CROSSWALK AND TRAFFIC LIGHT DETECTION - A SURVEY

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Abstract— Computer vision-based way finding and navigation aid can improve the mobility of blind and visually impaired people to travel independently. Blind people face many problems in well-known environment. They are not able to detect crosswalk and traffic lights, stairs, and other objects. It is also important to detect traffic light and traffic light sign for autonomous vehicle system to avoid road accident. Many researchers proposed various algorithms that help blind people and autonomous vehicle to detect traffic light sign and cross the road safely. In this paper, we presents the survey of traffic light detection methods, crosswalk detection methods, some issues about to detect traffic light and crosswalk and comparison of various methods.

Index Terms— Crosswalk detection, Traffic light detection, Color segmentation, Template matching.

I. INTRODUCTION

In today's world, independent walk is the main issue for the visually impaired peoples. Peoples who are completely blind or low vision often have problem in self-navigation outside the well-known environment. People who are blind or visually impaired can travel and cross streets using a human guide, using a long white cane to identify and avoid obstacles, using a dog guide, using special optical or electronic aids, or using no additional aid. The main barriers for blind people are detecting crosswalk (zebra crossing) and detecting traffic lights colors. Blind and impaired people face many dangers as pedestrians in a big city.

Many electronic mobility assistant systems are developed based on converting sonar information into an audible signal for the visually impaired persons to interpret [1]. Mobility aids such as walking sticks and canes can provide support or are used to help deaf blind people to find their way around the well-known environment. As well as the white cane that blind people use to navigate their surroundings and let people know they are blind. There is also a red and white cane to show that someone is deaf blind.

In general, there are two types of traffic lights: Suspended traffic light and supported traffic light. Suspended traffic light is much easier to detect because the background area is almost static and generally include a sky area. Crosswalk is alternative pattern of black and white stripes.

Rest of the paper is organized as follows: In section II, we presents the literature survey. In Section III, represent some issues about to detect crosswalk and traffic light. In Section IV, we concludes the literature survey.

II. LITERATURE SURVEY

In this section, we discuss the literature survey of different papers of crosswalk detection and traffic light detection.

A. *Traffic Light Detection*

There are various condition like rainy, cloudy and foggy in which researcher detect traffic light and crosswalk. Because of this condition the

traffic light detection is affected. In traffic light detection task, researcher remove the background and noise, leaving only detected edge of traffic light. This process damage the edges that are of traffic light causes a false negative error. Because of this, the traffic light detection is failed. Another issue about traffic light detection is state estimation of traffic light. This problem due to two factor: First, blurred light bulb and low contrast light bulbs. Blurred light do not have fully circle only have semicircle. Second, bulb with low-contrast do not have enough color to show. Following are some methods to detect traffic light and traffic light sign.

- Hidden Markov model [2].
- Color segmentation [1].
- Template matching approach [3]
- Color and edge information [4]
- Hough transform [5]

Andres E. Gomez et al. [2] present a Hidden Markov model through the Viterbi algorithm that helps to determine the current state of traffic light detected, based on the obtained states by image processing. There are three steps for traffic light detection. First, image is captured by camera mounted on the autonomous vehicle system. Second, frame is converted from RGB to gray scale. Morphological operation are applied to remove sky, building and pole. Third, using the threshold value they determine the traffic light location. Color Segmentation using HSV color model is used to determine the current active state of traffic light. There are some images in which system was not able to detect the current state of traffic light because of the cloudy day. Because of cloudy day, the brightness of the environment constantly change.

Color Segmentation is very popular method for traffic light and traffic light color detection. Chulhoon Jang et al. [1] proposed multiple exposure images based traffic light recognition. This method consist two parts. First, two images with two different exposure times are captured sequentially. Second, for candidate region recognition are generated by color detection based on low exposure image. Next, classified the candidate region to indicate the status of traffic light by SVM classifier. This method has two advantages: First, color threshold region can be determined as narrow, therefore false positive error are strongly reduced. Second, saturation problem is not occurred.

Template matching also widely used method for traffic light recognition. Adaptive template matching, probabilistic template matching and scale invariant template matching are mostly used by researchers. Shuihua Wang et al. [3] proposed traffic sign recognition method for pedestrian crosswalk. In which, Gaussian smoothing used to remove noise from original input image. Then, scale invariant template matching approach and color segmentation are applied to detect candidate traffic sign region. Histogram orientation gradient feature are extracted from detected candidate traffic sign region. Finally, Support vector machine used to recognize crosswalk red sign from non-red sign. For traffic sign database, they captured 412 images of intersection areas in New York City. Among these images, 230 images are used for training and 182 images are used for testing. Among 182 testing images, 173 images are correctly detected and recognized. So, detection and recognition accuracy is very good of this algorithm.

Xu Qingsong et al. [6] used color segmentation based on HSI and symmetry property of circle are used to detect traffic light sign. They used HSI color model because illumination condition have less effect on HSI model than on the RGB model. Algorithms which are sensitive to the color information used this model.

Raoul de Charette et al. [7] present real time visual traffic lights recognition based on spot light detection and adaptive traffic lights template matching approach. But, some issues are present in spot light detection. Spot light detection is most time consuming task. So, most of suspended traffic light can be detect by color based Thresholding and color Segmentation. Jongwon Choi et al. [8] proposed algorithm for detecting traffic for autonomous vehicle system using probabilistic template matching approach. Researcher used three camera mounted on vehicle to capture images. First one is zoom camera for distant view, second is front camera for nearby front view of road and last camera is tilted camera used for looking down a road very closely. The proposed algorithm and frame work are easy to implement and easily embedded in autonomous vehicle system with low computational complexities.

Traffic light sign color and traffic light circle edge information are also used to detect traffic light. Masako Omachi et al. [4] present a fast

method for detection traffic light in a scene image. There are four steps for traffic light detection. First, converting the color space from RGB to normalize RGB, some region are selected as candidate region of traffic light. They covert input image from RGB to normalize RGB because in normalize RGB image effect of the change in lighting condition are eliminated. Second, there are three condition to extract the candidate region of traffic light. Third, Sobel operator is used to detect the edge of candidate region. Fourth, Hough transform is used for detect a traffic light. This method can detect traffic light in less time and the detection accuracy also improved than tradition Hough transform method used for traffic light detection. Hough transform algorithm used to detect circle, but it has more computation time make it unsuitable for real time detection. In [5], structural information was used to detect traffic light. Using structural information, Hough transform algorithm used to detect traffic light. For this, pixel are clustered to detect the color of the turned on and turned off light. Then, Sobel filter used to detect edge of turned on light. Once detect turned on light, a filled circle of which color is the one of the traffic light was detected. For this task, voting procedure of Hough transform was used.

Moises Diaz-Cabrera et al. [9] proposed novel technique to detect suspended traffic light based on color and feature such as black area of traffic light or the area of traffic light lamp. This method detected suspended traffic lights located up to 80 meter distance. If the distance is up to 60 meters, then the car correctly detect the traffic light. This technique work based on assumption that the traffic light with black circle and only one traffic light bulb turned on and other bulbs are turned off.

B. Crosswalk detection

For crosswalk detection there are various methods. To detect crosswalk many researcher take crosswalk images or video frame as input. Following are some methods used to detect crosswalk.

- Segmentation and projective invariant [10]
- Homography search approach [11]
- Vanishing line [11]
- Two vanishing point [11]
- Projective geometry [12]
- Hough transform [3]

Mohmmad Shorif Uddin et al. [10] present robust zebra crossing detection technique based on bipolarity based segmentation and projective invariant based recognition. There are three steps for detecting crosswalk. Various lighting condition can affect the detection of zebra crossing. So first, to cope with this situation they use Histogram equalization if the average intensity of the image is less than a threshold. Second, extract the candidate crossing based on bipolarity feature and check the position of the candidate as well as direction. Third, extract the feature point on the central vertical line of the binarized candidate area and taking the final decision of a crossing or not using projective invariant. 118 real time images are taken to perform evaluation of the algorithm. Among 118 images, 81 images are crosswalk images and 37 images are have no crosswalk. These images are of different condition like sunny, cloudy and rainy. Proposed algorithm is quite successful and robust to detect crosswalk with different background. This method does not make any dangerous error such as it decide the existence of a crossing for a scene without crossing. Also this method has disadvantages: If the crosswalk is occluded by any vehicle or any person than this method is fails to detect crosswalk. If there are any vehicle on the crosswalk than method deliver a voice message to the user to take another picture of crosswalk.

Stephen Se et al. [11] present three methods for crosswalk detection. These three methods are Homography search approach, vanishing line and two vanishing point. First method, Homography search approach find the Homography using points and does not require partitioning the edge. Reprojection error of Homography search approach is limited by image resolution. Second method, two vanishing points method is most simple and vanishing point of two side line is required. Two vanishing points method is not efficient when the part of the structure is occluded by any obstacle. Third method, vanishing line method does not require end point. It work under occlusion. Vanishing line method is more accurate than these two methods because vanishing point method does not depend on the end point. The algorithm proposed in this paper is slow and far from real time.

Tadayoshi Shioyama et al. [12] proposed method for image analysis of a crosswalk. Method provide information about the length of

the crosswalk. The total length of the crosswalk is estimated by the projective geometry using the white line painted on a road at a zebra crossing. This method have three steps. First, a color image is transformed to a gray scale image according to National Television System Committee formula. Second, the gray scale image is binarized with the threshold determine by the analysis. Sobel filter is applied on the binarized image to extract the edge. Third, Hough transform method is used to extract the horizontal white line edges. The length of the crosswalk has been well estimated by proposed algorithm.

Vidya N. Murali et al. [13] describe the recent work on the crosswalk project. In which, computer vision-based smartphone system developed for provide crosswalk guidance to blind and visually impaired people at traffic intersection. A full 360° panorama image is taken by the smartphone user, using a simple app to acquire a sequence of VGA images. The panorama image taken by the user is converted into an aerial view of the nearby intersection. The aerial image in panorama matched to a template of the traffic intersection to determine the current location of user's in the intersection. For every interested intersection, template is obtained from Google Maps satellite images by manually Segmenting out the crosswalk black and white stripes. This method is time consuming because creation of templates is time consuming process.

In [3], Researchers also proposed method for crosswalk detection and stairs detection. There are four steps for crosswalk and stairs detection. First, start with the edge detection by applying Sobel operator on input image taken by RGB-D camera. Second, Hough transform is applied to extract the line of a crosswalk and stairs. Third, one Support vector machine classifier is used to classify the crosswalk and stairs. Fourth, use second Support vector machine classifier for further classify up stairs and down stairs. The main disadvantages of this method is stairs with less than three steps cannot be detected. Overall the detection accuracy of this algorithm is very good.

In [8], method of crosswalk detection via integral framework is proposed having five steps. First, V value of HSV domain was used. Second, 1-D mean filter was applied on the image. After applying 1-D mean filter, they get two binary images of crosswalk. Third, the binary images of crosswalk are de-noising through erosion, dilation and blob-labelling. In fourth step, these two binary images are combined by OR operation. Fifth, band like object can be searched by 2-D mean filter. Finally, when result of filter is over a predefined threshold value, presence and the location of the crosswalk can be obtained.

C. Comparative Evaluation

In this section, we describe the comparative evaluation of different existing methods. Table 1 present the comparison of traffic light detection based on parameter precision and recall. Table 2 represent the detection accuracy of traffic light. Table 3 represent the detection accuracy of crosswalk.

TABLE 1: COMPARISON OF PRECISION AND RECALL PARAMETERS OF TRAFFIC LIGHT

Method	***Precision***	***Recall***
Adaptive Template Matching [7]	95.38	98.41
Histogram Orient Gradient [6]	89.04	72.22

TABLE 2: COMPARISON OF DETECTION ACCURACY PARAMETER FOR TRAFFIC LIGHT

Method	**Accuracy**
Hidden Markov Model [2]	98.30
Scale Invariant Template Matching / color segmentation [3]	95.05
Probabilistic Template Matching [8]	95.97
Hough Transform [4]	86.66
Hough Transform [5]	89.00

TABLE 3: COMPARISON OF DETECTION ACCURACY PARAMETER FOR CROSSWALK

Method	**Accuracy**
Hough Transform [3]	78.90
HSV domain [8]	96.20
Segmentation / Projective Invariant [10]	95.06

III. CHALLENGES AND ISSUES

Following are few of the challenges encountered by the blind people and while designing software for traffic light detection and crosswalk reorganization.

- Way finding is huge challenge for blind people.

- They cannot cross the road and detect the traffic light without someone's help.
- It is not easy task for blind people to detect obstacle (if any) during crosswalk (zebra crossing).It is hard to clearly detect the stripes of crosswalk because the stripes are erased by many factors.
- Detection of traffic light is also an issue because there are many objects whose color is similar to one of the traffic lights color.
- We cannot clearly detect traffic light from scene image because the traffic lights are very small compared to other object.

IV. CONCLUSION

We studied different methods of crosswalk and traffic light detection, it is very help full to autonomous vehicle system and blind people. All the methods detect traffic light and crosswalk from scene image and from video frame. Hidden Markov model and template matching approaches have good detection accuracy. But template matching is time consuming process. Another method is color segmentation, which is widely used for traffic light detection. In color segmentation method, saturation problem has been not occurred. In Hough transform, the computational time more that make it unsuitable for real time application.

For crosswalk detection, bipolarity based segmentation and projective invariant based recognition method quite successful to detect crosswalk. This method cannot make any dangerous error. Vanishing line method is more accurate than Homography search approach and two vanishing point method because vanishing line method does not depend end point of crosswalk.

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