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Traffic sign Detection using CNN

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Abstract: ***Lane Detection and Traffic sign detection are the essential components in ADAS .Although there has been significant quantity of analysis dedicated to the detection of lane detection and sign detection in the past, there is still need robustness in the system. An important challenge in the current algorithm is to cope with the bad weather and illumination. In this paper proposes an improved Hough transform algorithm in order to achieve detection of straight line while for the detection of curved sections, the tracking algorithm is studied. The proposed method uses Hybrid KSVD for removing the noise and Hybrid Lane Detection Algorithm is used for identifying the lanes and CNN based approach is used for the Traffic sign Detection. The proposed method offers better Peak Signal to Noise Ratio (PSNR) and Root Mean Square (RMS) in contrast to the existing methods.***

Keywords: ***Traffic-Sign, Convolution Neural Network (CNN),Hybrid KSVD, Lane Detection, Hybrid Lane Detection Algorithm (HLDA)***

I. INTRODUCTION

Now a day's most of the researchers focus on the increasing need for traffic safety systems to reduce the risk of accidents. There are large numbers of vision based systems for vehicle control, collision avoidance and lane departure warning, which have been developed during the last two decades. Recently, many Driver Assistance systems (DAS) are up-and human drivers are also coming forward to work together, e.g. Forward Collision Warning System (FCWS) and on-board Lane Departure Warning System (LDWS). Such systems are used to preventing driver's mistakes and reduce traffic accidents effectively. Many Methods are proposed by various authors in the literature. Most of them can be applied only to noise-free images and do not yield better results in case of challenging situations. Detecting and recognizing traffic signs automatically are important in managing traffic-sign inventory. It involves less effort but offers exact and well-timed results. In the area of Computer Vision, discovery of traffic sign is a current problem of research.

II. LITERATURE REVIEW

The lane detection can be done using various approaches such as the Feature-based; Region-based; Combination of the both, etc.

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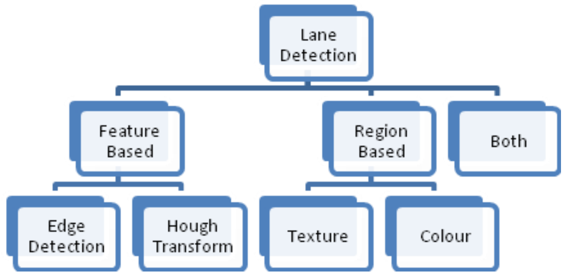
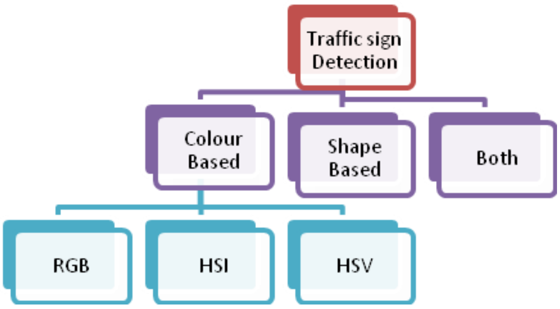


Moveh Samuel (2018) proposed an Edge detection based method for detecting the lane. In this paper the author had compared four edge detection techniques for detecting the lane ie Sobel, Canny, Prewitt and Roberts has been evaluated for edge detection and Hough transform based lane detection are applied .Time taken for detecting the edge and Time taken for the overall lane detection are considered .The author has concluded that from results obtained, Roberts edge detector proved to be more suitable in terms of simplicity, image quality and speed, whereas Canny, Sobel and Prewitt on the other hand prove to be the more sensitive and time consuming. But in cases where simplicity and speed are not dominant factors, Canny, Sobel and Prewitt could be very suitable and robust for lane detection purposes

Md. Rezwanul Haque(2019) has proposed a lane detection system using computer vision-based technologies that can efficiently detect the lanes on the road. Different techniques like pre-processing thresholding, perspective transform are fused together in the lane detection system. Gradient and HLS thresholding detect the lane line in binary images efficiently. Sliding window search is used to recognize the left and right lane on the road. The cropping technique worked only the particular region that consists of the lane lines. a real-time system with hardware implementation will be developed that will capture the images from the real-time scenario and detect the lanes based on the proposed technique as well as generate a warning for the concerned persons (drivers or visually impaired people). Suvarna Shirke(2019) has presented the lane detection algorithm the first process is a preprocessing step and next step is the segmentation method, named region based iterative seed, for the detection of multi-lanes from the images based on an iterative approach and the author had also compared the results with the existing system. Suvarna Shirke, R. Udayakumar(2019) has presented the lane detection algorithm the first process is a pre-processing step and next step the author has used(EW-CWA) Under DCNN(Deep Convolutional Neural Network) technique are used to find the multi lane detection and region based iterative seed. For the detection of multi-lanes from the images based on an iterative approach are also used to find the multilane and then both the approaches which are combined based on entropy based fusion method in order to have a effective multilane detection

Traffic sign Detection



Difficulties Faced during Traffic sign detection

1. Road Sign may appear damaged
2. Occluded by other Objects
3. When the sign is very small it will be Unrecognizable
4. Similarity and standardization of signs

Ellahyani et al (2016) have presented a Traffic Sign Detection and Recognition (TSDR) technique that involves three steps. The image is segmented using HSI colour space. The traffic signs are detected by handling blobs. Finally, the traffic signs are recognized. Invariant geometric moments are used for classification instead of Machine Learning (ML) algorithms. To determine descriptor, HOG features are extended to HIS (Hue Saturation, Intensity) colour space and combined with Local Self-Similarity (LSS) features. RF(Random Forest) and Support Vector Machine (SVM) are used for classification.

Yuan et al (2016) have dealt with video-based traffic sign detection. They have dealt with improving detection performance by using contextual information. The tracking performance and accuracy of localization are improved using a framework that contains offline and online detectors. Motion predictor is developed for detecting and tracking traffic signs. For better classification, intra-frame fusion method is proposed.

Tabernik&Skočaj (2019) have addressed the issue of automatically managing traffic-signs. They have used Convolutional Neural Network (CNN) approach to detect and recognize images. They have propounded improvements to detect traffic signs for better performance. They have applied to detect 200 traffic-sign categories

Advantages of Colour Based Traffic Sign Detecting

- Low Computing
- Good Robustness

Disadvantages

- Strong Illumination

Advantages of Shape Based Traffic Sign Detecting

- Good Robustness

Disadvantages

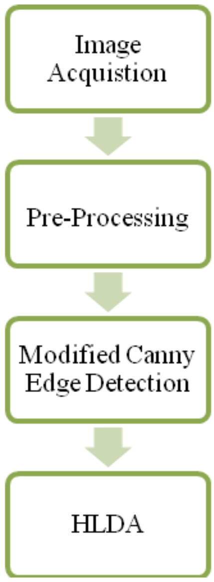
- Sensitive to Noise

Advantages of Both Traffic Sign Detection

- It Gives better Results

III. METHODOLOGY

3.1) Lane Detection Module



A) Image Acquisition

The image are taken from the data set

B) Pre-processing to remove noise

Images are pre-processed to remove noise using existing algorithms like Discrete Cosine Transform (DCT) and K-SVD. The proposed Hybrid K-SVD yields better results

i)K-SVD Algorithm

K-SVD, a dictionary learning algorithm is designed for building sparsely represented dictionaries using singular value decomposition. It is a generalized form of K-means clustering, and it iteratively interchanges between sparse representation of input data and updating the atoms in the dictionary (Aharon et al 2006, Rubinstein et al 2010).

The K-SVD tries to iteratively minimize the cost function by coding the signals using the Orthogonal Matching Pursuit (OMP) algorithm based on the initial estimate of the dictionary. The main aim is to reduce the error as well as maintain a sparsity constraint.

$$\min_{D,X} \|Y - DX\|_F^2 \text{Subject to } \|x_i\|_0 < T,\ \forall_i \quad (5)$$

Where,

X - Formed by column stacking all vectors 'x_i'

$\|.\|_F^2$ - Frobenius norm square

Frobenius norm square is the square of every element in the matrix

Once sparse coding stage is finished, the atoms of the dictionary are updated one at a time so as to reduce error.

Given an initial estimate, say 'D', the cost function is broken down into multiple optimization problems as shown below.

For i = 1, 2, ...,N,

$$\min_{x_i} \|y_i - Dx_i\|_2^2 \text{subject to } \|x_i\|_0 \quad (6)$$

After finding a coding vector, the dictionary is tuned to reduce the error.

Error term is represented as,

$$\|Y - DX\|_F^2 = \|E_k - d_k x_k^T\|_F^2 \quad (7)$$

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Instead of performing SVD on the matrix (E_k), matrix is manipulated to change it into a form where SVD can be directly applied.

$\|Y - DX\|_F^2 = \|E_k^R - d_k x_k^R\|_F^2$ (8)

'E_k^R' Considers only the errors of signals supported by the atom 'd_k'.

If the signal vectors are of high dimensions, then the size of the dictionary should be increased to support stable rebuilding. This may not suit the situation as the computational complexity increases with the size of vectors and the number of atoms in the dictionary.

To deal with this issue, the noisy image can be broken into patches and the vectors of each patch are considered to be signals, thus reducing the dimensionality of each atom. The size of the patch should be capable of encoding sufficient details of the underlying signal. Blocking is reduced by choosing overlapping patches.

An image is a set of signals 'Y', the denoising problem finds a collection of patches 'Z' given by,

$y = Z + \eta$ (9)

Where,

η - Noise that corrupts patches

The noise over the whole image is taken as zero mean Gaussian noise. The patches 'Z' of the denoised image is found using optimization that reduces the cost function.

$\hat{X},\hat{Z} = \arg\min_{X,Z} \|Z - Y\|_2^2 + \lambda \|DX - Z\|_F^2 + \sum_i \mu_i \|x_i\|_0$ (10)

ii) Discrete Wavelet Transforms (DWT)

Discrete Wavelet Transform (DWT) is used in numerical and functional analysis, wherein wavelets are discretely sampled. The main merit over Fourier transforms is the temporal resolution as it deals with both frequency and location.

It differs from Continuous Wavelet Transform (CWT), wherein the signal is broken into equally orthogonal collection of wavelets. Hence, it is otherwise called Discrete-Time Continuous Wavelet Transform (DT-CWT).

The wavelet is built from a scaling function. It is essential that the scaling functions are orthogonal to discrete conversions.

$\phi(x) = \sum_{k=-\infty}^{\infty} a_k\, \phi\,(S_x - k)$ (11)

where,

S - Scaling factor (taken as 2).

The region between the functions must be normalized and the scaling function is orthogonal to its integer translates.

$\varphi(x) = \sum_{k=-\infty}^{\infty} (-1)^k a_{N-1-k} \varphi(2x - k)$ (12)

where,

N - Even integer

The wavelets that are used to decompose signal form an orthonormal basis.

iii) Hybrid KSVD

The proposed Hybrid KSVD is a combination of K-SVD and Discrete Wavelet Transforms (DWT)

C) Edge Detection

Canny edge detection

The Canny edge detector operator(Canny 1986)is a multi-stage algorithm to identify edges in an image. The author has dealt with computational method of detecting edges.

It is used in extracting beneficial structural information from diverse vision objects. It intensely reduces the quantity of data. The edge detection on diverse vision systems are comparatively similar(Canny 1986).

The general criteria for edge detection include:

1. The error rate should be minimized by finding a number of edges
2. The edge point should be precisely placed on the centre of the edge.
3. The edges should be uniquely marked avoiding false edges

Calculus of variations is used to find an optimization function. The optimal function is the sum of exponential terms approximated by Gaussian's first derivative.

Canny edge detection algorithm provides dependable detection. It yields optimal solution and is simple.

The algorithm includes the following steps:

1. Remove noise by smoothening images using Gaussian filter
2. Compute the intensity gradients of the image
   G_x - First horizontal derivative
   G_y- First vertical derivative

The edge gradient and direction for each pixel is found as follows:

Edge_Gradient (G) = $\sqrt{G_x^2 + G_y^2}$ (13)

Angle (θ) = $\tan^{-1}\left(\frac{G_y}{G_x}\right)$ (14)

3. Circumvent false detection by using non-maximum suppression
4. Find potential edges using double threshold
5. Use hysteresis to track edges by destroying weak edges and those not connected to strong ones

i) Modified Canny Edge Detection Method

Canny method of edge detection is a renowned edge detector; wherein in addition to filtering, optimization stages are also defined. It widens the edges to a width of One-pixel and makes them continuous by removing spaces between edge fragments (Mokrzycki&Samko 2012).

The Canny algorithm is modified. The edges are represented in the form of tree-based structures like beamlets. The number of pixels is reduced by using Ramer-Douglas-Peucker algorithm on the edges sensed by the Canny method. The edges are obtained as curves for easy storage in the beamlet. Binarization with hysteresis is the final stage of Canny algorithm. The pixels are scanned and their values are checked. A pixel with value more than or equal to threshold is found, it is taken as the edge pixel. Neighbours, approximately 8 numbers. are checked and their values are compared with 'T_L'. Pixels with value greater than or equal to 'T_L' aretaken as edge pixels. The neighbors are scanned recursively. A sequence of neighboring pixels that form an edge is found.

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Once the last pixel is reached, other edges are found and labelled. The reduced number of pixels is passed to the Ramer-Douglas-Peucker algorithm. An edge with minimum number of points is formed and is signified by a polygonal curve.

D) Hybrid Lane Detection Algorithm

(HLDA)

In this paper, a Hybrid Lane Detection Algorithm (HLDA) is proposed for lane detection. Initially, the support points are extracted to arrive at postulates with two lines. Haar-like features are involved and integral images are used to remove redundancy in computing. The candidate points that act as support points to get lines that are mined using Haar-like features. The algorithm uses rules to verify hypothesis. It is assumed that the camera is fit at the center of the vehicle. Once verification is done, then each lane is perceived. Finally, the algorithm identifies lane departure and intimates the driver when a vehicle moves out of the lane.

a)Candidate Extraction

The nature of the gray level of the road surface is always homogeneous. The lane has intensity values more than the road surface. Thresholding can be done to identify lanes. But this method may not be robust in case of changes in illumination. On the other hand, a highly responsive filter can be used to deal with intensity value. In this paper, a steerable filter is used instead of edge detectors as they are less sensitive to noise.

b)Local Search

A local search region is set to deal with the complexity in the computation of the integral image and the chances of incorrect detection in case of outliers. Only 3 local regions for each lane are taken for searching. The computational cost goes down as the integral image is partly computed only for these 3 regions. Traffic markers in the middle of the lane are removed.

c)Hypothesis Generation

The lanes are calculated from the points identified using the following equations.

$$l_1 = p_1 \text{ x } p_3 \qquad (16)$$

$$l_2 = p_4 \text{ x } p_6 \qquad (17)$$

where,

'p_i' - Homogeneous coordinate of point 'i'.

'l_1' and'l_2' - Left and right lanes

The vanishing point is calculated.

$$v = l_1 \, x \, l_2 \quad (18)$$

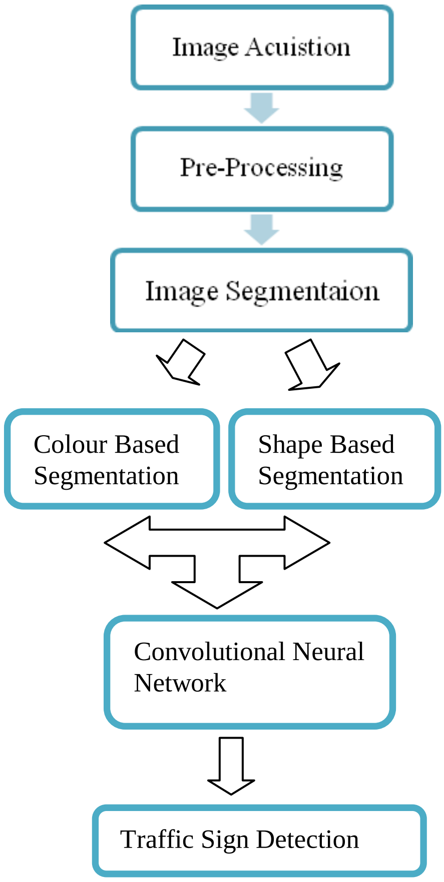
d)Hypothesis Verification

Hypothesis verification is done for two lanes and the vanishing point 'v'. It is done to ensure the correctness of the extracted lane by computing the distance between a point and a line.

e)Lane Departure Detection

After detecting the lanes, the lane departure detection is done. Initially, a horizontal center line is defined to decide whether the vehicle is within the lane. When a vehicle moves out of a lane, there is an increase in the distance between the vanishing point and the horizontal center line.

3.2 Traffic Sign Detection



Flow Chart

There are diverse methods to detect traffic signs including color based and shaped based schemes.

a) RGB based Segmentation

In RGB based colour detection, the color coordinates are given by imaging sets. They include the sensor data sent to a set of filters, which act as an counterpart of human colour discernment and duplication. This can be achieved by modulating 3channels corresponding to colors Red, Green and Blue. Two colors can be compared using Euclidean distance.

$$\Delta C = \sqrt{\Delta R^2 + \Delta G^2 + + \Delta B^2} \quad (19)$$

Some issues arise with matching human perception of colour differences. Humans are more sensitive to some colours, wherein the sense in difference is better. Colour changes are different on diverse areas in the colour space.

As the Euclidean distance is standardized and isotropic in the RGB color space, these shades in the difference between colors cannot be reproduced.Different alternatives dealing with these challenges namely, HSI, Lab and Luv color spaces are dealt with.

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The human insight of color is interpreted into figures. Lab and Luv are used to define space, wherein the Euclidean metric gives the difference between colours.

There are other methods of color representation like Smeulders and Gevers(Gevers&Smeulders 1999).A set of color invariants is generated using results of a color invariant derived from a reflectance model.

b) Shape based Detection

To detect shapes, Machine Learning (ML) algorithms like Support Vector Machine (SVM) and K-Nearest Neighbours (KNN) are used.

i)Support Vector Machine (SVM)

Support Vector Machines (SVMs) is one of the best methods for classifying patterns, and is used in many applications.

It is a supervised model allied with learning algorithms to analyze data and identify patterns. The kernel parameters used in training has a greater impact on the classification accuracy.

Feature selection also influences the classification accuracy. SVMs suggested by Vapnik (1995) are used in a variety of problems including pattern recognition (Pontil&Verri 1998), bioinformatics (Yu et al 2008) and text categorization (Joachims 1998).

It classifies data into different classes by finding support vectors that belong to a set of training inputs that sketch a hyper plane in the feature space. It fits the hyper plane to the training data using a kernel function.

SVMs are also suited for non-linear classification by indirectly mapping the inputs into high dimensional feature space.

ii)K-Nearest Neighbours (KNN)

K-Nearest Neighbours (KNN) is a technique that keeps in store the possible instance and classifies them based on the similarity measure like distance function. It has been used for long in numerical approximation and pattern identification from1970s.

An instance is classified based on the highest vote of its neighbours and assigned to the class that is familiar amongst its 'K' nearest neighbours. In case K = 1, then the instance is allocated to the class of its nearest neighbour.

c)**CNN(Convolutional Neural Network)**

It is seen that the deep learning methods yield better performance, though they demand more computing resources. These approaches may deal with a single image, which may not suit real-world applications. A unified computational framework using Conventional Neural Network (CNN) is proposed for detecting, tracking and recognizing traffic signs. Cameras are mounted on moving vehicles.

There are 3 elements involved in the convolution operation:

- ✓ Input image
- ✓ Feature detector
- ✓ Feature map

A feature detector is considered as a window with 9 cells.

- ✓ The feature detector is placed on the image at the top-left edge. The numbers of cells where the feature detector and the input image match are found.
- ✓ The matching cells are moved to the top-left corner in the feature map.
- ✓ The feature detector is relocate done cell right and the process is repeated. As it is moved one cell at a time, it is the stride of one pixel.
- ✓ After going through the whole first row, the same process is repeated in the next row.

The following steps are involved in detecting traffic signs using CNN.

- ✓ A traffic sign image is taken as input
- ✓ The image is divided into regions which are considered as separate images
- ✓ All these regions are passed to the CNN and classified into various classes
- ✓ Once the regions are divided into corresponding classes, the regions are combined to get the original image with the sensed objects

Convolution is based on a function derived from two functions. It states how the shape of one is changed by the other. The process of Convolution is given by,

$$(f * g)(t) = \int_{-\infty}^{\infty} f(\tau)g(t-\tau)d\tau \quad (20)$$

IV. RESULTS AND DISCUSSION

The performance of the proposed method is measured in terms of Peak Signal to Noise Ratio (PSNR) and Root Mean Square (RMS).

Table 1: Noise reduction

[1] S. **No**	**[2] Algorithm**	**[3] PSNR**	**[4] RMS**
[5] 1	[6] DWT	[7] 36.4	[8] 0.35 6
[9] 2	[10] KSVD	[11] 37.2	[12] 0.33 2
[13] 3	[14] H-KSVD-DWT	[15] 39.4	[16] 0.21 3

Image sign detection, using feature extraction based (color, texture, shape, wavelets) using optimization algorithm based sign detection.

The following Figures show the Screenshots of Lane detection (Figure 1), Vehicle detection with count (Figure 2), Pedestrian detection (Figure 3), Give way Sign detection (Figure 4), Stop (Figure 5) and No stop Sign detection (Figure 6).

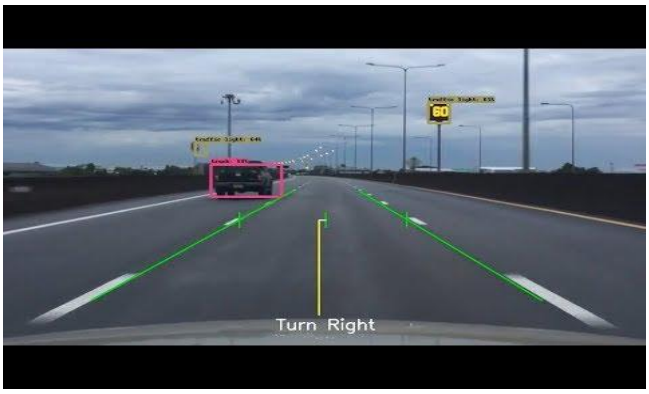

Figure 1: Lane detection

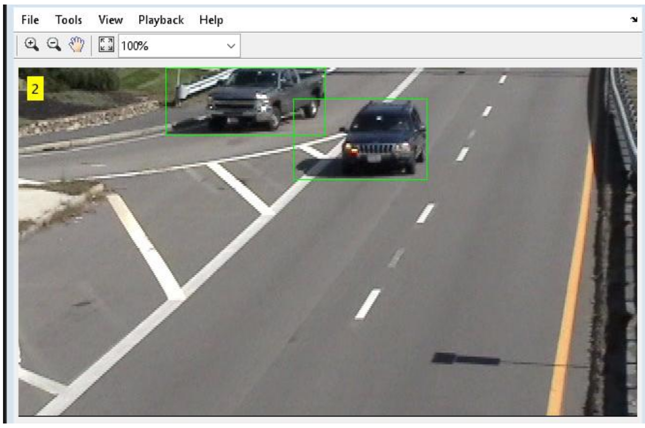

Figure 2: Vehicle Detection and Count

Figure 3: Pedestrian Detection

Figure 4: Give way Sign Detection

Figure 5: Stop Sign Detection

Figure 6: No Stop Sign Detection

V. CONCLUSION

In this paper an improved Lane detection algorithm and Traffic sign detection has been proposed .Here we focused on handling two real driving environment challenges: illumination and roads geometry The noise is removed using Hybrid KSVD algorithm. Lanes are detected using Hybrid Lane Detection Algorithm (HLDA).and for Traffic sign Detection Convolutional Neural Networks (CNN) is proposed The proposed scheme yields better results in terms of PSNR and RMS in contrast to the existing schemes

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