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A Robust System for Automatic Road Sign Detection and Recognition

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***Abstract*— This paper presents a robust approach for detecting and recognizing road sign in traffic scene images captured by a moving vehicle. Traffic sign detection is an important step for providing many advanced applications. The road sign recognition system is divided into two stages: detection stage and classification stage: ie, signs will be localized from a whole image, and than classifies into one of the reference signs. The images are pre-processed with several image processing techniques and morphological operations. The challenges for the system include the necessity for accurate detection as well as the high computational requirements of the algorithms**

***Index Terms*— Road sign, segmentation, recognition, neural network**

I. INTRODUCTION

Road signs are used to guide drivers for direction, and to warn them of any special road condition. They provide important visual information that can help the drivers operating their vehicles in a manner that enhances road safety. A driver may not however notice road signs under adverse road condition. Failure to notice or disregard of road signs may directly or indirectly contribute to some road accidents. The occurrence of these accidents can be reduced using an automatic road sign recognition system that can alert the driver.

Detection and recognition of traffic signs has long been in the center of interest for having great impact on the safety of the driver. The objective of this paper is to explore the possibility of developing a computer vision system which is able to perform automated recognition that could be used to notify a human driver to the presence and nature of road signs. Their liability demonstrated by the proposed method suggests that this system could be a part of an integrated driver warning and assistance system based on computer vision technology

This information can be useful when the driver is distracted or not responsive and improve the road safety. Traffic sign detection is an important step for providing advanced in-car driver assistance, mapping data for geographical information systems, and also developing autonomous cars. On the other hand, Google car project which uses sign detection cameras in addition to radar, laser range finder and other sensors demonstrates the possibility of cars without drivers. Several car companies are integrating such systems such as Ford Focus which can display certain number of traffic signs in the instrument panel. Therefore, automatic sign detection has been an emerging field of research in recent years

We know that traffic signs are made in a standardized colors (red and blue), shape (circle, triangle and square) and pictograms. In many cases, the traffic signs use easily recognized symbols or pictures rather than words. Detecting shapes in an urban environment is very challenging and unreliable due to visual clutter. They are also situated in a specific position on the road side to provide sufficient information like speed limit, bumper, stop etc. In last decade due to heavy traffic, it becomes very difficult for a driver to monitor all the traffic sign along the road, which sometime leads to accident. So, this paper will help to develop an efficient, robust and reliable real time driver assistant system which will be able to detect the traffic sign with minimum error in different lighting conditions. But this work is primarily concerned with the day time detection of traffic signs. Night time would be different due to low light conditions and reflections. This algorithm had been implemented and tested using Matlab.

II. RELATED WORKS

An automatic road sign recognition system identifies road signs from within images captured by an imaging sensor on-board of a vehicle, and assists the driver to properly operate the vehicle.

Problems in road sign recognition and colour based and shape based approaches are discussed in [2]. Problems are:

- Lighting condition is a very difficult problem to regulate because it depends on the time of the day and also on the weather conditions.
- Images may suffer from bluffing effect due to vibration of moving vehicle.
- The direction of sign's face is not always ideal. It can be affected due to the viewing angle.
- Colors on road sign may fade due to long exposure to the sun and rain.
- Road signs may place one over the other.
- Sign can be confused with other similar man-made objects such as commercial signs and building windows.
- Obstacles, such as tree, street lamp, buildings, traffic

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lights, vehicles and pedestrians, may partially occlude road signs

In [3], a new computer vision design flow for real time detection and recognition of traffic signs is discussed. It develops a three stage algorithm that is based on detection of traffic sign locations using HSV color space, detection of traffic signs using discriminative features and recognition of traffic signs using interest point descriptors. The benefits of this color space is to code the color on one single plane instead of three as is the case in the RGB color space, or two in the case of the YUV. With this color space, detecting colors is very simple since Hue directly gives the color information. Morphological functions are used for extracting color boxes. The second part of the algorithm handles the sorting and detection of actual traffic signs from the list of boundary boxes. The last stage of the algorithm is the recognition of the traffic signs. The key principle is to match the detected signs to a database (library) of traffic sign templates. Using norm squared difference is straightforward, however it fails to work when the traffic signs are distorted, marked or seen from an angle.

Paper [4] introduces a framework using the smartphone to increase ambient intelligence and road safety of moving vehicles through traffic sign alert application. The driver is alerted of the incoming traffic signs in different modes depending on the user's preference. Unlike conventional research work, this paper emphasizes on portability and expandability. Portability means there is no additional installation or placement of electronic hardware required in the vehicle in order to make the system work. Expandability focuses on the transparency of the traffic sign recognition output to other applications within same hardware device or external devices

A method for some prohibition traffic signs designed for drivers is proposed in [5]. Prohibition traffic signs have many characteristics, such as brilliant colors, striking positions, special shapes, etc.The color information in HSI color space and the symmetry property of circles are used to detect signs, and the Histograms of Oriented Gradients feature and the nearest distance method are used to recognize them. There are three main reasons which will lead to miss detection for the proposed algorithm: far distance, serious occlusion and overlapping.

In [6] presents a study to recognize traffic sign patterns using Neural Networks technique. The images are pre-processed with several image processing techniques, such as, threshold techniques, Gaussian filter, Canny edge detection, Contour and Fit Ellipse. Then, the Neural Networks stages are performed to recognize the traffic sign patterns. The system is trained and validated to find the best network architecture. The main objective is to reduce the search space and indicate only potential regions for increasing the efficiency and speed of the system. This study investigates only to circle and hexagonal shape objects because these shapes normally present in many types of traffic signs.

Most existing road sign recognition systems include colour detection process that extracts out the coloured road-sign objects from the background for recognition. These approaches are discussed in [7]. Colour-based detection methods aim at segmenting out the typical colours of road signs in order to provide a region of interest for further processing. Several widely used techniques on colour-based recognition are summarized in this paper.

II. PROPOSED SYSTEM

In this section, the proposed road sign recognition system is described. The system consists of two modules: detection and classification. Captured images are fed into the detection module. The regions containing road sign patterns are extracted and forwarded to the classification module. The classification module further analyzes the extracted road-sign patterns and identify the type of road signs they represent. The two modules of the system are explained in details in the following subsections.

Fig.1: System overview

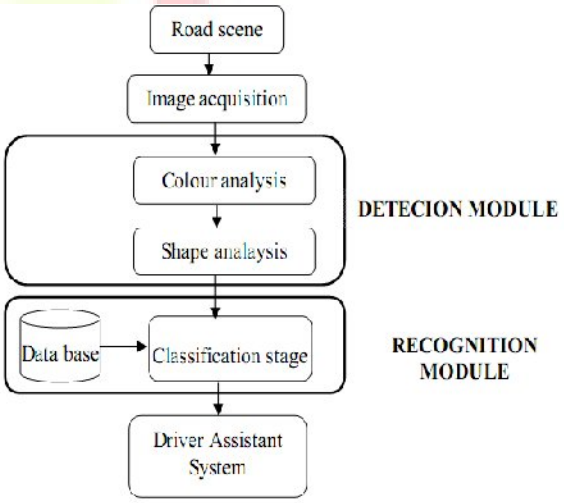

Fig.2: Block diagram

A. Detection Module

The main task of the detection module is to segment the input image and extract out the areas that contain road sign patterns, and then forward them to the classification module for identification. The proposed algorithm uses the colour and

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the shape properties of the road signs in order to locate the candidate regions. Detection algorithm consists of two parts:

- Candidate detection
- Filtering candidates

Fig. 3: Detection results

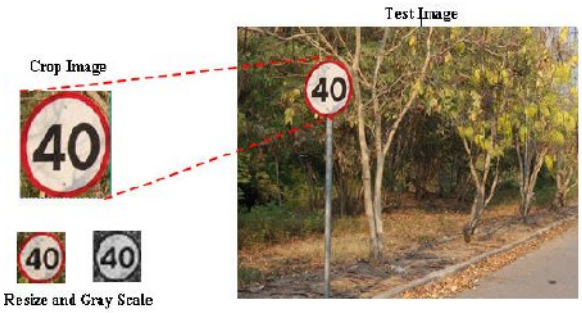

Fig.4: Crop image from traffic sign region

In the candidate detection part of the algorithm, colour properties of the signs have been used. At the second step, several constraints on the shape properties are used to eliminate some of the candidates which cannot be a sign. The success of the detection algorithm often depends on the initial segmentation of the relevant colours of the image.

Next, shape detection based on a similarity measure between the grey-level image of the unknown road sign and the objects of the database has been adopted. This method assumes that both sample and segmented image have the same dimensions. First, the road sign is normalized to a size of 50x50 pixels by linear interpolation of the grey levels. Secondly, the normalized cross-correlation between the road sign and the templates of the database related to the proper shape is computed. The best N templates of the score list that fall within a fixed range of the maximum value have been then considered (in both). The similarity coefficient is calculated for angle value to find the greatest similarity factor. The final reduced and normalized regions of any road sign candidate have been directly used as the input vector of a neural network classifier

1) Histogram equalization

This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. It can also be used on color images by applying the same method separately to the Red, Green and Blue components of the RGB color values of the image. However, applying the same method on the Red, Green, and Blue components of an RGB image may yield dramatic changes in the image's color balance since the relative distributions of the color channels change as a result of applying the algorithm

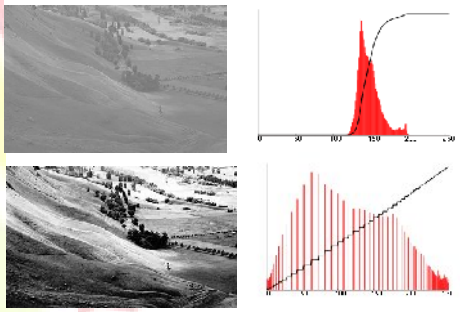

Fig.5: An unequalized image and image after histogram equalization

II) Morphological operations

In order to reduce the number of detected boundary boxes (possible traffic signs), we apply morphological functions which help smoothen the image and remove artifacts. Opening function removes isolated pixels. Closing operation, smoothen and join small, neighboring areas.

Structuring element: The basic idea in binary morphology is to probe an image with a simple, pre-defined shape, drawing conclusions on how this shape fits or misses the shapes in the image. This simple "probe" is called the structuring element, and is itself a binary image (i.e., a subset of the space or grid).

Opening: The opening of A by B is obtained by the erosion of A by B, followed by dilation of the resulting image by B: can be used to eliminate all pixels in regions that are too small to contain the structuring element.

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Closing: The closing of A by B is obtained by the dilation of A by B, followed by erosion of the resulting structure by B: the closing operation has the effect of filling in holes and closing gaps

B. Classification Module

The main task of the classification module is to classify the extracted regions of interest presented to its input into the road-sign category they belongs. In this work, the MLP networks have been employed to implement the classification module because they have proven to be good classifiers and have been able to successfully solve several object recognition problems.

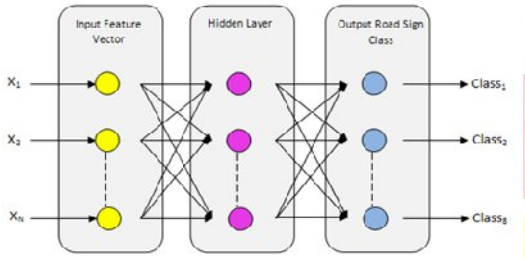

Fig.6: Structure of the utilized MLP

The Perceptron has multiple inputs fully connected to an output layer with multiple outputs. Each output is the result of applying the linear combination of the inputs and an activation function which is generally non linear. Multi Layer Perceptron extend the Perceptron by cascading more than one extra layers of processing elements. These extra layers are not connected directly to the external world and so called as hidden layers. A Multi Layer Perceptron (MLP) network has been used as the next step of the detection module to extract road sign objects. Each network composed by around 2500 input neurons corresponding to 50x50 pixel input images. The number of output neurons corresponds to the number of signs which have to be distinguished. A back propagation approach is used to train the networks, using 50x50 synthetic images for each sign. Training set is actually composed of gray-scaled sample images and their rotated and translated versions.

III. EXPERIMENTAL RESULTS

Each input image was reduced by uniform sub-sampling. It is well known that the advantages of sub-sampling include the reduction of processing time, noise, as well as image instability. And the matlab output is shown below:

A. Recognition of Hump Sign

Fig.7: Input image

Fig.8: Adjusted image

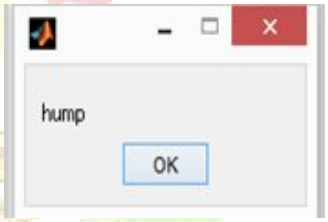

Fig. 9: Output dialog box

A great amount of variation of the signs is tolerated. In fact, up to 25° rotation about the horizontal axis have not cause any misdetection

IV. CONCLUSION

In this paper, a design flow for recognition of traffic signs is proposed. The proposed algorithm is based on colour segmentation, morphological functions and use of discriminative features. In the detection phase, thresholds are set to segment the red areas and blue areas and to obtain the potential region, and the shape information is used to affirm the signs. it can detect signs even if they are viewed from an angle or distorted and the traffic sign template database can be updated if needed. The recognition system has to be fast and robust which decrease the difficulty of the automatic

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detection of the road signs. However, some improvements remain as tasks for the future. With the research and development of the intelligent traffic system, traffic sign recognition system is developing fast, and this system will emerge at the future vehicles

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