An Intelligent Approach towards Autonomous Vehicle

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***Abstract*— In the future era, the vehicles are viewed to be autonomous to give driver less/ relaxed driving. In the field of automobile various aspects have been considered which makes a vehicle autonomous. In this paper we have focused on two applications of an autonomous car, one in which obstacle avoidance and another one is traffic sign detection using image processing. Obstacle avoidance based on ultrasonic sensor using raspberry pi is presented in this paper. Traffic sign detection is implemented using python and opencv library. The idea described in this paper has been motivated by the Google's self driving car.**

Keywords—Obstacle avoidance, Image Processing, Traffic sign detection, Ultrasonic Sensor, Web Cam, Motor Driver IC, Battery, Car-Model, Raspberry-pi.

I. INTRODUCTION

An autonomous car is a vehicle that can guide itself without human conduction. This kind of vehicle has become a concrete reality and may cover the way for future systems where computers take over the art of driving. An autonomous car is also known as a driverless car, robot car, self-driving car or autonomous vehicle. Driverless cars, including Google's autonomous car design, have tested on American roads, but they are not yet commercially available on a large scale. Autonomous cars use various kinds of technologies. They may use sensors and other equipment to avoid collisions. They also have the ability to use a range of technology known as augmented reality, where a vehicle displays information to drivers in new and innovative ways. Day by day the road accidents are increasing. The 80 percent of accidents happen due to the driver mistakes. These mistakes are red signal jumping, over speeding, not following road signs like speed breaker, speed limit, stop board etc. In order to overcome these problems a car is designed in such a way that itself takes real world challenges and behave accordingly. So that human errors can be reduced as well as decrease the traffic problems caused by humans with phone calls and other entertaining stuff.

The rest of the paper is organized as follows: Section II provides the brief discussion on the literature review related to designing of the autonomous vehicle. Section III highlights on the theoretical background of the proposed architecture followed by Experimental set up in Section IV. Section V provides in detail the results of the experimentation and discussion. Conclusion and future scope has been provided in Section VI.

II. LITERATURE REVIEW

Autonomous car idea has been discussed by different researchers. In this section we can see through a literature review how the development of research has focused mainly on technology development and just begun to focus on legal liability and policymakers while research on customer acceptance has been more limited. Autonomous cars are not that far away, for example Audi and Mercedes [1] have announced almost being ready from production in highly automated features. In another approach mentioned in [2], as a reflection of the daily news, we can steadily see how this technology manages to get closer to be in our everyday life, with examples of cars driving a blind man for tacos already on 2012, coast to coast trips [3][4], an Italy to China trip and 700,000 miles already travelled by Google. According to [5] main automakers in the race such as Audi, BMW, Cadillac, Ford, General Motors, Jaguar, Land Rover, Lincon, Mercedes-Benz, Nissan, Tesla and Volvo are trying to integrate it slowly to their models despite the fairly readiness of the technology. This can be interpreted as a futile attempt to keep this totally disruptive technology under control and to have overall slower customer integration, but this old model will prove to be not good enough due to the magnitude and impact of this technology [6].

According to a survey presented in [7] with more than 200 experts on autonomous vehicles by the IEEE 14, the world's largest professional association for the advancement of technology, the three biggest obstacles to reach the mass adoption of driverless cars are: legal liability, policymakers and customer acceptance, while the following three; cost, infrastructure and technology are seen as less of a problem. [8] For all the reasons mentioned above from the IEEE Interview, the authors and experts focus on the technology in relation with human interaction [8], the general a priori acceptability of autonomous driving in recent and smaller studies, the companies approach to the technology introduction, as well as recent studies with future users concluding that trust and acceptance increases with high antrophormism in technology. It is essential to start understanding and integrating customers in order to build deep and meaningful customer insights which can be used to deliver the products that the customers are looking for as discussed in [9].

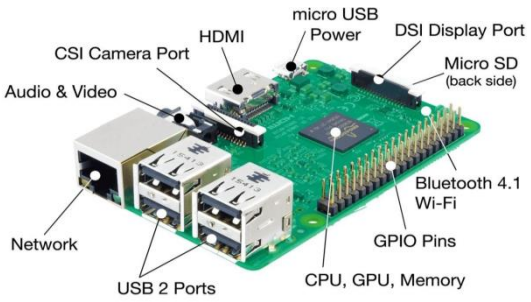
The idea that human beings are poor drivers is well documented in popular culture [10]. While this idea is often over-dramatized, there is some truth to it in that we're at times distracted, drowsy, drunk, drugged, and irrational decision makers [11]. However, this does not mean it is easy to design and build a perception-control system that drives better than the average human driver. The 2007 DARPA Urban Challenge [12] was a landmark achievement in robotics, when 6 of the 11 autonomous vehicles in the finals successfully navigated an urban environment to reach the finish line, with the first place finisher traveling at an average speed of 15 mph. The success of this competition led many to declare the fully autonomous driving task a "solved problem", one with only a few remaining messy details to be resolved by automakers as part of delivering a commercial product. Today, over ten years later, the problems of localization, mapping, scene perception, vehicle control, trajectory optimization, and higher-level planning decisions associated with autonomous vehicle development remain full of open challenges that have yet to be fully solved by systems incorporated into a production platforms (e.g. offered for sale) for even a restricted operational space. The testing of prototype vehicles with a human supervisor responsible for taking control during periods where the AI system is "unsure" or unable to safely proceed remains the norm [13], [14]

III. THEORETICAL BACKGROUND

To design automated car is a challenging task. The method discussed in this paper is as shown in fig. 1 constitutes different components. The details of which are as per following:

A. Raspberrypi-3b+-

The Raspberry pi is a series of credit card-sized single-board computers developed in the United Kingdom by the Raspberry pi Foundation to promote the teaching of basic computer science in schools and developing countries. The Raspberry pi has a Broadcom BCM2835 system on a chip (SOC), which include an ARM1176JZF-S 700MHz processor, Video Core IV GPU and was originally shipped with 256 megabytes of RAM, later upgraded (Model B & Model B+) to 512MB. It does not include a built-in hard disk or solid-state drive, but it uses an SD card for booting and persistent storage, with the Model B+



using a MicroSD.

Fig.1. Schematic of raspberry pi board

The Foundation provides Debian and Arch Linux ARM distributions for download. Tools are available for Python as the main programming language, with support for BBC BASIC (via the RISC OS image or the Brandy Basic clone for Linux), C, Java and Perl. The allure of the Raspberry Pi comes from a combination of the computer's small size and affordable price. Enthusiasts envision using the small form-factor PC as a cheap home theater PC (HTPC), or secondary low-power desktop. Institutions, like schools and businesses, could benefit from deploying a fleet of computers for a fraction of the cost of traditional desktop towers. The small size makes for an easy to- hide computer that sips power and can be mounted behind the display with an appropriate case. It could also be used in niche applications, like digital signature.

The Raspberry Pi model available for purchase at the time of writing the Model B features HDMI and composite video outputs, two USB 2.0 ports, a 10/100Ethernet port, SD card slot, GPIO (General Purpose I/O Expansion Board) connector, and analog audio output (3.5mm headphone jack). The less expensive Model A strips out the Ethernet port and one of the USB ports but otherwise has the same hardware. The raspberry pi model aboard is designed with 256MB of SDRAM and model B is the serial data in the form of text and it is useful for converting the debugging code.

Designed with 51MB.Raspberry pi is a small size PC compare with other PCs. The normal PCs RAM memory is available in gigabytes. But in raspberry pi board, the RAM memory is available more than 256MB or 512MB.

- CPU (Central Processing Unit):

The Central processing unit is the brain of the raspberry pi board and that is responsible for carrying out the instructions of the computer through logical and mathematical operations. The raspberry pi uses ARM11 series processor, which has joined the ranks of the Samsung galaxy phone.

- GPU (Graphics Processing Unit):

The GPU is a specialized chip in the raspberrypi board and that is designed to Speed up the operation of image calculations. This board designed with a Broadcom video core IV and it supports OpenGL.

- Ethernet Port:

The Ethernet port of the raspberry pi is the main gateway for communicating with additional devices. The raspberry pi Ethernet port is used to plug your home router to access the internet.

- GPIO Pins:

The general purpose input & output pins are used in the raspberry pi to associate with the other electronic boards. These pins can accept input &output commands based on programming raspberry pi. The raspberry pi affords digital GPIO pins. These pins are used to connect other electronic components. For example, you can connect it to the temperature sensor to transmit digital data.

- Power Source Connector:

The power source cable is a small switch, which is placed on side of the shield. The main purpose of the power source connector is to enable an external power source.

- UART:

The Universal Asynchronous Receiver/ Transmitter is a serial input & output port. That can be used to transfer data.

B. Web-Cam

Camera module is used to capture the images and process the frames. Experience sharp, smooth video calling (720p/30fps) in a widescreen format with the C270 HD Webcam.Automatic light correction shows you in vibrant, natural colors.

Specifications of camera is as follows:

1. Max. Resolution -720p/ 30fps
2. Focus type- Fixed Focus
3. Lens technology- Standard
4. Still Image Sensor Resolution - 3 megapixel

C. Ultrasonic Sensors-

Ultrasonic sensors work on a principal similar to radar or sonar, which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. This is used in this intelligent vehicle to detect what obstacle lies in the front. Ultrasonic sensor or sonar sensor Ultrasonic sensors operate by generating a high frequency pulse of sound, and evaluating the properties of echo pulse that is received. There are different properties of received echo pulse that may be evaluated for different sensing purpose:

1) Time of flight – for sensing distance

2) Doppler shift – for sensing velocity

3) Amplitude attenuation – for sensing distance, directionally, or attenuation coefficient.

In our case we have used the time of flight property to determine the distance of obstacles. The sensors used are the form of a pair of eyes, because of the two key parts of the sensor: the transmitter and the receiver. The transmitter emits a short burst of a sound reflected back by obstacles. Distance travelled (d) can be calculated by measuring the time 30 taken (t) by the sound to return to the receiver based on the speed of sound (s) by the following equation d = s*t. In this case distance calculated will be twice the distance from the sensor to the obstacle. So the distance (r) of the obstacle could be calculated by following equation: r= d/2. How ultrasonic sensors work the effective working angle of these sonar sponsors are approximately 30º.

Therefore, measurement will consequently be more accurate within the central cone of 30º, and less accurate towards the sides. But this property can be advantage towards a more effective scan of environment, and narrow objects, such as chair legs. Specifications:

- Model:HC-SR04
- Working Voltage: 5VDC
- Working Current:15mA
- Static Current: Less than2mA
- Detection Distance: 2cm to450cm

Fig 2. Mode of Connection: VCC / Trig / Echo /GND

D. DC Motor:

a. Shaft length: 7mm Size: 55x48x23mm
b. Operating Voltage - 3 to 12v Current (without loading) -40-180mA
c. Weight-30g
d. RPM: 150rpm
e. Output Torque -0.8

Fig. 3 DC motor

E. Software Design:

Open CV (Open Source Computer Vision Library) is an Application Programming Interface (API) developed by Intel which can be used for many image processing and computer vision applications. Open CV officially launched in 1999 and the project was initially an Intel Research initiative to advance CPU-intensive applications. Open CV library is a collection of algorithms and C/C++ functions and a few classes that implement some Image processing and computer vision algorithms. There is active development on interfaces for C, C++, Python, Ruby, Matlab and other languages. Open CV was designed for computational efficiency and with a strong focus on real time applications. Open CV is written in optimized C and can take advantage of multi-core processors. Open CV contains over 500 function that span many areas in vision, including factory product inspection, medical imaging, security, user interface, camera calibration, stereo vision and robotics. The principles behind the creation of the library is to aid commercial uses of computer vision in human-computer interface, robotics, monitoring, biometrics and security by providing a free and open infrastructure where the distributed efforts of the vision community can be consolidated and performance optimized. Open CV support for vision is extensively including routine support for input, display, and storage of movies and single images. One of the Open CV goals is to provide a simple-to-use computer vision infrastructure that helps people build fairly sophisticated vision applications quickly. There are several goals of Open CV in outset which are following:

- Advance vision research by providing not only open but also optimized code for basic vision infrastructure.
- Disseminate vision knowledge by providing a common infrastructure that developers could build on, so that code would be more readily readable and transferable.
- Advance-vision based commercial applications by

making portable, performance optimized code available for free- with a license that did not required commercial applications to be open or free themselves.

Open CV provide a set of image processing functions and computer vision applications. The functions are optimized for Intel architecture processors and are particularly effective with MMX technology. The Open CV Library is a way of establishing an open source vision community that will make better use of up-to-date opportunities to apply computer vision in growing PC environment and mobile platform. The library is open and has platform independent interface and supplied with whole C sources. Open CV was designed to be portable. Open CV library is multi platform, and runs on both Windows and Linux Operating System. Open CV is quickly gaining popularity for developing real-time computer vision applications. Some examples of applications include face recognizers, object recognizers, and motion trackers, just to name a few. It allows researchers to get demos or research projects up and running quickly,and take advantage of the large collection of algorithms that are already available. The use of term of computer vision and image processing is commonly interleaved. . In contrary, there is a gap between computer vision and image processing. Image processing is of low-level processing of still or video image, while computer vision is high-level processing of still or video image. Open CV is specifically designed to an advent to computer vision development. Open CV aimed at providing the basic tools needed to solve computer vision problem.

Generally speaking, the mandatory and cautionary signs are most important for drivers and their contents must contain a red circle or triangle frame. Hence, color extraction is a very effective and efficient solution for selecting candidate sign regions in each image. However, each color of the human vision has a fuzzy range in computer color spaces. For example, the proposed scheme wants to extract all regions which are “red” as the frame of a sign from an image. In order to extract all “red” regions, some color conditions are needed to select red pixels by computers. In this paper, the color selection is performed in the HSV color space. This color space can be obtained from the RGB color space at the preprocessing stage itself. The proposed scheme defines thresholds for hue (H), saturation (S) and value (V) color channels, respectively. This paper detects colors in the HSV space. This color space only stores the brightness information in V color channel. Hence color thresholds can be defined for H and S color channels to reduce the effect of brightness. In HSV color space, the most brightness information is stored in V channel and color information is recorded in H and S channels. Hence, the influence of variable brightness can be reduced when the “red” pixel selection is determined by H and S values. H records the hue value of each pixel and the colors similar to the red are around 0°, this paper uses two thresholds $\xi 1$ and $\xi 2$ to define the range of the red. Another threshold ξ sat is used to define the range of the satisfied saturation. The “red” pixel fred(x,y) can be defined as: The color selection is a suitable and simplest solution for detecting traffic sign candidate regions. However, the image may contain other red-likeness objects, such as, commercial sign boards, vehicles, flowers or any object with red color. Hence, this color selection method only can be used to obtain all candidates of prohibitory and warning signs. This paper presents a simple traffic sign object filter which can be performed to remove most objects which are not traffic signs.

The traffic sign detection and extraction scheme can be used to obtain the traffic sign sub-images from each video frame. Besides, the shape recognition can provide the preliminary category information of each traffic sign object to help the following stages further recognize traffic sign more efficiently.

In order to gain more performance this stage can be applied in the images with lower resolution. When any satisfied traffic sign cannot be detected in certain frame, this frame would be not processed in the following stages. The following stages focus on traffic sign content recognition.

F. Programming Language:

Python:

Python is a widely used high-level, general-purpose, interpreted, dynamic programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than possible in languages such as C++ or Java. The language provides constructs intended to enable writing clear programs on both a small and large scale. Python supports multiple programming paradigms, including object-oriented, imperative and functional programming or procedural styles. It features a dynamic type system and automatic memory management and has a large and comprehensive standard library. Python interpreters are available for many operating systems, allowing Python code to run on a wide variety of systems. Using third party tools, such as Py2 installer, Python code can be packaged into stand-alone executable programs for some of the most popular operating systems, so Python-based software can be distributed to, and used on, those environments with no need to install a Python interpreter. C Python, the reference implementation of Python, is free and open-source software and has a community based development model, as do nearly all of its variant implementations. C Python is managed by thenon-profit Python SoftwareFoundation.

IV. EXPERIMENTALSETUP

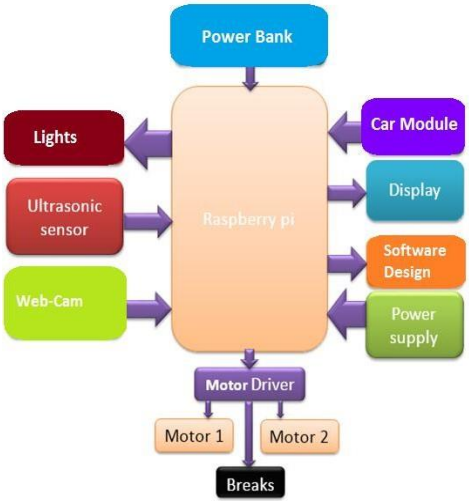


Fig. 4 System block diagram.

The main function of the system is to provide vehicle security by using a ultrasonic sensors attached to the vehicle. It will continuously monitor the data regarding vehicle and store it in the Raspberry pi. In this the usage of sensors such as ultrasonic sensors, Web- cam and so on is done. These data's are fed in to Raspberry pi for further processing. As the vehicle starts the safety case will be in active mode. The ultrasonic sensor is mounted on the every side of the vehicle which detects the obstacles around the vehicles. This is used in this intelligent vehicle to detect what obstacle lies in the front. Ultrasonic sensors also find the distance from the any object around the vehicle. The Web-cam also does the important role which capture continuously. Detects the road side traffic signs. If turn left sign is detected then vehicle automatically turns left. The captured image is then processed after image processing raspberry pi module takes the decision.

V. RESULTS ANDDISCUSSSION

This project results in an intelligent vehicle approach towards autonomous vehicle. In this section, we represent the results achieved in thearea of autonomous vehicle technology. We focus on the technological side of the autonomous car and cover key software components and algorithms that include computer vision, control and communication. Before presenting the aforementioned topics, we outline some real world experiments to assess the feasibility of autonomous cars. Different tests performed (both as individual projects and competitions) on driverless cars between 1990 and 2013. These tests were performed in different scenarios ranging from free road with no traffic to public roads. Furthermore, the results from these tests provide a close insight to the behavior of the driverless cars in different environments.

A. Computer Vision in Autonomouscars

Object detection and vision are two of the most critical and essential features of autonomous cars. To mimic the human driver behavior, autonomous cars must "see" the road and detect any obstacle in front of and around it, be it another car, pedestrian, vegetation, or any other type of obstacle. These two key features along with other modules enable the autonomous car to drive along the road and respond to any unwanted situation in a safe, or at least fail-safe way, for instance stopping at a traffic signal, slowing down if the preceding car reduces the speed, avoiding running in to pedestrians, and soon. To date, many research results have been achieved in both computer vision and object detection for autonomous car. Here we succinctly outline the current state of these algorithms. However it is important to mention that most of the currently available pilot versions of autonomous cars use proprietary components and their details are not publicly available. Therefore, we could only report research results that are publicly available.

B. Sensors and Control

The heart of an autonomous car is its computing unit that implements the logic of the autonomous car in holistic way. Sensors play a pivotal role in the realization of an autonomous vehicle means handling of both known and unknown environments without any human intervention and needs artificial algorithm techniques. These algorithms are data intensive, and the data is acquired through arrays of different sensors which collectively form a massive sensor network within the car. Therefore, data acquisition, collection, storage, processing, communication among different entities within the car and with the environment, and the control of autonomous car are key aspects that need proper mechanism. On the other hand, with the removal of human involvement, autonomous cars have to make autonomous decisions based on what is best in a particular circumstance. This characteristic also requires the autonomous car to be more connected to the surrounding environment and draw as much data as it can from neighbors, infrastructure, and the Internet to make the best decision. Therefore, communication within the autonomous car among different modules, communication between the autonomous car and environment and in-car sensor data analytics.

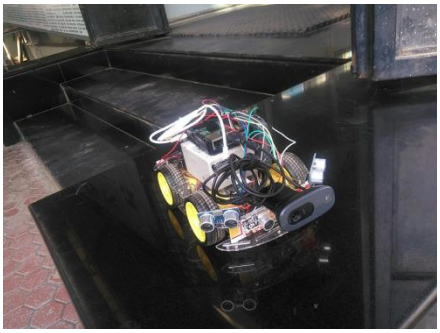


Fig. 5 Experimental Set up

VI. CONCLUSION AND FUTURESCOPE:

A. Conclusion:

In this paper our focus on collision warning and avoidance systems and their impact on driver's comfort, safety and traffic flow. The vehicle based assist systems have few barriers to pass before they can be used widespread. The in which automatic collision control system can improves the drivers comfort and the different viewpoints of the safety are discussed. Collision avoidance systems and sign detection and automatic lane change system have the added complexity that they should be able to recognize a hazardous situation and communicate it to the driver assist system. This system makes the vehicle intelligent towards the autonomous system.

B. Future Scope:

Environment detection algorithms for autonomous driving have been proposed. The algorithms have been designed for static environments of rural and off-road. SONAR detection has been used to detect obstacles. The algorithm has been designed to generate a local obstacle map, instead of a global map, because of difficulties in using accurate vehicle position information. The proposed algorithms have been successfully implemented and tested using a test vehicle. It has been found that the proposed environment-detection algorithm shows good performance in detecting the positions of obstacles, lanes, pedestrian crossing, and speed bumps.

A low cost GPS guidance system has been designed and implanted, in which the functions of guidance, obstacle avoidance, and wireless communication for monitoring multicar are realized. An extended application of this project would be the future parking lot (outdoor). Combining the GPS guidance system with the "automatic parallel parking system", i.e., the friendly parking management system which can support a service like this: The driver gets off the car after identification at the gate of the parking lot and the car will be guided to and parked at the assigned position by the smart system. Inversely, after identification at the gate the whole thing rewind and the car appear in front of thedriver.

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