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Self-Driving Car: Using OpenCV2 and Machine Learning

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Abstract – *The project aims to represent a prototype of a monocular vision self-driving car model using latest technology of OpenCV2 and Machine Learning. Self-driving cars are autonomous vehicles that would minimize human intervention thereby minimizing the risk of accidents and make transportation safer, comfortable and that which can be done anytime. The car model will be able to detect the lane path, sign boards, traffic light signals and respond to real time traffic. Raspberry Pi is the central processing unit used along with peripheral devices such as Arduino Uno, L298 H-Bridge and the raspi Cam2 to bring about the desired control needed for our car. Algorithms like Lane Detection, Object Detection, Canny Edge Detection, Harr Cascade Classifier are amalgamated with Computer Vision to provide the necessary functionalities in the car.*

***Key Words*: Open CV, Machine Learning, Raspberry pi, Lane Detection, Object Detection, Canny Edge Detection, Harr Cascade Classifier.**

1. INTRODUCTION

Driving error is one of the most dangerous and causes loss of lives and leads to traffic. The common error that humans make like talking on the phone while driving or by loud entertainment systems in cars the accidents are more likely. Apart from these errors mental and physical disabilities are also a factor in driving failure.

These errors are increasing day by day and have become more important to reduce them by today's technology. Self-driving cars are the solution not just to minimize these errors but also to new possibilities of our driving and efficient road management systems.

With the rapid change in technology, scientists are coming up with new ideas in the field of self-driving cars. These cars are autonomous cars that can drive by themselves without human interference. This is basically a miniature model of self-driving car in best available resources. In this prototype, we have used a Raspberry Pi controller and Arduino with H-bridge to drive motors. The car is being powered by a simple 10000mah power bank.

The self-driving car would eradicate human intervention in the field of driving making driving safer and comfortable. The input to it is provided by continuous streaming of images via Raspi Cam2. This input is sent to the processing algorithm over local host. Here we use Computer Vision and Machine Learning to evaluate the output which is fed to the Arduino Uno. The Arduino feeds the appropriate signal to the H Bridge to control the left and the right motors accordingly.

1.1 Raspberry pi with Raspi cam.

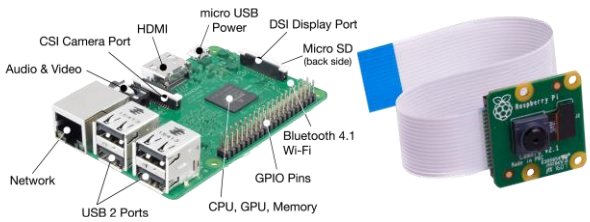

Fig -1: Raspberry Pi (3 Model B)

In this self-driving car, we are using raspberry pi (3 model B) which has a built-in Wi-Fi and Bluetooth module, as the main processing chip. This raspberry pi module has abilities to compute the output like a computer just in a mini credit card size version. We can even connect the mouse and keyboard to this module. We have used a 16GB micro-SD card as internal memory to store booting files and installed the Raspbian OS. The input to it is provided by continuous streaming of images via Raspi Cam. This Raspi Cam is being connected to the raspberry pi module through the CSI port. This input is sent to the processing algorithm over the local host. Here we use Computer Vision and Machine Learning to evaluate the output which is fed to the Arduino Uno.

1.2 Arduino

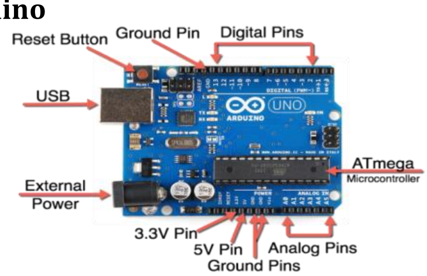

Fig -2: Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). With a 14-pin configuration for input/output, a USB connection, a power jack, an ICSP header, and a reset button, it has everything needed to support the microcontroller. This module can be easily connected to any computer using a USB cable and can be accessed by its environment called IDE. This IDE has a text editor with a toolbar for common functions and a series of menus. The raspberry pi module gives input to Arduino through digital pins (0,1,2,3) The Arduino feeds the appropriate signal to the H Bridge through the rest of the pins to control the motors accordingly.

1.3 L298 H bridge

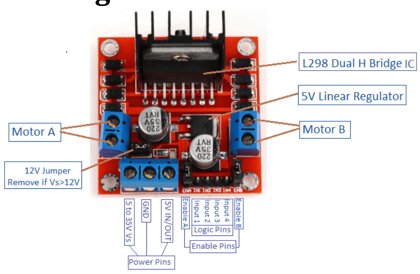

Fig -3: L298 H-Bridge

The L298 called a dual H-bridge is an integrated circuit in 15-lead Multi watt and PowerSO20 packages. It is generally used to reverse the polarity of the motors connected to it. This circuit has a high voltage and high current dual bridge driver which can accept TTL logic levels fed by Arduino. By using this element our car can easily stop and run according to the inputs fed.

2. RELATED WORK

In [1], Introduction to Open CV basics, installation of Open CV and its libraries and how to read/write images and videos in open CV. Building GUI and basic filtering operations on the images. Object segmentation and detection using image pre-processing techniques such as thresholding and contouring. Finally, image processing using object recognition and machine learning algorithms.

In [2], Visual recognition tasks for example image classification, localization, and detection, are the major building blocks of many of autonomous applications, and recent developments in Convolutional Neural Networks (CNNs) have led to outstanding performance in visual recognition tasks. This application is for multiple object detection in a given video based on Open Computer Vision (OpenCV) libraries.

In [3], Car navigation system, path planning, environment perception and car control are the four main technologies involved in Self driving car. A detailed review about all four of them and how they are brought together in this project is discussed.

In [4], This paper proposes a working prototype of self-driving car that is capable of driving safely or to say on different types of tracks such as curved tracks, straight tracks and straight followed by curved tracks. A camera module is mounted with proper inclination on one end of the car along with Raspberry Pi. This sends real time images to the Convolutional Neural Network (CNN) which in turn predicts the path to be followed by the car i.e., right, left, forward, stop or reverse this commands are send from the Arduino to the motor controller as a result the car travels in the desired direction without any human errors.

3. DESIGN ARCHITECTURE

In our self-driving car, we are using raspberry pi as the main processing chip. Raspberry pi model 3 B is used as it has a Wi-Fi module to connect our car via localhost. We downloaded the Raspian Operating System and flashed it in Raspberry pi. Then for the first time, an RJ45 Ethernet cable was used to connect it to our PC. Wi-Fi sharing was allowed through Ethernet cable using the IP address provided to Raspberry pi. Thereafter OpenCV was installed in the OS. The input to the Raspberry Pi is provided by continuous streaming of images via Raspi Cam2. This input is provided to the processing algorithm over the localhost. Here Computer Vision and Machine Learning are used to evaluate the output. This output is fed to the Arduino UNO. The Arduino takes the input from Raspberry pi and sends the respective algorithm to the H Bridge to bring about the desired control in the motors. The below block diagram represents the connections between various elements in our car.

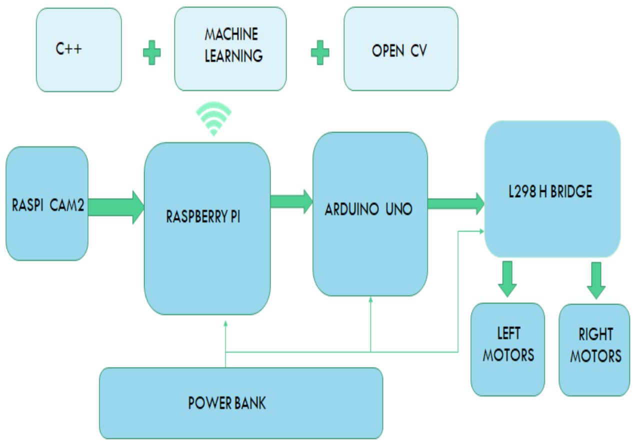

Fig -4: Block diagram

3.1. IMAGE PROCESSING

The input to the car is taken as a stream of images by the Raspi cam2. The necessary camera libraries were installed and built in the OS. There are algorithms for image capturing, video capturing, and finally to calculate frames per second. The CV2 works on the BGR image so the final image is converted from BGR to RGB using appropriate functions. Then we created Region of Interest (ROI) where the actual detection is required. This ROI undergoes perspective transformation for appropriate image analysis. Thereafter image thresholding is done to convert the grayscale image captured by the raspi Cam2 into the black and white image. On this threshold image, canny edge detection is done and both the threshold and the canny images are cascaded together.

3.2 LANE DETECTION

For detecting lanes, after image processing, we found the distance of the white pixels (255) from the left side of the ROI. For this, the pixels are treated like vectors to find their positions. The histogram is used for this purpose. If the distance of white pixels increases appropriate commands are sent to the Arduino UNO for taking the right turn. If the distance decreases it indicates the Arduino UNO to take the left turn. The degree of turn required is calibrated depending on the distance calculated.

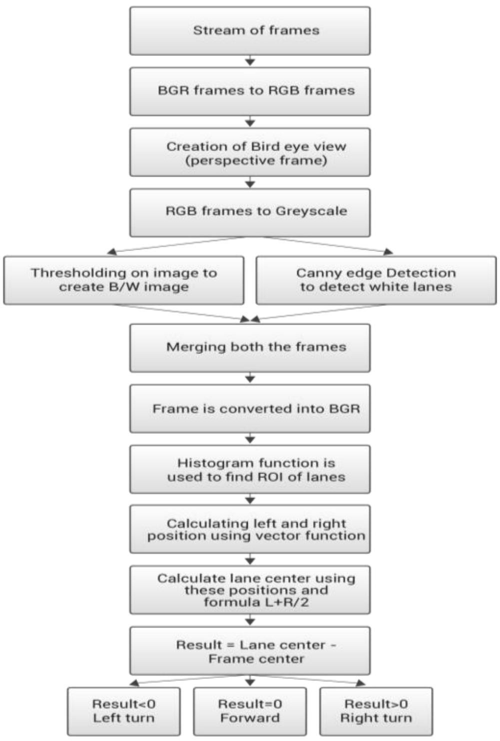

Fig -5: Flow chart for Image Processing and Lane Detection

3.3 OBJECT DETECTION

Machine Learning comes into picture while performing object detection. First, we take samples of object to be detected. These are called the positive samples. Then we take multiple images where our object to be detected is not present. These are the negative samples. For training and detection, we made use of Cascade Classifier software. After this, in the function for detecting the target object, various open CV methods are used for identifying the detected object and using distance formula(y=mx+c) we calculated the distance between the camera and the object by taking the distance and the pixels in the detected object as the parameters. Eventually, as the distance is known we created another function for halting the car within a desired range and by sending the command to Arduino UNO where it has algorithm for Stopping the car.

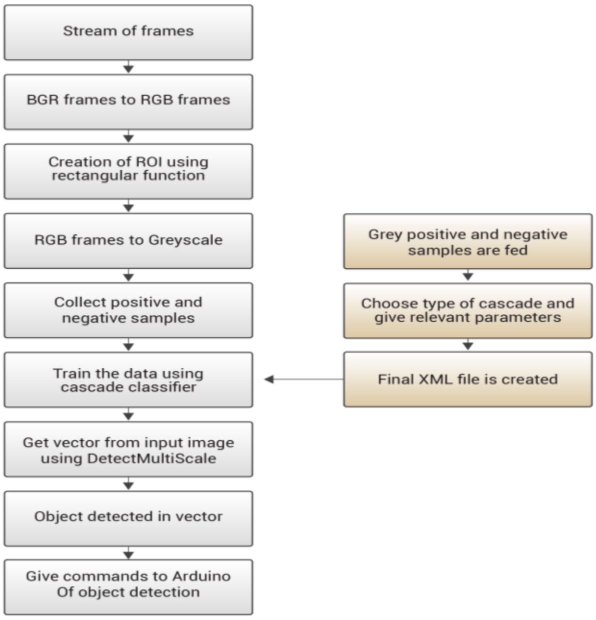

Fig -6: Flow chart for Object Detection

3.4 ARDUINO COMMANDS FOR MOTOR CONTROL

We created majorly 10-12 commands to bring about the necessary control in the car. These include algorithms for moving forward, taking a left turn, right turn and Stop. Each side of motors are assigned three parameters i.e. ENABLE, HIGH and LOW. Enable is for switching the respective motors ON and changing the polarities of HIGH and LOW parameters would result in making the motors move in forward and reverse direction as required. For taking right turn, we divided the speed in 3 different parts. This would help in achieving the degree of turn needed for the car. For e.g., if there is a sharp right turn the speed of the right motor is decreased to a greater extent while if there is a slight turn, the speed would be decreased relatively less. Similar algorithm is followed for taking left turn using left motors. Reducing the speed to zero would bring the car to halt.

4. ADVANTAGES

- The transportation of goods in and out of cities will become safe and efficient. This can also be used as cars having self-driving mode, the person on the driver set can do other important jobs while his attention is not on the traffic. Human intervention will also reduce in this process.

- With Self driving cars becoming the reality, the elders and disabled will be able to travel on their own accord. They won't need a driver to drive for them. Children would also be allowed to move on their own since the car will be driving on its own and is under strict observation.

- The duration of traffic jams will significantly reduce since the cars will run on algorithms and would avoid unnecessary mistakes. This in turn will improve the overall decision-making process of the vehicles in traffic.

5. LIMITATIONS

- For a self-driving car to become a reality in India, the first thing which needs to be improved is infrastructure. Without proper road infrastructure, the cars would not be able to take accurate decisions on their own.

- One of the major issues which are present is the interaction of self-driving cars and human drivers on roads. Human drivers drive their car intuitionally and their actions on roads become unreadable for self-driving cars in real-time which can prove dangerous for all.

- The working efficiency of equipment reduces while functioning in extreme weather conditions. Thus, the time taken in the process is significantly affected and is not reliable. Sometimes when the weather is cloudy or rainy wrong input signals also appear which may lead to unexpected results.

- Proper and accurate signboards are necessary for the self-driving car to operate safely.

- One of the major threats to self-driving cars is that they are prone to hacking because of technologies.

6. OUTPUT

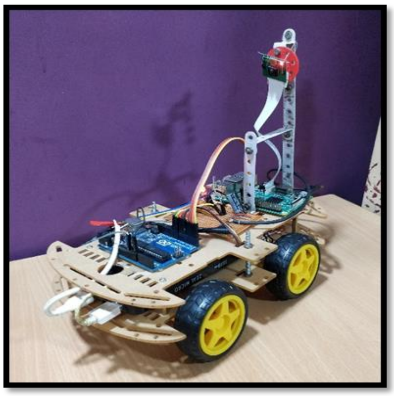

Fig -7: Output Model

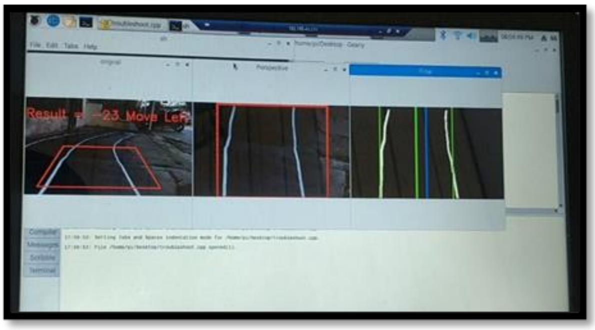

Fig -8: Left Turn

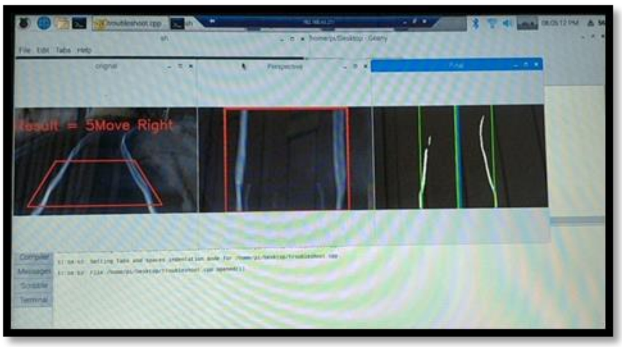

Fig -9: Right Turn

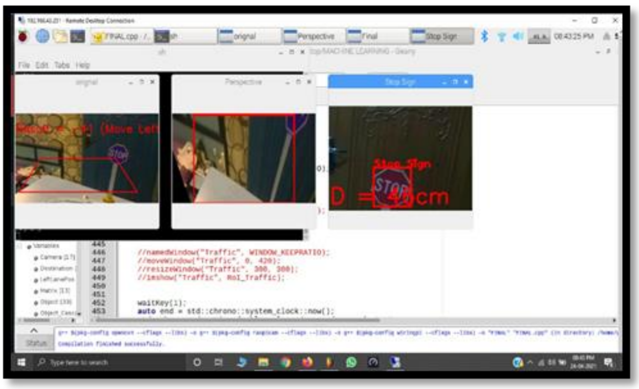

Fig -10: Stop Sign Detection

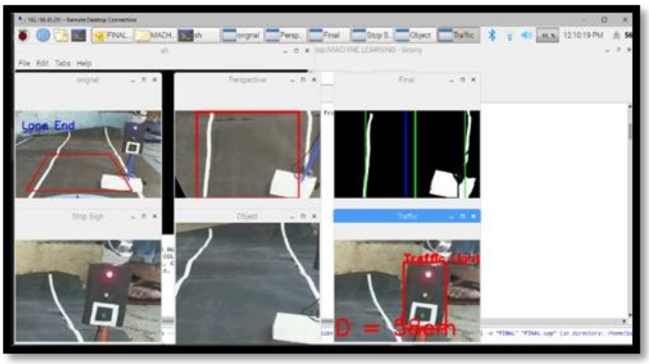

Fig -11: Traffic Light Detection

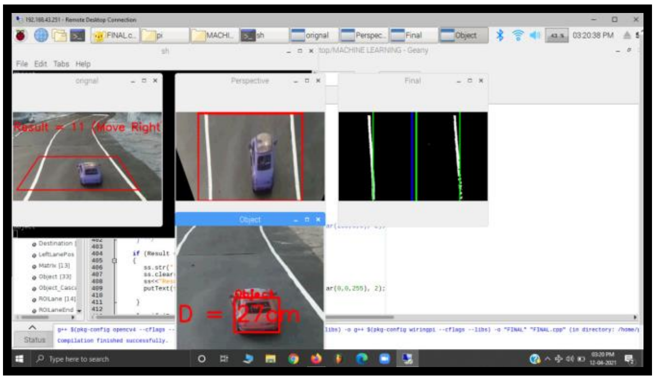

Fig- 12: Object Detection

7. FUTURE SCOPE

If the car is incorporated with the GPS system, it would reach the desired location on its own thus making it fully autonomic. A person can reach the destination without exerting strain on the brain while indulging in some other activities apart from driving.

CONCLUSION

In our project we aimed at making the travelling and transportation a safer and comfortable mode. The car was able to move from one point to another point automatically on the provided road. While doing so, the car was successful in viewing the forthcoming turns, traffic light signals, other vehicles, etc. and making decisions accordingly and independently. Thus, the car was able to overcome all the obstacles and drive safely on the road track.

ACKNOWLEDGEMENT

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