Auto Pilot for Car using Fuzzy Logic and Laser Scanning Radar Sensor

A.P. Mittal
Prerna Gaur
Bhuvnesh Agrawal
P. Supreet Kumar

Department of Instrumentation and Control Engineering
Netaji Subhas Institute of Technology
University of Delhi, Delhi

Abstract: *This paper describes a fuzzy logic approach to creating auto pilot software for car. The car gathers knowledge of its surrounding via the use of LIDAR sensors (Light Detection and Ranging). The data is then fed to a decision making unit based on fuzzy logic. For all the development and test purposes, Virtual Reality has been used as the simulation platform.*

Keywords: *Auto Pilot, Autonomous Navigation, LIDAR, Virtual Reality, Fuzzy Logic, Simulation*

1. INTRODUCTION

With advancements in the field of computational intelligence, computers have increasingly taken control of work that previously required human expertise. This has resulted in the activities becoming more time efficient and better managed, at the same time freeing up the human operator to invest his resources in other meaningful pursuits. The paper is aimed at using computational intelligence to build an auto pilot system that will be able to maneuver the vehicle on road, in real time. The system is based on services of existing hardware that is available to the industry and is being currently used by auto majors. The software has been built upon the hardware layer, such that the services of underlying hardware are being assumed by the software in decision making. The software uses fuzzy logic as the main decision making unit.

2. PROBLEM FORMULATION

The trajectory of a car has to be controlled and manipulated by taking into account other vehicles on road. For such a system, the input has to be a group of sensors working together to detect obstructions and objects in path. This system's inputs comprise of four LIDAR sensors placed as shown in Fig.1.

Each sensor performs visual scanning of the surrounding and thus determines the position and proximity of any obstacle, which is then fed as an input signal to the decision making fuzzy logic. All the four sensors function in parallel to accurately identify both moving and stationary obstacles. Based on these signals representing proximity with other vehicles or obstacles, fuzzy logic then evaluates its rules to obtain optimum output values of throttle and steer. Speed can be varied by controlling throttle to accelerate or decelerate, whereas direction could be controlled by the steer signal that ranges from -90° to + 90°.

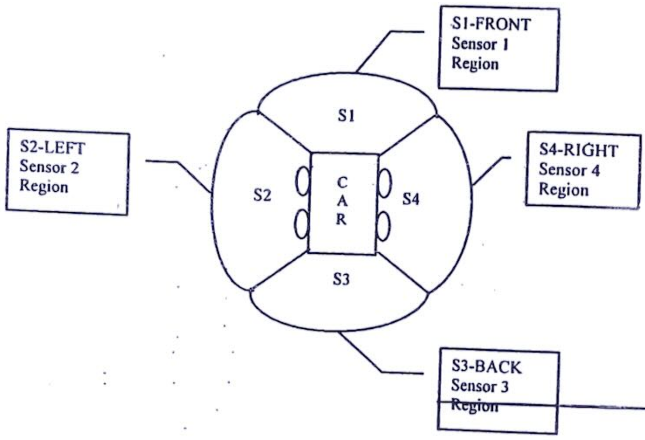

Fig.1. Placement of sensors

3. FUZZY LOGIC MOTION CONTROL

As shown in Fig.2, fuzzy inference system has been used for driving the car as it has the inherent ability to evaluate conditions and arrive on results, on basis of inputs that are partially true and partially false, for particular criteria or rule.

Coupled with the parallel evaluation of rules that allows to maneuver the vehicle with regards to all the

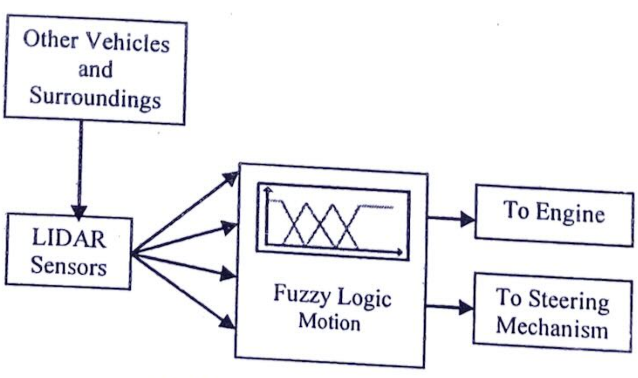

Fig.2. Conceptual schematics

inputs simultaneously, this paradigm of programming enables to lay the program in form of simple rules that could be linguistically described with ease, as against other computational intelligence techniques such as artificial neural networks, which need to have pre-collected data that has to have all the features one needs the system to exhibit, or others where the program has to be hard-coded to encompass all possible cases.

Fuzzy logic enables human like control of the vehicle that seems more 'natural'. And so on similar lines, the rules of the system are formulated based on simple observations. Each of the four sensor's outputs is used by the fuzzy rule engine to gauge the proximity of obstacles in the direction of the sensor. Based on the sensor input, corresponding throttle and steer output values are computed which simply aim at moving the vehicle away from the obstacle. This function is carried out for all the four sensors concurrently and the resultant values of all evaluations is then aggregated to produce a final throttle and steer value that aims to avoid collision from all the obstacles sensed collectively by the sensors.

In effect, what we have is a system that avoids collision with obstacles by applying brakes, moving away from them, or accelerating.

For example, if there is a vehicle that is speeding up from behind, then the fuzzy system will evaluate whether there is any other car in front, if yes then is it near or far, is there any vehicle near to the right or not, is there any vehicle near to the left or not. Now all the above conditions are evaluated simultaneously to obtain a feasible throttle value, i.e. whether to accelerate or decelerate, and a steer value, i.e. to steer left or right or maintain current direction.

4. SIMULATION

Virtual reality is used as the simulation platform to carry out the development and testing of the program. A virtual world was created as shown in Fig. 3, with roads and other cars besides the one being controlled by fuzzy logic.

The sensors are simulated by calculating the difference between coordinates of the car and other vehicles which would be in the detection range of sensors in the real world. The demarcation of road boundaries in the real world could be painted with a specific color that can then be recognized with the help of LIDAR visual scanning.

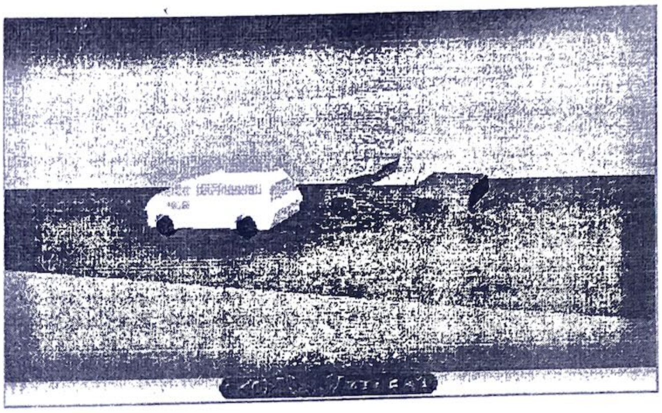

Fig. 3. Virtual world for simulation

5. RESULTS

Simulations have been conducted in a virtual world to affect basic overtaking and collision avoidance in presence of one other car as shown in Fig. 4.

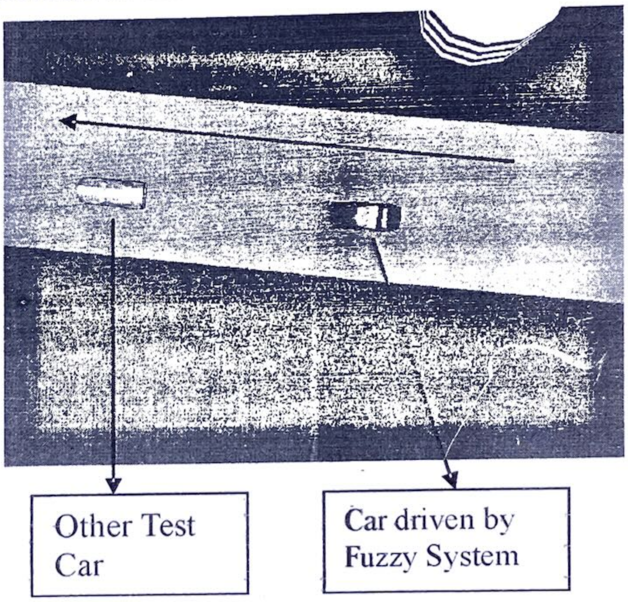

Fig.4(a). Showing the moving cars on road

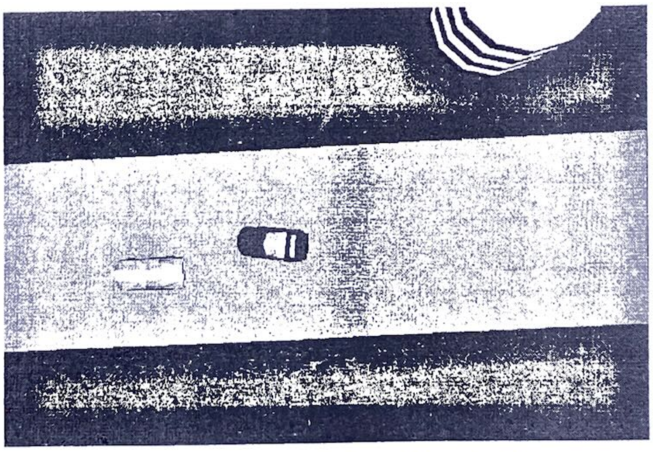

Fig. 4(b). Avoiding collision with car in front

The axis alignment is such that the cars are moving in positive z direction, and the direction perpendicular to it, on the plane of the road is positive x to the left of cars as shown in Figs.5 and 6. The scope here shows how the difference in X and Z coordinates varies with time.

For the plot in Fig. 5, the difference in coordinates along an axis is calculated as:

(*coordinate of the other test car – coordinate of fuzzy car along the same axis*)

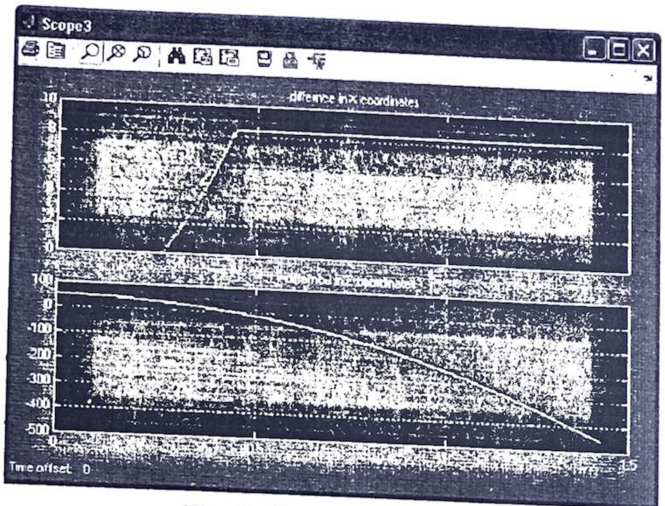

Fig. 5. Output Scope Values

Initially when other car is in front of fuzzy car the difference in Z is positive and when fuzzy overtakes other car the difference becomes negative. For difference in X, initially fuzzy car moves straight for some time then it senses other car in front of it and moves to right direction increasing the difference in X and when it completes the overtaking it maintains its position in X.

Fig. 6 contains two plots viz., throttle vs. time and steer vs. time. Both are outputs from Fuzzy Logic

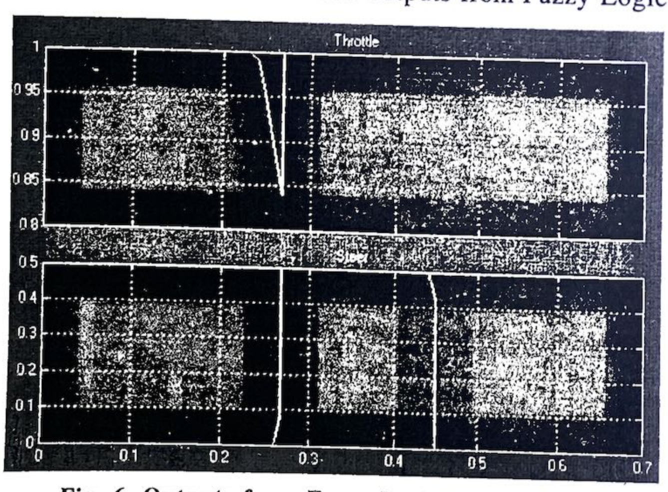

Fig. 6. Outputs from Fuzzy Logic Motion Control

inference system. Initially when fuzzy car senses no other car in front then throttle is a maximum of 1 and steer value is 0. When front sensor senses the other test car, the throttle output reduces in order to stop speeding towards the test car and steer output changes to steer away from the test car to avoid collision. Both changes happen simultaneously. In order to continue its course, fuzzy logic's steer output increases to turn the fuzzy car in right direction and throttle output reduces. Once overtaking is done and the sensors sense no other imminent collision, the fuzzy car returns to its original orientation and acceleration as shown.

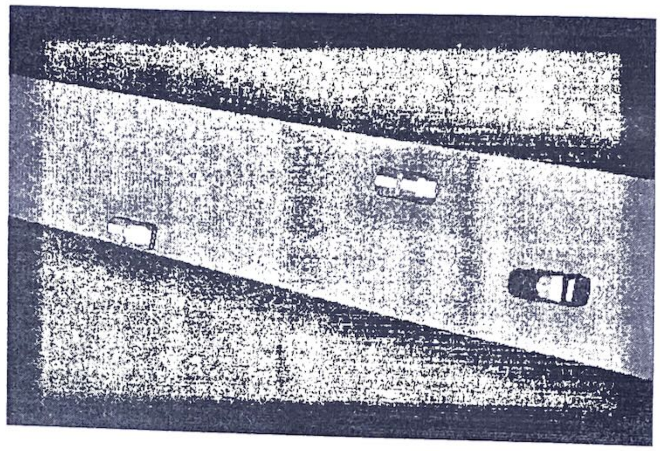

Fig. 7. Car beginning to avoid collision

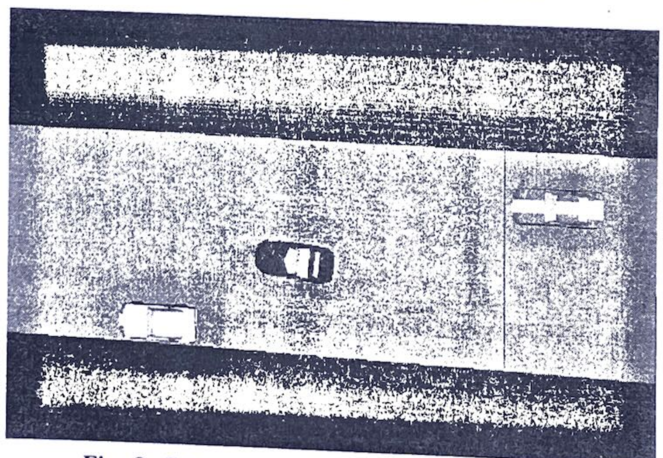

Fig. 8. Car maneuvering among two other cars

The turning in simulation is implemented by mapping the steer output between -90 degrees to +90 degrees and then taking the sine of the current velocity to get the velocity in direction of turning.

Another test case is simulated and results are presented where the car avoids collision with two other moving cars on road. This result is also a generalized case for several cars on a real world road wherein fuzzy logic negotiates multiple entities both consecutively and concurrently.

6. CONCLUSION

This paper has presented a new approach to making auto pilot for cars that mimics human driving using fuzzy logic. The collision is avoided in both the cases successfully using fuzzy logic i.e. two or more cars on the road. Virtual reality platform under MATLAB/ SIMULINK is used here to simulate and test the program successfully. The hardware requirements that are assumed in the program simulation as sensors are to be implemented by the use of LIDAR sensors in real time system. Practical implementation of the suggested system may be done using Digital Signal Processor.

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