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Traffic Sign Detection and Recognition

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Abstract – *The goal is to design a system which detects and recognizes traffic signs in real-time scenarios. For this, a robotic self-driving car is built and the traffic sign detection and recognition system are implemented into it. The car will read the traffic signs and take actions accordingly.*

Key Words: **Detection, recognition, traffic signs, robotic self-driving car, real time.**

1.INTRODUCTION

There are various concerns about road and transportation safety. The Traffic Sign Detection and Recognition System helps is reducing those concerns. The Traffic Sign Detection and Recognition System (TSDRS) can detect and recognize traffic signs in real time with a live video feed streamed through camera. Simultaneously, the robotic self-driving car will process the videos and detect and recognize the traffic signs at every frame of the video and function accordingly.

1.1 Background:

The motivation behind the project is Self-Driving cars developed by Tesla and Google. The cars developed by these tech giants are not quite affordable by everyone.

These cars use traffic sign detection and recognition in real time but they work on a high computational hardware. Instead, we have used comparatively low-cost processing hardware and achieved a good accuracy with it.

2. Literature Survey

Paper I: An Automatic Traffic Sign Detection and Recognition System Based on Color Segmentation, Shape Matching and SVM by Safat B. Wali, Mahammad A. Hannan, Aini Hussain, and Salina A. Samad.

The goal of this research was to develop an efficient TSDR system based on Malaysian Traffic Sign dataset. In the image acquisition stage, the images were captured by an on-board camera under different weather conditions and the image preprocessing was done by using RGB color segmentation. The recognition process is done by SVM with a bagged kernel which is used for the first time for traffic sign classification.

The developed system has shown promising results with the respect to the accuracy of 97.51% false positive rate (0.009) and processing time (0.43 seconds).

Variant lighting conditions, occultation and illumination of traffic signs are the main reasons for false detection. It is only applicable for red traffic signs. It has a low detection rate due to color factors like low illumination, blurring and fading. Lack of images in Malaysian Traffic Sign Database.

Paper II: Traffic Sign Detection and Recognition for Driving Assistance System by Huei-Yung Lin Shu-Chun Huang.

The proposed approach in this research consists of two subsystems for detection and recognition. First the road sign detection subsystem adopts the color information to filter most irrelevant image regions of road signs. For a road sign subsystem, a CNN is adopted to classify traffic signs for candidate regions.

The overall accuracy is good as it uses Google Net Deep Learning architecture for large amounts of data.

The disadvantage of this system is it only records the sign with red color. The dataset that is used is weak. It works on a single image at a time and then works on detection. Hence, there is no real time approach.

Paper III: Traffic Sign Detection and Classification using color feature and neural network by Md. Abdul Alim Sheikh, Alok Kole, Tanmoy Maity.

This paper proposes a framework that will detect and classify different types of traffic signs from images. This system consists of two main modules: Road sign detection, classification and recognition. In the first step, color space conversion, color-based segmentation is applied to find outif a traffic sign is present. If present, the sign will be highlighted, normalized in sign and then classified. Neural network is used for classification purpose.

Accuracy of detection is above 90% and accuracy of recognition is more than 88%.

The major disadvantages are that for evaluation purpose, only four types of signs i.e., Stop sign, no entry sign, give way sign and speed limit sign are used. This system takes static color images from the web as input. No real time approach is used.

Paper IV: Automatic Detection and Recognition of Traffic Signs by M. Sajjad Hossain, M. Mahmudul Hasan, M. Ameer Ali, Md. Humayun Kabir and ABM Shawkat Ali.

A new approach namely automatic detection and recognition of traffic signs considering color segmentation, movement invariants and neural network has been proposed in this paper.

Experimental results show superior performance in the detection and recognition of road signs. Computational time complexity is also quite low that makes it applicable for the real time system. Detection rate is 95% and works

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independent of light conditions. It does not have a real time approach.

3. Proposed System

The efficiency of the TSDRS is to be measured by implementing it in robotic self-driving car. The robotic self-driving car will follow a lane and maintain it. A traffic sign will be installed at several intervals. The car will detect the traffic signs, recognize it and take appropriate actions accordingly.

3.1. System Architecture Diagram

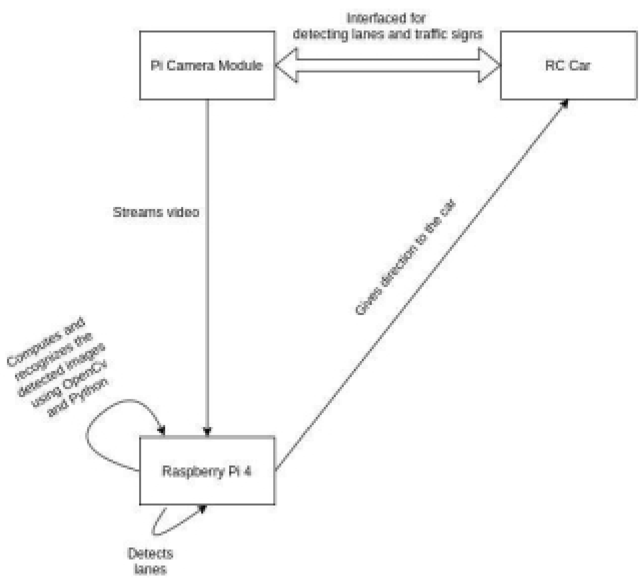

Figure 1: Block Diagram of the system

3.2. Sequence Diagram

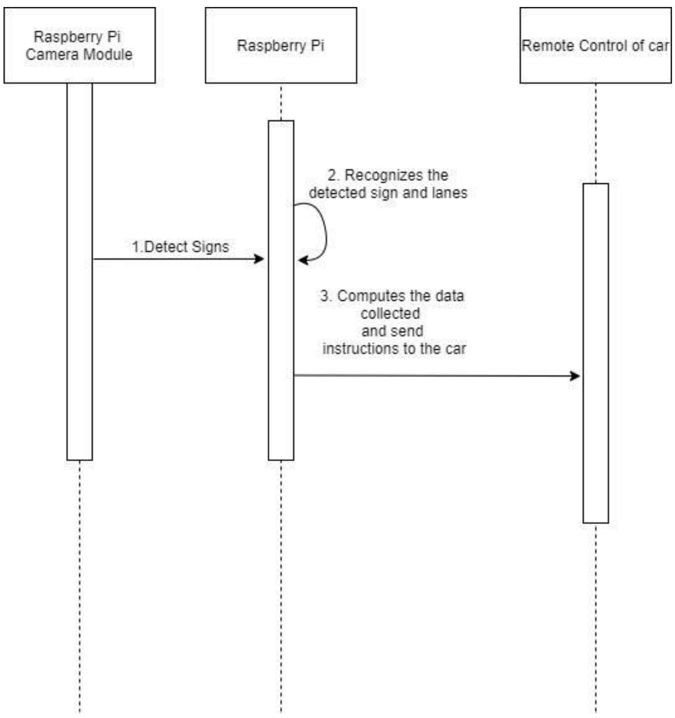

Figure 2: Sequence Diagram of the system

3.3. Use Case Diagram

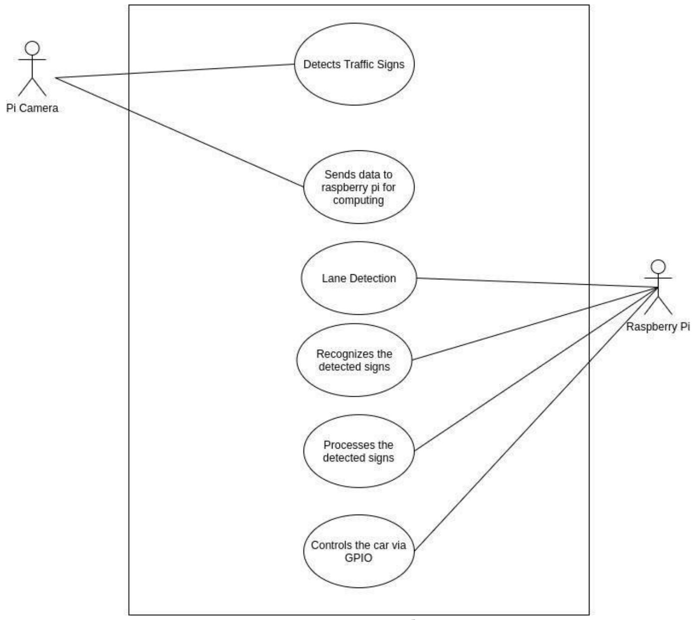

Figure 3: Use case diagram

3.4. Phases of the system

The entire system is divided into two major phases:

Phase I: Lane Detection for self-driving car

The lane detection system is the system that will help the car to maintain the lane while running. This will prevent the car going off-road. The edges of the road will be marked and the path will be computed for the car to move.

Phase II: Traffic Sign Classifier

The dataset used for making this classifier is German Traffic Sign Recognition Benchmark (GSTRB). Although this dataset has some major flaws, these flaws are eliminated by implementing image augmentation. The GSTRB dataset consists of 43 traffic sign classes and nearly 50,000 images.

4. Methodology

This section describes the designing process of the entire system. It provides the flow of modules and in-depth description of different phases.

4.1. Hardware Used:

a) Raspberry Pi 4 (4GB RAM)
b) Web camera / Pi camera
c) L298N motor module
d) RC car kit
e) Jumper cables
f) 9V – 12V Power Supply

4.2. Software / Framework / Libraries Used:

a) Anaconda (For python and installation of libraries)
b) OpenCV
c) TensorFlow
d) Keras

4.3. Lane Detection

A camera is to be mounted on the self-driving car. The input will be in the form of a video stream which will be in real time. The processing is done at every frame of the video simultaneously. At each frame, an image will be processed and the output will be reflected in no time.

Figure 4: Udacity Self Driving Car

The five major steps involved in lane detection are:

Thresholding: It is a type of image segmentation technique where we change the pixels of an image to make the image easier to analyze. Thresholding is the process of convertinga color or grayscale image into a binary image which is simply black and white. We use it to partition the image so as to calculate the lane where the car will move.

Figure 5: Thresholding of image

Warping Lane: Image warping is the process of digitally manipulating an image such that any shapes portrayed in the image have been significantly distorted. Image distortion can be corrected by warping, but it can also be used for artistic purposes (e.g., morphing). The same methods can be applied to video as well.

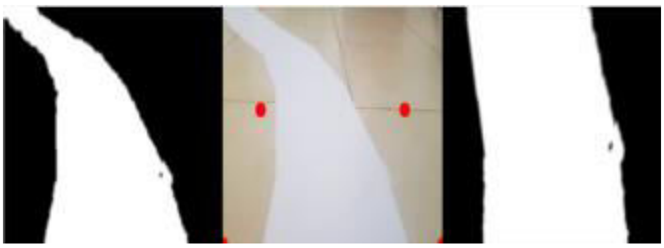

Figure 6: Warping of Image (having bird's eye view)

Finding the curve: This is achieved using pixel summation and creating a histogram resulting into the region of interest.

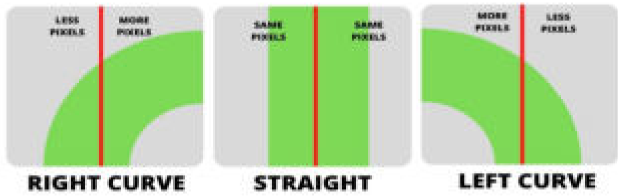

Figure 7: Pixel Summation

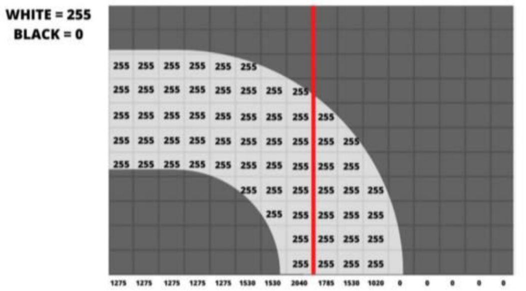

Figure 8: Curve detection

Optimizing the curve: To optimize the curve, the car needs to know the center of the path. This is done by averaging the histogram values.

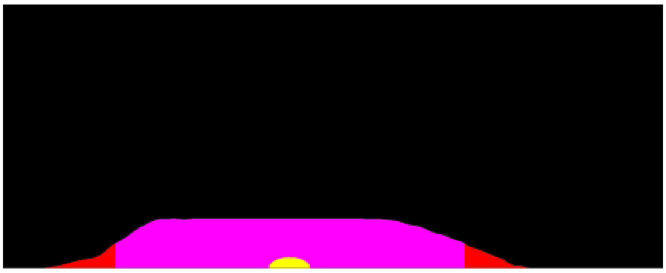

Figure 9: Optimized curve resulting in center of the lane

4.4. Traffic Sign Classifier

Dataset: The German Traffic Sign Recognition Benchmark (GTSRB) is a dataset of traffic signs having a total of 43 traffic sign classes and nearly 50,000 images.

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Figure 10: Preview of the GTSRB Dataset

For the model robotic self-driving car, we have considered 7 classes of most commonly found traffic signs which are as follows:

i. Stop
ii. No entry
iii. Turn right ahead
iv. Turn left ahead
v. Ahead only
vi. Go straight or right
vii. Go straight or left

One of the major drawbacks of this dataset is that it is inconsistent. Some classes have a large number of samples and some classes have very few samples. This will affect the training process of the Traffic Sign Classifier. To overcome this, we have used Image Augmentation.

Image Augmentation: We have used image augmentation to expand an existing image data set. It is a powerful technique to artificially create variations in existing databases as the data set is very large and inconsistent. Various transformations such as zooming on an existing image, rotating an image by a few degrees, shearing and cropping the existing set of images, etc.

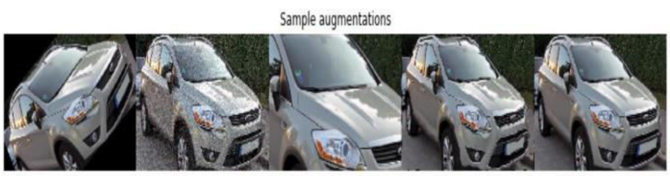

Figure 11: Sample image augmentation

5. Result

The Traffic Sign Classifier is 99.26% accurate as we have reduced the dataset to 7 classes. This has been done to avoid load on raspberry pi. Also, the most commonly found traffic signs are taken into consideration.

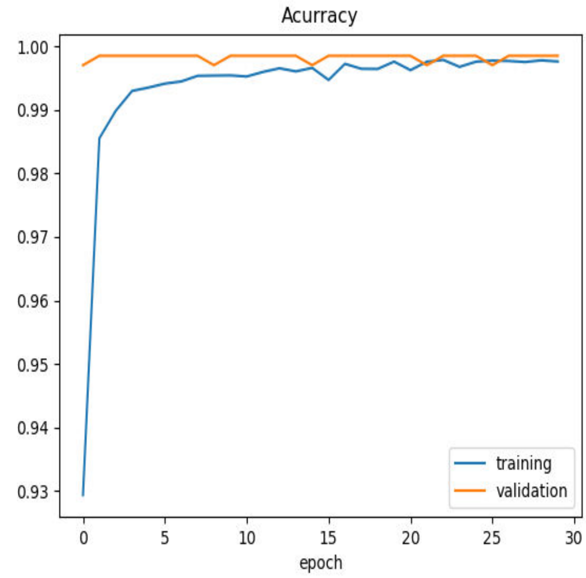

Figure 12: Accuracy graph

Lane Detection Module

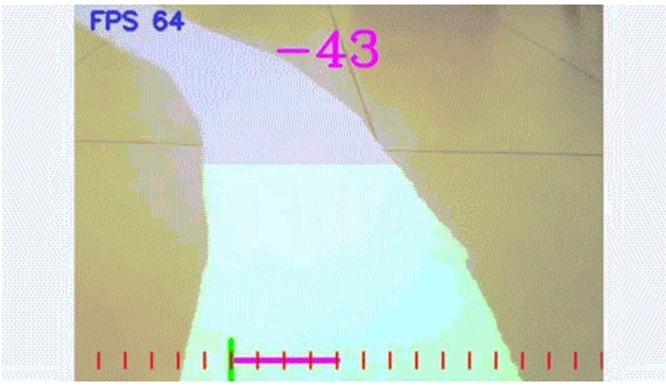

Figure 13: Real time detection of lane with curve value

Traffic Sign Classifier

Figure 14: Real time recognition of STOP sign

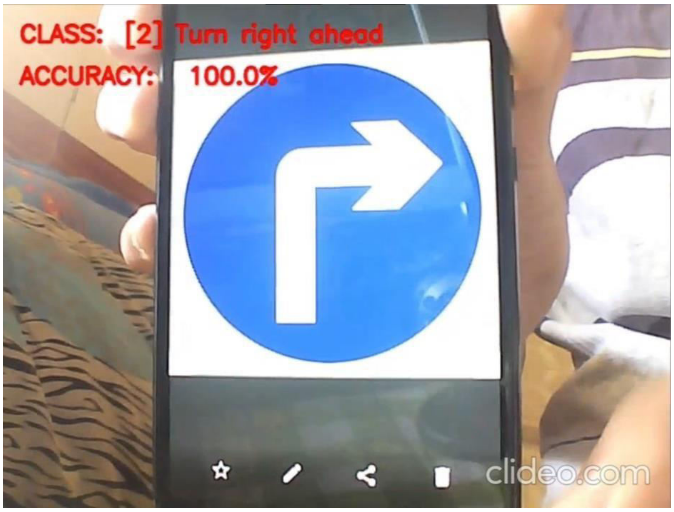

Figure 15: Real time recognition of turn right ahead sign

6. Limitations

6.1. Hardware limitations:

The hardware used is Raspberry Pi 4 (4GB RAM) model which has a mediocre computation power. To have a better computation power, the best alternatives are Nvidia JetSon, Raspberry Pi 4 (8 GB RAM) model. Also, to improve the real time detection and recognition we can use Google Coral USB Edge TPU ML Accelerator. All the above will increase the overall cost of hardware but provide a better result.

6.2. Challenges with dataset:

The images are of low resolution and poor contrast. The top class (speed limit 50kmph) has over 2000 examples while the least represented class (speed limit 20kmph) has under 200 examples which is a huge magnitude difference. Such inconsistent dataset leads to inaccurate results.

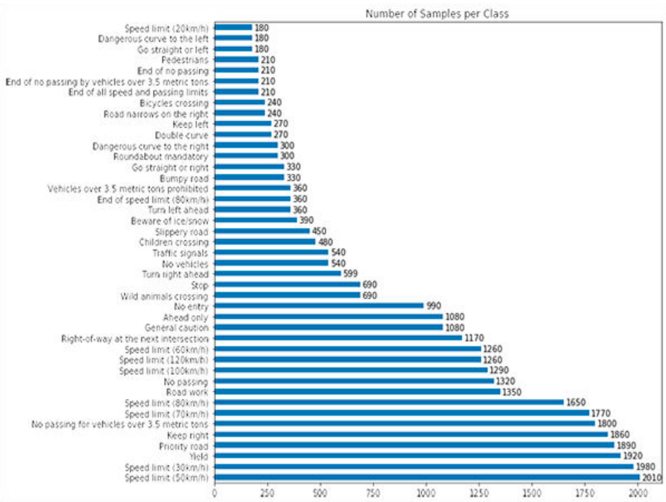

Figure 16: Graph of images in classes of the dataset

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