A Study on the Traffic Light Identification and Guidance System for the Elderly Drivers

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***Abstract*—** Recently, as the aging of society has progressed rapidly, the number of elderly drivers has increased dramatically. As the elderly people have lower physical and cognitive abilities compared to the general public, the increase and the damage of the traffic accident rate are becoming a social problem. Therefore, in this paper, we propose the identification and guidance system of traffic lights for elderly people with low physical and cognitive ability. A large portion of this system is based on the information processing based on visual surrounding using computer vision or image processing on Matlab. In the future, it will be possible to reduce the traffic accident rate by recognizing the traffic light with the black-box and smart-phone attached to the car and informing the elderly how to drive by voice.

Keywords*— *Advanced Driver Assistance System(ADAS), Traffic Light Detection (TLD), Voice Guidance, Elderly Drivers

I. INTRODUCTION

As Korea becomes an aging society, traffic accidents caused by drivers aged 65 years and older are increasing. The number of traffic accidents caused by elderly drivers aged 65 and older increased from 13,596 in 2011 to 23,063 in four years, up by 69.6% [1]. A further problem is the vulnerability of elderly drivers in accident exposure situations, unlike young drivers, it can be seen that the rate of deaths among elderly drivers aged 65 and older is dramatically increasing.

Advanced driver assistant systems (ADAS) are systems developed to enhance safety and better driving [2]. Many safety features are designed to avoid collisions and accidents by offering technologies that alert the driver to avoid collisions by implementing safeguards and taking over control of the vehicle [3-5].

The starting point for ADAS for the elderly is to recognize the traffic lights correctly [6]. Since traffic scenes can be a complex scenes and contains a lot of information, keeping a constant focus on that can be a challenging task even for a seasoned driver. The idea of using vision for ADAS in urban environments so that Traffic Light Detection (TLD) can be achieved was first introduced in the late 90's and has been studied so far [7-10]. Since the conventional TDL method is difficult to implement due to its complexity of the algorithm, we propose a simple and accurate way to recognize the traffic signals through picture from black-box

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II. CONVENTIONAL TLD METHODS

The idea of applying ADAS using image processing was used in [6] which performs image enhancement from a grayscale image and after that using edge detection algorithm such as Sobel, Prewitt and Laplacian operators for image matching.

However, such method does successfully detect the traffic light but only on clear weather. Another approach is to use color threshold segmentation method to identify the candidate regions using a HSI (Hue, Saturation, Intensity) color space instead of RGB (red, green, blue) color space [7]. Along with noise removal and two types of filtering which take account of the shape information and finally using a template matching to eliminate false positive. Using HSI color model does create a conceptual vision similar to human vision and now many researchers are adopting this color space.

A spot light detection was adapted for detecting the candidate region and adaptive template for recognition of the traffic light [8]. This method is later compare with other standard traffic light recognition system to test the accuracy of their system.

A more advanced image processing method using color, symmetry and spatiotemporal information was proposed to adverse a variety of weather conditions [9]. They achieve it using L*a*b color model instead of RGB color model and perform color pre-processing to enhance the red and green regions in the image. The fast radial symmetry transform was utilized to detect the traffic light candidate region and to reduce any false positive information, the spatiotemporal persistency was used for verification. This method works well under all-weather condition whether during day or night time.

A similar approach proposed in using the L*a*b color space by [10]. This approach still utilizes the L*a*b as [9] but instead of performing color enhancement on the red and green color, they perform the detection of traffic lights using color histogram to separate the intensity and the color information on the traffic lights.

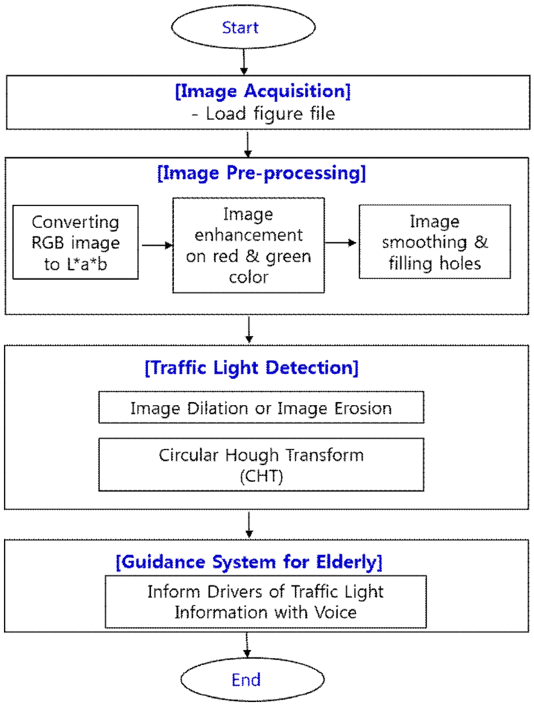
Most of the conventional can accurately detect the traffic light candidate. However, those systems are only effective when the weather is clear and only during daytime as can be seen in [6-10]. The systems cannot detect traffic light correctly during night time, however it is crucial to the elderly because their vision at night are drastically decreased. Plus, even on an unclear weather, some of the systems [6-7], have difficulties to correctly identify the traffic light.

III. THE PROPOSED TLD METHOD

The proposed method starts with color pre-processing method. The hardware setup is similar to most related applications which the standard vehicle has installed black box (car camera) in it. The image acquisition will be taken from the camera based on the video frames shot by the camera. The goal of the pre-processing module is to enhance the discrimination of the red and green color which can be done through modified L*a*b color model.

The image produce in which the red traffic lights will appear as white circular blobs and the green traffic lights will appear as dark circular blobs. The image from the pre-processing module will then be used to detect the traffic light candidate which include the finding the local maxima and minima using morphological algorithm on the top half of the image. For this proposed method, we are assuming the traffic lights will always be on the top half of the image, because at the intersection the car is at the bottom and the traffic lights are hanging in the high position.

The fig. 1. Shows the steps for the proposed algorithm, which is composed of 3 stages: Image acquisition, Image preprocessing and Traffic light detection.



[Fig. 1] Processing steps for the proposed algorithm

A. Image Acquision

Load image or figure file from the black-box or camera on the smart-phone installed in a car.

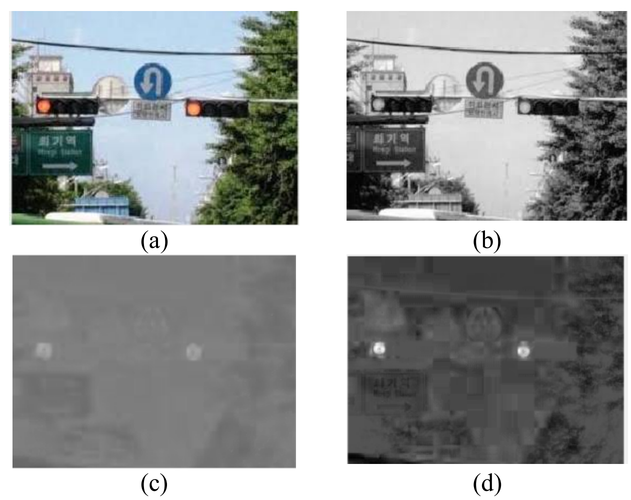
B. Image pre-processing

In order to perform a better traffic light detection, the difference between red and green color must first be enhanced. Only red and green colors are selected because these two colors play an important role in road traffic. The colors will tell whether a car should stop or go. Plus, these colors hold a certain duration than yellow traffic light, therefore we can ignore the yellow traffic light. The a* from the L*a*b color place positive value on red color and negative value on the green color. If we were to put a maximum positive pixel value and minimum negative value, we can achieve the ideal white circular blob for red color and dark circular blob for green color. This method aligns with the concept specify in [9].

In order to enhance the red and green color, the pixel values in a* channel are multiplied by the pixel values in channel L, producing a new enhance red-green channel defined as

$$RG(x,y) = L(x,y) \times a(x,y), \quad (1)$$

where, the x and y variables represents the pixel coordinates of the image. The multiplication of both of these channel will impact the pixel value. This will increase the absolute pixel value on the traffic lights as it tends to exhibit a high luminosity values thus turn the advantage of multi-plying with the luminosity channel (L channel). Objects will low luminosity value will not be affected to the same degree as the traffic lights. However, if there are any lights that appears to have the same luminosity as the traffic lights, then they are affected the same way as the traffic lights. The transformation of this process can be seen from fig. 2.



(a) (b) (c) (d)

[Fig. 2] Red - green color enhancement. (a) Original RGB image, (b) L channel, (c) a* channel, (d) L, a* multiplication result (RG channel)

Enhancing the image such as in figure 1 should suffice to achieve the goal of image pre-processing. However, in some cases where the condition of the road traffic in darker, a “blooming effect” is often produce. This can be seen from figure 2a. The blooming effect of the traffic lights can be caused by two reasons [9-10]. The first one is red traffic lights often emit some orange color while green traffic lights emit blue color. The second is depending on the type of the camera where the camera might be sensitive to bright lights.

To overcome the blooming effect, red and green color areas are combined with the yellow and blue color. Before combining, we must first apply the same step of color enhancement for yellow and blue color (YB channel) and after that adding the resulting image to the previous enhance red-green image with the following steps:

$$YB(x,y) = L(x,y) \times b(x,y), \tag{2}$$

$$RGYB(x,y) = RG(x,y) + YB(x,y) = L(x,y) \times (a(x,y) + b(x,y)) \tag{3}$$

C. Traffic Light Detection

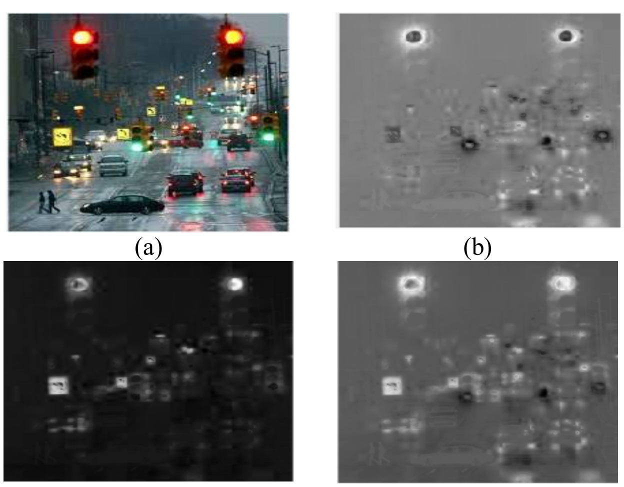
From the previous RGYB figure, it can be seen that the pixels with red intensity exhibits a bright intensity in the grayscale image. Applying a dilation operation will reveal more bright pixel intensity in that region, separating the brighter foreground from the darker background. Hence, we can detect more local maxima in the gray level image. In mathematical morphology, the dilation operation uses a structuring element to morph the shapes contained in the input image. The dilation in grayscale morphology is given by

$$(f \oplus b)(x) = \sup_{y \in E}[f(y) + b(x - y)] \tag{4}$$

where, f(x) is denoted as the image, b(x) as the structuring element, and sup is referred to supremum or also known as least upper bound (LUB). The red colors which has a bright intensity is expanded after dilating the image. From here on, it is easier to detect the red traffic lights.

$$(f \ominus b)(x) = \inf_{y \in B}[f(x + y) - b(y)] \tag{5}$$

where f(x) is denoted as the image, b(x) as the structuring element, and the inf is referred to infimum or greatest lower bound (GLB).



(c) (d)

[Fig. 3] Removing the blooming effect. (a) Original RGB image, (b) RG channel, (c) YB channel, (d) RGYB channel.

The erosion operation is the complement of the dilation operation. Applying this operation to the previous RGYB image will reveal more local minima present in the image. The bright pixels in the RGYB image is thinned and the dark pixels are more expanded. Like dilation operation, erosion operation also uses a structuring element as well.

The results of removing the blooming effect process are shown in figure 3. In figure 3(b), while the traffic light color should be red color, however it appears to be in negative values which is green color on the inner part. This the blooming effect and can cause several issues during traffic detection method further on. By adding the YB channel to the RG channel, the blooming effect is removed as can be seen from figure 3(d).

IV. CONCLUSION

In this paper, we have studied a traffic signal recognition system for the elderly drivers whose eye-sight and cognitive ability are lower than normal people. From the computer simulation results, we can find that the proposed TDL method can detect the stop and progress signal from the traffic lights not only in day time but also in the night. By recognizing the color of the traffic lights on the black-box or smartphone camera and confirming the voice to the elderly in advance, the driver who is confused at the intersection can get a great help from traffic accidents.

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