Traffic Light Detection for Colorblind Individuals

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***Abstract*— This paper proposed an algorithm that detects traffic light colors for colorblind individuals, the proposed algorithm employs image processing techniques associated in image processing toolbox in LabVIEW to help colorblind individuals in identifying the colors of traffic lights. It uses a fixed mobile camera to capture traffic light images taken in different roads and streets in Jordan and Kuwait. It detects traffic lights by comparing the candidate traffic light with some in-house collected traffic light templates, comparison is based on correlation. The templates represent 22 different shapes of traffic lights in Jordan and Kuwait. Finally, the algorithm extracts the green and the red planes and recognizes their colors. Experimental results reveal the accuracy of proposed algorithm in identifying the colors of traffic lights in different cases and circumstances. Hence, our proposed algorithm is helpful for colorblind drivers.**

Keywords—colorblind; traffic light detection; LabVIEW; image processing

I. Introduction

Color blindness is defined as the inability of seeing colors in normal lighting conditions [1-3]. Some colorblind individuals can not see some colors, while others see colors differently [1]. Eight percent of men and 0.4 percent of women among Northern European ancestry experience congenital color deficiency [4, 5]. Color blindness is due to the fault in development of one or more sets of retinal cones that perceive color in light and transmit information to the optic nerve [6]. Color blindness is also due to genetic, diabetes, aging, and medications [7]. Assistive technologies cover wide range of assistive devices for color blindness people that improve their visual capabilities, many of these technologies use image processing techniques that could be implemented using LabVIEW and many other software packages [8-10].

Many of the assistive technologies help colorblind individuals in their daily life using color and objects recognition techniques, these technologies include image recognition and traffic light detection. For example, a color recognizer for the colorblind patients is used to identify object colors in [11], image recognition using algebraic feature extraction is used in [12], an Italian-style car license plates recognition using neural networks is implemented in [13], traffic elements are estimated using Markov logic networks in [14], and an online navigation approach using images captured by a camera mounted on the vehicle is implemented in [15].

Other various traffic light recognition techniques are covered in literature. These techniques include the following: traffic light recognition using computer vision and machine learning [16], traffic light detection algorithm used in electronic travel aids [17], traffic light detection based on converting the RGB color space to normalized RGB [18], community sensing service using smart phone accelerometer to detect and to predict accurate traffic signal schedules [19], intelligent vehicles with color segmentation and continuously adaptive mean shift to track traffic lights [20], traffic light recognition using morphological filtering and statistical classification [21], estimating visibility of traffic signals for drivers in rainy weather conditions [22], suspended traffic light detection and distance estimation using color features [23], traffic lights detection and recognition [24], red traffic light detection using fast radial symmetry transform [25], traffic light detection using color-vision specialized mobile standards [26], and traffic light recognition using on low-cost field-programmable gate array devices [27].

Among robust and real time traffic light recognition methods earlier investigated by researchers are: multi-feature fusion based real-time traffic light recognition algorithm for intelligent vehicles [14], a real-time traffic light recognition for on-vehicle camera applications [28, 29], real-time traffic red light recognition under mobile platforms [30], low cost real-time traffic light recognition [31], real-time traffic light recognition system for intelligent vehicles [32], real-time traffic light recognition in urban environment [33], computer vision based real time traffic light recognition color blindness patients [34], and hierarchical vision architecture based real-time traffic light recognition [35].

Other related services to traffic light detection are introduced in [36], where a video scene analysis algorithm to estimate road traffic congestion is used, their algorithm applies similar morphological operations and other techniques to detect vehicles and to estimate speeds.

This paper presents a system that helps colorblind people to recognize traffic light colors, comparing to other detection techniques, the proposed traffic light detection is simple and effective.

The rest of this paper is organized as follows: section II presents the proposed algorithm for detecting color traffic lights for color blindness, section III presents experimental results and the related discussions, and finally, section IV concludes the paper.

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II. A PROPOSED ALGORITHM FOR DETECTING TRAFIC LIGHTS FOR COLOR BLIDNESS

The proposed algorithm for detecting traffic lights for colorblind individuals enables colorblind drivers to recognize the existence of traffic light and its color, the proposed algorithm assumes the existence of a special camera in the car of the colorblind driver. The algorithm also assumes that the colorblind driver is not a deaf.

Step 1: Traffic light image acquisition: a special camera installed in the car of the colorblind driver acquires the image that may contain a traffic light. i.e. the camera acquires images periodically.

The camera is the 8-megapixel primary camera that comes with Apple iPhone 5s, the resolution is 640x1136 pixels. Fifty images are captured using the iPhone 5 camera, 22 of them are cropped and used as templates (See Fig.1) and 4 images for each weather status are used to test the performance of the algorithm.

Using a region-of-interest selection, 600×1000 pixel region is cropped of the captured images, less than 30 degree field of view is selected, moreover, the resolution of the iPhone was sufficient to detect traffic lights images of not more than 100 m away.

It should be noted that the proposed algorithm is tuned to detect traffic lights up to 100 m away, it uses a camera that captures 600x1000 video frames. The tuning process is conducted empirically.

Step 2: Traffic light detection: originally, the detection algorithm contains 22 traffic light templates (see Fig.1) that represent the traffic light shapes and cases, the detection algorithm compares the acquired image with the mentioned 22 templates, if the acquired image correlates at least to one of the templates, the detection algorithm proceeds to the next traffic light identification step, otherwise, it returns again to the traffic light images acquisition step.

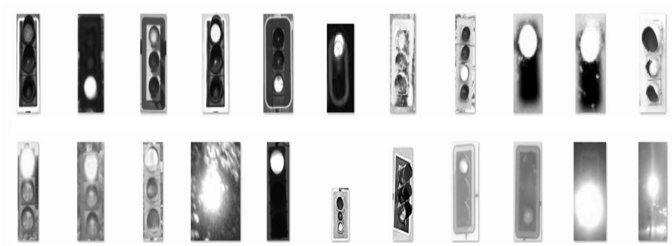


Fig. 1. Trafic light templates.

Step 3: Traffic light identification: In this step (see Fig.2), the detection algorithm extracts the green and the red planes of the detected traffic light. A density thresholding technique is used to locate the green or the red spots in the detected traffic light; this density thresholding technique is based on segmenting the image into segments (circular spots). The detection algorithm discards the other segments and only retains the candidate green or red spots.

Fig. 2. Trafic light identification.

Step 4: Traffic light color identification: in this step, the color of the identified spot is determined, i.e., the color of the traffic light is identified using a color comparison technique, the algorithm just compares the color of the spot with the red and the green colors, consequently, the color is determined and a warning audio is played.

Fig.3 illustrates the detailed steps for the proposed algorithm:

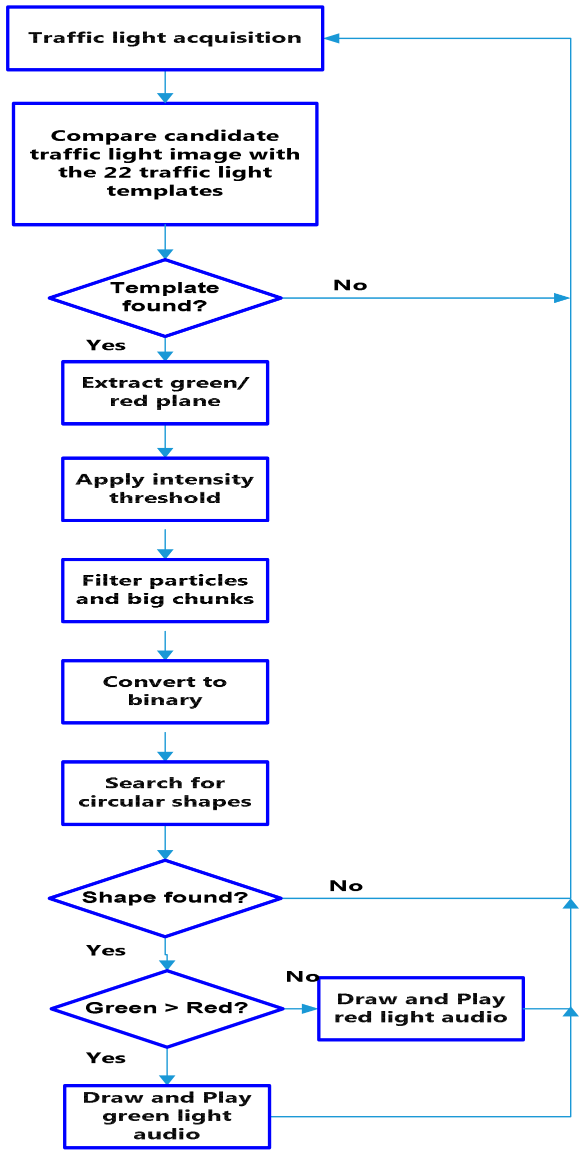


Fig. 3. The proposed algorithm flow chart.

1. It captures the traffic light image using iPhone S5 camera.
2. It compares the candidate captured image with the 22 traffic light templates; these templates represent the common shapes and styles of traffic lights in Jordan and Kuwait.
3. When matching one of the templates, the algorithm extracts the green and the red regions of the traffic light.
4. It applies intensity level thresholding filters to remove the other unwanted particles and chunks.

   It should be noted that the detection algorithm uses morphological operations to "clean up" traffic light images, moreover, to detect traffic lights clearly, images are adjusted by median and linear Kalman filters, especially to adjust the colors of traffic lights that look different depending on the weather conditions, time, and locations.
5. It converts the processed image to binary images in order to simplify and to speed up the processing steps.
6. It finds the circular shapes and examines their colors.
7. If the intensity of green is more than the red's intensity, the proposed algorithm displays a green spot and plays a warning audio for green otherwise it displays a red spot and plays a warning audio for the red.

It should be noted that different tuning parameters for the detection algorithm are used to accommodate the different weather conditions and to enable the algorithm to accurately work robustly to help colorblind individuals to drive safe.

III. EXPERIMENTAL RESULTS

The proposed algorithm is implemented using the image processing package comes with LabVIEW and it is tested using many images taken from various streets in Jordan and Kuwait. The images are taken using a mobile camera iPhone S5. Fig.4 shows a traffic light in a clear day and Fig.5 shows the corresponding detected traffic light using the proposed algorithm. Fig.6 shows a traffic light at night and Fig.7 shows the corresponding detected traffic light. Fig.8 shows a traffic light while raining at night and Fig.9 shows the corresponding detected traffic light. Fig.10 shows a traffic light while snowing and Fig.11 shows the corresponding detected traffic light. Fig.12 shows different color traffic lights and Fig.13 shows the corresponding detected nearest traffic light. Fig.14 shows a traffic light combined with other light sources at night and Fig.15 shows the corresponding detected traffic light

Fig.16 shows a yellow traffic light and Fig.17 shows the corresponding detected traffic light taking in consideration that the proposed algorithm considers the yellow as red for the safety of colorblind drivers.

Fig. 4. A traffic light in a clear day.

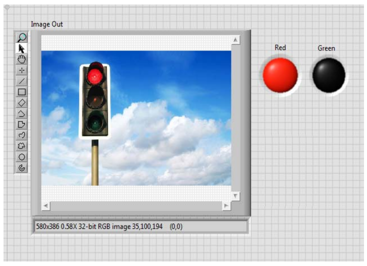


Fig. 5. Detected traffic light in a clear day.

Fig. 6. A traffic light at night.

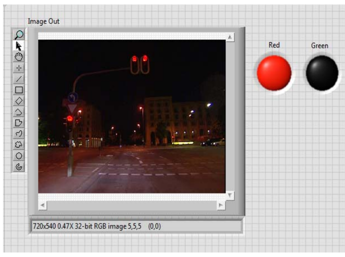


Fig. 7. Detected traffic light at night.

Fig. 8. A traffic light while raining at night.

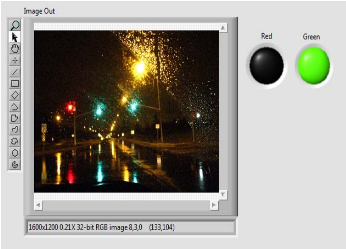


Fig. 9. Detected traffic light while raining at night

Fig. 10. A traffic light while snowing

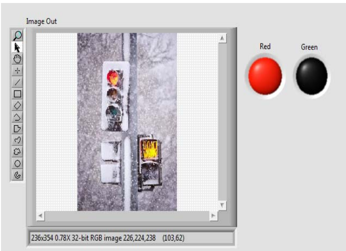


Fig. 11. A detected traffic light while snowing.

Fig. 12. Multi trafic lights with different colors.

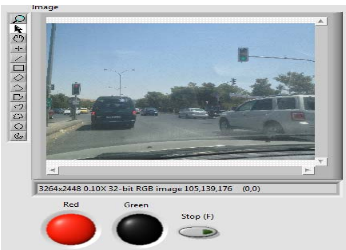


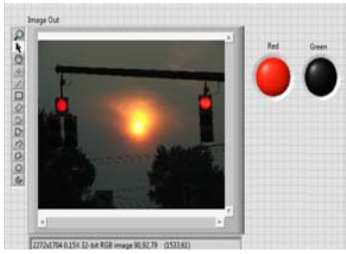
Fig. 13. Detected the nearest traffic light.

Fig.18 shows a horizontal traffic light and Fig.19 shows the corresponding detected traffic light. It is clear that the proposed algorithm works robustly in different cases and is able to correctly detect the targeted traffic lights.

(a) Traffic lights at sun set

(b) Traffic lights with many street light sources.

Fig. 14. A traffic light combined with other light sources at night.



(a) A detected traffic light at sunset

(b) A detected traffic light with different street light sourses.

Fig. 15. Detected traffic lights

The proposed algorithm recognizes traffic lights in clear day time (see Fig. 5), moreover, it recognizes traffic lights accurately at night (see Fig.7), it also recognizes traffic lights while raining (see Fig.9) and snowing (see Fig.11) as it filters and smoothes rain drops and snow spots. The proposed algorithm uses the principle “Closer is larger” to detect traffic lights when dealing with multi-color traffic lights in the same image, i.e. it recognizes the closer traffic light as it is bigger one (see Fig.13) and it distinguishes the targeted traffic light in the case of multi light sources (see Fig.15) as it matches the candidate traffic light with the 22 templates, i.e. it finds the three circles inside a rectangle and then identifies its color.

Fig. 16. A yellow traffic light.

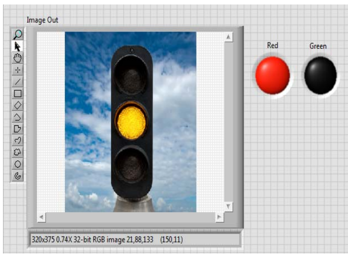


Fig. 17. A detected yellow traffic light as red.

Fig. 18. A horizontall traffic light.

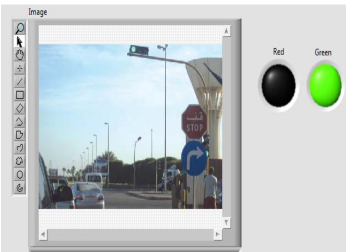


Fig. 19. A detected horizontall traffic light.

It is known that a traffic light changes from green to yellow then to red in most countries, hence, the proposed algorithm considers the yellow traffic light as red for the safety of colorblind drivers (see Fig.17). In addition to vertical traffic lights, the proposed algorithm can deal with horizontal traffic lights as well, i.e. it is able to correctly detect the color of traffic lights regardless their alignment vertical or horizontal (see Fig.19). In addition to the computer based testing results shown in Fig.4-19, it should be emphasized that the mentioned testing images are taken from various streets in Jordan and Kuwait. Moreover, after implementing and testing the algorithm using these images, an on line test is conducted, a real colorblind driver used the proposed algorithm to detect traffic lights in some streets in Kuwait, results revealed that the detection algorithm is robust enough to help colorblind drivers to drive safe.

IV. Conclusion

In this paper, authors proposed algorithm to help colorblind drivers in car driving. Image processing toolbox in LabVIEW was used to build this algorithm. The proposed algorithm captures images for traffic lights by a fixed mobile camera. These images are taken in various roads and streets in Jordan and Kuwait. Then the algorithm detects traffic lights by comparing the targeted one with an in-house collected traffic light templates using correlation principle. The templates characterize 22 common shapes of traffic lights in Jordan and Kuwait. After that, the algorithm extracts the green and the red planes and recognizes their colors accurately in real time manner. Investigating the results reveal the ability of the proposed algorithm to help the colorblind drivers to correctly identify the color of traffic lights in different cases and circumstances.

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