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Fuzzy Control Mechanism For Anti-Lock Braking System By Using Fuzzy Logic

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Abstract -*This paper describes an intelligent method of using a fuzzy logic to control an anti-lock braking system (ABS). Parking in a hurry on slippery roads can be very challenging.The anti-lock braking system (ABS) solves many challenges from this sometimes nerve-wracking incident. In fact, on slippery roads, even professional drivers cannot stop as quickly as ordinary drivers with ABS without ABS. Compared with the braking system without ABS, the anti-lock braking system improves the controllability of the vehicle. Fuzzy logic is a multi-valued logic that is used to cope with data that is erroneous or ambiguous. Everything, according to classical logic, may be expressed in binary: 0 or 1. Everything is either in one set or the other in Boolean algebra, but not both sets at the same time. Partially membership is allowed in the fuzzy logic set, with values ranging from 0 to 1. When fuzzy logic is used with an expert system, this permits logical inferences to be derived from incorrect relationships.*

Fuzzy controllers for nonlinear, time-variant, and sophisticated systems have been attempted. In emergency scenarios, fuzzy controllers have been designed to reduce sliding and retain steering control. ABS systems use a variety of control algorithms, which play a key part in determining their performance. We show how Fuzzy Logic is utilised to control an ABS system in this study. Many different control algorithms govern ABS systems, and these algorithms determine the performance of these systems in part..

Key Words*: *Fuzzy logic , Anti lock braking system , Fuzzy controller ,Brake performance.

1. INTRODUCTION

Fuzzy logic is a technique for representing and processing uncertain information. In more traditional propositional logic, every fact or proposition must be true or false. However, most of the information people use about the world contains a certain degree of uncertainty. It deals with vague and inaccurate information. This is a serious over-simplification of the world problem of the real situation and is based on the degree of truth rather than the usual 1/10 of true/false or Boolean logic.

Recently, Anti lock Brake system has gradually been accepted as standard equipment for vehicles. Anti lock Brake System is a device that can prevent the car from locking up during emergency braking. Because the tire road slip is controlled within an acceptable range, the maneuverability of the vehicle when turning can be maintained. By maintaining maximum friction during braking, ABS can shorten the braking distance. Due to the popularity and commercial value of ABS, it has attracted a large number of researchers in this field. LI Davis, Jr., GV Puskorius, F. Yuan and LA Feldkamp at all, provided the neural network modeling and control of the anti-lock braking system [1]. Drakunov, Ozguner, U provided the control design for ABS through the sliding mode method [2]. Layne and Kevin used fuzzy model reference learning control technology [3] to maintain sufficient performance even under unfavorable road conditions. A phase-locked loop control scheme was used by Yeh E and Wang JY to study ABS [4]. Guntur, R.R. applied the parametric plane method to study emergency conditions when handling a vehicle [5] .Other researchers have also done a lot of intensive works on ABS controller design ,vehicle performance,development of linear hydraulic ABS & wheel slip ratio [6][7][8].In these paper on the basises of these simulation results, we developed some design principles for fuzzy controller designs for antilock braking systems. Additionally, we intend to use fuzzy logic to develop a fuzzy controller model for auto antilock braking systems..

1.1 FUZZIFICATION

Fuzzy controllers, in general, look at input values to see if they're crisp or fuzzy. Crisp values are referred to as such because they are represented as a single integer rather than a fuzzy one.

This method changes the crisp input to a fuzzy number, which the fuzzy controller can understand. Fuzzification is the term for this procedure. Information from the knowledge base is utilised to convert an input value to a fuzzy value in order to implement fuzzy logic in it. The Gaussian, triangular, and trapezodial MFs are the most widely utilised in the fuzzification process, according to the literature.

A fuzzy subset, also known as a membership function, is a fuzzy variable that can be used to divide a continuous number into multiple levels. Each level may be viewed as a fuzzy variable depending on the requirements.

1.2 DEFUZZIFICATION

The method of getting quantifiable results is known as fuzzy logic. The fuzzy system's ruleset consists of a set of rules that change some variables into fuzzy outcomes. This outcome is depicted as being part of a fuzzier collection. The simplest and least helpful method for non-fuzzy is to choose the sentence with the highest membership. The process of transforming fuzzy inference findings to sharp values via a decision-making process that selects the optimal sharp value based on the output of all rules is known as defuzzing. The process of converting a collection of ambiguous outcomes into a single number.

2. METHODOLOGY

A real-time professional gadget that implements a number of human operators is known as a fuzzy genuine judgement manage device. In the proximity of PID parameters or differential equations, these operators are difficult to specify in terms of movement instructions. In areas where the classical management concept has been significant for many years, fuzzy genuine judgement management systems were a huge success. In a few ways, this differs from the traditional management concept. One of the principle abilties of fuzzy genuine judgment manage is that it exists at one-of-a-type levels. On the most effective hand, there are symbolic if-then guidelines and qualitative and fuzzy portions and values such as "negative". Here, the moderate boom and excessive voltage are fuzzy values and fuzzy operators. The IF element is referred to as the "preceding" and the THEN element is referred to as the.

The purpose of fuzzy control is to translate differential equation-based procedures into artificial intelligence strategies and solve the entire problem. One method of combining fuzzy and PID-control is to utilise a linear PID tool sooner or later of the set-point, in which it performs its function, and to delinearize the tool in specified areas using a method of expressing the well-known behaviour or control technique with fuzzy rules. Conceptually, fuzzy top judgement controllers are relatively straightforward.

They consist of :- An Input Stage, A Processing Stage, An Output Stage

Sensors or specific information sources (like switches, thumbwheels, etc) are planned to proper participation capacities and truth esteems by the info degree. The processing degree invokes each applicable rule, provides a stop end result for each rule, and then combines the rules' effects. Finally, the output degree turns the combined stop result to a specific manipulation output value once more.

There are lots of rules in a now not uncommon fuzzy now not uncommon sense manipulating mechanism. The "max-min" inference procedure, in which the output club feature is assigned the truth fee generated via the premise, is the most currently not exceptional and brilliant one. In hardware, the rules can be solved in parallel, while in software, they must be solved sequentially. All induced rules' effects are "defuzzified" into smooth values using one of several ways. The "centroid" approach, in which the "centroid" of the surrender give up end result delivers a crisp fee, may be highly popular. The "height" technique, which takes the fee of the most important contributor, is another option. The centroid technique favours the thumb of thumb of thumb guideline with the most critical output area, whereas the pinnacle approach clearly favours the thumb of thumb of thumb guideline with the most essential output fee. On this paper, stick to the centre of gravity.

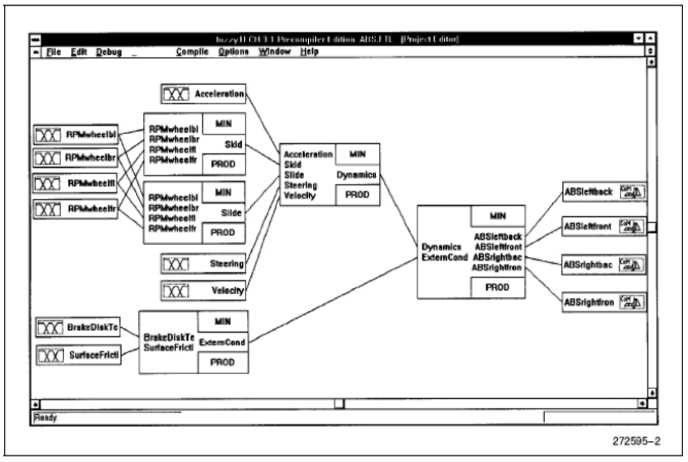

Figure-1: Flow chat of Fuzzy logic precomplier action

3.THE FUZZY LOGIC-ABS ALGORITHM

The Fuzzy-Controller uses two input values:-
The wheel slip - The Wheel Accelaration-

$$s_B = \frac{v_{Fzg} - \omega R}{v_{Fzg}} = \frac{v_{Fzg} - v_{Wheel}}{v_{Fzg}}$$

$$a_{Wheel} = \frac{\partial v_{Wheel}}{\partial t} \approx \frac{\Delta v_{Wheel}}{\Delta t},$$

With wheel speed v haggle speed v fuz, that is given with the guide of utilizing the Fuzzy-Estimator. The enter factors are changed over into fluffy factors slip and dv wheel/dt with the guide of utilizing the fuzzification cycle. The two factors use. Seven semantic qualities, the slip variable is characterized with the guide of utilizing the terms.

Where, Slip = it can be zero,or up to very small than optimum, Optimum very lage for the acceleration.

dv_{wheel}/dt= it can be small negative, medium negative and large negative, zero, small postive, large positve.

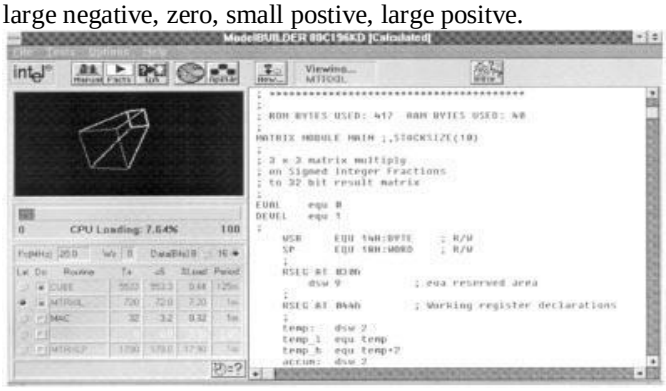

Figure-2 : Computation Simulation of Fuzzy logic based calculated

4. FUZZY LOGIC BASED ANTI-LOCK BRAKING SYSTEM

The anti-lock braking system (ABS) is a car safety feature that prevents the wheels from locking up when the vehicle is braking. Anti-lock brake controller is another name for it. Vehicles with this ABS have the best vehicle control and the lowest braking distance possible during emergency braking. An anti-lock braking system (ABS) prevents the wheels from locking up while braking, allowing the driver to better manage the vehicle and maintain traction on the road. ABS was originally used in the 1950s, decades before contemporary systems were developed. As a result, the "Rail Vehicle Anti-Skid Regulations" were enacted. Gabriel Voisin, a French automobile and aircraft pioneer, tested a mechanism in 1920 to lessen the risk of tyre slippage by regulating the hydraulic braking force on aircraft brakes. Threshold braking on an aeroplane, for example, is nearly impossible.

The lower rear of anti-lock brakes is based on a simple principle. A wheel that is slick has much less traction than a wheel that is not slippery (tyre contact ground sliding relative to the road). ABS is a dynamic, non-linear material. ABS is now universally recognised as an important aspect of vehicle safety. The management mechanism of ABS is in charge of tool performance. The flywheel and valve are connected by a hydraulic line that delivers oil to the brake cylinder. The flywheel is attached to a drum that rotates at the same rate as the wheels. This causes the valve to open, enabling a tiny amount of brake fluid to bypass the draw close cylinder and into the communal reservoir, reducing cylinder pressure and releasing the brakes.

5.COMPONENTS OF FUZZY LOGIC ANTI-LOCK BRAKE SYSTEM

There are four main parts in ABS.
They are :-

- Wheel speed sensors
- Electronic Controller Units (ECUs)
- Hydraulic valves
- Pumps

Anti-lock brakes need a way to detect when the wheels are about to lock. Wheel speed sensors are used to determine whether the wheels are speeding up or slowing down. These sensors use magnets and Hall effect sensors, as well as gears and electromagnetic coils, to generate signals. The spinning of the wheels or differential creates a magnetic field surrounding the sensor. When the magnetic field fluctuates, the sensor generates a voltage. The sensor may become erroneous at low speeds because the voltage created in the sensor is caused by wheel rotation. Because of the slower wheel rotation, erroneous magnetic field changes can occur, resulting in inaccurate controller readings. In the braking line, each brake has an ABS-controlled valve. In the brake line, each brake has an ABS-controlled valve.

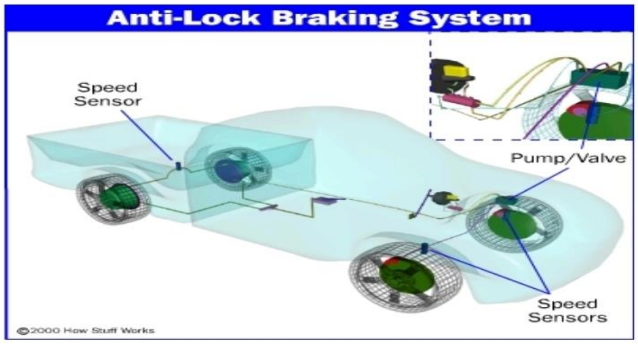

Figure -3: Configuration of Fuzzy logic anti brake system

The valve on this framework has three positions: position one opens; the tension from the expert chamber is straightforwardly sent to the brake. Position two shuts the valve; the tension from the expert chamber is straightforwardly communicated to the brake. Position three shuts the valve; the strain from the expert chamber is straightforwardly sent to the brake.

In 2nd position, the valve closes the pipeline, disconnecting the brake from the master cylinder. The pressure will not rise any further if the driver presses harder on the brake pedal.

In 3rd position, the valve releases some braking pressure. Because the valve can discharge braking pressure, there must be a way to restore it. As a result, the pump recovers the pressure in the pipeline when the valve lowers it. ABS significantly enhances safety.

When wheel slip is detected, the ABS pump is used to re-establish hydraulic braking pressure once the valve is released. Once the user's pressure is released, the pump restores the appropriate pressure to brake the system. The controller will regulate the pump's condition to deliver the required pressure and reduce slippage. The controller of an automobile is an ECU-like unit that receives data from each wheel speed sensor individually. If the wheels lose traction, the controller receives a signal. The ABS regulator is then activated, which opens and closes the brake valve and regulates the braking force (EBD).

6.WORKING OF FUZZY LOGIC ANTI LOCK SYSTEM

The ABS system comes in a variety of configurations and control algorithms. ABS performance is partially down on the control algorithm. The speed sensor is constantly monitored by the controller. It's checking for unusual slowing of the wheels. It will experience rapid deceleration just before the wheels lock. The wheels will halt far faster than any car if left unchecked. A car can stop from 60 mph (96.6 km/h) in 5 seconds under perfect conditions, while a locked wheel can cease spinning in less than a second. Because the ABS controller recognises that such rapid deceleration is impossible, it will lower the brake pressure until it detects acceleration, then increase the pressure until it detects

deceleration.It can do this quickly, and the tyres can then dramatically vary the speed. As a result, the tyres descend at the same pace as the vehicle, and the brakes come the tyres dangerously near to locking up. This gives the system's maximum braking force. Simple if-then rules are insufficient for fuzzy ABS, which necessitates a more complicated control structure. The input variables are directly marked as output variables in if-then rules. It is possible to set up a control with intermediate fuzzy variables.

If the back wheels are turning slowly and the speed was high not long ago, lowering the rear brake pressure is a good rule of thumb when using fuzzy variables. When the ABS system is turned on, the valve opens and closes quickly, causing the brake pedal to pulsate. In rare circumstances, ABS systems can cycle up to 15 times per second. The ABS working principle is shown in the diagram below.

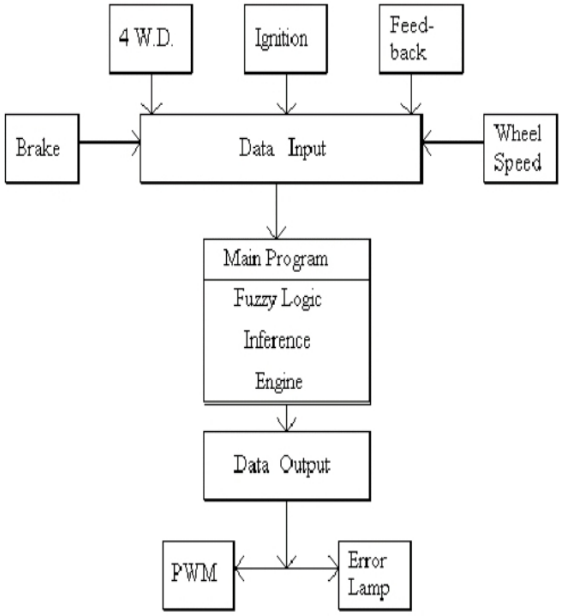

Figure-4: Working schematic block diagram of fuzzy logic based fuzzy control anti lock braking system.

7. FUZZY LOGIC CONTROLLER OF ANTI LOCK BRAKING SYSTEM

Fuzzy logic controllers could be used to control non-linear, time-variable, and sophisticated systems. ABS, as a non-linear system, may be difficult to regulate using traditional control methods. For this type of nonlinear system, an intelligent fuzzy control strategy is particularly effective. The slippage performance of an intelligent fuzzy ABS controller may be adjusted for a range of roads. The biggest disadvantage of standard brakes is that the brake torque applied to the brake cannot be accurately controlled by the driver. Furthermore, because the driver lacks sufficient knowledge about the road conditions, he may cause wheel locking by applying excessive brake pressure. Anti-lock When compared to braking systems without ABS, brake enhances vehicle controllability.

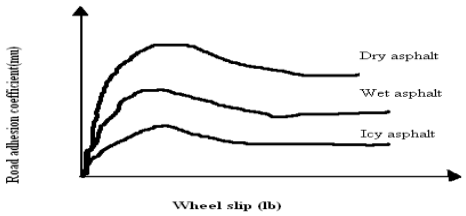

Figure-5: Graph plotted between wheel slip & Road adhesion

The wheel slip, addressed by lb, is the proportion of the contrast between the vehicle's speed and the wheel's translational speed to the vehicle's speed. The purpose of ABS is to keep each vehicle tyre functioning at the peak of the mu-lb curve for that tyre, implying that ABS performance is highly dependent on the surface condition.

8. THE STRUCTURE OF FUZZY LOGIC ANTI-LOCK BRAKING SYSTEM

The defuzzification of the linguistic variable pressure yields the best breaking pressure. Finally, a three-step controller decides the location of the magnetic valves, as well as whether the pressure should be increased, maintained, or reduced. The figure depicts the total number of fuzzy calculations. The quantity of fuzzy rules is indicated by the numbers within a rectangle.

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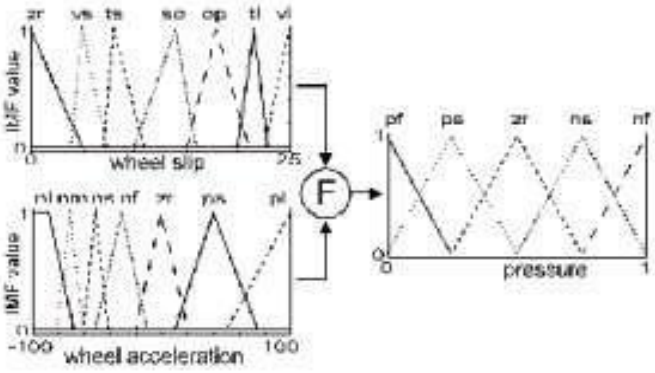


Figure-6: Structure analysis of wheel slip & wheel acceleration

It should be mentioned that language variables and rule tables can be constructed using numerical optimization approaches; however, in this study, they were created utilising expert knowledge and data analysis during ABS braking action. The microprocessor SAB 80C166 and the fuzzy coprocessor SAE 81C99A are used in the fuzzy ABS controller [2]. The host processor's calculation speed rose dramatically as a result of the inclusion of Fuzzy algorithms in the coprocessor's hardware. The computation time was only 0.5 milliseconds while the control cycle time was set to a standard value of 7 milliseconds! This provides the means to implement advanced vehicle dynamics control. . The coprocessor is quite versatile,

as it can handle up to 64 rule bases, each having 256 inputs and rules. There is also an interface for the majority of commonly used microprocessors. Because it includes limitless shapes of membership functions, multiple defuzzification modes, including "Center of Gravity," and a huge rule engine that can do up to 10 million rule calculations per second, this device is a particularly exciting product in the field of real-time fuzzy control.

9. IMPACT OF FUZZY LOGIC ANTI LOCK BRAKE SYSTEM

The motivation for the development of fuzzy antilock brakes is straightforward. If one or more of a vehicle's wheels lock (begin to skid) when braking, a number of things can happen:
a) The braking distance grows.
b) Control of the steering wheel is lost.
c) Abnormal tyre wear is expected.

The obvious result is that an accident is much more likely to happen. Brakes produce a force that obstructs a vehicle's motion by applying a force in the opposite direction. During severe braking conditions, a point is reached where the tyre surface's tangential velocity and the velocity of the road surface are not the same. The slip ratio is the proportion of the tangential velocity of the tyre to the vehicle's real ground speed, represented as: The circumferential velocity of the braked wheel is Vg, while the vehicle's road speed is Vt. The slip of a free rolling wheel is 0%, while the slip of a locked wheel is 100%. Slip is a function of braking force or the adhesion coefficient of braking force (f) measured in the direction the wheel is turning. Vg is the circumferential velocity of the braked wheel, and Vt is the vehicle road speed. The slip of a free rolling wheel is 0%, while the slip of a locked wheel is 100%. Slip is a function of braking force or the adhesion coefficient of braking force (f) measured in the direction the wheel is turning. f is determined by a multitude of factors, the most important of which are:-

a)Material condition of the road surface.
b)tire construction, tread depth, tread pattern, and inflation pressure.

The goal of an ABS is to reduce braking distance while maintaining steering ability even while braking aggressively. Consider the following diagram to grasp the underlying physical effect that causes wheel-blocking when braking:

a: Coefficient of friction is shown as a function of wheel slip:-

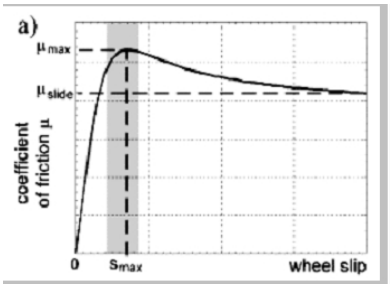
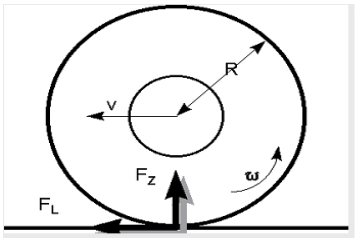


Figure 1: a) Friction characteristics

Figure-7.1.a: Friction characteristics

b:wheel model is shown as:-



b)Wheelmodel

FZ: Wheel load
R: Wheel radius
w: Angular wheel frequency
v: Velocity of wheel center
FL: Longitudinal force

Figure-7.1.b: Wheel model

10. BENEFITS OF FUZZY LOGIC BASED ANTI-LOCK BRRAKING SYSTEM

- Automobiles can be stopped faster, and braking distances are less. While braking, you can still steer.
- The percentage of road crashes has decreased significantly thanks to fuzzy ABS. ABS will be standard equipment on 35 percent to 50 percent of all automobiles made worldwide in five years, according to experts.
- Insurance premiums are lower. Because it is a tried-and-true safety equipment with a proven track record of performance, insurance companies frequently offer clients a discount for having a FUZZY ABS system installed in their vehicle.
- These new technologies aid in ensuring that each wheel has traction on the road, making it simple for manufacturers to integrate these features into the engine system.
- Even in slick conditions, the usage of FUZZY CONTROL ABS prevents lock-ups and sliding..
- If the signal to the fuzzy logic is low, the brake actuator is engaged, and the value is controlled to lessen the braking pressure on the car wheel while the vehicle is in motion.

11. CONCLUSIONS

The nonlinear characteristic surface formed by fuzzy logic serves as the foundation for the control method. The primary advantage of fuzzy logic is that it can modify and adjust particular areas of the feature surface quickly and precisely. All that is required is a change in the language rules or variables. This drastically streamlines the development process and reduces the amount of time it takes. The use of fuzzy ABS produces good results when assessing the vehicle's braking behaviour. The level of deceleration and steering ability are equivalent to commercially available systems. In automotive applications, the integration of fuzzy logic and microcontrollers together is a relatively new invention. At this time, Intel is not aware of any ABS-related projects. Fuzzy Sets and Systems is a fantastic publication devoted to fuzzy logic and fuzzy logic-based control systems.

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