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Car Traffic Sign Annunciator

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Abstract— Automatic detection and recognition of traffic signs is an essential part of automated driver assistance systems which contribute to the safety of the drivers, pedestrians and vehicles. This paper presents the advanced driver assistance system (ADAS) based on Raspberry pi for traffic sign detection, recognition and annunciation. Such a system presents a vital support for driver assistance in an intelligent automotive. The proposed algorithm is implemented in a real time embedded system using OpenCV library. Proposed method introduced a new method for detection and recognition of traffic signs. Firstly, Potential traffic signs regions are detected by colour segmentation method, then classified using HOG features and a linear SVM classifier to identify the traffic sign class. The proposed system shows good recognition rate under complex challenging lighting and weather conditions. Experimental results on the accuracy of the road sign detection are reported in this paper.

Keywords- *ADAS; OpenCV; Raspberry Pi; HOG; SVM.*

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I. INTRODUCTION

Traffic sign detection and recognition have become a vital area of research in recent years. Due to growing number of vehicle owners, the road safety has become important matter of concern. To regulate the traffic and guide the driver, road sign plays a major role. These traffic signs have particular color (red, black, white, yellow and blue) and shapes (triangle, rectangle, circle, octagon), which attract the driver's attention and guide them. To increase road safety, Advanced Driver Assistance Systems (ADAS) are introduced. ADAS refer to various high-tech in-vehicle systems that increase road traffic safety by helping drivers gain better awareness of road and its potential hazards. Traffic sign detection and recognition is one of the subsystems of ADAS [7].

The field of traffic sign recognition is not very old with the first paper on the topic published in Japan in 1984 when the aim was to try computer vision methods for the detection of objects. Since then however, the field has continued to expand at an increasing rate [7].

Traffic sign recognition is used to maintain traffic signs, warn the distracted driver, and prevent his/her actions that can lead an accident. A real-time automatic traffic sign detection and recognition can help the driver, significantly increasing his/her safety. Traffic sign recognition also gets an immense interest lately by large scale companies such as Google, Apple and Volkswagen etc. driven by the market needs for intelligent applications such as autonomous driving, driver assistance systems (ADAS), mobile mapping, Mobileye, Apple, etc. and datasets such as Belgian, German mobile mapping [7].

II. RELATED WORK

Many techniques have been developed to detect and recognize road signs. Normally, the design of road sign detection and recognition algorithm is composed of two phases: detection and recognition. Color segmentation is the most common method applied for the initial detection of road signs.

Ghisio *et.* al proposed a procedure with three phases which composed of color segmentation, shape detection and sign classification using neural network. They use RGB color space in order to reduce processing time, and employ simple models of pattern matching, edge detection and geometrical cues in the recognition phase [2].

Lopez and Fuentes *et.* al detected the road signs in CIELab color space, and modeling color pixels using Gaussian distributions. Their approaches are tested using image sequences with extreme clutter [10].

Wu *et.* al converted images into HSV color space to detect the road signs. They also used morphological techniques to reduce noise environment. Finally, the road signs are extracted using geometric property [17].

Lalonde and Li *et.* al described a color indexing approach to isolate the road signs. Road signs are identified by comparing color histogram produced by the extracted road signs images with those pre-stored in a database [12].

Shneier *et.* al detected the road signs using rules that limit colors and shapes and require signs to appear only in limited regions in an image. Then, road signs are recognized using a template matching method and tracked through a sequence of images [13].

Farag and A. Hakim *et.* al used Bayesian approach for detecting road signs from input images based on color information. Scale Invariant Feature Transform (SIFT) is employed in order to extract a set of invariant features for detecting the road signs labels. Road sign recognition is done by matching the extracted features with previously stored features of standard signs [1].

Fang *et.* al studied an approach for detecting and tracking road signs in complex traffic scenes. In the detection phase, two neural networks are developed to extract color and shape features of traffic signs from the captured images. In the tracking phase, Kalman filter is used to track road signs that are identified in the preceding phase through image sequences [6].

Liu *et.* al applied Step Genetic Algorithm(Step-GA) and Simple Vector Filter (SVF) for recognizing road signs from moving images. The Step-GA code with search region limits is employed to detect the position and size of the road signs; their SVF was employed to segment the road signs colors [8].

Fawnizu Azmadi Hussin *et.* al used HSI color space and a simple algorithm based on region of interest (ROI) are used to detect the shape of road signs. The characteristics evaluation in the region of interest (ROI) will indicate the shapes of the road signs whether they are triangular, diamond, rectangular, square, circular or hexagonal. Library templates of a MATLAB-based algorithm are developed by considering shape measurements. The ratios of area and perimeter are finally determined to recognize the actual image of the road signs such as a crossroad sign, a stop sign, and others [3].

Table I. Summary of various detection and recognition methods

Authors	Year	Detection Algorithm	Recognition Algorithm
Eclasera and Salichs	1997	Color thresholding	Neural network
Benallal and Meunier	2003	Color segmentation	-
Escelera	2003	Genetic algorithm	Neural network
Claus Bahlaam	2006	Ada Boost algorithm.	Bayesian generative modeling.
Mourtarde	2007	Shape detection through Hough transform	Neural network
Arlicot	2009	color segmentation	SVM
Oruklu	2013	Color segmentation.	Template matching and Neural network
Chokri Souani	2013	Color segmentation	Neural network
A.T .Hoang	2014	Shape detection through rectangle matching algorithm	-
Karunalithika	2015	OpenCV Library is used for detection	Mobile based application
Rihab Hamida	2016	Color segmentation based on Xilinx System Generator	Simulink model based on Xilinx System Generator

Most of the previous work is done on the MATLAB software for detection and recognition of road traffic signs. As i want to develop the real time based portable system for road sign detection and recognition, I am not using the MATLAB software because it do not supports to every OS and requires large memory space for installation. For these reasons, I m using OpenCV software instead of MATLAB for image processing.

This paper is an extension to the previous work which provides the portable system for traffic sign detection, recognition and annunciation based on raspberry pi. In proposed method, firstly a color based segmentation method is applied to generate traffic sign candidate regions. Secondly, the Histogram Oriented Gradient (HOG) features are extracted to encode the detected traffic signs and then generating the feature vector. This vector is used as an input to an Support Vector Machine (SVM) classifier to identify the traffic sign class. This system provides several enhancements to the proposed shape classification methods in order to select the best technique with high efficiency and less processing time for the implementation in embedded systems.

III. METHODOLOGY AND COMPONENTS OF SYSTEM

A good recognition system needs to have a good discriminative power and a low computational cost. The system should be robust to the changes in the geometry of sign (such as vertical or horizontal orientation) and to image noise in general. Next the recognition should be started quickly in order to keep the balanced flow in the pipeline of Raspberry Pi allowing for processing of data in real time.

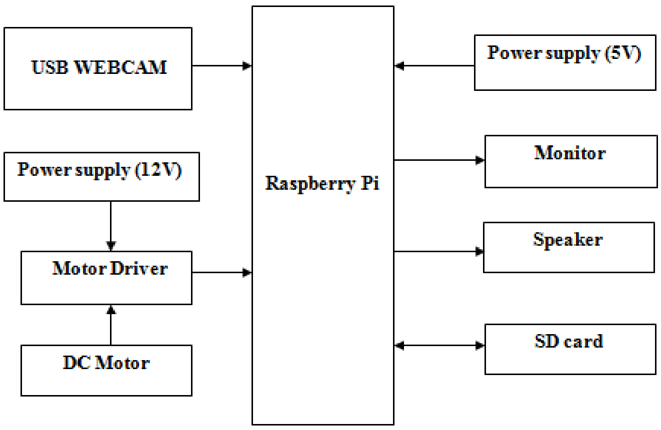


Figure 1. Constructional block diagram of Car Traffic Sign Annunciator System

Figure 1 shows the Constructional block diagram of Car Traffic Sign Annunciator System which consists of Raspberry Pi 3, Motor Driver L298N, USB Webcam, Power supply (5V and 12V), Audio power amplifier and speaker, two DC motors, Monitor (laptop). At first power supply is given to the raspberry pi by power bank (5V). Webcam is connected to raspberry pi through USB cable which will take the real time video in front of vehicle and extracts the sampling frames from video at certain rate. Whenever the traffic sign is capture it will go to the raspberry pi. On raspberry pi, there is OPEN CV library which has various algorithms like HOG, LBPH, SVM classifiers which will extracts the features of captured road traffic signs and give the results. GPIO of raspberry pi is connected to the motor driver for enabling and disabling the DC motors. Two motors are connected to the motor driver. The power supply of 12V is given through the batteries to the motor driver. Power supply is turned ON by the switch. Whenever the sign is recognized, accordingly the motor driver will take a action. There is a audio power amplifier and speaker for announcing the traffic signs. The potentiometer is for adjusting the sound frequency. And the sign will display on the monitor (laptop) [7].

A. Raspberry Pi 3

The Raspberry Pi is maybe the most motivating computer accessible today. Although the vast majority of the processing gadgets being utilized (counting telephones, tablets, and game consoles) are intended to prevent individuals from tinkering with them, the Raspberry Pi is precisely the inverse. It enables the client to push it, play with it, and make with it. It accompanies the apparatus expected to begin making ones possess programming.

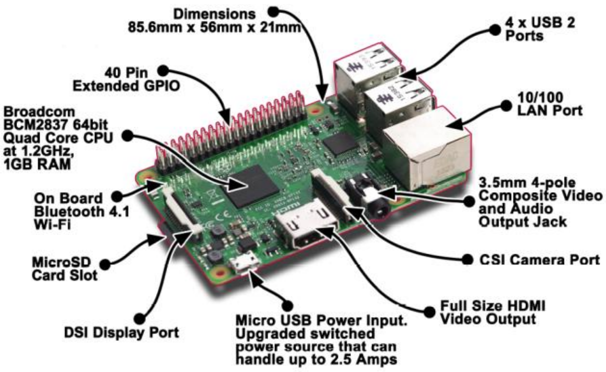


Figure 2. Raspberry Pi 3

The Raspberry Pi Foundation developed the Raspberry Pi which is a family of credit card-sized Single Board Computer (SBC) in the United Kingdom. Raspberry Pi Foundation''s Raspberry Pi was discharged in 2012. It was a huge hit and sold more than two million units in two years. Subsequently, the Raspberry Pi Foundation revised versions of the Raspberry Pi [16]. The latest one is Raspberry Pi 3 and it is shown in Figure 2.

Raspbian OS

Raspbian is a Debian-based computer operating system for Raspberry Pi. Since 2015 it has been authoritatively given by the Raspberry Pi Foundation as the essential operating system for the group of Raspberry Pi single- board computers. Raspbian was made by Mike Thompson and Peter Green as a free undertaking. The underlying form was finished in June 2012. The operating system is still under dynamic advancement. Raspbian is very enhanced for the Raspberry Pi line's low-performance ARM CPUs. Raspbian utililizes PIXEL, Pi Improved Xwindows Environment Lightweight as its fundamental work area condition as of the most recent refresh. It is made out of an adjusted LXDE work area condition and the Openbox stacking window supervisor with another subject and couple of different changes. The appropriation is transported with a duplicate of computer variable based math program Mathematica and a version of Minecraft called Minecraft Pi as well as a lightweight version of Chromium as of the latest version [16].

B. L298N Dual H-Bridge Motor Driver

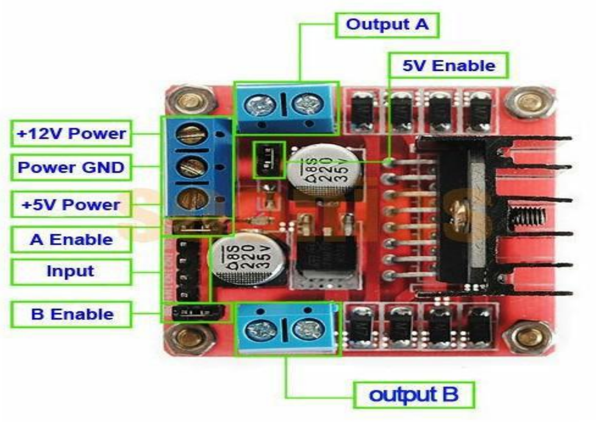


Figure 3. L298N Motor Driver,

The L298N is an incorporated solid circuit in a 15-lead Multi watt and Power SO20 bundles. It is a high voltage, high current dual full-bridge driver intended to Accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two empower inputs are given to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An extra supply input is given so that the logic works at a lower voltage. H-bridge controlled the direction rotation of the DC motor. When there is voltage applied across a load in either direction the DC motor able to move in clockwise or anti clockwise [9].

C. Dual Audio Power Amplifier

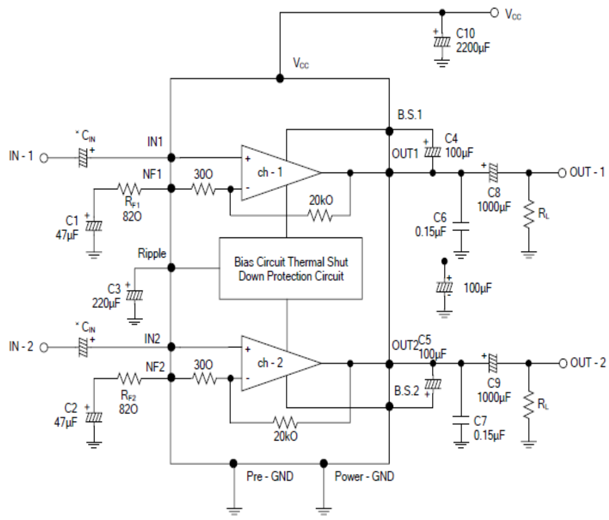


Figure 4. Circuit diagram of Dual Audio Power Amplifier

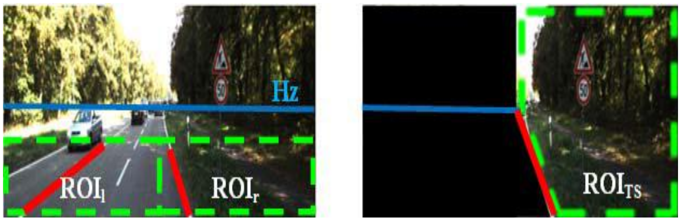
UTC A6283 is an audio power IC with built-in two channels created for convenient radio tape recording device. On account of the parts decrease and sip (Single In line Package), space justify is noteworthy. Warm close down security circuit is inherent. This IC can be utilized without coupling capacitor (C_{IN}). If volume slide noise occurred by input offset voltage is undesirable, it needs to use the capacitor (C_{IN}).

D. Traffic Sign Detection

The traffic signs detection aims to find out the potential road signs regions.

a) Delimitation of Region of Interest of traffic sign (ROITS)

We create a reduced search mask to perform the detection step and reduce the search effort for these signs through simple image processing techniques. In this manner, we apply a disposing of procedure to dismiss TSs that have a place with different streets. Consequently, we connected our proposed algorithm for lane limit detection proposed in [18]. Relying on the detected lane limits in the near region (ROI_r and ROI_l) (Figure 5 (a)), we used the right lane limit and the Horizon line (Hz) to draw a quadrilateral on the right side of the image (Figure 5 (b)). This quadrilateral is considered as our new Region Of Interest (ROI).

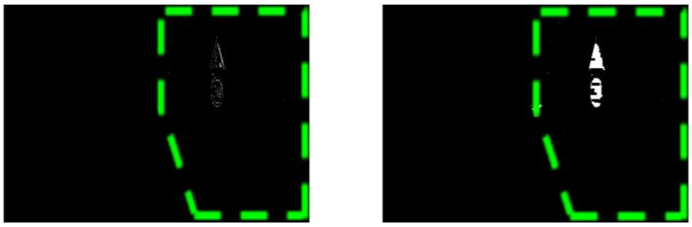


(A) Lane Limit Detection (B) Delimitation of ROITS

Figure 5. Delimitation of the Region of Interest (ROITS)

b) Segmentation

In this progression, we continued with shading division inside this ROI of traffic sign. Actually, the deliberate shade of a TS is frequently a blend of the TS original color and the additional outside lighting. In this way, the shading model for TS division ought to be appropriate chosen. As it is regularly known, the shading utilized as a part of TSs tries to capture the human attention.



a) HSV Thresholding of ROITS (b) ROITS after Closed Transformation

Figure 6. Traffic Sign Segmentation

In this manner, we chose the HSV shading space as it depends on human color observation [18]. In reality, the hue value is invariant to light and shadows variation in daylight [15]. Applying a thresholding on every one of HSV component, we segmented the TSs appearing on the ROITS (Figure 6 (a)). At that point we apply a closed morphology operation to have more compact areas of interests and eliminate interruptions (Figure 6 (b)).

c) Detection

This progression means to identify the exact area of the TSs. To accomplish this objective, an analysis of the segmented regions is carried out. Hence, we marked the associated areas so that all the associated applicant pixels are gathering as one potential region (using 8-neighbors). Next, a bounding box characteristic (height, width, area) is figured for every single potential regions.

Figure 7. Potential Traffic sign detection

Therefore, we characterize an arrangement of potential regions R = {R1, R2, …, RN} where N is the number of potential TSs regions. A few imperative guidelines in view of shape properties [12, 16] are applied to every potential region with a specific end goal to take out potential regions that cannot be a TS. In this way, for each potential region, we checked the accompanying standards:

- The height and the width of every potential TS region should be greater than 14 and lower than 100.
- The area of every potential TS region has to be greater than 30% and less than 80% of the corresponding minimum bounding box area.
- The rate of height and width of a potential TS should be an interval of [0.5, 1.5] Accordingly, these rules allow reducing the number of potential TS regions which helps accelerating the process and improving the accuracy. These regions are going to be the input of the next classifying step (Figure 7).

E. Traffic sign classification and recognition

The classification of potential traffic sign regions is a key step since it settles on a choice to keep or reject a potential traffic sign. To guarantee an unmistakable classification, we applied the Histogram of Oriented Gradients (HOG) operator to extract the HOG feature vector. Next, an SVM classifier is applied depending on the already extracted feature vector.

a) Histograms of Oriented Gradients (HOG)

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The Histograms of Oriented Gradients (HOG) is one of the notable highlights for object recognition. The HOG features imitate the visual information processing in the human brain. They can manage neighborhood changes of appearance and positions [18]. The appearance and shape of nearby object are regularly depicted somewhat well by the distribution of local gradients intensity or edge detection. In this manner, the HOG features are calculated using the orientation histograms of edge intensity in local region. Since that traffic symbols are composed of strong geometric shapes and high-contrast edges that encompass a range of orientations, we find that applying HOG features is suitable in our context of study. In our proposed technique, every potential TS region is standardized to 32×32 pixels. At that point, the region is isolated into 12×12 non-overlapping neighborhood regions. The HOG features are extracted from each one of the local region. Histograms of edge gradients with 9 orientations are calculated from each of 4×4 local cells. These histograms capture local shape properties and are invariant to small deformations. The gradient at each pixel is discretized into one of 9 orientation bins, and each pixel "votes" for the orientation of its gradient. The size of the HOG feature vector (N) is computed using following equation:

$$N = \left(\frac{R_{width}}{M_{width}} - 1 \right) \times \left(\frac{R_{Heigth}}{M_{Height}} - 1 \right) \times B \times H$$

Where R is the region, M is the cell size, B is the number of cells per block, and H is the number of histograms per cell. The values used were : R = 32×32, M = 4 × 4, B = 3, and H = 9.

b) SVM Classifier

In our investigation, we are interested to recognize the 25 risk and prohibitory TSs since the reduced concentration on them constitute the major accident-prone situations [12]. To construct our TSs recognition system, we have continued with SVM classifier on account of its execution in statistical learning theory. All things considered, Support Vector Machine is an efficient technique for classification [16] which carries out an implicit mapping of data into a higher dimensional feature space. Given a training set of labeled examples

A={(xi, yi), i= 1…n} where xi € Rn and *yi € {1, -1}*. Another test information x is classified using the decision function f(x) characterized by following equation:

$$f(x) = \text{sgn}\left(\sum_{i=1} a_i y_i K(x_i, x) + b \right)$$

Where i are the Lagrange multipliers of a dual optimization problem, and K(xi, x) is a kernel function. Given a nonlinear mapping that implants input information into feature space, kernels have the type of following equation:

$$K(x_i, x_j) = (\phi(x_i)\phi(x_j))$$

SVM finds a direct isolating hyper plane with the maximal margin to isolate the training information in feature space. b is the parameter of the ideal hyper plane. Since SVM classifier makes binary decisions, multi-class classification here is refined by a set of binary classifiers together with a voting scenario. In this way, we have represented each TS region by an HOG features vector. At that point, a SVM classifier is connected to discover the isolating plane that has maximum distance to the closest points (support vector) in the training set. Figure 8 shows results of classifying correctly two traffic signs.

Figure 8. Classified Traffic Signs

IV. Result And Analysis

The paper reports an Raspberry Pi based system for the traffic sign detection, recognition and annunciation In experiments of this project, the images were captured at different distances between camera and road sign. Hence, our input data set is realistic. Following Figures shows some example of detected road signs.

Figure 9. Detection of Left Sign

The 'Left Sign' is detected, recognized and announced successfully. Figure 9 shows the detected sign, its name and distance between camera and sign. Whenever the system detects 'LEFT' sign, car will take a left turn.

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Figure 10. Detection of Speed Sign 30

The 'Speed Sign 30' is detected, recognized and announced successfully. Figure 10 shows the detected sign, its name and distance between camera and sign.

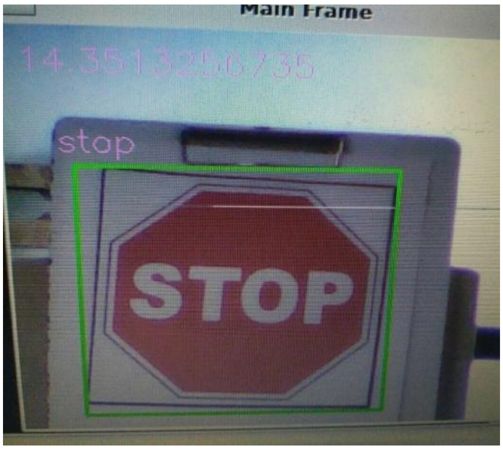

Figure 11. Detection of STOP Sign

The 'STOP Sign' is detected, recognized and announced successfully. Figure 11 shows the detected sign, its name and distance between camera and sign. Whenever the system detects 'STOP' sign, it will take a action by stoping the system immediately.

Figure 12. Detection of School Ahead Sign

The 'School Ahead Sign' is detected , recognized and announced successfully. Figure 12 shows the detected sign, its name and distance between camera and sign.

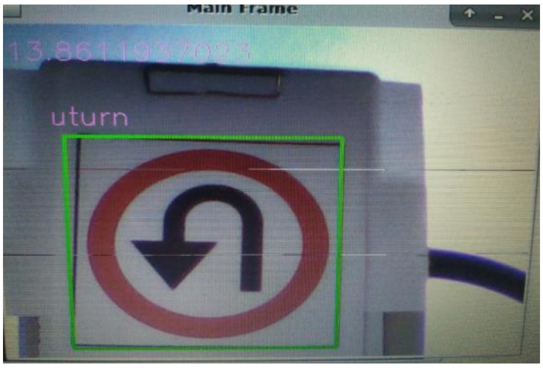

Figure 13. Detection of UTURN Sign

The 'UTURN Sign' is detected, recognized and announced successfully. Figure 13 shows the detected sign, its name and distance between camera and sign. Whenever the system detects 'UTURN' sign, car will take a U turn.

Distance between camera and detected traffic sign (D) is calculated by following formula:

$$D\ (\text{Inches}) = \frac{(\text{known width} * \text{focal length})}{\text{per width}}$$

Where, Known width of object = 7.0
Focal length = 427.002973284
Per width = x_cord + width

The Table2 shows the result of detection, recognition and annunciation of traffic signs. And also shows the distance between camera and detected traffic sign.

Table II. Result of Detection and Recognition of Traffic Signs

Various Traffic Signs	No. of signs	Detected signs	Recognized Signs	Announced signs	Distance betn camera & sign (Inches)	Success Rate (%)
Left	5	5	4	4	13.49	93
Right	5	5	4	4	14.10	93
Stop	5	5	5	5	14.35	100
Uturn	5	5	4	3	13.86	89
Pedestrian Prohibited	5	5	4	3	11.73	95
School ahead	5	5	3	4	14.99	94
Narrow road ahead	5	5	4	4	14.88	94
Falling rocks	5	5	4	4	15.16	95
Dangerous dip	5	5	3	3	13.23	92
50	5	4	3	3	15.40	89
30	5	5	4	4	15.28	95
Total	55	54	42	40	-	95.71

Table III. Comparison with Respect to Detection and Recognition Accuracy

Method	Recognition Accuracy (%)
Proposed method	95.71
[5]	90
[4]	86.7
[8]	92.79

The proposed framework has been compared with [5], [4] and [8] in respect to recognition of Road signs. Their success rate of recognition were 90%, 86.7% and 92.79%

respectively. The comparison between proposed method and [5], [4] and [8] with respect to average recognition accuracy has been shown in Table 3.

IV. CONCLUSION

The traffic sign recognition is a very helpful driver assistance technique for increasing traffic and driver safety. This project provides the portable system for traffic sign detection, recognition and annunciation based on raspberry pi. As compare to the other softwares such as MATLAB, Xilinx etc for image processing, OpenCV software has more advantages in terms of memory space, supportable to every OS, less processing time, high efficiency. Proposed method introduced a new method for detection and recognition of traffic signs. Potential traffic signs regions are detected, then classified using HOG features and a linear SVM classifier. The proposed system shows good recognition rate under complex challenging lighting and weather conditions. This system has advantages such as high stability, good reliability, high precision, a higher real-time of driver assistance, high degree of automation. This is Cost-effective and also provides a long-time and continuous observation. This system can be used in Public transport, Ambulances, Cabs etc.

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