A TRAFFIC LIGHT DETECTION AND ALERT SYSTEM USING COLOR VISION DEFICIENCY

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Abstract-Traffic light detection and recognition is essential for autonomous driving. A camera based algorithm for real-time robust traffic light detection and recognition was proposed which is especially designed for autonomous vehicles. Although the current reliable traffic light recognition algorithms operate well under way, most of them are mainly designed for detection at a fixed position and the effect on autonomous vehicles under real-world conditions is still limited. Some methods achieve high accuracy on an autonomous vehicle, but they can't work normally without the aid of high-precision priori map. In order to reduce accident at traffic and autonomous driving during day and night, the algorithm of traffic light detection and recognition which is applied in a vehicle driver assistance system is designed by using the image processing technology. The system of traffic light detection includes three parts, including pre-processing, detection and recognition. First, Red-Green-Blue (RGB) colour space is converted to Hue-Saturation-Value (HSV) as main content of pre-processing. In detection step, the edge detection and background subtraction method is used for segmentation. For recognition, histogram of oriented gradients (HOG) features and support vector machine (SVM) is used to recognize the state of traffic light.

Keywords –Traffic Light Detection, Image Acquisition, Image Pre-Processing, Image Segmentation, Circle Detection, Feature Extraction and Classification.

I INTRODUCTION

Over the past few decades, lots of attempts have been made to autonomous vehicles. Nowadays, driving highway with autonomous vehicles has become more and more reliable, while fully autonomous driving in real urban environment is still a tough and challenging task. Robustdetection and recognition of traffic lights is essential for autonomous vehicle to take appropriate actions on intersection in urban environment. Different types of traffic lights are available Human vision is seemed the only way to detect the state of traffic lights. Almost all experimental autonomous vehicles for urban environment are equipped with cameras used to detect and recognize traffic lights. This project investigates and implements an algorithm using MATLAB. The proposed method implements an algorithm with machine learning methods. To train the proposed system a database of images that contain about 300 pedestrian traffic lights has been created.

The scope of this project is within the domain of computer vision, software engineering and machine learning. This study is conducted in order to evaluate an algorithm for traffic lights. The are divided into two parts, the first part measuring the Precision and Recall in different weather conditions in the video recordings. The second aims on evaluating various parameters that affect the detection rate. The algorithm will be evaluated in several complex traffic environments, with different scenarios from a large set of video recordings provided by the case company. The study is crucial for identifying a SVM-algorithm for detecting traffic lights while handling a large amount of videos recorded in different weather conditions. The contribution of this project is valid on video recordings including traffic lights of different designs. Furthermore, the project also aims to provide recommendations for software engineers facing the challenges of object detection in various environments.

II RELATED WORKS

HSV thresholding, geometrical information, and color density of an image are used to detect traffic lights. The color density method recognizes the color of an object by comparing the densities of each color belonging to the object. This method is robust, only requires RGB images and high detection rate[9][6]. Most existing approaches concerning such problem use color thresholding solely or use simple template matching methods, thus tend to be affected by light changes. A new traffic light candidate extraction algorithm, ,AdaBSF on collected video data and public dataset, improvement over conventional approaches is achieved. The whole detection procedure can be performed in real time [6][9][7].

The detection model combination prior feature and inter-frame analysis with feature learning algorithms. Through statistics of shapes, location and context of traffic lights, only candidate regions with physical meaning are selected .While the introduction of adjacent frame information solves the drawbacks when detecting the fake flashing luminous objects by single image frame[16][2].A principled approach to took the collection of higher-level information from camera image, utilizing strong constraints in template creation and weighting is proposed. Accounting for possible sources of error inherent in the traffic light detection problem, they specifically analyze those errors which contribute to uncertainty in our pipeline[19][6].

The Traffic Light Mapping and Detection approach to solving these two tasks has been to automatically construct maps of the traffic light positions and orientations, and then to manually add control semantics to each light. Then use this map to allow an onboard perception system to anticipate when it see and react to a traffic light, to improve the performance of the traffic light detector by predicting the precise location of the traffic light in the camera image, and to then determine whether a particular route through an intersection is allowed[6][19]. Image processing toolbox in LabVIEW was used to build the captures images for traffic lights by a fixed mobile camera.Investigating the results reveal the ability to help the colorblind drivers to correctly identify the color of traffic lights in different cases and circumstances[1].

Alearning based detector based on aggregated channel features to two detectors based on heuristic models have to compared. The learning based detector reached the best AUC, because of the significantly higher precision and recall.The learning based detector achieves an AUC of 0.4 and 0.32 for day sequence 1 and 2, respectively[2][16]. The system was developed for a Nokia N95 mobile phone and tested in real environment. It runs with about 5 to 10 frames/s so that in general a feedback is given in less than a few seconds. Tested this prototype in several situations, e.g., rainfall, snowfall, dusk, frontlighting, and soon[17].A technique to detect suspended traffic lights and estimate their distance, working in real time, is presented. The work focuses not only on detection, but also on distance estimation[18].Presented a large real-world data set for evaluating such algorithms together with a reasonable performance metric, baseline results, and a web-interface for comparing approaches[10].The color segmentation iscompleted in the HSI color space and the segmentation threshold is obtained through the statistical analysis of the training image.And then it use the robust template matching[5][7].

Color images are more complex than gray scale images as instead of a single intensity value for a pixel, each pixel is usually denoted by three component values as red, green and blue. Both color segmentation and shape recognition used to improve the detection rates. First, candidate regions are selected using color features, and then, an edge based method is employed to the perimeter of the regions for the detection step. The technique embeds multi resolution and multi scale edge detection, adaptive searching, color analysis, and affine rectification in a hierarchical framework to handle text in different sizes, orientations, color distributions, and backgrounds. This system is a combination of knowledge based analysis and radial basis function neural classifier (RBFNN). second, the traffic signs are detected from the natural image using color image segmentation technique. The recognition system consists of three stages: color histogram classification, shape classification and RBF neural classification[7][5][6].Color is the most dominant features in retrieving the road symbols from the natural image. Due to change of whether conditions, such as sunny, cloudy and rainy, the color of the traffic may appear different. The color spaces such as HIS, RGB, L*a*b* are normally limited to only one lighting conditions.

III OVERVIEW OFTHE PROPOSED SYSTEM

The main objective of this paper is to develop an effective vision-based traffic light detection system for automatic vehicle,drivers and people with color vision deficiency using supervised learning methods.

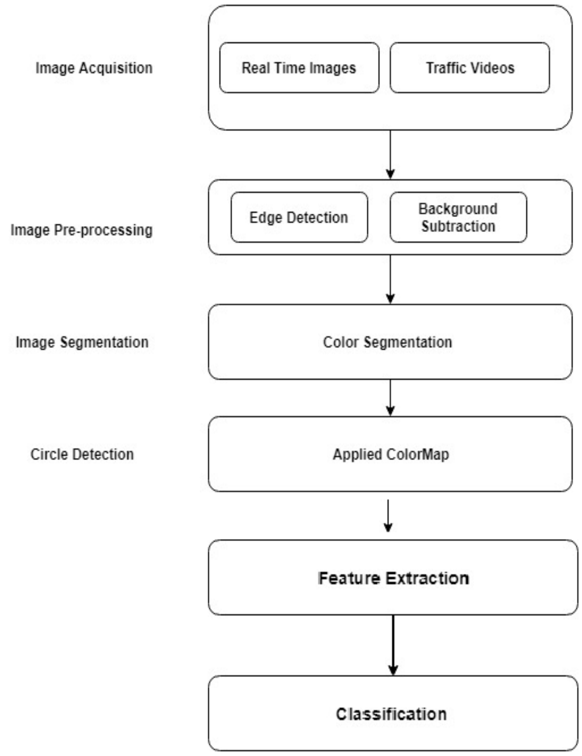

Figure 1 Overview of the proposed system

Figure 1 shown the Overview of the proposed system. The proposed traffic light detection system is divided into two four subsection. In the first subsection explains the image acquisition process. The second subsection explains the images pre-processing steps. The third subsection explains the image segmentation method and the third section explains the circle detection process and final section explains the feature extraction and classification.

A. RGB to HSV Colour Tranformation

In colour transformation better information from a HSV colorspace has been obtained usually. HSV = rgb2hsv(RGB) converts RGB values to the appropriate hue, saturation, and value (HSV) coordinates. HSV is the same size as RGB.

B**. Image preprocessing**

Preprocessing is a common operation with images at lowest level of abstraction both input and output are intensity images. The aim of Pre-Processing is an improvement of the image data that suppresses unwanted distortion or enhances some image features important for futher preprocessing.

C**. Sobel edge detection**

The Sobel operator is very similar to Prewitt operator. It is also a derivate mask and is used for edge detection. Like Prewitt operator, Sobel operator is also used to detect two kinds of edges in an image:

- Vertical direction
- Horizontal direction

When this mask has been applied on the image it creates prominent vertical edges. It simply works like as first order derivate and calculates the difference of pixel intensities in an edge region.

D. **Background subtraction**

Background subtraction is a widely used approach for detecting moving objects in videos from static cameras. The rationale in the approach is that of detecting the moving objects from the difference between the current frame and a reference frame, often called "background image", or "background model". This technique is used for the post processing method for the background subtraction for videos.

E. **Detection and Segmentation**

The goal of detection phase is to extract candidates for traffic lights and some initial filtering by colour information first. The proposed method colour image segmentation method is used for traffic light segmentation.Assuming that the input is a color image, the first stage is to convert the image into three binary images representing images with red, green and yellow color, respectively.The traffic light colors can vary depending on the intensity levels and other factors, use samples from traffic lights with darker and brighter colors as the lower and upper bounds.

F. **Circle Detection for Object Recognition**

Circle Hough Transform method is implemented for Circle detection. A circle with radius r and center (a,b) can be represented by equation:

$$(x - a)^2 + (y - b)^2 = r^2 \quad (3.1)$$

It starts by traversing edge pixels of an object. Assuming that the radius r is known, then circles will be drawn with edge points as the circle centers.Otherwise, the object is not a circle. The threshold is determined as the lower limit to define a circle.

G.**HOG Feature Extraction**

The HOG (Histograms of Oriented Gradients) is a feature extraction method that was first proposed by Dalal and Triggs [18] in 2005. HOG describes the distribution of gradient orientation and gradient intensity in an image, so the image can be better shown in shape and appearance. The HOG feature generation process is as follows: the image is divided into a plurality of small units called "cells", which consist of a block, called "block"; finally, the histograms of the oriented gradients "cell" and "block" were counted. The gradient value of the horizontal direction and the vertical direction of the image is calculated in following Equation.

$$\begin{cases} G_x(x,y) = H(x+1,y) - H(x-1,y), \\ G_y(x,y) = H(x,y+1) - H(x,y-1). \end{cases}$$

The gradient magnitude and direction of the pixel are calculated in the given Equations.

$$G(x,y) = G_x(x,y) - G_y(x,y),$$

$$\alpha(x,y) = \tan^{-1}\left(\frac{G_x(x,y)}{G_y(x,y)}\right).$$

The image is uniformly divided into several cells, divide the gradient direction into 9 bins, then get the HOG characteristics of the cells. The adjacent cells (5, 5) constitute one block, finally the blocks are normalized to obtain the HOG feature of the block.

H.**SVM Classifier**

SVM is a pattern recognition method based on statistical learning, and is widely used in areas of pattern recognition, such as pedestrian detection and face recognition. It is a common method of machine learning when the training samples are limited. The HOG features were extracted using alinear SVM classification which was coded in the Matlab computer language.

I**. Training**

Pictures of traffic lights were collected from the video under actual road conditions; the color of the lights might be red or green, and the shape might be round or arrow. The pictures were collected in different sizes, under different weather conditions and at different times of day when they were taken, so there was enough generalization ability. 300 positive samples and 480 negative samples were collected for training. We arranged and combined the positive and negative samples to extract the HOG feature and generate the feature vector, which was obtained and trained by the linear SVM.

IV RESULTS AND DISCUSSION

The proposed method is implemented the system using MATLAB 2015. The system takes images captured from camera or video as input. This section introduces the results of this study based on data from the benchmarking. The results are categorized into weather conditions, which will contain a representation of the performance of the chosen algorithm in terms of precision and recall together with information about the total amount of frames for each category. Table 1 and Fig 6 shows the accuracy rate of our proposed method.

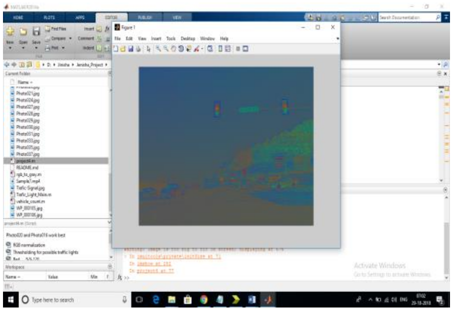

Figure 2. HSV image

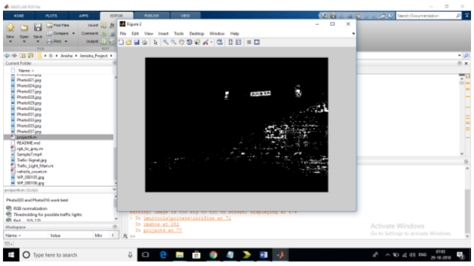

Figure 3. Image for Edge Detection

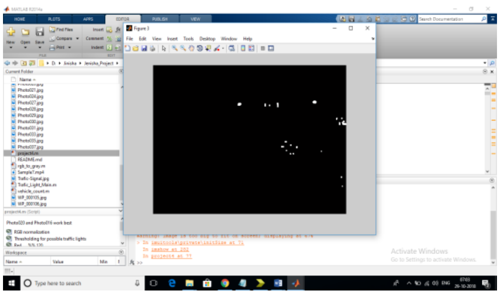

Figure 4. Code for Background Subtraction

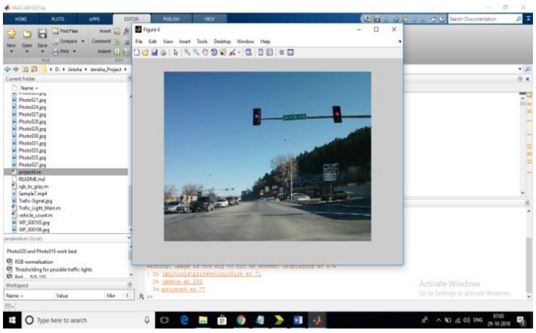

Figure 5Segmented Result.

Table1 Comparison with Other Methods

Method	Red Light	Green Light
[6]	83 %	89 %
[16]	86.67 %	96.84 %
[5]	91.67 %	92.72 %
[7]	92.72 %	97.11 %
Proposed Method	95 %	94.78 %

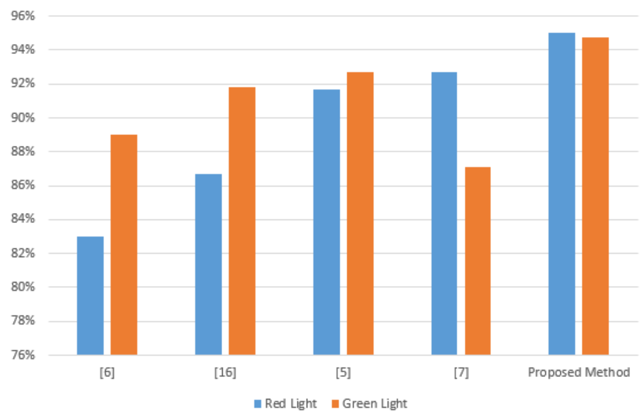

Fig 6 Graphical Representation of total accuracy rate

V CONCLUSION

A camera-based algorithm for real-time robust traffic light detection and recognition is proposed. This algorithm is designed mainly for autonomous vehicles. Experiments show that the algorithm performs well in accurately detecting targets and it also determines the distance and time between those targets. However, the current method proposed here does have some drawbacks. First, the method performs well in the daytime but not as well at night. The false alarm rate increases at night due to more light interference. While the method can detect both circular traffic lights and arrows, only the classical suspended vertical traffic lights were detected.

In the SVMalgorithm can be extended to recognize more complex traffic light system that includes separate left-turn signal lights. In addition, this method will be tested on datasets from different countries. Additionally, more environments such as raining, night, or fog conditions, will be included in test cases. Moreover, the detection of arrow-shaped TLs is also a problem that needs to be solved in the future. Finally, to gain the benefits from sequences of images, to research will include a tracking stage to provide better results.

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