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Autonomous Vehicle Prototype Based on Image Processing

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Abstract:

These days, vehicle automation is prioritized so that drivers may take it easy behind the wheel. There have been several developments in the automotive industry that allow for the automation of vehicles. This study presents a small-scale prototype design for a robotic vehicle with three wheels that can stay in its lane and prevent collisions, taking into account a number of factors including features and cost. The technology behind autonomous automobiles is still in its infancy, but it has the potential to revolutionize the way we travel. The research begins out with an overview of the autonomous vehicle industry and its major competitors. Key enabling technologies and their current capabilities, limitations, and prospects are evaluated, and the social and environmental effects of these developments are discussed. When autonomous cars become ubiquitous and inexpensive, they will have the greatest influence in a variety of areas, including traffic and parking congestion, impoverished people's independence in getting about, greater safety, decreased energy consumption and pollution. Our self-driving vehicle's brain is a Raspberry Pi. The camera captures a wide variety of photos, and then AI is achieved by applying different image processing methods to those images.

Keywords: Artificial Intelligence, Camera Module, Image Processing, Raspberry Pi.

1. INTRODUCTION

Public transit has become so inconvenient that more and more individuals are opting to use their own cars these days. The congestion is a result of the enormous number of cars on the road. The creation of traffic regulations is an attempt to address this issue. But disregard for such regulations is a leading cause of accidents. Most mishaps, however, will be the result of carelessness on the part of humans. We need Autonomous Vehicles to decrease these incidents and increase transportation safety [18][19]. The advent of autonomous driving technology is a game-changer for the automobile sector. If we can successfully apply this technology while maintaining complete command, it has the potential to have far-reaching positive effects on people's lives and the larger community. In 2040, IEEE members estimate that self-driving vehicles will account for as much as 75 percent of all vehicles on the road. Since road accidents are responsible for the deaths and injuries of tens of millions of people every year, our project aims to develop a reliable autonomous vehicle that can save countless lives. Human error accounts for almost all road mishaps. Statistical projections show that in the following decade, annual fatalities will quadruple. Autonomous vehicles are the solution to this issue [18][20].

2. METHODOLOGY

2.1. Block Diagram

Here we see a basic block diagram of the prototype for the autonomous vehicle, outlining the real structure of the project and the flow of commands between the many sub-systems. The graphic reveals two distinct sub-systems. Both the imaging system and the obstruction detecting system are components. Camera and associated image processing subsystem that obtains the picture. The picture is parsed for information, and a turn instruction is then generated by the system. Lane detection is accomplished mostly via the use of image processing. The generated instructions are sent on to the obstacle detecting module. The primary function of the obstacle detection subsystem is to identify any potential roadblocks ahead of the vehicle and determine how far away they are. And if there is enough room to go ahead, the Raspberry Pi will send the order to the car's engine, else it will not.

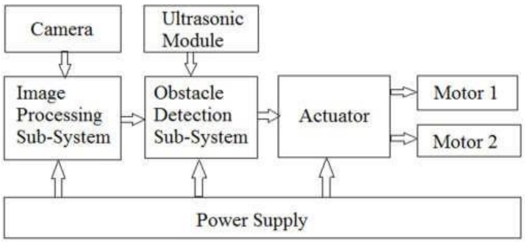

Fig 1: Block Diagram of the Autonomous Vehicle Prototype.

2.1.1 Module for Handling Images

Raspberry Pi 3 B models and camera modules make up the image processing sub-system. [4] [5] [9] Here, the picture in front of the automobile is captured using a simple software, and the captured image is then utilized to identify the lane and a predefined template. Vehicles decelerate or stop as indicated by the template. This system also sends turn commands to an Arduino, or other obstacle detecting mechanism, based on the lane's position.

We simply utilize image processing to look out for LANE and potential danger. In the grayscale version of the picture, the pixel values of the LANE lines, as far as can be determined, range from roughly 195 to 256. [2] [3] The picture is transformed from RGB to grayscale, and the pixel values between 195 and 256 are used as 1s and the rest as 0s, to produce this effect. As of right now, the picture simply shows LANE delineation. Identifying the lanes is done by a process of pixel processing. The position in the lane is used to determine what actions to take. The resulting commands are sent to Arduino through the GPIO ports. Likewise, it's crucial to identify risky areas in images, which is why most alerts are shown in Commonly, reds are seen on the left side of the road. Following this line of thinking, we may crop the image of the left side of the road and identify the red pixel inside it. When the volume or area of a pixel exceeds a certain threshold, it is crucial to bring the vehicle to a halt. Then, the Arduino receives these instructions that were created.

2.1.2 Subsystem for Identifying and Avoiding Obstacles

The ultrasonic range is where its strengths lie. The collected echoes of ultrasonic waves that have been bounced back from objects in front of the automobile offer information about those obstructions [1]. To do this, Arduino is used to acquire data from sensors in real time. Arduino's speed makes it ideal for controlling and analyzing data from sensors in real time. Only when an obstruction is not in the way can the image processing sub-instruction system's reach the driver/actuator.

There is currently no way to identify potential roadblocks in an image processing system. This requires an obstacle detecting sub-system that operates in real time. When comparing real-time sensor performance, Arduino beats out Raspberry pi. Since ultrasonic waves are not impacted by their surroundings and move in a straight line, we are employing them for obstacle detection in route. They create an echo when they collide with a surface, and we captured the reflected echo from the item and the time it took to catch the echo. Distance is determined by using this amount of time. In the prototype, if the distance is less than 10 cm, the vehicle stops; if it is larger than 10 cm, the system sends commands to the driver from the Raspberry pi, as seen in the flowchart.

2.2. Component Description

2.2.1. Hardware Details

Raspberry pi:

Raspberry pi is a tiny computer that runs the open-source Raspbian operating system. It does many tasks at once. The processor is a four core ARM cortex A-53 running at 1.2 GHz, and there's 1 GB of RAM on board. [1]

Power consumption was minimal in comparison to a PC, topping out at 5V at 2.5A. [1]

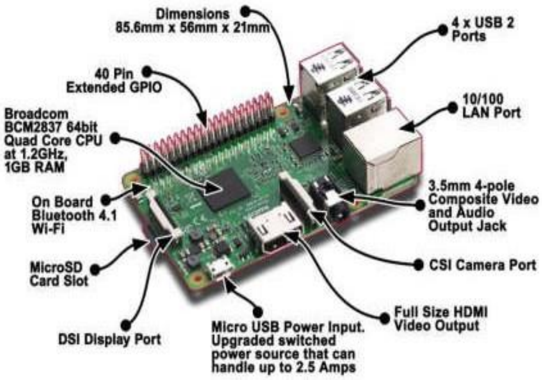

Fig 2: Raspberry Pi, four core ARM Cortex A-53

Pi-camera:

The 8-megapixel fixed-lens camera utilized for this project. Taking photos of 3280 by 2464 pixels is possible with this device. [2]

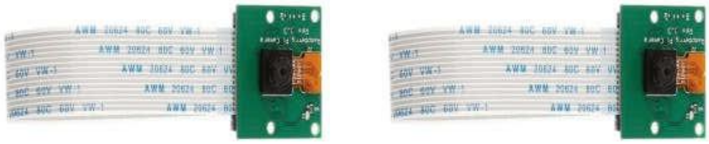

Fig 3: Pi- Camera Module

Ultrasonic Module:

Since the ultrasonic module is not susceptible to external interference, it is often utilized for distance measurement purposes. [3] The module employed here has a measuring range of 10 cm to 400 cm and operates at a frequency of 40 Hz. [4]

Using this module, you may take measurements at an angle of 15 degrees. [4]

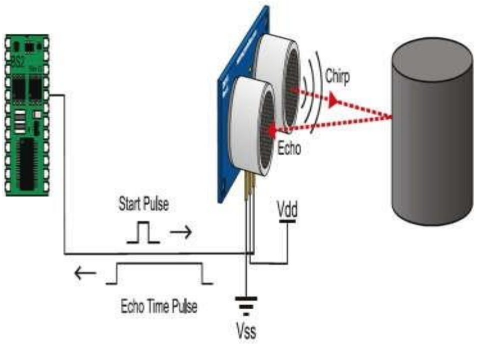

Fig 4: Ultrasonic Module

Arduino board:

Arduino is a microcontroller board used to make electronic gadgets and other interactive things. The C programming language is supported. The analog-to-digital converter is built right in.

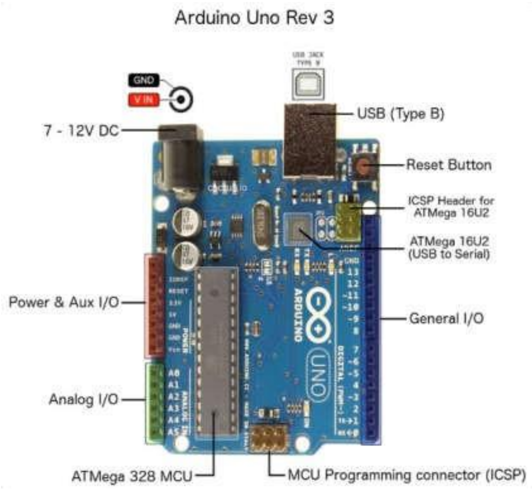

Fig 5: Arduino Board

2.2.2. Software Details

Raspbian OS:

When compared to other Raspberry Pi operating systems like Arch, Risc OS, Plan 9, and Raspbian, Raspbian stands out as the most user-friendly, best-looking, and having the greatest choice of default software's [8]. Raspberry Pi users may download Raspbian, a free operating system that is based on Debian (LINUX), directly from the Raspberry Pi website [8].

Python:

Python is an extremely popular high-level language that may be utilized for a variety of programming tasks [7, 9, 10]. When compared to other languages like C, C++, or Java [9, 10], its syntax helps programmers to express concepts in fewer lines of code.

This prototype uses libraries like TensorFlow or PyTorch for deep learning model implementation and OpenCV for image capture and manipulation. It is written in Python. These models can recognize traffic signs, detect objects, and detect lanes after being trained on large datasets like CIFAR-100 and ImageNet.The creation of an independent vehicle with autonomous navigation and obstacle avoidance is made easier by the integration of these technologies.

GPIO Python Library:

Using the RPi.GPIO Python package, the input/output pins on the Pi's GPIO header may be readily configured and read/written from inside a Python script [7, 9]. In contrast to the rest of Raspbian, this package is not included in the base distribution.

OPENCV:

Open-Source Computer Vision is a collection of coded operations with the primary goal of facilitating real-time imaging processing. Over 2500 optimized algorithms, including both a set of classical algorithms and the state-of-the-art algorithms in Computer Vision, are at your disposal for a wide variety of imaging-related tasks, such as detection and face recognition, object identification, classification actions, traces, and more [10]. This toolkit facilitates the implementation of such capabilities on computers, and it provides a straightforward computer vision architecture on which to rapidly prototype complex applications [9, 10].

Google, Yahoo, Microsoft, Intel, IBM, Sony, Honda, Toyota, and local startups Applied Minds and Video Surf all make heavy use of the library. In addition, several academic institutions and government agencies make use of it [10].

Although it was originally written in C++, it now has Python wrappers. In our project, [10] is utilized for road detection and navigation.

Arduino Language:

The Arduino Integrated Development Environment (IDE) supports C and C++ with a few extra restrictions for code structure. The Wiring project's software library is included in the Arduino IDE, and it contains several frequently used input and output routines [14][15].

3. AN AUTONOMOUS VEHICLE MOCULATION PROTOTYPE

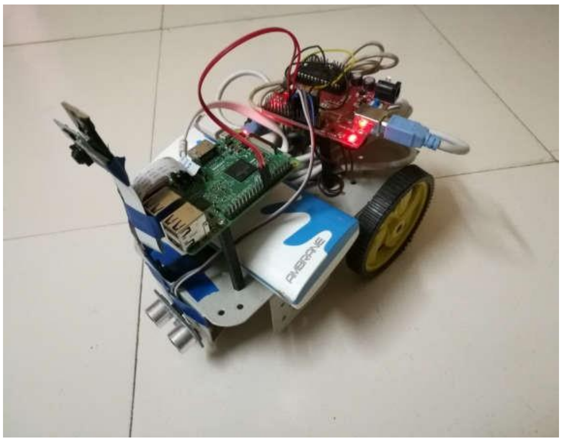

Fig 6: Autonomous Vehicle Prototype

4. RESULTS

This prototype of an autonomous vehicle requires AI, which can only be achieved by simultaneously considering a wide range of variables and making suitable software-based judgments. That's why we've included a camera module into our system; it takes pictures and feeds them into a database where an algorithm then makes judgments on its own [16][17]. The following are the outcomes we observed:

4.1 For Forward Operation

4.1.1 Raspberry Pi's camera module has taken the picture.

Fig 7: Camera module image

4.1.2 Input picture converted from red-green-blue to grayscale.

Fig 8: Image converted from RGB to Gray

4.1.3 Image colorization from grayscale to black and white

Fig 9: Image converted from Gray to Black and white.

4.1.4 The correct choice was shown after execution.

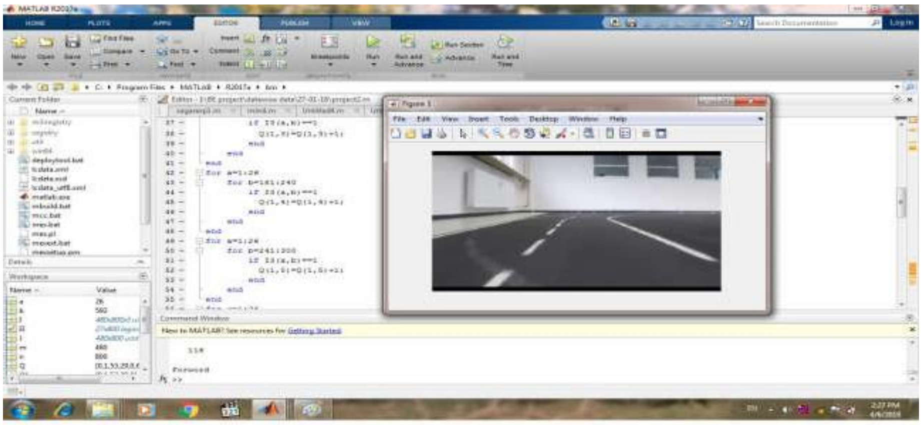

Fig 10: A suitable choice was presented after execution.

5. ADVANTAGES

- *Reduce the risk of collisions and enhance transportation safety:*

Since human error is a leading source of accidents, the advent of autonomous vehicles promises to greatly improve transportation safety.

- *Anybody, even those with disabilities, may go anywhere:*

This vehicle is accessible to passengers who are unable to drive owing to factors such as age or physical impairment. No one would need to drive anything anymore.

- *The concept of saving time:*

Time may be saved on the road since all autonomous automobiles will be abiding by the regulations of the road.

- *Developing more space for vehicles on roads:*

If safety distances between cars were reduced, the number of vehicles that could use each lane would grow dramatically.

- *Bringing the traffic situation under control:*

All traffic jams could be avoided if all cars were self-driving and could detect other vehicles and lane markings.

6. CONCLUSION

The goal of the current "driverless car revolution" is to create fully autonomous cars that can be operated without the need for a driver. Autonomous technology has far-reaching consequences for the economy, society, and individual enterprises. In this research, we use OpenCV to discover a strategy for identifying and explaining designated road boundaries. Self-driving cars have the potential to vastly enhance road safety, fuel efficiency, productivity, and accessibility. This is because they are designed to reduce accidents by mitigating human factors like driver error, distraction, and drowsiness, which account for the vast majority of traffic collisions. Successful implementation of the method described in this work has been achieved in an autonomous vehicle prototype.

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