed range of the lower gear. When accelerator pedal is released, the gearbox will automatically change up again. Some gearboxes have a "kick down" system that also works at part throttle. It is because of the different methods in which gear changes can occur that drivers are sometimes uncertain as to what action they should take to negotiate a hazard in the correct gear.

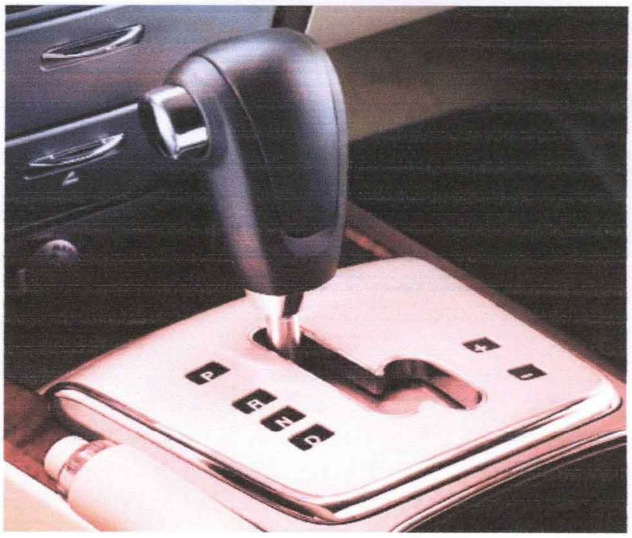


Figure 2.7 : An Automatic Gear Selector(Knob) In A Car

2.3 AN OVERVIEW ON RELATED PAST INVENTIONS

2.3.1 INVENTION 1

This invention is about the *"Mechatronic Design of an Automated Gear Box using Bond Graphs"*. This project has been invented by N. Coudert, G.Dauphin-Tanguy and A. Rault. This invention is about a model of vehicle driveline is made in order to study an automatic gearbox. The effect of pressure modulation on the output torque is seen. As more precise study is needed, a generic model of automatic gearbox is made and the dynamics of the model explained. With this model, different pressure variations can be tested, the aim being is to reduce the peak on output torque during gear shifting.

2.3.2 INVENTION 2

This inventon is about the *"Passenger Car PowerTrain : Model and Gear Shift Logic"*. This project has been invented by G. Achtenova from Czech Technical University in Prague. This invention is about the modeling and validation of passenger powertrain. The model is a part of research project focused on automatisation of passenger car transmission, design of a new shift system and solutions for optimal shift strategy. The vehicle parameters, determination of E-line as well as extraction of vehicle resistance parameters were programmed in Matlab M-Files. The vehicle model is built in Simulink and SimMechanics. For the classical control strategy resulting from shift limits based on vehicle speed and gas pedal position is used Stateflow. In the future this shift algorithm will be compared with the fuzzy and neural network strategies.

2.3.3 INVENTION 3

This project is about the *"Direct –Drive Rotary-Linear Electromechanical Actuation System for Control of Gearshifts in Automated Transmissions"*. This project was invented by Andrew Turner, Keith Ramsay, Richard Clark and David Howe. This project is about a direct-drive electromechanical actuation system has been developed which acts directly on the shift rails of either Transmission(DCT) to facilitate gear selection. Direct-drive electromechanical actuation schemes offer a number of advantages over electric motor and gearbox systems in that they have reduced mechanical hysteresis, backlash and compliance, have fewer components, are more robust, and exhibit a better dynamic response. A high-force, moving-magnet linear actuator is combined with a moving-magnet rotary actuator to enable multi-axis control and, hence, enable the selection of all transmission ratios. The measured and predicted static performance of the rotary actuator, and the dynamic performance of the combined rotary linear actuator, mounted on a gearbox test rig, are presented.

2.3.4 INVENTION 4

This project is about the *"Fuzzy Driving Strategies for Cars in Several Traffic Situations"*. This project was invented by Ricardo Garcia Rosa, Teresa de Pedro Lucio, Ailson Rosetti de Almeida. This project is about to cope with automatic pilots for cars by means of putting on board cars sensors and controllers. Among the available sensors DGPS are considered as the most convenient to estimate the position and orientation of the cars. The approach envisaged for controlling cars is to design elemental fuzzy controllers dealing with simple traffic situations. When complex traffic movements have to be carried out the fuzzy elemental controllers will be combined to obtain the global one. Simulations have been done taking into account that fuzzy controllers will run in fuzzy coprocessors.

CHAPTER 3

METHODOLOGY

3.1 DESIGN PROCEDURE OF FUZZY LOGIC CONTROLLER

There is a general procedure that can be followed for designing a fuzzy control system. Firstly, the designer has to identify the process input and output variables that need to be considered. Thus, one must have a good knowledge on the system to be controlled. Next, one should determine on the number of fuzzy partitions (or fuzzy subsets) for the input and output linguistic variables. The number of fuzzy partitions of the input-output spaces should be large enough to provide an adequate approximation and yet be small enough to save memory space. This number has an essential effect on how fine a control can be obtained. In the third step, the designer has to choose the membership functions for the input and output fuzzy variables.

There are different types of membership functions available. However, the most common types are triangular, trapezoidal and bell-shaped functions. After choosing the membership functions, the designer need to derive the fuzzy control rules based on one of the four methods that have been discussed. In many practical applications method such as deriving from expert experience and control engineering knowledge have been used. Next the inference mechanisms need to be defined, but there is no systematic methodology for realizing the design of an inference engine. Most practitioners use empirical studies and results to provide guidelines for their choices.

Finally one has to choose the right choice of defuzzification method for their particular application. Once the fuzzy control system has been constructed, the simulation of the system can be carried out. The performance of the system can be analyzed. If the results are not as desired, changes are made either to the number of the fuzzy partitions or the mapping of the membership functions and then the system can be tested again. This trial-and-error approach will continue until satisfactory results are obtained. Although this method is rather time-consuming and nontrivial, it has been widely employed and has been used in many successful industrial applications.

3.1.1 BLOCK DIAGRAM

The block diagram in figure 3.1 below shows the membership input that are the pedal, brake and tyre speed. The output is the gear knob shifting whether it is gear1, gear 2 or gear 3.

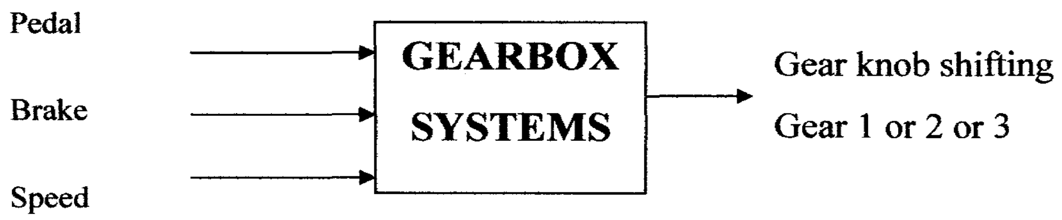


Figure 3.1 : Block Diagram of Input And Output Membership

3.1.2 MEMBERSHIP FUNCTIONS

Figure 3.2 below shows the diagram of the membership function. It involves the conversion of the input/output signals into a number of fuzzy represented values (fuzzy sets). Next, an appropriate Membership Function has been chosen to represent each Fuzzy Set. The input membership consists of the brake, pedal and the speed. The output membership is the gear shift knob. Finally, the Fuzzy Sets has been labeled appropriately such that they give a standard labels used for Quantization into three Fuzzy Sets that are Very Low, Low and High

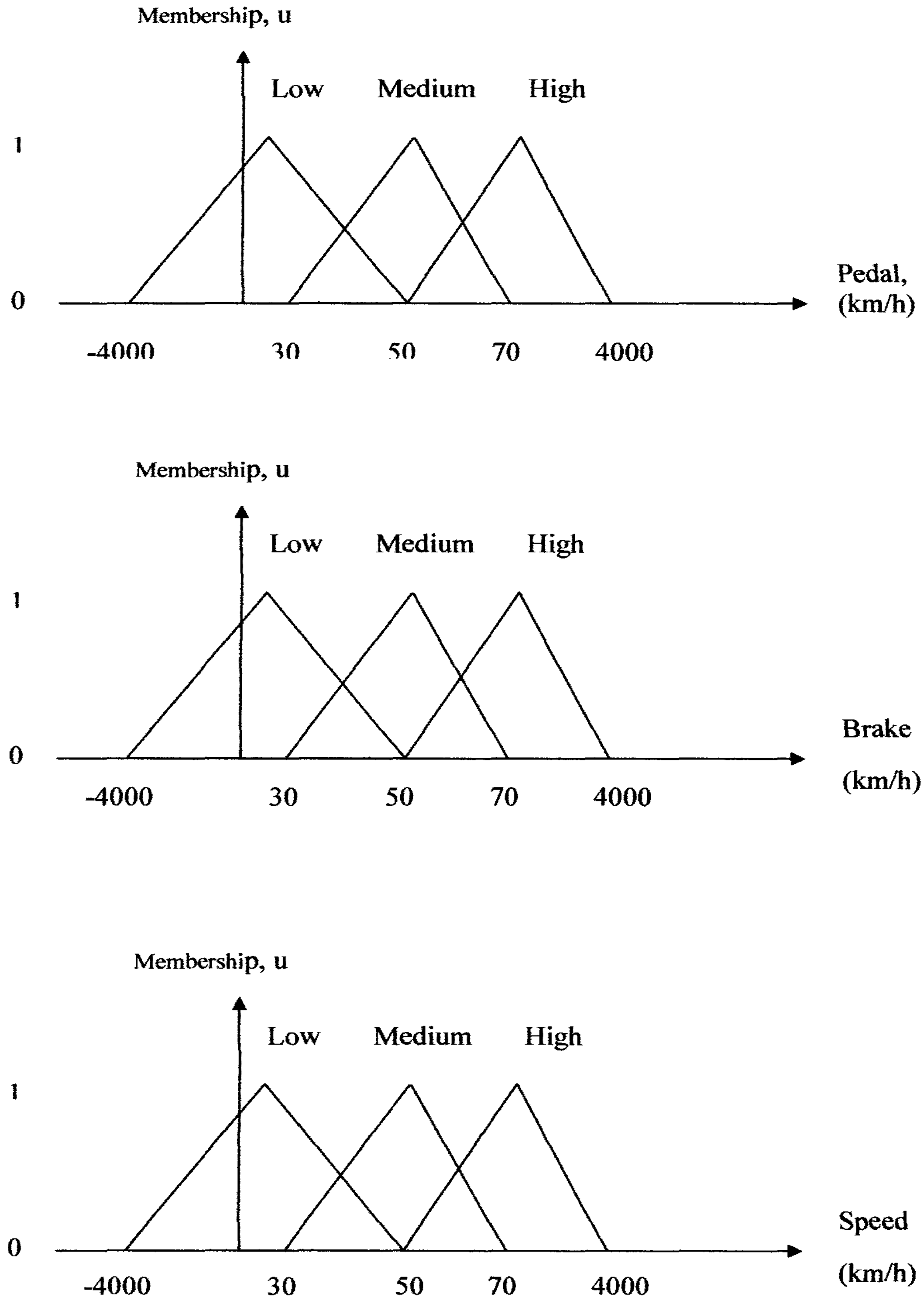


Figure 3.2 : Graf of Membership For Pedal, Brake And Speed

3.1.3 EQUATIONS OF MEMBERSHIP

Below are the calculations of equation for the pedal membership. This calculations has to be implemented for the other two membership function that are the brake and the speed. The ways of the calculation are just the same but the value that are chosen for x –axis are accordingly to the knowledge base. This equation will be used to be implemented in the Fuzzy Logic algorithm later.

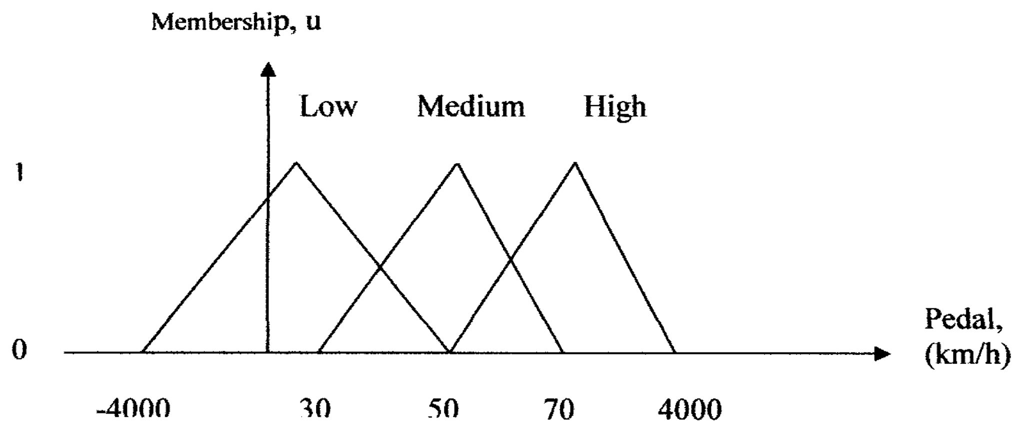


Figure 3.3 : Example of Pedal Membership Function

i) Equation = Low

$$y = \frac{1}{4030}x + \frac{400}{403} \quad , \quad -4000 \leq x < 30$$

$$y = -\frac{1}{20}x + \frac{5}{2} \quad , \quad 30 \leq x < 50$$

ii) Equation = Medium

$$y = \frac{1}{20}x - \frac{3}{2} \quad , \quad 30 \leq x < 50$$

$$y = -\frac{1}{20}x + \frac{7}{2} \quad , \quad 50 \leq x < 70$$

iii) Equation = High

$$y = \frac{1}{20}x - \frac{5}{2} \quad , \quad 50 \leq x < 70$$

$$y = -\frac{1}{3930}x + \frac{4000}{393} \quad , \quad 70 \leq x < 400$$

iv) Overall equations

$$
y = \begin{cases}
\frac{1}{4030}x + \frac{400}{403} & , \quad -4000 \le x < 30 \\
-\frac{1}{20}x + \frac{5}{2} & , \quad 30 \le x < 50 \\
\frac{1}{20}x - \frac{3}{2} & , \quad 30 \le x < 50 \\
-\frac{1}{20}x + \frac{7}{2} & , \quad 50 \le x < 70 \\
\frac{1}{20}x - \frac{5}{2} & , \quad 50 \le x < 70 \\
-\frac{1}{3930}x + \frac{4000}{393} & , \quad 70 \le x < 400
\end{cases}
$$

3.1.4 RULES OF FUZZY LOGIC

Below are the table of Fuzzy Logic Rule in matrix form. This rules can be determined with knowledge base. The knowledge base of a fuzzy logic controller consists of a data base and a rule base. The basic function of the data base is to provide the necessary information for the proper functioning of the fuzzification module, the rule base and the defuzzification module. This information includes the meaning of the linguistic values of the membership functions of the process state and the control output variables, physical domains and their normalized counterparts together with the normalization, denormalization and scaling factors, the type of the membership function of a fuzzy set and the quantization look-up tables in Table 3.3 defining the discretization policy. The Table 3.1 and 3.2 below shows the combination of the input membership that are the speed and the brake and the other combination of the input membership that are the pedal and the brake to produce the output.

Table 3.1 : Table Of Fuzzy Logic Rules (Speed Vs Brake)

BRAKE \ SPEED	L	M	H
L	L	M	H
M	L	M	M
H	L	L	L

Table 3.2 : Table of Fuzzy Logic Rules (Pedal Vs Brake)

PEDAL \ SPEED	L	M	H
L	L	L	M
M	M	M	M
H	H	H	H

Example : **IF** the Pedal applied are High

AND the Speed applied is Low

THEN the Gear Knob Shift is High

Table 3.3 : Quantization Label Representation

Full labels representation quantization	Short label representation quantization	Gear knob shifting representation
Low	L	1
Medium	M	2
High	H	3

3.1.5 FUZZY LOGIC INFERENCING USING TAGAKI SUGENO (MIN-MAX) COMPOSITIONAL OPERATOR

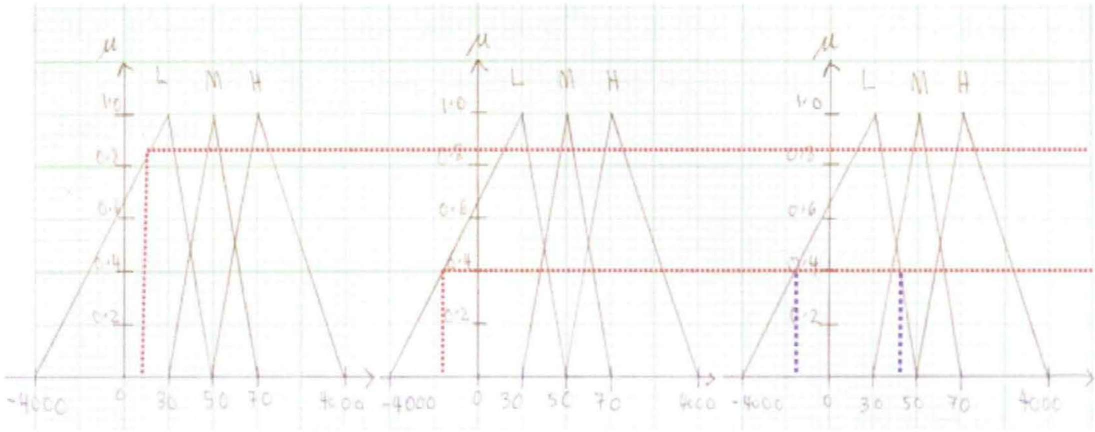
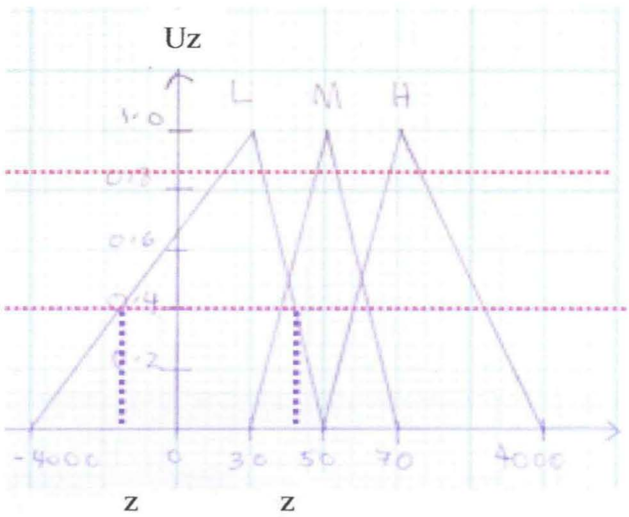


Figure 3.4 : Diagram of Tagaki Sugeno Fuzzy Inference

Figure 3.4 above shows the Fuzzy Logic Inferencing Mechanism using Tagaki Sugeno (Min-Max) Operational Operator. This inferencing mechanism used the membership equation graph of combination two rules to get the Min-Max value. The combination of the two rules will create a region where this region will be calculated using the Weight Average (WA) equation.

3.1.6 DEFFUZIFICATION

Figure 3.5 below shows the defuzzification. The value of the Weight Average (WA) will be calculated using the below equation. This value will determine the gear knob shifting that will be used as the output whether it is gear 1 or gear 2 or gear 3.



$$z^* = \frac{\sum \mu_z(z).z}{\sum \mu_z(z)}$$

Figure 3.5 : The Weight Average Method

3.2 SOFTWARE DEVELOPMENT

This project used Microsoft Visual C# software to run the project. This software consists of Graphical User Interface (GUI) and the C# Programming to make the project running.

3.2.1 GRAPHICAL USER INTERFACE DEVELOPMENT

Figure below shows the Final Draft of Graphical User Interface that has been built. It has been built using the Microsoft Visual C#.

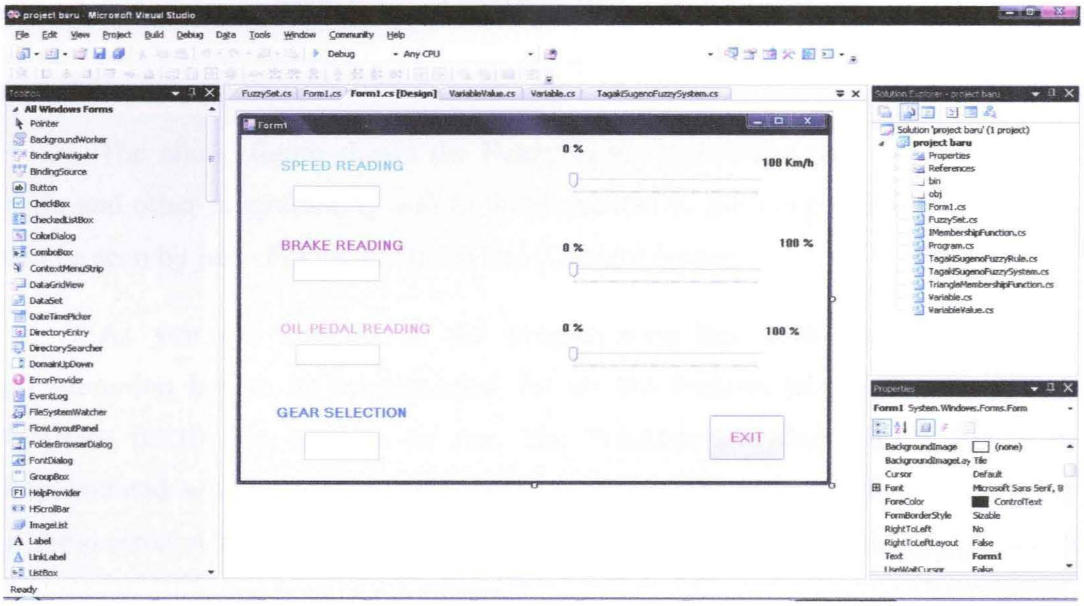


Figure 3.6 : Graphical User Interface (GUI) Draft

3.2.2 FUZZY LOGIC ALGORITHM DEVELOPMENTS

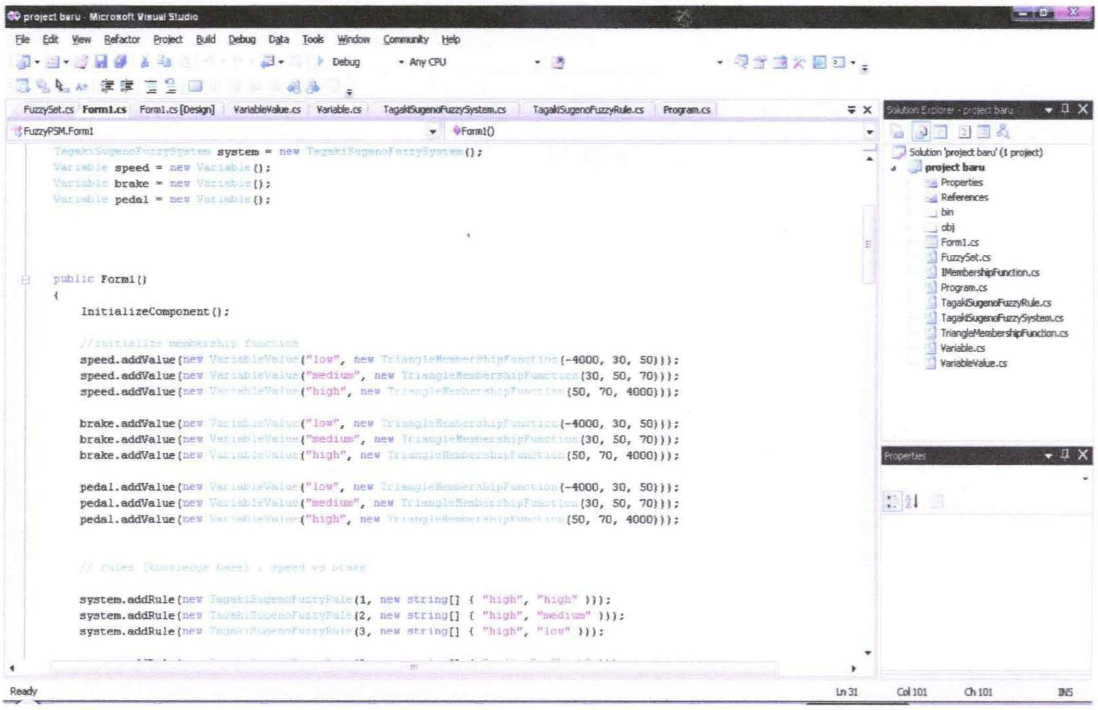


Figure 3.7 : Programming Development

The above figure shows the Fuzzy Logic algorithms part where the fuzzy logic and other programming will be implemented to run the project. This window can be seen by just clicking the Form1.cs [Design] button.

As you can see above, the programming has been implemented. The programming has to be implemented for all the features in the Graphical User Interface (GUI) that need to be run. The Trackbar and Exit Button had to be implemented with their own programming so that the project will run smoothly without error. After the fuzzy logic algorithms have finished, click save all to save it in the folder that you have made before.

CHAPTER 4

RESULTS & DISCUSSIONS

4.1 RESULTS & DISCUSSION

4.1.1 GRAPHICAL USER INTERFACE RESULT

From the Figure 4.1 below, this Graphical User Interface, in order to develop the shift fuzzy logic controller for car gearbox system, there are many elements that need to be considered. Though, the factors that could effect the gearbox shifting also need to be considered such as the membership of the brake, pedal and also the speed. Brake, Pedal and Speed will act as the input and the gear knob shifting will be the output of this project.

The three trackbar will give the reading value by just dragging the trackbar and the value will appears in the reading box. Each of the two combination of the trackbar, for example the brake trackbar and the speed trackbar, have been implemented with the fuzzification, the knowledge base, inference mechanisms and the defuzzification. The Fuzzy logic algorithm will run and the combination of the brake reading and speed will determine the gear selection whether it is gear 1 or gear 2 or gear 3 according to the fuzzy logic algorithm that had been implemented before. The gear selection will appears in the gearbox selection of the Graphical User Interface (GUI) that have been built before .

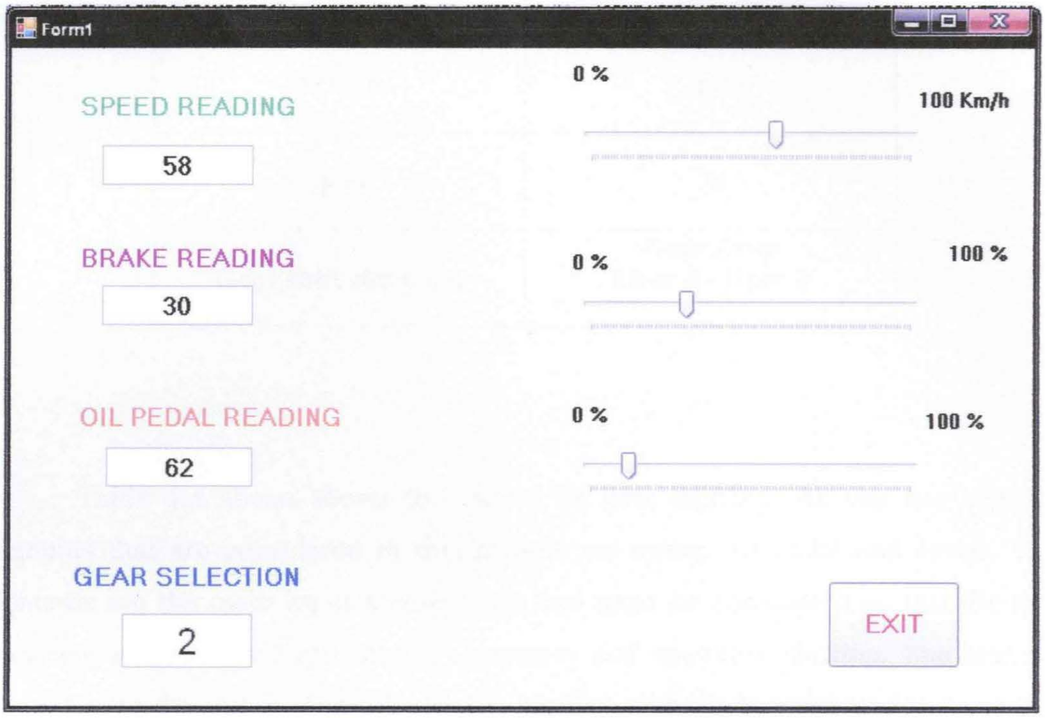


Figure 4.1 : Final Result After Debugging

4.2 DATA ANALYSIS

4.2.1 CASE 1

Table 4.1 : Case 1 gear shifting

ELEMENTS	VALUE (%)
Brake	0
Oil Pedal	60
Speed	70
Gear shift changing	**Gear Drop Gear 4 - Gear 3**

Table 4.1 above shows the case 1 of gear shifting. As you can see, the elements that are considered in this project are brake, oil pedal and speed. This elements are the main input membership that must be considered so that the gear changing will be more efficiently, accurately and smoothly shifting. The brake is applied with 0% value. The oil pedal is applied with 60 % value and the speed is applied with 70 % value. The gear shifting is changing to gear 3. This is because the oil pedal is given with very high value and the brake does not give any impact to the gear shifting because of the 0 % value. This means that the gear will be shifting to the high gear shift.

4.2.2 CASE 2

Table 4.2 : Case 2 gear shifting

ELEMENTS	VALUE (%)
Brake	0
Oil Pedal	40
Speed	40
Gear shift changing	**Gear Drop Gear 3 – Gear 2**

Table 4.2 above shows the case 2 of gear shifting. As you can see, the elements that are considered in this project are brake, oil pedal and speed. This elements are the main input membership that must be considered so that the gear changing will be more efficiently, accurately and smoothly shifting. The brake is applied with 0 % value. The oil pedal is applied with 40 % value and the speed is applied with 40 % value. The gear shifting is changing from gear 3 to gear 2. This is because the oil pedal is given with medium value, the speed is given with medium impact and the brake will not give an impact to the gear shifting. This means that the gear will be drop to the lower gear shift.

4.2.3 CASE 3

Table 4.3 : Case 3 gear shifting

ELEMENTS	VALUE (%)
Brake	90
Oil Pedal	0
Speed	68
Gear shift changing	**Gear Drop Gear 2 – Gear 1**

Table 4.3 above shows the case 3 of gear shifting. As you can see, the elements that are considered in this project are brake, oil pedal and speed. This elements are the main input membership that must be considered so that the gear changing will be more efficiently, accurately and smoothly shifting. The brake is applied with 90 % value. The oil pedal is applied with 0 % value and the speed is applied with 68 % value. The gear shifting is changing from gear 2 to gear 1. This is because the brake is applied with very high value and the speed is applied with high value. This means that the gear will be drop to the lowest gear shifting.

According to the theoretical, Fuzzy Logic Controller should give better performances rather than other controller.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 CONCLUSION

This project was done using the Microsoft Visual C# where the Graphical User Interface (GUI) and Fuzzy Logic Controller algorithms were applied in the software. The fuzzification, knowledge base, inferencing mechanisms and defuzzification algorithms have been implemented in this system. The input membership are the speed, brake and pedal. Next, the fuzzy logic rule have been built using knowledge base and implemented in the software. The inferencing mechanisms will determine the Min-Max output from the graph. Finally, the Weight Average (WA) will act as the defuzzification to determine the gear shifting of the gearbox. When using this Fuzzy Logic Controller application, the system will be simpler yet easy to understand and can operates smoothly rather than other controller. Hence, this automatic gearbox system will contribute to the smart and enhance the ability and the performance of the automatic gearbox system.

5.2 RECOMMENDATIONS

For a future development of this project, The Fuzzy Logic Controller designed can be enhanced by applying more membership function such as vehicle speed, acceleration, throttle opening, time rate of change of the throttle opening, and a vehicle running resistance, and fuzzy control section for determining a desired gear ratio by fuzzy inference using predetermined membership functions of the vehicle conditions. This means that more parameters and measurement should be considered. Besides that, this project needs and experts for applying the membership function graph and for the fuzzy logic rules. This is because only an expert knows how the graph shape will be look like and how the rules adaptation can be accurately implemented in the fuzzy logic rule matrix form. This will give better accuracy, efficiency and better performance that contribute to the smart automatic gearbox system.

5.3 COMMERCIALIZE POTENTIAL

For the past few years, there are many car systems application development that uses the involvement of electronic roles and intelligent system such as Antilock Braking Systems(ABS), Triptonic Gearchanges and Sensotronic Brake Control (SBC). Therefore, by the results of this project, it is seen that this project has the potential to be enhance and commercialize in the automotive industry. It can be sell to many automotive company such as PROTON, PERODUA, NAZA-KIA and many more like the Figure 5.1 below.

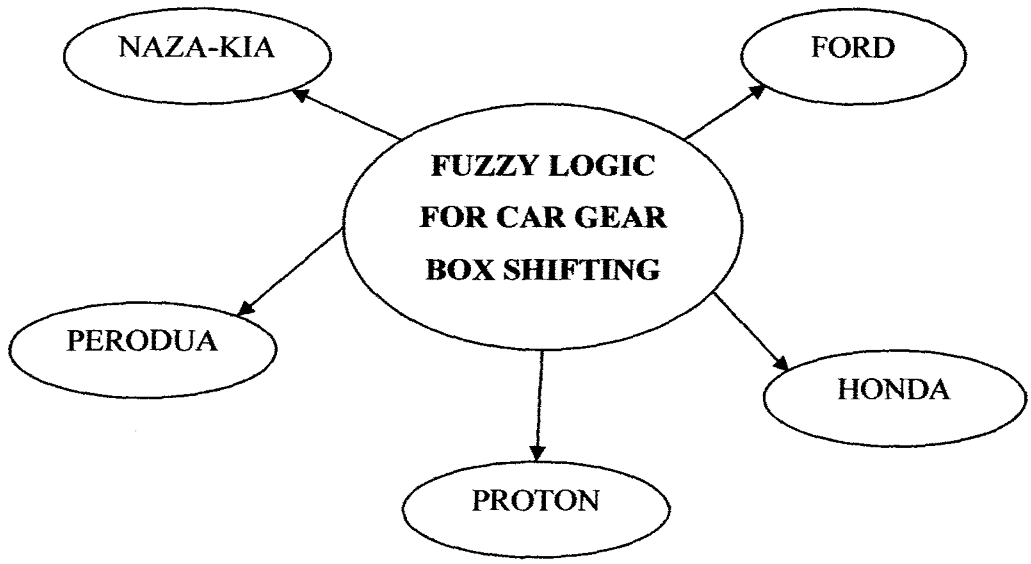


Figure 5.1 : Chart of Commercialize Potential

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APPENDICES

APPENDIX A : GANTT CHART

		PSM													
NO	PROGRAM / WEEKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Choose Project Title														
2	Information seeking														
3	Literature review														
4	Develop Project Proposal														
5	Prepare PSM 1 Presentation Slide														
6	Seminar 1														
7	Software Development (GUI)														
8	Report PSM 1														
9	Software Development (Programming)														
10	Complete Full Thesis and Presentation Slide														
11	Submit Full Thesis														
12	Seminar 2														
13	Demonstration														