PAPER • **OPEN ACCESS**

Low Cost Autonomous Driving Architecture using Ultrasonic Sensors and Camera

To cite this article: S Manivannan and R Jagadeesh Kannan 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **925** 012037

IOP Conf. Series: Materials Science and Engineering **925** (2020) 012037 doi:10.1088/1757-899X/925/1/012037

Low Cost Autonomous Driving Architecture using Ultrasonic Sensors and Camera

S Manivannan[1] and R Jagadeesh Kannan[2]

[1]Senior Embedded Software Developer
[2]School of Computer Science & Engineering, Vellore Institute of Technology Chennai Campus
[1]sivan.manivannan@gmail.com, [2]jagadeeshkannan.r@vit.ac.in

Abstract. The existing autonomous vehicles cost are very high due to inclusive of various range of LIDAR, RADAR and multiple cameras for autonomous features. The proposed autonomous vehicles can operate at low speed with limited sensors which will cut the cost by half. The purpose of this research is to make an auto driven platform, which can be ported in any electric vehicles. The prototype also has features including a safety system, control panel, route recognition, android device assistance, Wi-Fi, & battery updates. Our study findings are carefully analysed. This leads to less emissions of the electric vehicle powered by man.

Keywords: Autonomous Driving, Beacon, Electric Vehicle, Open CV, Raspberry Pi 3

1. Introduction

ICE-powered vehicles are the biggest challenge to green gas emissions in emerging transport technology. The recent autonomous vehicles are also too costly to afford in public transportation. Our research in autonomous driving architecture leads to low cost autonomous vehicle which can operate in closed environment with limited speed 25Kmph (Ref ARAI Certification Specification for EV). The planned stand-alone vehicle includes an 8Mega pixel monitor, User Interface touchscreen display, Ultra Sonic Sensor Design, Beacon module, distance speedometer, Motor driver & DC motor. The proposed architecture has been implemented in smaller vehicle with operating voltage of 12Volt with UI, Array of ultrasonic sensor, HC-06 module. This entire architecture can be ported in existing electric vehicle is added advantage. The Raspberry Pi 3 is used as vehicle controller unit and atmgega328 is used as secondary controller. The secondary controller receives data from array of ultra-sonic sensors and process the data and feedback the signal information to vehicle control unit.

2. Literature review

The primary autonomous robot development and collision avoidance is route planning. Mobile Robot Road Planning is to find a collision-free route from which to divide the goal into global route and local route maps [1]. The global path management is focused on knowledge of the work situation of the robot. Local path scheduling is useful for applications that do not know or slightly know the mobile robot's work atmosphere [2-3]. The able to sense the real reality and to respond appropriately relies on

independent behaviour in urban environments [4]. That involves making sure in compliance with traffic regulations and viability constantly for some pleasure-optimized operations [5]. This paper presents a new, longitudinal framework for planning developed as a discreet plan. In the near future, independent driving will become a truth. In recent years, driver assistance systems for manufacturing vehicles have increased steadily their automation standard [6-7].

3. Background of technologies behind autonomous vehicle in closed environment

The closed environment will comprise of speed limit to 25Kmph (For all vehicles), perfect lane marking throughout the region, traffic signs shall be properly installed as shown in figure.1. For example, consider the environment like amusement parks, Universities. In OpenCV, the road lanes are detected using Hough Line Transform. The edges and thresholds are defined to detect turning lanes and differentiate dotted partition lines in the mid of the road. The figure.2 illustrates the lane detection and action to be taken for left, right curve. The raspberry Pi 3 with Pi camera V2 is used in autonomous vehicle to detect the lanes.

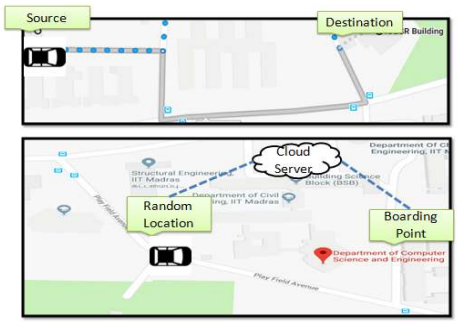

Figure 1. Autonomous vehicle in closed environment map

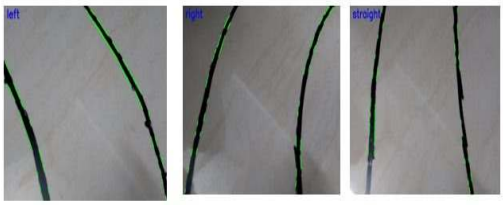

Figure 2. Lane detection using OpenCv

3.1. Motor Controller

Generally, the motor controller can be controlled by two different signals. To control the speed, PWM signal is passed to PWM pin and to control the direction in forward or reverse, 5volt signal is passed to Direction pin. In our controller, a single PWM signal can control both speed and direction. When the PWM signal is 50% duty cycle, the motor stops running. If the PWM has less than 50% duty cycle, the motor will rotate in Clockwise direction. If the PWM signal has more than 50% duty cycle, motor will rotate in Counter clockwise direction.

3.2. Path following accuracy using beacon

To improve the accuracy in corner detection and landmark detection, the beacons are placed in every corner, landmarks to emit unique identification number. In figure.3 indicates the location of beacon modules in every corner.

Figure 3. Location of beacons in every corner

3.3. Path following accuracy using beacon

Beacon modules are placed in every corner which emits unique value. Initially the vehicle is operated in learning mode by manual driving, where the controller observes the unique number of beacon in each corner. Once the complete is mapping is done, the vehicle is changed to auto driven mode.

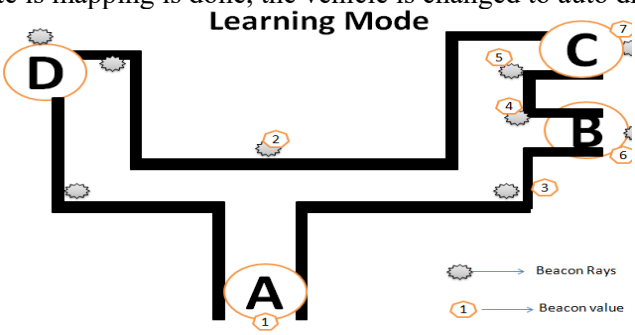

Figure 4. Learning mode to observe the beacon values

3.4. Path following accuracy using beacon

From figure.4 if a vehicle wants to travel from point A to C. In learning mode, it recognizes all the turns from A to C. Then in auto driven mode, the vehicle recognizes the beacon value and takes action which was taken in manual mode as shown in figure.5.

A location to C Location

Beacon Rays	1	2	3	4	5	6	7
Action	Straight	Right	Left	Straight	Right	*	Stop

C location to A Location

Beacon Rays	1	2	3	4	5	6	7
Action	Straight	Left	Right	Straight	Left	*	Stop

Figure 5. Data mapping algorithm

4. Architecture overview

In proposed architecture as shown in figure.6 the ultrasonic sensors used to detect obstacle in 10ms time delay and cameras are used for lane detection and object identification like differentiate between cat and wooden block. GPS and beacon module used for accurate localization. The three objectives of sensor fusion in architecture is Lane detection, object classification and localization. The controller programmed to have different call thread for each sensor input, so it can be run in parallel.

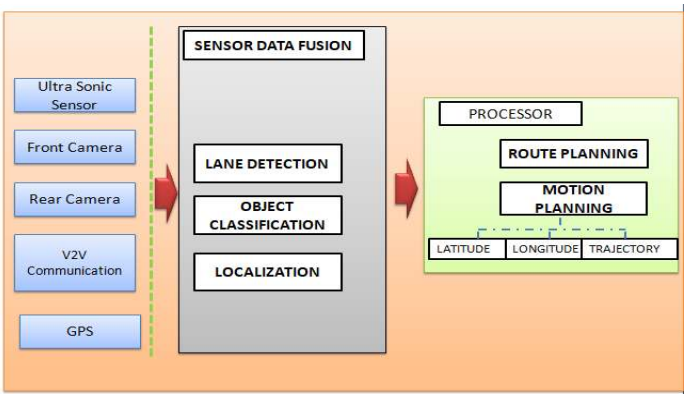

Figure 6. Architecture Overview

The MCU is designed with a route search algorithm, obstacle avoidance, & a route after an algorithm is configured for the system. The figure 7 denotes the prototype of autonomous vehicle. As per the architecture, it is fitted with Camera in front for lane detection and ultra-sonic sensor for object detection.

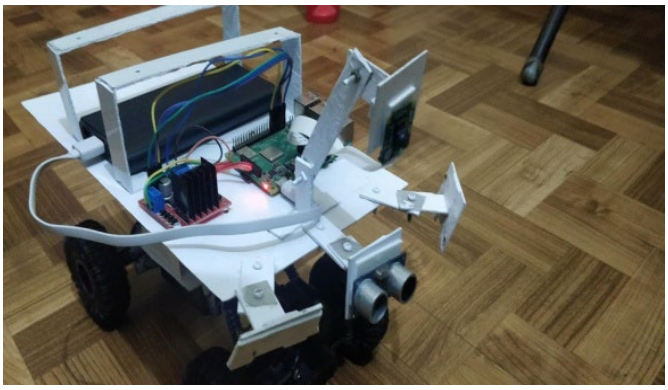

Figure 7. Prototype of Autonomous vehicle

In the sealed environment, prototype consists of Beacon, GPS with 32-bit microcontroller. The EV database monitors the GPS coordinates of the vehicle at different station boxes located in closed environments. With the aid of the Button, the car is pushed in automatic mode.

5. Discussion

The system is sponsored by the built-in solar panel for more study that can run for up to six hours. The performance of the vehicle with a solar panel is evident from Table.1 and Table. 2. From figure 8 we can able to refer the simulation results for the proposed work.

Table 1. Power consumption of autonomous vehicle

Vehicle operative data	Value
Power intake by vehicle / hour	410 W
Total Operating time	6 Hours
Total Energy consumption	2460 Watt Hour

Table 2. Solar power generation in autonomous vehicle

Solar power generation data	value
Power generated by solar panel	500 W
Average fall of direct sunlight per day	5 Hours
Total Energy	2500 Watt Hour

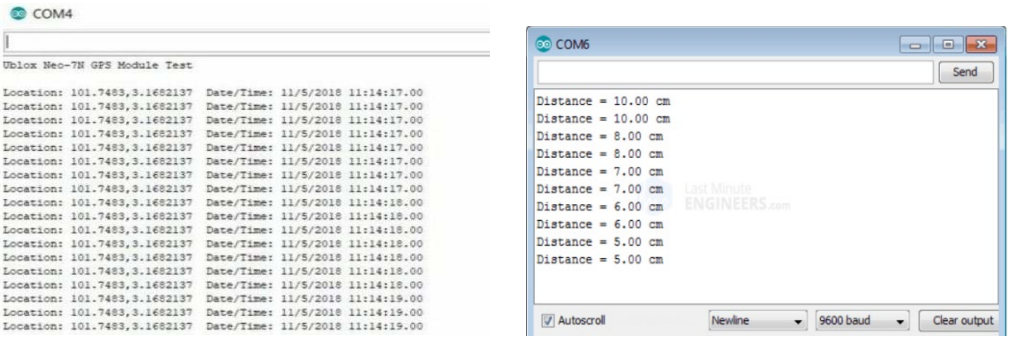

Figure 8. Simulation results of range and location over GPS

6. Conclusion and Future works

Autonomous driving architecture provides pollution less transportation and cost effective auto driven electric vehicle. End users like business, university campus and entertainment parks will benefit from this design. This innovation used in vehicles helps renewable transport. Physically disabled people will benefit from automated mode.

References

[1] Yalong Z, Zhenghua L and Le C 2017 A new adaptive artificial potential field and rolling window method for mobile robot path planning *29th Chinese Control and Decision Conference (CCDC)* 7144-7148

[2] Constantin H, Michael A and Christoph S 2016 A generic driving strategy for urban environments, *Intelligent Transportation Systems (ITSC) 2016 IEEE 19th International Conference* 1010-1016 2016

[3] Gaku T, Makoto O and Uto K 2017 Posture-to-posture trajectory planning for an autonomous car using triple clothoid segments, *Decision and Control (CDC) IEEE 56th Annual Conference* 299-306

[4] Sundaram A, Ramesh GP 2015 Investigation of Solar Based SL-QZSI Fed Sensorless Control of BLDC Motor *Intelligent Computing in Engineering. Advances in Intelligent Systems and Computing* 1125

[5] Shermin S and Mubarakali A 2019 Smart agriculture using IoT *International Journal of MC Square Scientific Research* **11** 543-545

[6] Biruk Z and Demissie M IoT based lawn cutter *International Journal of MC Square Scientific Research* **11** 2019

[7] Waleed AB 2019 Underground pipeline water leakage monitoring based on IOT *International Journal of MC Square Scientific Research* **11**