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Recent Developments in Traffic Signs Recognition Techniques

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Abstract:- The traffic signs play a vital role for accident free and smooth fast driving. If the recognition of traffic signs done by the accurate and fast automated systems, it provides the extra edge in efficient navigation. Thus automatic traffic signs recognition is an important task, particularly in intelligence transportation system. Automated recognition system collects useful information about traffic signs, helps the driver to make timely decisions, and increases driving safety and comfort. This paper presents an overview of the different methods and techniques used in traffic sign detection and recognition. It describes the physical properties and characteristics of the road signs, potential difficulties and problems that occur during detection of real-time images. The detection and recognition techniques are classified into three stages i.e. Color-based filtering, shape-based analysis and final recognition. Thus, we have chronologically discussed some of the referred previous work theme-wise with respect to the different approaches and techniques used in these stages. In future, new techniques should be involved to increase the robustness, and to get faster systems for real-time applications.

Index Terms:- Artificial intelligence, Driver assistance system, Thresholding, hough Transform.

I. INTRODUCTION

The automated road sign recognition system is an intelligent vision system for recognition of the traffic signs particularly in an autonomous vehicle. In driver assistance systems, it helps the driver by providing useful information about the road signs. Thus, false recognition of the traffic signs caused by the human errors and other environmental factors can be avoided by automated recognition system, which increases driving safety. The automated traffic sign recognition system should have in-built artificial intelligence and fast computing processors to accurately extract the information signified by the traffic sign to the driver. If the road signs are falsely predicted, it may cause serious accidents on the behalf of human error. The false predication of traffic signs in the outdoor images is mainly caused in various conditions such as illumination changes, rotation, shadows, and partial occlusion of the images, dirt, different lighting conditions, paint degradation, deformation and motion blur etc. These are various critical factors that affects the reliability of an automatic sign recognition system. Thus, the traffic sign recognition becomes a challenging task in real time. Furthermore, a fast approach is needed to operate in the real time environment. Generally, the automated traffic sign recognition system is divided into three stages i.e. the detection stage which finds the region of interest from an image, and the classification stage where the detected signs are classified into one of the road signs and the finally the information presented by it is recognized in the last stage. The aim of automated sign recognition is to provide the Driver with the ability to understand its neighborhood environment and so permit advanced driver support such as collision prediction and avoidance. Driving is a task based fully on visual information processing. The road signs and traffic signals define a visual language interpreted by drivers. Road signs carry many information necessary for successful driving - they describe current traffic situation, define right-of-way, prohibit or permit certain directions, warn about risky factors etc. Road signs also help drivers with navigation. Two basic applications of traffic sign recognition are under consideration in the research community – Driver support system and automated surveillance of road traffic devices. It is desirable to design smart car control systems in such a way which will allow evolution of fully autonomous vehicles in the future. The traffic sign system is also being considered as the valuable complement of the GPS-based navigation system. The dynamical environmental map may be enriched by road sign types and positions and so help with the precision of current vehicle position.

II. TRAFFIC SIGN RECOGNITION SYSTEMS

The generalized TSR system consists of three stages shown in Figure 1.

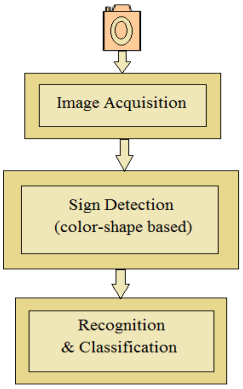

Fig.1 Traffic sign Detection System

In first stage a real time video from the camera mounted on the top of the vehicle desk can be used as an input. Detection of traffic sign directly from video is complex; hence detection is mostly preferred by using the collection of static images of sign extracted from video.

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In the second stage, extracted images are enhanced and segmented according to shape and color of the traffic sign. The detection methodology is one of the essential elements of TSR as it reduces the large search area into a small region of interest (ROI) for recognition of possible traffic sign. The detection stage should be efficient and fast enough to reduce the total processing time of TSR.

In third and final stage, each candidate present in the ROI is tested against the set of features to decide whether the detected candidate is a traffic sign or not. The recognizer should have good discriminative power and low computational cost. It should be fast and robust for real time applications.

The rest of the paper is organized as follows. The physical properties and characteristics of traffic sign is described in Section III. Section IV describes the literature work used for detection and recognition of traffic signs. Section V describes the various difficulties arises in detection process, while Section VI includes discussion and commentary about the survey discussed in this paper. Finally, in section VII conclusions are drawn.

III. CHARACTERISTICS AND PHYSICAL PROPERTIES OF THE TRAFFIC SIGNS

Table 1. Color and Shape properties of traffic signs

Types of Sign with Pictures	Color-shape features	Function	Example
Warning 	Triangle shape with Red border, White or yellow background, black pictogram	Indicates possible dangers or critical condition, alert drivers on the possible hazards, show the road layout	No-entry etc
Prohibitory 	Circle / Octagon shape with Red border, White or Blue background	Prohibit certain types of vehicles, restricts the actions of the drivers and road users	No U-Turn, No Overtake and Speed Limit Signs, no standing, No-parking .
Regulatory 	Circular shape of Blue background, White pictogram	Regulate the action of the drivers	Turn right, turn right ahead, keep right etc.
Information 	Rectangle shape of Blue border, White background	Helps the driver in emergency condition	Hospital.

Tabel. 1 illustrate the general color-shape characteristics and the properties of traffic signs with examples Another important property of most of the road signs is that they are designed using necessary colors, pictogram and text with the center of shape as orientation. Most countries post signage, known as road signs or traffic signs, at the side of roads to impart information to road users. Since language differences can create barriers to understanding, international signs using symbols in place of words have been developed in Europe and adopted in most countries of the world. The research for detection of signs had been started in the recent past (from 1984 onwards). The different object recognition techniques had been used to locate the sign candidate in the digital image. For this purpose, many researchers have done lots of work, but the satisfactory results are pouring in since 2000 onwards. The traffic sign detection technique is broadly divided into two major steps. The first step is Location of exact sign candidate in overall captured image which generally involves color and shape based filtering, and second step is Recognition of sign.

Since Recognition and Detection system are categorized into color based detection, shape based detection and Recognition; we have chronologically discussed some of the referred previous work theme-wise.

A. Color based analysis

The most common color based recognition technique used in past literature is simple adaptive thresholding. Some approaches only used color- based filtering to detect the region of interest, while others used a combination of color based segmentation technique with additional subsequent stages to locate the sign candidate. The main drawback of color based recognition is that color cannot be a reliable feature for detection as it depends on various factors like weather condition, illumination, and shadow effect and so on. The digital images were first captured in RGB color space but as it is considered to be illumination dependent, thus many authors choose other color spaces to carry out segmentation process. As red, white, blue , yellow, black and green are the principal colors generally found in traffic signs, hence color based recognition was based on these six different colors.

The Arturo de la Escalera et al. in [1] illustrate a adaptive thresholding method to segment color of interest in the captured image. By matching the values of each pixel in the image with the predefined range of threshold values, the pixels were classified into foreground (color of interest) or background (non-sign region). The Benallal et al. in [2] analyze the real time images of traffic signs in different hours of the day(morning, noon, evening). He proposed a simple color segmentation algorithm after concluding that the difference between the RGB components of road signs colors is independent to different illumination conditions.

Priese et al. in [3] proposed a simple Region growing technique for region-based image segmentation, by starting with the initial seed pixel, then examines the neighboring pixels of seed pixels and determines whether the neighboring pixel should be added to the region on the basis of similar characteristics. As it requires initial seed pixel and only applicable till the criteria of neighboring pixel having similar color properties is met. That makes it unrealistic for real time application.

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Ritter et al. in [4] located the traffic sign candidate after removing non-sign regions using a reference table of color values in RGB color model containing a different code for each color of interest and then shape detection is carried out of the located sign candidate.

Ruta et al. [5] first segment the red, blue and yellow colors from the image based on fixed thresholds, and then enhance the obtained colors.

Priese et al. [14] proposed a method to detect and recognize the traffic sign candidate. First color segmentation was done based on the color of traffic signs and then a local and global growing technique was applied to classify the information and form the sign candidates. Finally shape analysis is done by matching the shape of these detected sign candidates to a predetermined set of shapes.

Gao et al. [15] use the CIECAM97 model to experiments the segmentation results in different illumination and weather conditions such as average daylight, sunny, cloudy and rainy weather. The images are transformed into CIE XYZ and LCH color spaces one after another, using the CIECAM97 model. Only hue and chroma values are used to segment the regions by using quad-tree approach, considering the lightness values to be invariant for red, blue, and the background color. Fleyeh et al. in [16] used a device independent IHLS model to for color base filtering of false-positive regions.

B. *Shape based analysis*

Recognition of traffic sign candidates using shape information is done to further filter out false-positive regions. Only shapes information is considered as sufficient to detect road signs in many researches. Due to lack of standard colors, shape information is also used for road signs recognition as the colors found on traffic signs varies according to illumination and also by moving from one country to another. Shape detection will be a good alternative in case where it is difficult to extract color information such as twilight time and night time. Shape based detection has certain properties and it may face some difficulties in case of disoriented or tilted signs. Similar objects to the traffic signs may exist in the scene like windows, mail boxes and cars. Road signs may appear damaged, occluded by other objects. They may appear disoriented vertically or horizontally. The size of the sign varies with respect to the distance between the camera and the sign. If the sign is very small, difficulties may arise in detection process as it will be unrecognizable. The aspect ratio may also affect if the viewing angle is not head-on.

Shape detection requires robust boundary detection or matching algorithm to detect the relevant shapes. This becomes difficult when the road sign appears relatively small in the image, a situation that often occurs in low resolution cameras.

Gareth et al. [6] used Hough transform to isolate features of a particular shape within an image. It is generally used to detect of regular features such as lines, circles, etc having regular features and requires the desired features be specified in some parametric form. A generalized Hough transform can be implemented in applications where a simple analytic description of a feature is not possible. Its advantage is that it is tolerant to gaps in feature boundary descriptions and is relatively unaffected by image noise. But as this process is considered to be slow and computationally complex, it does not fit for real time applications. To reduce the computational complexity and speed, Piccioli et al. in [12] used color segmentation to filter out the non-sign regions, followed by a geometrical analysis on the edge map to detect circular and triangular shapes.

Gavrila et al. in [7] used Distance Transform Matching to detect the shape of the candidate sign within the image. It uses a template hierarchy to capture the different shapes of the candidate. The advantage of using this approach is that it allows certain level of dissimilarities between input sign candidate and template, but the main drawback of this technique was matching between the object and the template was dependent counter segmentation. The authors in this paper reported excellent detection rate after testing the approach on various static images.

Pavel et al.[11] used Hierarchical Spatial Feature Matching technique to search for the geometrical shapes within an image to detect the probable traffic sign. It creates a list of regions where some geometrical objects resembling road signs have been found, which is then passed to the classification module. This technique works for grey-level image. Vitabile et al. [13] performed a straight-forward Similarity Detection technique by computing a similarity factor between a segmented region and set of binary image samples representing shape of various road signs, in which both are considered to have same dimensions. Both color and shape information is considered for detection process. The performance of this approach was reported to be good with triangular shape giving the lowest hit rate.

C. *Recognition and Classification*

It is the last part of the detection process. Once the region of interest is located and is predicted to be a probable traffic sign candidate, the information present in the sign in the form of pictogram is then recognized using a predetermined set of database containing different types of traffic signs.

To build a good recognizer, several factors should be taken into consideration. The recognizer should be fast, cost-effective, computationally less expensive, independent of size, position and geometrical orientation of sign, noise-free and should be fast enough to fit for real time applications.

Krumbiegel et al. in [20] implemented a neural network, which is trained on the color, shape and texture of the traffic sign templates. Douvilee et al. in [18] implemented a multilayer perceptron on the fast Fourier transform of the detected sign and a bank of filters. It was also reported that it achieved better results than the template matching approach. Cyganek et al. in [19] used two committee networks operating in the spatial domain and the log-polar representation. Each committee network was composed by several Hamming neural networks trained on a set of signs of reference.

Zadeh et al. in [12] proposed a method for model matching analyzing the area ratio of the colors in the regions of interest horizontally and vertically in order to differentiate between traffic signs with similar overall color ratios. This method is independent to rotation and size of the region and thus the number of potential models is reduced, which accelerates the recognition time.

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In case of occlusions of traffic sign, the region of interest may contain non-sign regions due to the global nature of template-based matching,. Thus, Paclik et al. in [17] propose a novel trainable similarity measure based on individual matches in a set of local image regions to cope with the global nature of template matching method. The set of regions relevant for a particular similarity measure can be filter out by training process. Ruta et al. in [5] implemented a different method of step forward in measuring the dissimilarity between different signs, where a special color distance transform enables robust comparison of discrete color image signs. Some other approaches were also used to detect the traffic sign in digital images. For example, Aoyagi et al. in [8] used Genetic Algorithm to find the traffic sign in the image by matching with the given gene information. The gene of individuals can be represented by expression using a set of equation to determine its characteristic. Estevez et al. in [9] used Histographic recognition to detect the traffic sign in images. The histogram of sign extracted from region of interest can be analyzed to determine if any sign candidate is present in the image. The histograph is obtained by overlaying a mask over the image. Escalera et al. in [10] used Nearest Neighbor Classification, which is the most straightforward and classic type of classification. An image in the test set is recognized by assigning to it the label of most of the closest points in the learning set. All images are then normalized to certain value. The image in the learning set that best correlates with the test image is then the result.

IV. DIFFICULTIES IN DETECTION PROCESS

The detection of traffic sign is sometimes becomes difficult in adverse conditions in case of poor lighting effect which varies according to the time of the day, bad weather conditions in different season where the atmosphere may be brighter, wet, cloudy, and so on. Road sign patterns within images can be affected by shadows from surrounding objects.

In case of vibration of vehicle, shaking of the camera mounted on the vehicle, or any interlacing effects in digital camera used for the image acquisition of real time traffic signs, due to which the input Images may suffer from bluffing effect. Motion blur also occurs if the shutter speed of the camera is too long for the speed of the object. Blurred image may cause errors during detection and classification stage. Therefore, additional blur removing procedure from an image is the first priority tasks prior to sub-detection stages.

Due to the shadow of other obstacles on traffic sign such as nearby building and trees, the detection of traffic sign sometime becomes too difficult to handle. The sign on the road may be damaged or disoriented from its idle position. This may also trouble in automatic sign detection.

Due to hurricane or road accidents, traffic sign may get tilted or disoriented from their original position which causes errors in its detection or recognition.

V. DISCUSSION

Automated Road signs recognition system uses computer vision and artificial intelligence to extract the road signs from outdoor images in uncontrolled lighting conditions where these signs may suffer from different problems like occlusion, fading of colors, disorientation, and variations in shape and size. The process of sign recognition in automated system is divided in detection and recognition stages.

In the last decade, a large amount of work was done in the field of Traffic sign Detection and Recognition. Many companies and research groups were involved in this research, and very good results were achieved. Various commonly used techniques on road sign recognition have been presented. Some of these techniques can be used with others to realize a hybrid recognition system. According to the different approaches implemented in the related works, either of the color or shape based technique is enough to precisely recognize traffic signs from digital images. But the combination of the color-shape based techniques has been more effective and accurate. The shortcomings of color-based recognition such as illumination, weather conditions, shadow and faded color on sign can be compensated through the use of shape-based recognition in parallel, making the system more accurate. Similarly, color based recognition may be more helpful in case of tilted or disoriented signs. Camera mounted on the vehicle captures images in RGB model of which is not ideal for color based filtering in real time as the values of R, G and B components may vary with respect to different illuminations and weather condition. Thus, it is transformed into other color space like HSI, XYA space for processing. However, these transformations may become expensive in hardware realization. The Color- Thresholding is easy, but it may not be higly accurate in case of poor lightening, bad weather or fading of colors. In Automated traffic sign recognition system, Neural Networks classification is most popular amongst pattern recognition techniques. Some of the techniques are robust but computationally costly, while others are simple but unable to handle changes in road sign patterns. None of the existing methods can be totally immune to the problems faced by automated signs recognition system. One of the major drawbacks of current detection system for traffic sign recognition is the big shortage of public domain database that contains enough examples of a wide set of traffic signs acquired in uncontrolled environments. Most of the published works are presented on a limited number of signs with a small number of different examples.

VI. CONCLUSION

Road sign recognition in poor light conditions like twilight time, sunrise time, sunset time, and at night has not studied well. Due to the lack of sufficient research in these conditions, this area needs deep study. Another factor like poor lighting conditions that generally occurs in case of heavy rainfall, snowfall, and fog conditions, need a more attention. Extraction of color information is difficult in poor lightening case as the hue is meaningless if intensity of light is low below a certain level. As the color of every sign varies according to its age and physical condition, problems may occur in case of color based recognition. Thus, we have concluded that a global model for all possible combinations of colors and physical conditions is difficult to obtain. Another factor such as in shadow can be a potential problem which needs serious study, as cue from all color spaces, except the hue which is independent of lighting variations, may affect accuracy by producing partial segmentation results, which is similar to that condition where the traffic sign is occluded by another object.

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Due to fading, Old signs may also produce partial color segmentation results. New research in the area of occluded signs and partially segmented signs may provide solutions to all these problems.

A low resolution camera produces blurred images, which may cause errors in the detection process. Thus the removal of motion blur is another important task before the color segmentation stage. Using high resolution camera and blur removal techniques in detection system increases efficiency of the system and produces better results.

The complexity of automated road sign detection systems will diminish in the future with the advancement of technology. As technology advances, high quality sensors will become cheaper and more available in mass production. If every car is equipped with a high resolution color camera, a GPS receiver and an odometer, an infrared camera and other sensors in the future, the difficulties and problems that arises in detection process will be infinitely simpler. However, it will probably proceed slowly, because of the persistent need to minimize computational costs.

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