Traffic Sign Detection and Recognition Using Artificial Neural Fuzzy Network

Dr. K Bhanu Rekha
Department of Electronics and Communication Engineering
Presidency University,Itgalpur Rajanakunte, Yelahanka, Bengaluru,Karnataka 560064, India

Dr. Safinaz S
Department of Electronics and Communication Engineering
Presidency University,Itgalpur Rajanakunte, Yelahanka, Bengaluru,Karnataka 560064, India

Abstract- Object Detection is a key challenge in the field of Computer vision. Detection of the same object in different scenes becomes difficult due to variation in orientation, lighting, background, and occlusion. With the advent of machine learning and neural networks, we can tackle such issues efficiently. As imparting automation to machines to make it more and more independent has been a dream to sustain technology and easy the life of mankind. A lot of attention is drawn towards recognizing, extracting and classifying an object of interest. For an automated system such as driverless car, this task is accomplished by training the system to identify a particular Region of Interest (ROI) from various perspectives under different lighting, backgrounds, and occlusion. ROI detection deals with extracting individual objects of interest in a scene and ROI classification deals with categorizing objects belong to various classes. The algorithms developed can be divided into two phase, viz. training phase and testing phase. In the training phases, a predetermined set of images belonging to a particular class is trained and stored in a database. The trained set is used identify specified object in any given scene.

Keywords – Region of Interest (ROI), Machine learning, Neural networks

I. INTRODUCTION

The objective to localize and classify the objects in an image scene is pipelined into three stages: region selection, feature extraction and classification.

- Region Selection involves processing single sub-region of an image and leaving other regions unchanged. The sub-regions is filtered by creating a binary mask which is same size as the portion of image you want to extract. This is performed by defining the ROI pixels set to 1 and other pixels set to 0. This can significantly increase the performance of a training algorithm.

- Feature Extraction transforms the ROI into set of features. These features have distinct properties that help in categorizing different class of data present in an image. It also helps in representing large data into reduced sets of features, which summarize most of the information contained in the original data.

- Classification helps in distinguish a target region from all other regions. It makes the representation more hierarchical semantic and informative for visual recognition[1]

DESIGN AND IMPLEMENTATION

In this paper, we present a real-time traffic sign recognition system consisting of detection and classification modules [3]. The model automatically identifies different traffic sign under various lighting, background and occlusion based on trained dataset. The complexity is very low which is appropriate for real-time applications.

The three main stages of detection and recognition system [7][9] is shown in the figure1.

Figure1. Tracking and Detection system

Detection Phase: The initial stage in any object detection and recognition system is confining the image regions of interest from natural scene image input. In this stage ROI actually localized. As object detection has specific color attributes and shape these inherent characteristics distinct from other objects of non interest. These unique characteristics separates them other background scenes, which makes it suitable for processing automatically.
Tracking Phase: The tracking increases the robustness of detection system by feedback process which continuously monitors the candidate of interest in multiple frames. The accuracy of detection are shown up more than once. The computation time can be reduced by eliminating the frames if the object is not shown up.
Classification Phase: Once object is localized, we employ classification method which determines the accuracy of detection. Classification technique is based on set of features or certain characteristics of object to be detected.

As illustrated in the figure 2 detailed block diagram of Traffic sign detection and recognition is shown. At first, a raw database is developed by collecting set of traffic sign symbols at different circumstances that is affected by illumination, vandalism, posture and bad weather conditions as shown in figure 3. The raw database which is classified and used for training the system. The system can capture image from the camera mounted over the car and are given as the input to the system [5].

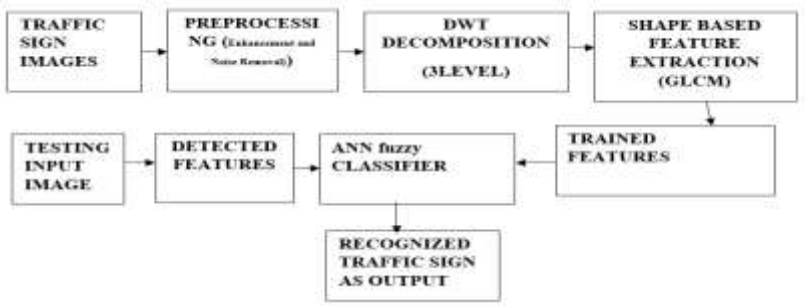

Figure 2. Block Diagram Traffic Sign Detection and Recognition System

Figure 3. Raw Traffic sign Database

II. Proposed Algorithm

The captured image in the real world scene is processed in following steps:
Step1: As a preprocessing step the input image is normalized in contrast and brightness effects. While dealing with color images, a color space transformation [6][12] (e.g. RGB to LAB color space) may help get improved results. Further, to reduce the computation an input image is cropped and resized to a fixed size. Resizing to fixed size image is important to perform feature extraction. Red band, Green band, blue band are separated from the image.

After separating the bands, histogram is computed for all the three bands separately. For better visualization an image is enhanced by using histogram equalization. The histogram equalization technique uniformly distributes the image pixel value over the scale from 0 to 255, thus increasing visual perceptional information.

Step 2: An important problem in computer vision is to recognize the sub-regions that represent ROI. This is easily accomplished by humans but surprisingly difficult for computers. Sub dividing an image into sub regions is called segmentation. Ideally, the subdivision represents either the partial ROI or entire ROI. Object of interest in an image is obtained by binary image masking using appropriate segmentation. The most popular binary masking operation can be obtained using thresholding that sets the points of interest to 1 and out of range to 0. This helps to separate the traffic sign i.e ROI from its background as shown in figure 4. For thresholding to be effective it is necessary for the image to have sufficient contrast and as we know the intensity level's range differs betweem salient regions[20] and background.

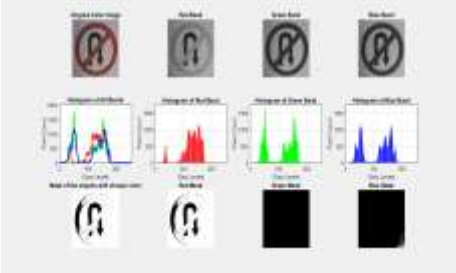

Figure 4. Preprocessing RGB color band with its corresponding histogram and Masking helps to identify ROI

Step3: As traffic sign images has to be detected from real scene, as we are capturing the image from a moving vehicle [13] [14]. These captured scene may include variety background and foreground or been deflected or faked by the lights, or contains incomplete object to be detected [10]. The primary phase is tough as we need to locate the object of interest from real scene, thereafter identify and distinguish the sign. Localizing the object of interest in an image scene is difficult without the enough prior information for the system. Thus segmentation is employed as unsupervised method to determine the regions without prior information. After the partitioning the regions , the next step is to predict whether the detected region contains the object of interest.The segmentation method [11]and the corresponding ROI identification methods are presented as follows.

Step 4: The features are properties which describe the whole image. In the image analysis, one requires feature extraction method to reduce the processing time and complexity [8]. This is done in order to get the most important features in the image. The input image is decomposed into 3 levels using Discrete wavelet transform (DWT) [21]. The decomposed image is used to acquire Gray level co-occurrence matrix (GLCM) to extract image features. Following are the textural features Energy, Entropy, Contrast, Homogeneity, Correlation, Shade and Prominence that can be used for training Neural Networks.

Step 5: Based on the inputs from GLCM, ANN classifier classifies the input image scene has object of interest or not. Further, segmentation extracts traffic sign region from the image. The fuzzy c mean algorithm proposed gives better accuracy in predicting the signs in the clusters defined. The extracted cluster which shows the predicted traffic symbols is further detected and classified by morphological operations.

Artificial Neural Fuzzy Classifier: The skill of identifying and classifying specific object in a scene is a automatic process for our human brain [4]. We use this process all the time. But for machines it is a challenging task. For developing an intelligent system [2] computer engineers need to be train the system to identify the object of interest in scene. And this is a tedious task for the developers.

The AI system automatically learns from the trained dataset by discovering the patterns and features of object of interest. Further process is improved and fine-tuned as it is exposed to more data, like how human learn from the experience. The AI system minics the human brain and labels the data based on the features extracted. More the number of images it is trained, accurate the prediction and validation. The training has to choose the object from different scenarios, affected by noise, blurring, occlusion, which will help AI understand change in their size, shape, color and coordinates don't affect its classification [16][17]. Despite, the whole process of AI training involves lots of resource requirement with increase power and computation time. But at the brighter side, without human intervention automatic learning and improvisation pre-trained model occurs which accelerates the process. Artificial Intelligence is progressing with GPU-graphics processing unit which allows to manipulate the memory and accelerate graphics processing.

In the proposed methodology, we employ ANN to classify the Traffic sign from unwanted objects and background. ANN are parallel adaptive networks of simple non-linear computing element. As Neural Network adapts multiple training and classification algorithm. The input to the neurons are the extracted features of the image using GLCM. The activation function helps to process the hidden layers of the network. Each node in the network is a binary sigmoid function defined by sgn=1. The output of activation function limits all the nodes in the network between 0 and 1. The ability of handling uncertainty is modeled by fuzzy logic. The neural network and fuzzy logic helps to mimic human brain to promise better accuracy in detection and classification of traffic sign in a given scene.

Fuzzy C Mean Clustering: In proposed fuzzy C mean (FCM) clustering method is an effective technique for shape detection segmentation[18]. FCM intends to find fuzzy partitioning of a given pattern-set by minimizing the Jn objective function. Supposed that the image I= {i1, i2, … ,im} is a collection of m pixels, the eigen value of the given image is ij , c defies the number of categories, and P = {p1, p2, … ,pc} is the cluster center collection. Let objective function Jn satisfy the constraint. The algorithm produces an optimal c partition as it is an iterative clustering method by produces an optimal c partition by minimizing the weighted within group sum of squared error objective function JFCM

$$J_n = \sum_{i=1}^{c}\sum_{k=1}^{m} {\mu_{ik}}^n [\![i_k - p_i]\!]^2$$

Where U, the fuzzy partition matrix, is compute as $U=[\mu_{ik}] \in M_{fcm}$

$$p_i = \frac{\sum_{k=1}^{m} {\mu_{ik}}^n i_k}{\sum_{k=1}^{m} {\mu_{ik}}^n}$$

And the membership value of the kth element belonging to the ith cluster, ${\mu_{ik}}^n$ is expressed as

$$\mu_{ik} = \frac{1}{\sum_{j=1}^{c} \left(\frac{d_{ik}}{d_{jk}}\right)^{\frac{2}{(n-1)}}}$$

with $r_{ik} = \sqrt{\|x_k - v_i\|^2}$ and n(>1) is a parameter, called fuzzifier. Fuzzifier selection is the most important parameter that determines the efficiency of FCM. The process is more fuzzy if n>>1. Following two constraints much be satisfies (i) $\sum_{i=1}^{c} \mu_{ik} = 1$ and (ii) $\mu_{ik} \in [0,1]$ for optimization of Jn(X; U,V), FCM gives best partitioning of the input image as shown in figure 5.

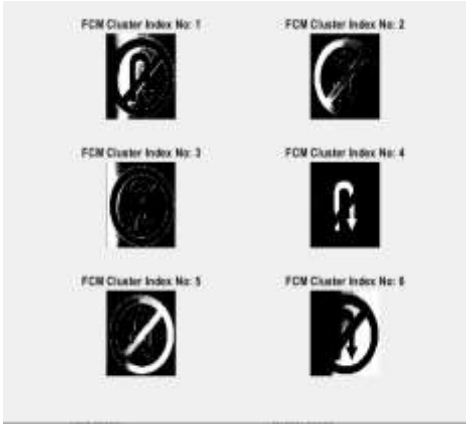

Figure 5. FCM clustering with c=6

In our design the number of clusters is pre-defined as c=6. Although the FCM segments the output image many connected regions but the connecting regions are still not clear. FCM only segments the pixels inside the image into groups according to their intensities. Pixels having similar intensity are clustered into same group and are marked by group number for identity. As pixels intensities are disturbed in the image, these pixels in the same group may formed variety of regions in the image. Therefore, the object of interest must be further identified from all of the clusters. The information about location, shape and color are used to determine whether the region represents traffic sign using region growing.

The region growing technique is helps in combining the pixels with similar properties together to form a particular region. Seed point selection begins with initial region as location of seed around which region is grown.
The seed point for the final object left after connected component analysis is calculated automatically and the neighboring pixels around the seed point pixels are analyzed by the pre-determined region growing formula. When all the neighboring pixels are included into the seed pixels domain, at that point the region is said to be grown and region growing stops. Finally morphological operations such as erosion and dilation are applied on grown regions to obtain the boundaries of the traffic symbols. The boundary detection is shown in figure 6.

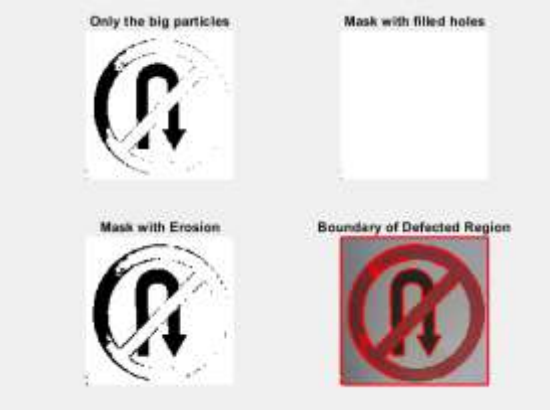

Figure 6. Boundary detection

III. EXPERIMENT AND RESULT

In the proposed methodology, we employ ANN to classify the Traffic sign from unwanted objects and background. ANN are parallel adaptive networks of simple non-linear computing element.The input to the neurons are the extracted features of the image using GLCM. The activation function helps to process the hidden layers of the network. Each node in the network is a binary sigmoid function defined by sgn=1. The output of activation function limits all the nodes in the network between 0 and 1. The ability of handling uncertainty is modeled by fuzzy logic.

In our Fuzzy clustering the number of clusters is pre-defined as c=6. As, FCM segments the output image as clusters of similar intensisties which is not clear. As pixels intensities are disturbed in the image, these pixels in the same group may formed variety of regions in the image. Therefore, the object of interest must be further identified from all of the clusters. The information about location, shape and color are used to determine whether the region represents traffic sign using region growing. The region growing technique is helps in combining the pixels with similar properties together to form a particular region.Finally morphological operations such as erosion and dilation are applied on grown regions to obtain the boundaries of the traffic symbols.

Finally the traffic sign expressions can be classified as U-Turn, Right-Turn, Left-Turn, Danger and Speed-Limit. Sign Detection using MATLAB. Zigbee transmitter and Receiver is implemented for transferring the recognized Traffic Sign. Based on the information received from the Zigbee Receiver, this will Control the Motor according to the Sign [19]. The results of Artificial Neural Fuzzy Classifier is displayed in figure 7 for No U-Turn.

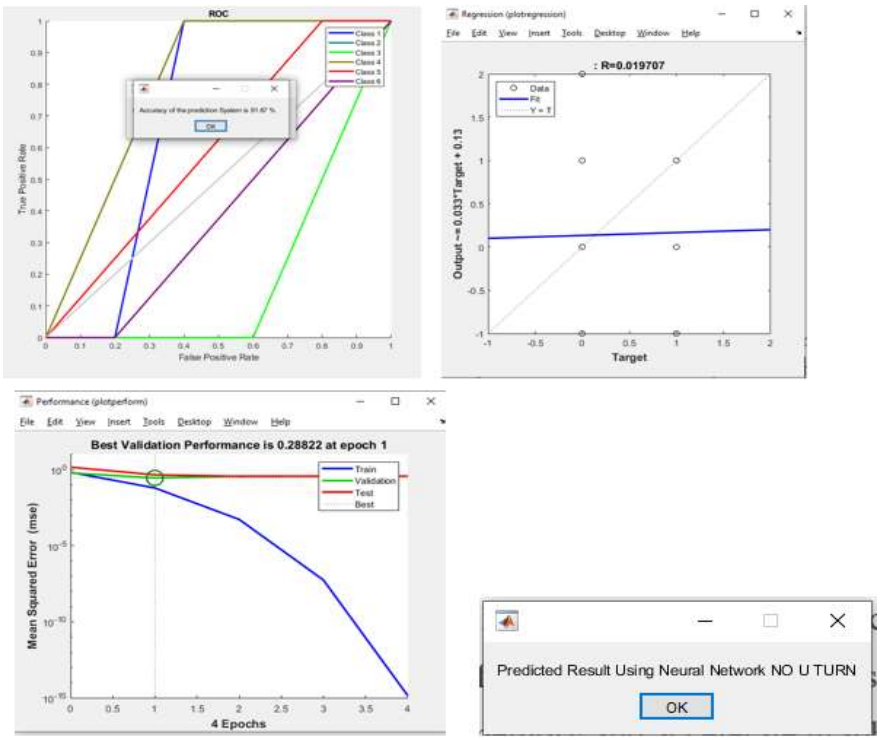

Figure 7. ANN predicted result and Performance analysis

IV.CONCLUSION

In this paper, we present an outline on detection and recognition of salient feature in an image scene, which consists of two phase: FCM segmentation is used to localize and identify the object of interest whereas the ANN is used to classify and label the object from the trained database in order find out the exact meaning of every detected scene. Finally the traffic sign expressions are classified as U-Turn, Right-Turn, Left-Turn, Danger and Speed-Limit. Sign Detection using MATLAB. Zigbee transmitter and Receiver is implemented for transferring the recognized Traffic Sign. Based on the information received from the Zigbee Receiver, this will Control the Motor according to the Sign.

Compared to the traditional method this fast recognition system with less complexity. Experiment result proves the effectiveness of the proposed method. The Artificial Neural fuzzy classifier produces results to the accuracy of 91.67%, and processing time (0.43s). The (ROC) is area under the receiver operating characteristic (ROC) estimates statistical recognition performance. The system design has relatively low computational time and complexity for real time application.

REFERENCES

[1] Alturki.A.S. “Traffic Sign Detection and Recognition Using Adaptive Threshold Segmentation with Fuzzy Neural Network Classification”. International Symposium on Networks, Computers and Communications (ISNCC), pp. 1–7, June 2018.

[2] Satılmı.s, Y. Tufan, F¸Sara, M.Karslı, M. Eken, S. Sayar, “A CNN Based Traffic Sign Recognition for Mini Autonomous Vehicles”. In Proceedings of the International Conference on Information Systems Architecture and Technology, Nysa, Poland ,pp. 85–94,September 2018.

[3] Madani, A, Yusof. R. “Traffic Sign Dataset for Traffic Sign Detection and Recognition Systems”. Journal of Telecommunication, Electronic and Computer Engineering (JTEC), Vol.8, No. 11, pp. 137–143, 2016.

[4] Henry X.Liu, Bin Ran . “Vision-based stop sign detection and recognition system for intelligent vehicles”. Transportation Research Record Journal of the Transportation Research Board, pp. 161–166, 2001.

[5] Yuan, Y. Xiong, Z.Wang, Q. “An incremental framework for video-based traffic sign detection, tracking, and recognition”. IEEE Transactions on Intelligent Transportation Systems, Vol.18, No.7,pp.1918–1929,2017.

[6] Nandi, D. Saif, A.S. Prottoy, P. Zubair, K.M. Shubho, “Traffic Sign Detection based on Color Segmentation of Obscure Image Candidates: A Comprehensive Study.” International Journal of Modern Education and Computer Science,Vol.6, pp.35-46,2018.

[7] J. P. C. Pascual, "Advanced driver assistance system based on computer vision using detection, recognition and tracking of road signs" [Ph.D. thesis], Charles III University of Madrid, Getafe, Spain, 2009.

[8] P. Paclík, J. Novovičová, and R. P. W. Duin, "Building road-sign classifiers using a trainable similarity measure," IEEE Transactions on Intelligent Transportation Systems, vol. 7, no. 3, pp. 309–321, 2006.

[9] Ruta, Y. M. Li, and X. H. Liu, "Detection, tracking and recognition of traffic signs from video input," in Proceedings of the 11th International IEEE Conference on Intelligent Transportation Systems (ITSC '08), pp. 55–60, IEEE, Beijing, China, December 2008.

[10] G. A. Tagunde and N. J. Uke, "Detection, classification and recognition of road traffic signs using color and shape features," International Journal of Advanced Technology & Engineering Research, vol. 2, no. 4, pp. 202–206, 2012.

[11] L. Priese and V. Rehrmann, "On hierarchical color segmentation and applications," in Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR '93), pp. 633–634, IEEE, New York, NY, USA, June 1993.

[12] M. J. Swain and D. H. Ballard, "Color indexing," International Journal of Computer Vision, vol. 7, no. 1, pp. 11–32, 1991.

[13] Hechri and A. Mtibaa, "Automatic detection and recognition of road sign for driver assistance system," in Proceedings of the 16th IEEE Mediterranean Electrotechnical Conference (MELECON '12), pp. 888–891, Yasmine Hammamet, Tunisia, March 2012.

[14] C.-Y. Fang, S.-W. Chen, and C.-S. Fuh, "Road-sign detection and tracking," IEEE Transactions on Vehicular Technology, vol. 52, no. 5, pp. 1329–1341, 2003.

[15] Y. H. Ohara, I. Nishikawa, S. Miki, and N. Yabuki, "Detection and recognition of road signs using simple layered neural networks," in Proceedings of the 9th International Conference on Neural Information Processing (ICONIP '02), vol. 2, pp. 626–630, IEEE, 2002.

[16] M. A. Hannan, S. B. Wali, T. J. Pin, A. Hussain, and S. A. Samad, "Traffic sign recognition based on neural network for advance driver assistance system," Przegląd Elektrotechniczny, vol. 1, no. 12, pp. 169–172, 2014.

[17] Y. Sheng, K. Zhang, C. Ye, C. Liang, and J. Li, "Automatic detection and recognition of traffic signs in stereo images based on features and probabilistic neural networks," in Optical and Digital Image Processing, vol. 7000 of Proceedings of SPIE, p. 12, April 2008.

[18] S. Yang, X. Wu, and Q. Miao, "Road-sign segmentation and recognition in natural scenes," in Proceedings of the IEEE International Conference on Signal Processing, Communications and Computing (ICSPCC '11), pp. 1–4, 2011.

[19] M. A. García-Garrido, M. Ocaña, D. F. Llorca, M. A. Sotelo, E. Arroyo, and A. Llamazares, "Robust traffic signs detection by means of vision and V2I communications," in Proceedings of the 14th International IEEE Conference on Intelligent Transportation Systems (ITSC '11), pp. 1003–1008, October 2011.