

Unmanned Automatic Vehicle Using Low Cost, Fuzzy Logic with Real Time Collision Avoidance System

H M Preeti¹, Dr. Baswaraj Gadgay², Mr. Veeresh Pujari³

P G Student, Department of VLSI Design and Embedded Systems, VTU Regional Centre, Kalaburagi, India¹

Research Guide and Professor, Department of PG Studies, M.Tech VLSI Design & Embedded Systems, VTU Regional Centre, Kalaburagi, India.²

Assistant Professor, Department of PG Studies, M.Tech VLSI Design & Embedded Systems, VTU Regional Centre, Kalaburagi, India.³

ABSTRACT: Car automation, navigation and driving assistance are one of the most active various in automobile researches. Recently NASA push for self driving Rover and Google's car project has pushed the limits of the automatic vehicle navigation systems. However, the response of vehicles in real time has been found to be poor due to conventional work flow of microcontroller based processing. With the advancement of IoT and improvement in Internet speed has enabled it to take the decision system to the core and the fogs from the edge devices. Even though there are have been several past works which are proposed effective technology for automated navigational support combined with obstacle avoidance and lane tracking, most of such systems, have been proved to be unrealistic for realistic driving. In this work, we try to solve the problem of computational and navigational latency suffered by existing systems by introducing a combined edge and fog based decision system for the vehicles. We have simulated and tested the proposed work using a custom designed remote control car powered by Intel Edison IoT device and with MQTT as the gateway protocol. Results show that the proposed system has exceedingly quick response over conventional systems. The proposed work combines Image Processing and Machine learning technology efficiently for the decision support system of the car. This results in more efficient and powerful architecture for automated and self driving car.

KEYWORDS: IoT, automatic vehicle, Image processing, fuzzy logic, Google's car, navigational latency.

I. INTRODUCTION

The cars are considered as the most safe and convenient way of travelling since its inception in late 1890s. But now-a-days the automatic cars are in demand. Before getting into detail, let's points out some of the advantages of the automatic car[5]:

- Fewer accidents: A considerable number of accidents and loss of life are due to human errors. Automatic car can reduce the death toll.
- Quality commuting: People can spend quality time while travelling by doing their work rather than concentrating on driving.
- Fewer traffic jams: It can be efficiently adapted to the dense traffic area. As it properly follows the lane traffic is reduced. Reduced congestion is achieved.

In this work, we tried to develop an unmanned vehicle using fuzzy logic, which will take the proper decisions rather than only two values in the case of Boolean logic. The applications of unmanned vehicles are spread in wide areas like in military applications[8]. It is mainly used where human presence can be dangerous or not possible like in

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

the rover. This is designed to travel an unknown path with collision avoidance, lane tracking and other conventional roadside obstacles. This work is done to-

- Model an unmanned vehicle
- Control strategy development including path planning to the target while using sensor information about the external environment for obstacle avoidance.
- Develop a real time collision avoidance system.

WHY FUZZY LOGIC?

Why fuzzy logic when the work is on real time then too challenging things are real time data which are dynamic and non linear[6]. In addition to the nonlinearity, the sensors can also be unreliable sometimes. Therefore, we need a logic which considers every input as partially true or partially false instead either true or false. More appropriate solution for these cases is the fuzzy logic, which is a methodology which simulates the conditions like a human and applies the strategy in a more natural way. Fuzzy logic has a set of if-then rules through which it can solve the complicated problems[7].

II. RELATED WORK

There have been many investigation into autonomous navigation using fuzzy logic techniques. Ramírez-Cortés J.M. et. Al[1] whose focus of the work is mainly based on the developing of the autonomous vehicle with machine technique which they tried to apply in the real time basis with capturing of the images simultaneously for academic purposes. The trial mainly included navigating the remote control car through a closed circuit. Wireless camera is also used and implemented with the help of computer vision techniques. The images are processed in a system on the LABview platform. Control decisions are done by the fuzzy logic.

Gyula Mester[2] focused on the sensor based Intelligent mobile robot travelling in an unknown environment. Fuzzy logic is used for the fuzzy control of mobile robot motion with obstacles which pass the signal wirelessly through sensor based remote control. The input from the sensor and target's position are the fuzzy controller's input. The output of the fuzzy controller will be the angular speed difference between the wheels. The mobile robot mainly uses the technology called Sun SPOT technology.

Whereas, Homayoun Seraji et. Al[3] described the navigation of mobile robots in a hazardous environment using fuzzy logic approach. It mainly focuses on three domains: seek goal, traverse-terrain and obstacle avoidance. The final movement is a result of appropriate weighting factors of the aforementioned domains. This decision is taken by a fuzzy logic controller. With no prior information, mobile robots can navigate. Results show that rule based robot navigation has major advantageous over critical methods. Fuzzy logic is also proved to be pleasing for outdoor navigation due to its accuracy.

SNG HL[4] described a method of finding the obstacles by two inputs –two outputs. The vehicle followed the wall and as per the suitable commands the vehicle was able to turn in particular direction. This work proves that hierarchical structure of a fuzzy controller uses fewer rules when compared with other methods. Three cases are presented in this work: the inverted pendulum system, double pole inverted pendulum system and an obstacle avoidance system.

III. STATEMENT OF THE PROBLEM

One of the major and critical components of self driving vehicle is its ability to integrate navigation system and obstacle avoidance decision into a homogeneous platform embedded based conventional solutions have failed to offer a realistic, quick response integration for both of these components. Due to latency in http (hypertext terminal protocol) protocol and higher response time of microcontroller device while working with the lane. We solve this problem through an IoT based state of the art solution. The problem can be summarised as to improve the performance of an automated navigation system by improving the decision response time.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

PROPOSED SYSTEM

The proposed system tries to solve the problem mentioned in the problem definition section. We use Intel Edison chip with Arduino compatible breakout board and grove shield to drive a DC car to simulate and test our automated navigation and obstacle avoidance system. The DC car has forward, Reverse, Right and Left motors which can be controlled remotely. The remote control unit is combined with Intel Edison to simulate a realistic electronic car. An IR based sensor is used for obstacle detection. We use node.js to mitigate the sensor data to the cloud as well as take a quick response local decision. The fuzzy logic controller running in the fog (local cloud) takes the guiding decisions for the vehicle and generates the control signal for the Edison Board. We also integrate an image processing technique for lane tracking which is combined with the sensor interface to provide a unified automated navigation system.

OBJECTIVE

The major objective of the work is to propose and validate a state of the art automated vehicle navigation system using IoT microprocessor and IoT gateway. The overall objective is to show that IoT can help processing complicated decision algorithm by taking the decision through code and fogs. The work must validate and justify the adaptation of integrated machine learning and Intelligence system powered by IoT gateway.

IV. DESIGN METHODOLOGY

BLOCK DIAGRAM EXPLANATION

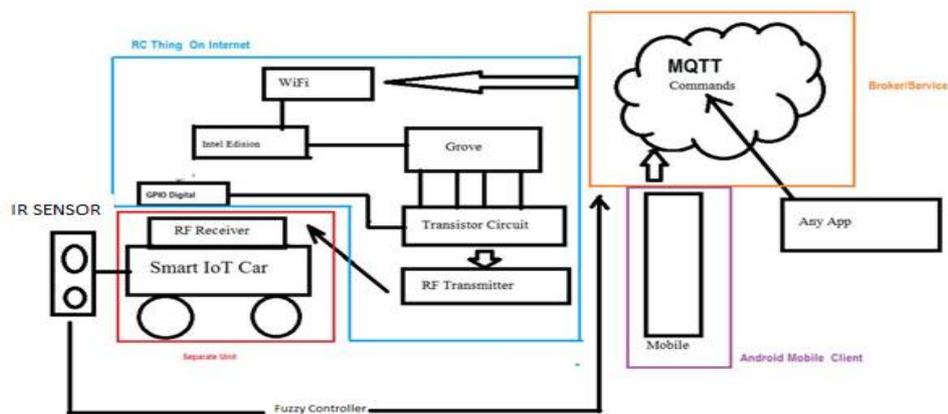


Fig.1 Basic block diagram

The working of this model starts as soon as the forward command is given from the app MY MQTT. The vehicle starts to move in a forward direction and continue to do so till the obstacle is sensed by the IR sensor. Once it detects the obstacle the vehicle stops thus avoiding collision. As the vehicle needs to bypass the obstacle it will go back little bit and then bypasses the vehicle. This is arranged by the program. The next module included here is the line tracking system. The lane tracking system and the collision avoidance is combined in the fuzzy logic so that it can avoid the collision as well as follows the lane. According to the fuzzy rules as mentioned above, depending on the condition of the vehicle the fuzzy controller takes the appropriate action. Once it bypasses the obstacle the vehicle starts to follow the lane again thus avoiding the non-linearity.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

MODULES

STARTING AND STOPPING OF THE VEHICLE THROUGH MQTT

Starting and stopping of the car is totally controlled by the humans. This can be done with the help of the MQTT command. On one side of the Edison is connected to the cloud and other side the MQTT which is IoT protocol is also connected to the cloud.

Therefore when a start command is given in the form of forward direction, the message is mitigated to the cloud and the forward code is executed and vehicle starts moving. Previous to that, in order to connect it to the Edison board we need to enter the ip address in the MQTT app as well as in the program. Although only forward command is sufficient to start the vehicle still in the extreme cases the user can make use of other commands also like right, left and the reverse, whenever the particular command is given that particular code is executed which is stored in the cloud.

COLLISION AVOIDANCE

This part is the major part of our project. Real time collision is one of the challenging tasks. This is achieved through the IR sensor connected in front and it is connected to the Edison Board. We have set a threshold value of the sensor for the obstacle to find. Whenever the threshold exceeds there is an indication of the obstacle. This signal is passed on to the program and immediately "stop" signal is generated i.e. the stop program is executed and the vehicle stops.

LANE TRACKING

Lane tracking is also another major part of the program in which the vehicle is supposed to follow the lane in order to move the car in a straight direction. The principle of lane tracking program is to detect the two long parallel line and virtually meeting at the end point thus forming the triangle. Once the camera finds such two lines, those two lines are considered as the lane. Once lanes are found the program tries to maintain the net difference as zero, i.e. when the vehicle is started it takes the real time value of the lane distance from the vehicle and starts making the difference as zero. By this the vehicle will be moving straight. Whenever due to some reason if the vehicle moves more towards any direction then the net difference becomes non zero and program moves the vehicle in the opposite direction so that again the net difference becomes zero.

V. RESULTS

SIMULATION RESULTS

We simulate the target tracking and obstacle avoidance first on a graphical simulation and then implement it in real time. We first provide a car with a destination and then we append fuzzy rule set on that. We observe the movement of the car. Here is a sequence of events.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016



Fig.2 Screenshot showing the vehicle seeking the target

Car moves direction in the presence of obstacle calculating the distance between itself and the obstacle. If the obstacle is nearby then the vehicle take the diversion and reach the target safely. This is mainly shows how vehicle is avoiding obstacles and moving in real time. This is done in concatenation with the fuzzy logic.



Fig. 3 Screenshot showing the vehicle seeking another target

Car goes straight when there is no obstacle. Above figure shows another situation where there are no obstacles nearby the target. In this situation also vehicle calculates the distance then takes a move. In this way the vehicle avoids collision in real time.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

MODULAR TESTING

MODULE NAME	INPUT	EXPECTED OUTPUT	ACTUAL RESULT	PASS/FAIL?
IR sensor	Senses the obstacle	Stop the vehicle	Stopped the vehicle	Pass
Lane tracking	Two big parallel lines	Follow the lane	Following the lane	Pass

INTEGRATION TESTING

INPUT	EXPECTED OUTPUT	ACTUAL RESULT	PASS/FAIL?
Collision avoidance	Triggers the Edison to stop the vehicle	Stopping the vehicle appropriately	pass
Fuzzy controller	Combining the IR sensor and lane tracking system, vehicle should follow the fuzzy rules	Following the fuzzy rules precisely	pass

Above two tables show two different tables with both individual testing and integration testing. In individual testing the different modules are tested individually where both the modules get through their functions properly. Then integration testing where all the modules are combined and tested all at once and here also the vehicle passes the test with both fuzzy controller and collision avoidance.

VI. LIMITATIONS

Even though we have used the most cutting edge IoT technology for detection and decision mitigation the system is constrained by communication overhead, available bandwidth and network latency. Due to which decision for driver guidance could be delayed. The work also suffers from interference as underneath WiFi is unlicensed open network access technology. These limitations can be overcome by dedicated bandwidth allocated separately for control and data channels of the navigational systems.

VII. CONCLUSION

Automated cars and intelligent driver assistance systems have been under research for over two decades. Recently this area of research has been pushed by NASA's self-driving Rover and Google's car project. Many other automobile companies are putting a significant investment in research and development in this specific area. With the standardization of IoT a whole new set of devices and protocols have emerged that enhances the capabilities of conventional embedded devices. There is still a huge scope of improvements in this area.

In this work, we have proposed a novel automated self-driving car architecture on top of IoT gateway and have combined machine learning and image processing with IoT infrastructure to offer an automated driving car. Results show that the proposed system offers better response time and needs less amount of bandwidth for communication. Also it offers a high degree of quality of services. The system can be improved by incorporating an automated machine learning solution that could run on a cloud or fog based on needed response and available bandwidth.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

REFERENCES

1. Ramírez-Cortés J.M. et. Al , A LabVIEW-based Autonomous Vehicle Navigation System using Robot Vision and Fuzzy Control: Ingeniería Investigación y Tecnología. Vol. XII, Núm. 2, 2011, 129-136, ISSN 1405-7743 FI-UNAM
2. Gyula Mester „Sensor-Based Intelligent Mobile Robot Navigation in Unknown Environments: International Journal of Electrical and Computer Engineering Systems Volume 1, Number 2, December 2010
3. Homayoun Seraji et. Al , Terrain-Based Navigation of Planetary Rovers: A Fuzzy Logic Approach: Proceeding of the 6th International Symposium on Artificial Intelligence and Robotics & Automation in Space: i-SAIRAS 2001, Canadian Space Agency, St-Hubert, Quebec, Canada, June 18-22, 2001
4. Sng, H.L., “Fuzzy Logic Control of an Obstacle Avoidance Robot”, *IEEE International Conference on Fuzzy Systems* Vol 1 pp 26-30, 1996.
5. <http://www.autoinsurancecenter.com/top-20-pros-and-cons-associated-with-self-driving-cars.htm>
6. Lotfi A Zadeh , *Advances in Fuzzy Systems — Applications and Theory: Volume 6, Fuzzy Sets, Fuzzy Logic, and Fuzzy Systems Selected Papers*
7. George J. Klir (Author), Bo Yuan (Author) , *Fuzzy Sets and Fuzzy Logic: Theory and Applications* 1st Edition
8. Jerry M. Mendel University of Southern California, Los Angeles, CA. *Uncertain Rule-Based Fuzzy Logic Systems: Introduction and New Directions*
9. Thomas Bräunl *EMBEDDED ROBOTICS Mobile Robot Design and Applications with Embedded Systems* Second Edition
10. Ronald C. Arkin, editor *Intelligent Robots and Autonomous Agents*

BIOGRAPHY



H M PREETI, PG Student, Department of VLSI Design and Embedded Systems, VTU PG Centre Kalaburagi, India. My areas of interests are VLSI Desing, Logic Design, Verilog Programming. I have completed my Graduation in Appa Institute of Engineering and Technology, Kalaburagi, India



Dr. Baswaraj Gadgay is a Research Guide and Professor in Dept. of PG Studies, M.Tech VLSI Design & Embedded Systems, VTU Regional Centre, Kalaburagi. He has 23 years of teaching experience and has published 15 papers in various international journals and conferences.



Mr. Veeresh Pujari is a Assistant Professor in Dept. of PG Studies, M.Tech VLSI Design & Embedded Systems, VTU Regional Centre, Kalaburagi. He has 3 years of teaching experience and has published 7 papers in various international journals.