Intelligent Vehicle Navigation using Fuzzy Logic

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ABSTRACT
The issue of Autonomous vehicle navigation has shown rapid progress due to advent of computer integration in mechanics. The field is developing due to tremendous size reduction in Electronic devices allowing us to embed the computing power into these mobile machines. The with final integration of Embedded Systems and Mechanics these vehicles will one day definitely become autonomous. Auto Cruise Control (ACC) is the technology in present implementation does this work efficiently.

But ACC is just the start. Many more ways are available like, Path Tracking, Visual Target Tracking are being implemented using Fuzzy Logic and other Artificial Intelligence techniques. The sole aim is to make system Automatic.

But every automatic system if given extensive degree of freedom then it tends to give unwanted or unexpected results, no matter how intelligent the system is. So aim of our idea is to confine the intelligence of these vehicles in some Protocols or Laws so that the domain of decisions by system is under control or even already known. Employing Fuzzy Logic we are making the decision structure of autonomous vehicles intelligent but also designing these in forms of protocols itself.

KEYWORDS *:* Fuzzy Logic, Autonomous Vehicle Navigation, Fuzzy Control.

1. INTRODUCTION
In the field of autonomous vehicle navigation many techniques are being employed, being used and tested. Automatic Cruise Control, Path Following with GPS, or using Fuzzy logic are in use extensively. But all these technologies do very little to avoid collision in cars. If they are designed to do so then they mostly have Centralized control like

1. In collision avoidance using GPS
2. Air Traffic Control Systems.

This Model represents Fuzzy Logic based Decentralized control system [2] for autonomous vehicles that employs some normal rules that we use in day to day life for driving vehicles. The rules are implemented using Fuzzy Logic and this whole system will be installed as embedded system in all cars that hit the road.

2. BASIC WORKING PRINCIPLE

When we, humans- one the best machines, drive vehicle, we follow some basic rules like

1. We maintain safe distance between our vehicle and the next vehicle.
2. We generally obey traffic Rules.
3. Before taking turn, we signal about it to the vehicle around us by either Indicator or by hand.

Any of these instinctive ideas if we don't follow then we are tend to collide with vehicles around.
Now, if these basic rules are made to follow strictly by all vehicles by programming them into cars then vehicles will be autonomous and safe. As of course the program will not disobey these finite instructions.
This idea can be implemented as follows.
Pre-requisites:

1. All the vehicles must have this system installed.
2. All cars will communicate with each other using CAN[4]
3. Data exchanged by vehicles through CAN (Controller Area Network) will be sent to the embedded system that employs this model.

3. GENERIC LAWS FOR AVNs
Terminologies:
If length of car is L meters then L+2 is the critical region of the car. Taking right/left turn is Action. Car must send ACTION SIGNAL to car behind.
Three Basic Laws to avoid collision in cars:
A. No car should enter in critical region of another car
B. All vehicles will obey traffic rules.
C. Before Action the car must send Action Signal and take Action only after acknowledgment

3.1 LAWS WITH MEMBERSHIP FUNCTIONS

LAW 1:
No car should enter in critical region of another car
If length of car is L meters then L+2 is the critical region of the car.
If this Law is enforced on vehicles then no collision will never occur.
This Law can be defined using three membership functions:

1. Distance
2. Position
3. Speed

Distance MF

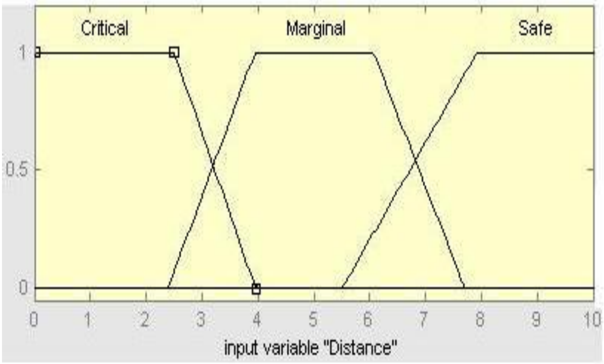

Fig 1: Distance Membership Function

Distance between vehicles is calculated using the co-ordinate information being exchanged by them using CAN. Critical =2 is the distance which is threshold for every car. No other vehicle can cross this limit marginal is the distance that two vehicles should safely maintain. Safe all distance over Marginal is safe.

Lane MF

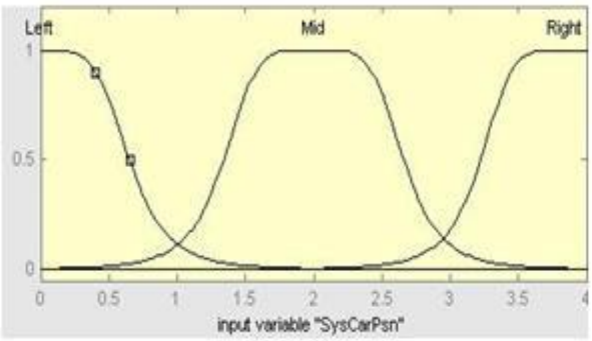

Fig 2: Lane Membership Function

Position of car on the road .i.e. the Lane in which the car is running is determined by the sensors. This data is sent to the Inference engine. Every car will send information about its position on network Via CAN.

Left lane 1 on road
Mid lane 2
Right lane 3

Speed Membership Function

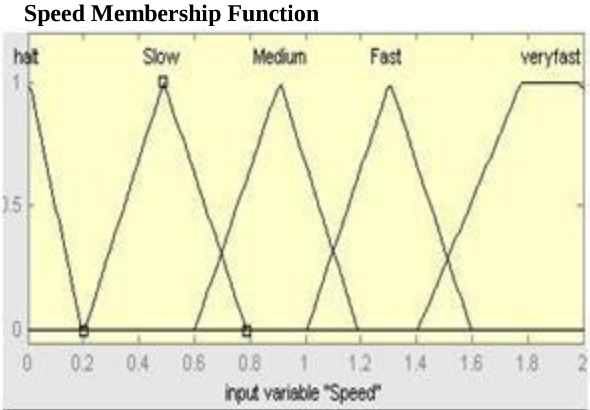

Fig 3: Speed Membership Function

Speed membership function decides the speed of the car. Halt sets the car speed to zero. The speed gradually increases from Slow, Medium, Fast to Very Fast.

LAW 2:

All vehicles should follow traffic rules. Traffic rules will include obeying Traffic signals. Driving in correct speed lane.i.e. If car wants to go slow it must drive in left most lanes. For high speed it should take high speed lane (rightmost) No Vehicle can exceed maximum speed limit which varies through route.

LAW 3:

Before Action the First car must send Action Signal and take Action only after acknowledgement.

In traffic if a car decides to take suppose right turn then it must send the Action signal to cars along with its positional data via CAN. According the car behind will either slow down a bit or will switch to slower lane. And after this only it will acknowledge the car to take turn. It should be noted here that this will not lead to chain reaction of Action Signals and wait state for their acknowledgements. Logically feasibility of this problem is very high but this won't arise if we look at how we handle this during driving. In real life when a vehicle needs to take turn it signals for permission generally. Then the vehicle just behind it takes necessary action granting the permission. This second vehicle never requires taking permission from vehicle behind it. Actually all the vehicles behind this second vehicle take necessary actions without procedure of signal and acknowledgement.

So in our system even only the first car behind action car will perform this acknowledgement procedure.

3.2 OTHER RULES

Start condition:

IF NO OTHER CAR IN SAME LANE IS IN CRITICAL REGION

Turn Condition:

Right turn

The car will send the Action Signal to car behind. The following car will check these conditions.

IF FRONT CAR IS NOT IN OUR LANE THEN SPEED UP.

IF FRONT CAR MID LANE AND OUR IS FAST LANE THEN SLIGHT SPEED DOWN.

IF FRONT CAR SLOW LANE AND OUR CAR IS IN FAST LANE THEN STEEP SLOW DOWN

The following car will satisfy one of above 3 rules. Same Rule set is employed for left turn.

4. ANALYSIS OF RIGHT TURN RULE

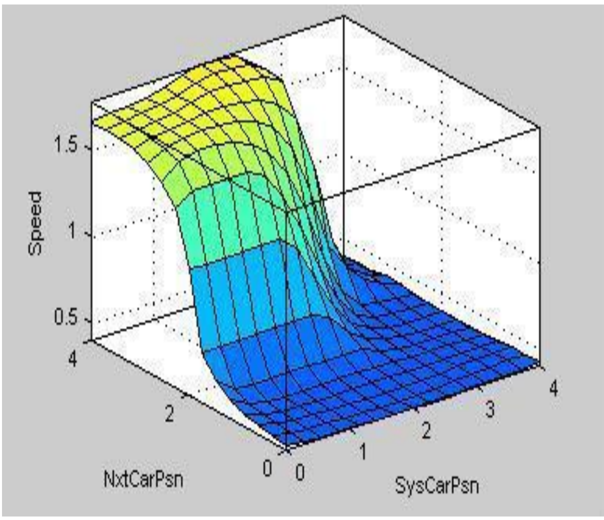

Fig 4: Surface for Turn Rule Base

In Figure 4, Surface of rule base for turn can be seen .speed of following vehicle varies according to the distance between the action or next vehicle and the following. As the distance between them, increases the speed of follower increases. Here the action car is plotted as NxtCarPsn and the Following car (the one on which this rule base will work) as SysCarPsn.

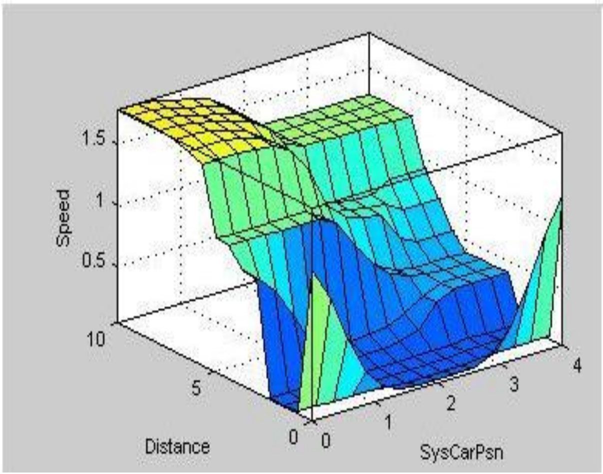

Fig 5: Surface for Turn Rule Base

This surface represents the logic of:
IF FRONT CAR MID LANE AND OUR CAR IS IN FAST LANE THEN SLIGHT SPEED DOWN
IF FRONT CAR SLOW LANE AND OUR CAR IS IN FAST LANE THEN STEEP SLOW DOWN
The surface in figure 5 shows nature of inference upon variation in distance between cars and their lanes. In the same way right turn is to be employed.

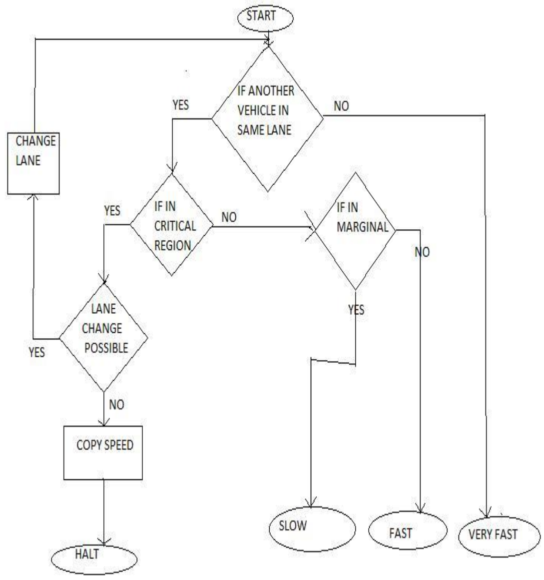

Fig 6: Flowchart

5. CONCLUSIONS

The system is deduced from or it is the prototype version of human decision structure while driving. As this decision is made compact, the system can easily follow them and as the system itself is programmed engine it is less likely to do any mistakes like disobeying the traffic rules. Also, this system being decentralized has more degree of freedom even then it manages to keep the domain of results restricted by employing three basic laws. So, the results are certain.

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