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Self-Driving Car Using Neural Network

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ABSTRACT:This research paper is about controlling self-driving cars using neural networks. This project can detect path, stop sign, traffic light detection, and preventing a front collision. The Raspberry Pi and Arduino are the key components of this project. In raspberry Pi, an ultrasonic sensor and Raspberry Pi camera module are used for the input signal. There is communication between the host and the client-server. A neural network algorithm is applied to the host server. When the input is coming from a client then it will wirelessly be sent towards the host. Wireless communication is achieved by a local Wi-Fi link. After calculating and taking proper decisions the car will automatically run on a track. The ultimate goal is to reduce human error while driving a car.

KEYWORDS: Numeral Network, OpenCV3, Streaming Video, Arduino,HC-SR04.

I. INTRODUCTION

"A self-driving car, also known as an autonomous vehicle (AV or auto), driverless car, or robo-car, is a vehicle that can sense its surroundings and drive itself safely with little or no human intervention"[11]."Radar, lidar, sonar, GPS, odometry, and inertial measurement units are among the sensors used by self-driving cars to sense their surroundings"[11]. Sensory data is interpreted by advanced control systems to determine suitable navigation routes, as well as obstacles and related signage."Personal self-driving cars, shared robotaxis, connected vehicle platoons, and long-distance trucking are all possible applications of the technology"[11].The concept of a completely self-driving commercial vehicle is in various stages. In 2020, "Waymo became the first company to sell robotaxi rides to the general public in Phoenix, Arizona in 2021, while Tesla has stated that it will offer subscription-based "absolute self-driving" to private vehicle owners, and Nuro has been given permission to begin autonomous commercial delivery operations in California in 2021"[12].

"Steam and electricity were used to power the first cars"[13]. It all started with the invention of a steam engine vehicle capable of human transportation in 1769, and a few years later, in 1806, cars powered by an internal combustion engine that operated on diesel, which paved the way for the modern gasoline or petrol-fuelled internal combustion engine, which was introduced in 1885.

Karl Benz developed a gasoline-powered automobile with a single-cylinder two-stroke engine in 1886, which is regarded as the first practical motorcar, and obtained a patent for it on January 29, 1886. In 1888, he started manufacturing automobiles.Electric cars were common in the late 19th and early 20th centuries, when electricity was one of the favored methods for automotive propulsion, offering a degree of comfort and ease of operation not possible with gasoline cars at the time, but due to certain inherent flaws, they did not survive long on the market.The Ford Model T was the most common and widely available automobile of the Edwardian (Brass) period. It was the most successful car between 1908 and 1927.In the vintage period (1924–1929), the Bugatti Type 35 was the most popular racing model, winning over 1000 races in just five years. The Ford Model A was introduced in 1927 with a completely different design than the Model T, and it quickly became the best-seller, with nearly 4 million cars produced.

Modern automobiles have features such as lane-keeping, speed limits, and emergency braking. Those features are only called driver assistance technologies because they still require human driver control, whereas fully automated vehicles operate without human intervention.According to Fortune, some newer vehicle technology names, such as automotive, PilotAssist, Full-Self Driving, or DrivePilot, can confuse drivers, leading them to believe that no driver input is required when, in reality, the driver must remain engaged in the driving task. According to the BBC, there are deaths as a result of misunderstandings between these definitions.When cars are unable to handle

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such driving conditions, some car manufacturers say or assert that they are self-driving. Although it is called Complete Self-Driving, Tesla has confirmed that it is not a completely autonomous driving system. This puts drivers at risk of being overconfident, resulting in distracted driving and accidents.In the United Kingdom, a completely self-driving car is described as one that is registered in a particular list. There have also been suggestions to incorporate aviation automation safety information into discussions about the secure deployment of autonomous vehicles, owing to the aviation industry's decades of experience with safety issues.

Self-driving cars are also expected to be safer. “These cars will not get drunk or high, travel too fast, or take unnecessary risks,” Chase said.“Over 90% of accidents today are caused by driver error,” said Professor Robert W. Peterson of the Center for Insurance Law and Regulation at Santa Clara University School of Law. “There is every reason to believe that self-driving cars will reduce the frequency and severity of accidents, so insurance costs should fall, perhaps dramatically.”[9]. Driverless cars have the potential to address a wide range of issues, including road congestion and crashes caused by driver error. But it doesn't stop there: autonomous vehicles can bring to market a slew of innovative and exciting applications for several industries, including shipping, transportation, and emergency response.

Figure 1: A side-by-side comparison with a conventional, human-driven car illustrates where the components of a self-driving car are located.

While contact between vehicles and infrastructure is critical, it is even more critical that vehicles are aware of pedestrians and their precise location. In the United States, motorized vehicles kill about 15 people every day, which is much too many.While self-driving cars may not be able to prevent all of these accidents, they will likely be able to greatly reduce the number of deaths in the future.We rarely leave the house without our smartphones or some other internet-enabled gadget (e.g., smartwatch, tablet, e-reader, etc.), which means we are almost always connected to the internet in some way. Surprisingly, many of these devices, such as smartphones, may use GPS to calculate the precise location of the person using the device.Driverless vehicles will be able to respond automatically to the location of a pedestrian with collision avoidance measures such as braking and automatic steering thanks to this degree of connectivity, making our streets much safer for pedestrians.

II. METHODOLOGY

A. Hardware

1. Raspberry Pi board (model B+),
2. Raspberry Pi Camera,
3. Arduino,
4. Dc Motor,
5. Ultrasonic Sensor,
6. Wires,
7. Stop Sign.
8. Computer
9. Radio Control Car

B. Software

1. Create a C program in the Arduino IDE.
2. Image calibration is done with Python 3.8, which receives data from the Raspberry Pi and drives the RC car based on model predictions.
3. Video frames in jpeg format are streamed to the host machine using the Thonny program.

C. System Design: The framework comprises three subsystems: input unit (camera, ultrasonic sensor), preparing unit (PC), and RC vehicle control unit.

1. **Input Unit:**A Raspberry Pi board (model B+), attached with a Pi camera module and an HC-SR04 ultrasonic sensor is employed to gather a computer file. Two client programs run on Raspberry Pi for streaming color video and ultrasonic sensor data to the pc via a local Wi-Fi connection.To attain low latency video streaming, the video is scaled right down to QVGA (320×240) resolution.

2. **Processing Unit:** The preparing unit (PC) handles numerous errands: accepting information from Raspberry Pi, neural organization preparing and prediction(steering), object detection(stop sign and traffic signal), distance measurement(monocular vision), and sending commands to Arduino through the USB connection.

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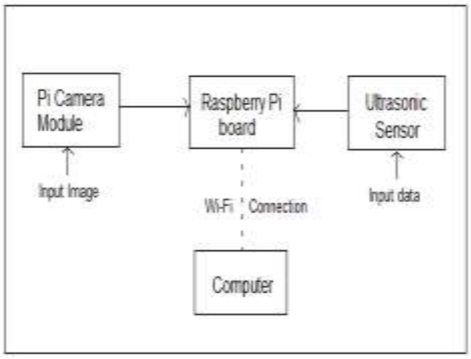

Figure 2: Block Diagram of Self Driving Car

a. **TCP Server:**The PC runs a multithread TCP worker program to gather streamed picture outlines and ultrasonic information from the Raspberry Pi. Picture outlines are decoded into NumPy clusters after being meant grayscale.

b. **Neural Network:** Neural networks are a group of algorithms that are programmed to identify patterns and are loosely modeled after the human brain. They may perceive data by clustering or marking raw information, which is a form of machine perception. They recognize patterns in numerical vectors, which contain all real-world data, such as text, sound, time series, and so on. The advantage of using neural networks is Neural networks have the potential to learn on their own and generate output that is not constrained by the data.

Since the input is stored in its networks rather than a database, data loss has little effect on the system's operation. These networks will learn from past events and adapt what they've learned when a similar situation occurs, allowing them to deal with real-time situations.

There are 38,400 (320×120) hubs in the information layer and 32 hubs in the secret (hidden) layer. The quantity of hubs in the hidden layer is picked genuinely subjective. There are four hubs in the yield layer where every hub relates to the directing control guidelines: left, right, forward, and reverse individually as shown in figure 2.

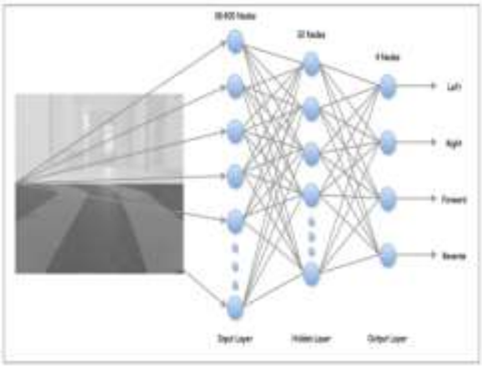

Figure 3: Neural Network

The training data collection method is depicted below. Each frame is first cropped before being converted to a NumPy array. The train picture is then matched with a train sticker (human input). Finally, a no file is generated with all of the paired image data and labels. The backpropagation approach is used to train the neural network in OpenCV. Weights are saved into an XML file until training is completed.

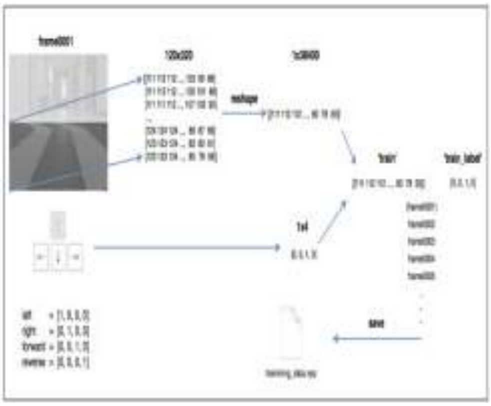

Figure 4: Collect Train Data

c. **ObjectDetection:**For object identification, this undertaking adjusted the shape-based methodology and Haar feature-based cascade classifiers.Since each item requires its classifier and follows a similar interaction in preparing and location, this task just shone on a stop sign and traffic signal recognition.

OpenCV includes both a trainer and a detector. Positive samples (which included the target object) were taken with a mobile phone and cropped so that only the desired object was visible. Negative samples (those that did not contain the target object) were obtained at random. Positive traffic light samples contain an equivalent number of red and green traffic lights.Both stop sign and traffic light training used the same negative study dataset. Some of the positive and negative samples were used in

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this project.Beyond detection, some picture preparing is expected to perceive various conditions of the traffic signal (red, green). The strategy for perceiving traffic signals is portrayed in the flowchart below.

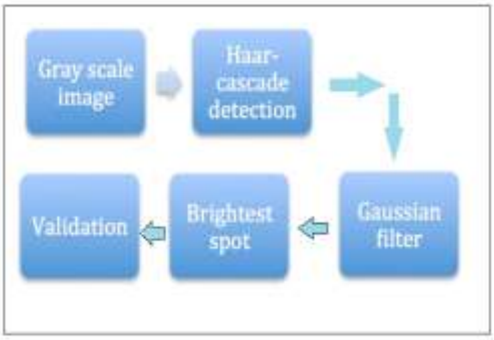

Figure 5: Traffic Light Recognition Process.

To detect traffic lights, a qualified cascade classifier is used first. A region of interest is described as the bounding box (ROI). Second, to suppress noises, Gaussian blur is added within the ROI. Finally, locate the ROI's brightest point. Finally, the location of the brightest spot in the ROI determines whether the state is red or green.

d. Distance Measurement: "Only one pi camera module can be used on a Raspberry Pi. Using two USB web cameras can add weight to the RC car and is also inconvenient. As a result, monocular vision is preferred. For distance measurement, the HC-SR04 ultrasonic sensor is used."[10]Chu, Ji, Guo, Li, and Wang proposed a geometry model for detecting a distance to an object using monocular vision in this project (2004).

P denotes a point on the target object, and d denotes the distance between the optical center and point P. Formula (1) illustrates how to measure the distance d using the geometry relationship above. In formula (1), f denotes the camera's focal length, a denotes the camera's tilt angle, and h denotes the optical center height.

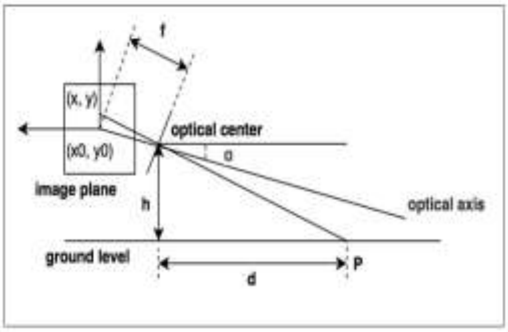

Figure 6: Distance Measure by Monocular Vision

The intersection point of the image plane and the optical axis is (x0, y0); the projection of point P on the image plane is (x, y). Assume O1 (u0,v0) is the camera coordinate of the optical axis and image plane intersection point, and that the physical dimensions of a pixel corresponding to the x- and y-axes on the image plane are dx and dy.

$$d = h/\tan(\partial + \arctan((y - y_0)/f)) \quad (1)$$

$$u = \frac{x}{dx} + u_0 \quad v = \frac{y}{dy} + v_0 \quad (2)$$

Let $x_0 = y_0 = 0$, from (1) and (2):

$$d = h/\tan(\alpha + \arctan((v - v_0)/a_y)), \quad (a_y = f/dy) \quad (3)$$

The object detection process can return v, which is the camera coordinates on the y-axis. The camera's intrinsic parameters can be obtained from the camera matrix for all other parameters.

OpenCV includes camera calibration features. After calibration, the sensor matrix for the 5MP pi camera is returned. ax and ay could, in theory, have the same meaning. Non-square pixels in the image can arise from variations in these two values. The matrix below shows that the Pi camera's fixed focal length lens performs admirably in terms of distortion control.Here's an interesting article that compares the focal length of a Pi camera with its stock lens to that of a 35mm camera.

$$\begin{bmatrix} a_x = 331.7 & 0 & u_0 = 161.9 \\ 0 & a_y = 332.3 & v_0 = 119.8 \\ 0 & 0 & 1 \end{bmatrix}$$

h is calculated in centimeters, and the matrix returns values in pixels. The physical distance d is measured in centimeters using formula (3).

3. RC Car Control Unit: The controller for the RC car used in this project is an on/off switch. The resistance between the related chip pin and ground is zero when a button is pressed. As a result, an Arduino board is used to mimic button presses. Four Arduino pins are used to connect the controller's four chip pins, which correspond to forward, backward, left, and right behavior.Pins on an Arduino Sending a LOW signal grounds the controller's chip pins; on the other hand, sending a HIGH signal maintains the resistance between the chip pins and land. A USB cable connects the Arduino to the motherboard.Using the serial interface, the device sends commands to the Arduino, which reads them and outputs LOW or

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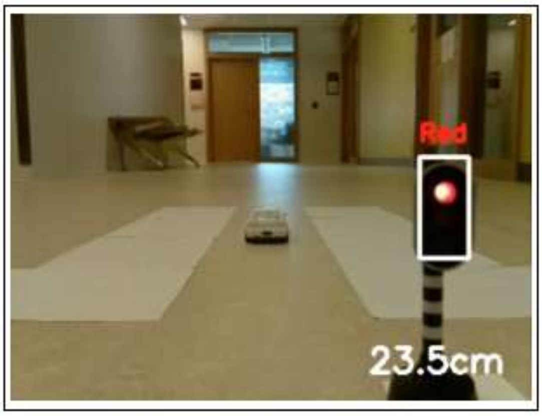
HIGH signals, simulating button presses to drive the RC vehicle.

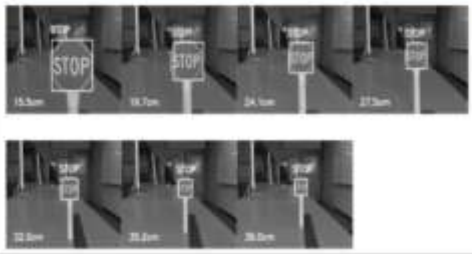
III. RESULT

The training samples predict with an accuracy of 96 percent, while the research samples predict with an accuracy of 85 percent. In a real-world driving situation, predictions are made about 10 times per second (roughly 10 frames per second).Haar features are rotation sensitive by default. However, rotation is not an issue in this project since both the stop sign and the traffic light are fixed structures, which is also the case in the real world.



The ultrasonic sensor is only used to calculate the distance to an obstacle in front of the RC car in terms of distance measurement, and it produces accurate results when proper sensing angle and surface condition are taken into account. The Pi camera, on the other hand, produces "good enough" measurement performance.In reality, we know when to stop the RC car as long as we know the corresponding number to the actual distance. The following are the experimental results of detecting distance with a Pi camera:

Order	1	2	3	4	5	6	7
Actual value (cm)	15	20	25	30	35	40	45
Measured value (cm)	15.5	19.7	24.1	27.5	32.0	35.2	39.0



The following factors may influence the accuracy of distance measurement using monocular vision in this project: (1) errors in real value estimation, (2) detecting process object bounding box variations, and (3) camera calibration process errors,(4) The distance and camera coordinate have a nonlinear relationship: the greater the distance, the faster the camera coordinate changes, and thus the greater the error.Overall, the RC car navigated the track safely, avoiding front collisions and responding appropriately to stop signs and traffic lights.

IV. CONCLUSION

Automation has the potential to help minimize the number of collisions on our highways. Driver activity or error is a factor in 94 percent of collisions, according to government statistics, and self-driving cars can help minimize driver error. Increased autonomy can reduce reckless and unsafe driving habits.Reduced destruction from intoxicated driving, drugged driving, unbelted vehicle occupants, speeding, and diversion could hold the most promise.One of the key motivations for the advancement of self-driving cars is the ability to drastically reduce the number of traffic incidents, some of which are fatal. Human error is unavoidable in existence. It is very easy for a driver to become distracted while driving. They may be having a lengthy conversation with another passenger or simply listening to music. You no longer have to think about being annoyed by other people or music in driverless cars and you can enjoy them.If you're on your way to work in the morning, it's also a good time to do some last-minute prep work before a major meeting.Many disabled people who are unable to drive rely on public transportation, which can be challenging depending on their situation. Many disabled passengers will benefit from increased mobility and no longer have to rely on public transportation thanks to driverless cars.

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