IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

REAL-TIME ROAD SIGN RECOGNITION SYSTEM USING MACHINE LEARNING AND IMAGE PROCESSING

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Abstract: Machine learning and digital image processing are the most frequently used technologies in object detection algorithms. The objective of this work is to formulate a method for traffic light detection and detection of road sign boards. With the help of this proposed work, one can accurately detect and recognize traffic light colors i.e. green, yellow and red, and different signs like speed limit, stop, turn right, turn left, turn back and forward. Road signs are mostly comprised of colors which acts as a basis for distinguishing it from all other objects. Computer vision technique is used in the field of smart and intelligent transport systems. Nowadays, the traffic sign recognition systems have become an integral and functional part of Driver Assistance Systems. Hence this system is proposed to recognize road signs while driving the vehicle and provide audio commands to the drive to assist him accordingly.

Keywords: **Machine Learning, Digital Image Processing, Computer Vision, Driver Assistance System, PCA, HSV, OpenCV, ANN, Raspberry Pi, OCR.**

I. INTRODUCTION

In present times, to assist the driver in driving vehicles, road sign detection is used by giving commands in the form of audio feedback. This makes the driver very easy to perceive the commands and directly following them. The main motive of this work is to capture the sign pictures and traffic light color using a camera and then using machine learning algorithms to categorize it and processing them. Processing mainly comprises of image processing algorithms. After processing, it will give an audio output of the meaning of the image to the driver. The intermediate device used for image processing will be a Raspberry Pi. The core process is being controlled by the Raspberry Pi which is responsible for taking input images from camera and producing output to the speaker or audio device.

II. LITERATURE REVIEW

[1] The road sign recognition mainly requires computation of large set of images, which is easily done using Python and OpenCV. The system captures the image, classifies it by processing the dimensions and colors and hence producing the output to audio device. [2] Another way like using MLL statistical classifiers and clustering tools is adopted. HSV color space algorithm is used which uses its value to pre-process the video frames as an image and then give result by also taking the shape into consideration. [3] All the images are captured through Pi camera module by converting the video frames to JPEG encoder format. Then they are processed through OpenCV. [4] The other way uses the Haar features and Cascade classifiers which is connected to whole circuitry of DC motor, Raspberry Pi and camera module. This whole system can be setup to build an autonomous driverless vehicle. [5] The pre-defined image templates are used to compare with the captured image and then are correlated based on features like pixel values, HSV color space value and classification technique.

[6] System comprises of detection module and recognition module. The methods used are Principal Component Analysis, Mean, Standard Deviation, Variance, Covariance, and Eigen Vector. Detection and classification are the principal components of the system. [7] Image processing techniques used for the system are Fit Ellipse, canny edge detection, threshold techniques, Contour and Gaussian filter. Images are cropped and resized and converted from RGB to Grayscale. [8] Instead of camera module, one can use smartphone camera to capture images and send via BT, Wi-Fi, and WiMAX to processing module and then showing an alert message or voice note. [9] The traffic sign recognition is handled by the Histogram of a SVM classifier on which Gradient is based upon.

III. PROPOSED SYSTEM

In order to design an efficient recognition system, it should have a lesser computational cost and better discriminative power. The proposed system is a real time one, hence it should be robust and process the image data quickly and accurately as much as possible. Image processing is a concept used at a lower computational level, hence OpenCV is used at a higher level of computation. OpenCV stands to be best in field of processing images at faster speed with better accuracy. The components used in the system are a high quality camera module, a Raspberry Pi, and an audio speaker. The components are integrated with each other connected to a power source and then is fixed in a car.

Initially while travelling, the camera module captures the video frames. These video frames are then filtered by processing each image in a pipeline. Filtration is based on the presence of road sign or traffic light, basis of color, shape, size, dimensions. The potential regions of those images are then improvised or enhanced on color and shape properties in order to recognize easily by machine learning algorithm. A dataset of all the road signs is maintained and a machine learning model is trained over a thousands of images. Then the image is classified according to the dataset and the final result is generated. The description of the resultant image is then given as an output in the form of audio command via a portable speaker.

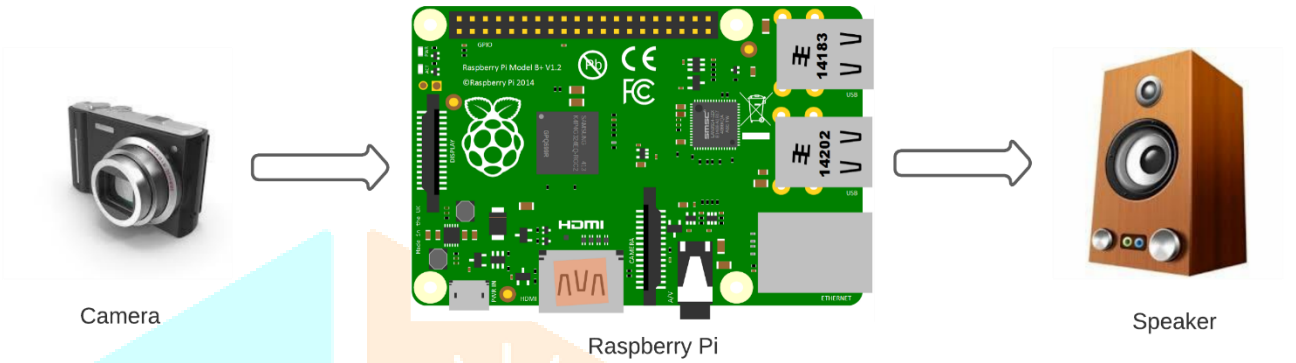


Figure 1:

IV. PROPOSED METHODOLOGY

4.1 Video Frames Acquisition:

To capture the continuous input video frames, a USB camera module is installed. The camera used is able to capture the video frames at a rate of 20fps at 640×480 resolution and the line of sight is 1000m – 1200m. At this resolution only the Raspberry Pi module is able to maintain the rate of flow of input as well as output. The synchronization of incoming and outgoing speed of the pipeline of Raspberry Pi plays an important role in robustness of the system. The major issue of a Raspberry Pi module is I/O bandwidth. Rapid capturing of images and the high quality image frames makes the process more inefficient. So it has to be well balanced.

4.2 Preprocessing Frames:

Image data is read by the system and then preprocessed by OpenCV in python. The intensity values of green, red and yellow is determined by HSV algorithm. This stage plays an important role in separating out those images which has less probability of presence of road sign or traffic light image. This filtering can be done by calculating HSV and RGB color space. At this stage, images captured are in varied conditions such as brightness, saturation, clarity, etc. with many background objects.

4.3 Traffic Sign Recognition:

To make this preprocessing algorithm more efficient to filter out images, Hough Transformation technique is used to detect shape and color of sign. It makes comparisons with circular, triangular and rectangular shapes and red, yellow and green colors. Also to detect shape of sign more efficiently, fast radial transform is used for detecting triangular and square shapes. The popular classification techniques such as Principal Component Analysis (PCA) is used which consists of Mean, Standard Deviation, Variance, Covariance, and Eigen Vector. And Artificial Neural Network (ANN) is used to obtain the accurate classification percentage. Parameters such as Sigmoid function, Goal, Epoch, and Threshold, Number of Hidden layers and Training type are some of the ANN learning parameters.

4.4 Image Enhancement:

Gaussians filter and Canny edge detection techniques are used to enhance the image quality. Edge and contour detection of the images are the initial parameters to be enhanced which is done by OpenCV. Images are cropped over the outline edges into the perfect road sign. Distortions in shape of the image and color distribution is made uniform in OpenCV which helps in easy classification of the road sign. To improve quality of color code of images, an OCR engine is integrated with the camera to improvise the color combination and Kernel Algorithm is used to smoothen the image. OpenCV libraries proves to be very useful in performing all the processing and OCR functions over images. The HSV and RGB color space is used as a key parameter to match the road signs in a database.

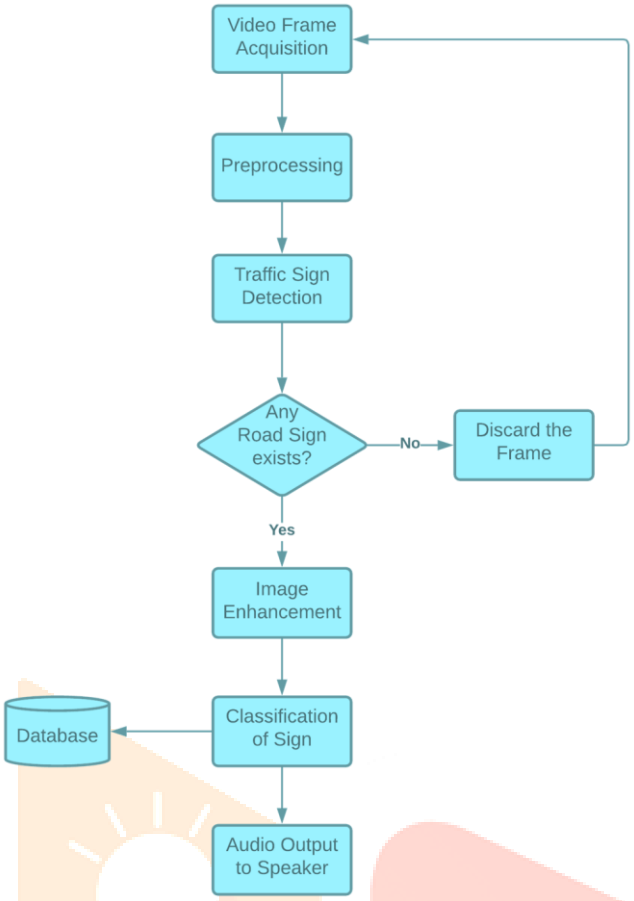


Figure 2: System Flow

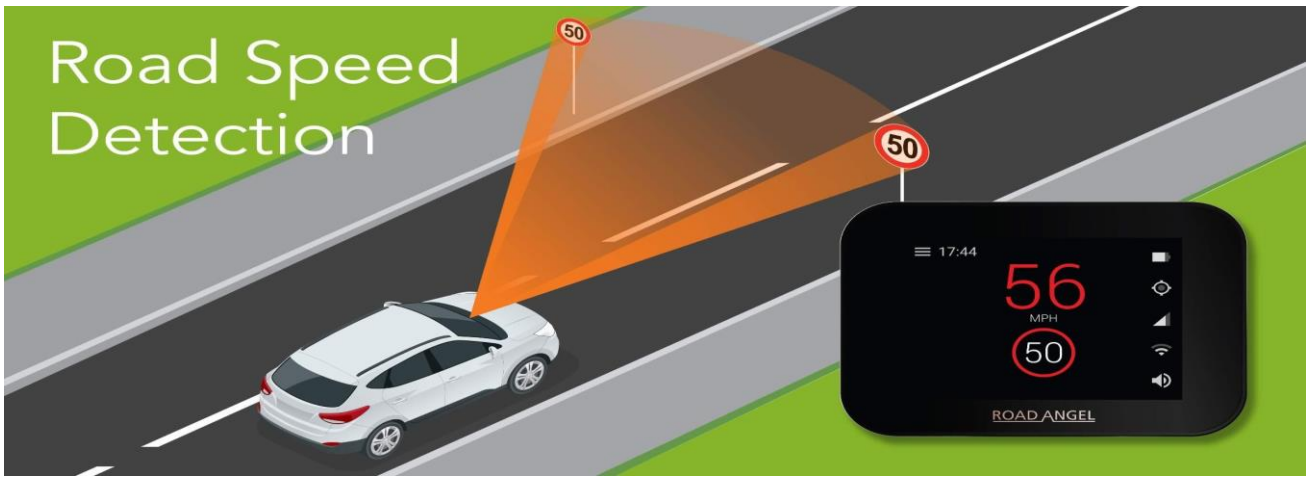
4.5 Classification of Images:

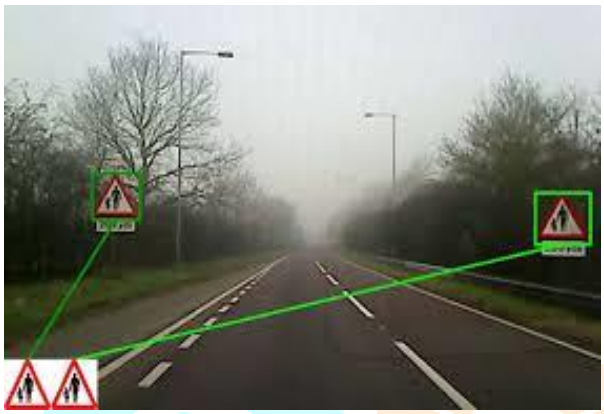
A machine learning model is used to train a database of all the road signs and traffic light. Clustering as well as classification techniques are prominently used to match the input images within the database. Database mainly comprises of the road signs and/or traffic lights along with its description. Color and shape selection are the key and simplest parameters to detect the appropriate road sign image from the database. ANN and PCA methods are used to extract features of input image and then comparing with the dataset. The geometrics of the road sign are calculated in both image as well as database. In order to get best match of an image in database, various parameters are calculated and then matched with the parameters in the image database. To improve accuracy, numerous cost functions are taken into consideration. The base window size of 24*24 is used by the Viola Jones Algorithm to evaluate features in any given image.

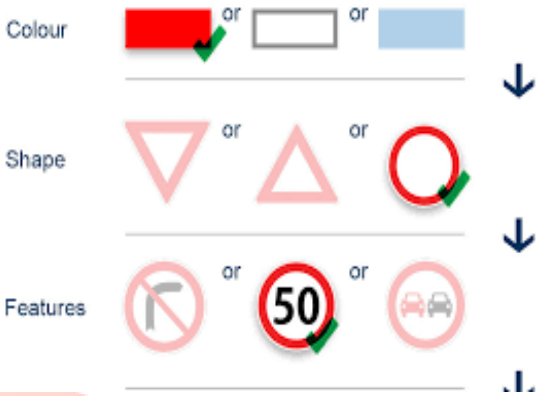
4.6 Audio Output:

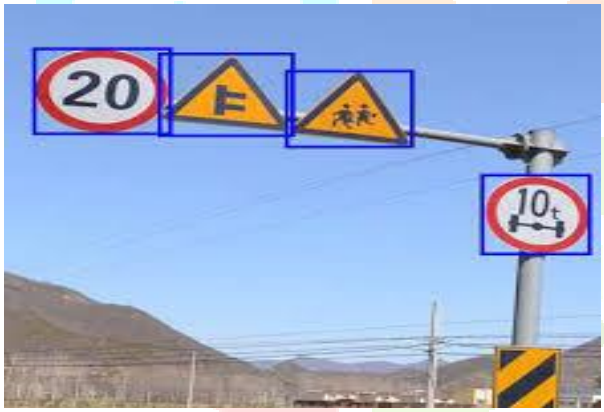
After the successful categorization of the road sign image, it is searched in the database. The database contains the description of the image. This description is then given as form of output to an audio device as a command in desired language which helps driver in perceiving it and take on the actions accordingly. Audio output needs to be clearly delivered via a speaker at an appropriate audio intensity.

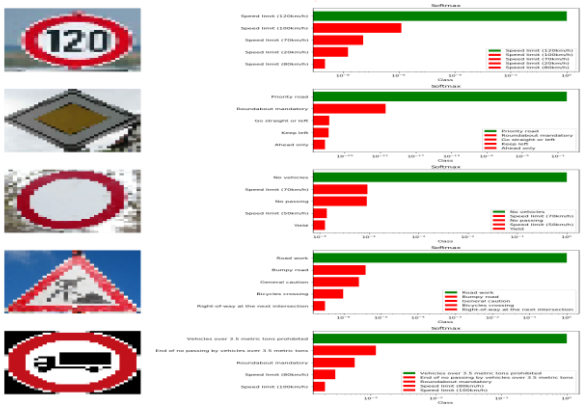
V. RESULTS











VI. Conclusion

This proposed work is built reliably and successfully which accurately recognizes the road signs in a real time environment and give an immediate audio response to the driver. Various Image Processing techniques such as HSV and RGB color space is used as well as Machine Learning algorithms such as PCA, ANN, Gaussian Algorithms and many more are used to perform all the operations accurately and obtain the desired result. This work can be successfully implemented in various ways, and this the one which combines almost all of them and present it in a simple way. The hardware components used are camera module, Raspberry Pi module, and an audio speaker.

VII. FUTURE WORK

This system is built at a basic to intermediate level by using simple components. But can be taken to a larger level by making use of high end GPUs for large computation in less processing time. Hence, the advanced version of this work can also be used to implement autonomous driving systems in vehicles. In real time environment, images have variations with shadows and light intensity which can cause hindrance in producing output, which can be solved using more intelligent algorithms. This can improve system efficiency and can be used in autonomous vehicles. System can be improvised by considering all other objects such as humans, other vehicles, etc. and take appropriate actions over it.

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