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Traffic Light Detection and Recognition for Self Driving Cars using Deep Learning: Survey

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ABSTRACT

Self-driving cars has the potential to revolutionize urban mobility by providing sustainable, safe, and convenient and congestion free transportability. Autonomous driving vehicles have become a trend in the vehicle industry. Many driver assistance systems (DAS) have been presented to support these automatic cars. This vehicle autonomy as an application of AI has several challenges like infallibly recognizing traffic lights, signs, unclear lane markings, pedestrians, etc. These problems can be overcome by using the technological development in the fields of Deep Learning, Computer Vision due to availability of Graphical Processing Units (GPU) and cloud platform. By using deep learning, a deep neural network based model is proposed for reliable detection and recognition of traffic lights (TL).

KEYWORDS: *Driver Assistance Systems (DAS), Graphical Processing Units (GPU), Traffic Lights (TL)*

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INRODUCTION

The road traffic scenes are usually complex and traffic video is vulnerable to external factors such as light, weather and obstructions. It is difficult to extract the traffic parameters and detect the traffic anomaly exactly with the existing image processing and analysis technologies under such uncertainty factors. A deep neural network based model is proposed for reliable detection and recognition of traffic lights and signs using transfer learning. The proposed method incorporates use of faster region based convolutional network (R-CNN) Inception V2 model in TensorFlow for transfer learning. The model was trained on dataset containing different images of traffic signals in accordance with Indian Traffic Signals. The model accomplishes its objective by detecting the traffic light with its correct class type.

LITERATURE SURVEY

1. Traffic Lights System Based on RFID for Autonomous Driving Vehicle

Abduladhem Abdulkareem Ali [1] proposed a RFID based method used to recognize traffic lights status. The proposed system mainly consists of two major block modules the traffic lights module and the vehicle module. The traffic lights module is made up of two electronic parts, the microcontroller and the XBee module. While the vehicle module is equipped with the preceding elements in addition to the RFID reader. The system is responsible for the recognition and proper presentation of those signs to the vehicle.

The RFID technology uses the electromagnetic fields to transmit signals, RFID tags can be placed on the road or being embedded into its infrastructure. In this prototype system, RFID reader of the vehicle is being placed under the vehicle to be in the closest position to detected the tags under the road which is shown in figure 1.

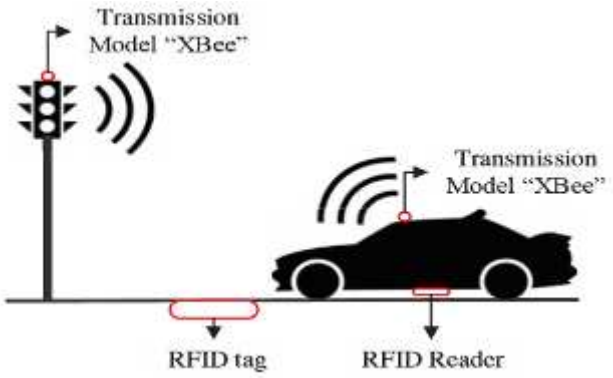

Figure1. Traffic light recognition system

Each of the RFID tags should be already defined to both the vehicle and the traffic light controller. Once the vehicle passes an RFID tag, it broadcasts a request message using the XBee module .Only traffic light controller receives that message. This message contains two fields: an RFID tag number for the vehicle detected and the vehicle ID number. While the vehicle ID number defines that address of that vehicle in order to

unicast an acknowledge message that contains the traffic light status on that road. If the road has multiple track and destinations, then all the status of road destinations is broadcasted to the vehicle.

2. Frame based Object Detection - An Application for Traffic Monitoring

Chin Hong Low, Ming Kiat Lee, Siak Wang Khor [2], describe a system that is capable of detecting and segmenting objects from video frames which helps in traffic surveillance. Shadow is one of the problems faced by most of the object detection systems. By differentiating the background and foreground of the video scenes using MATLAB embedded functions, the foreground regions are segmented as the objects. The segmented objects are saved forfurther development of computer vision applications such as object recognition and classification.

The first step in this method is to convert the video frames to images and after that subtracting the background from a particular frame. The result of the background subtraction is an image that only consists of foreground objects. However, this result might be affected by the change of light source, image noise and some other factors. To get a better result, a threshold should be obtained for the subtracted result. The next step is to find a threshold value to convert the subtracted image to binary image. The threshold value is a midpoint value to segment the foreground and background, a range of values are used to differentiate the object and the background. The value that is greater than the threshold will be taken as an object, otherwise it is decided to be the background. The final result will be a binary image where the background pixels are set to 0 (black pixels) and the objects pixels are set to 1 (white pixels). The result from the previous steps may include the shadows of objects in the foreground segments. The shadow will affect the accuracy of the object detection and segmentation result. Hence in the proposed system, the next step is to detect and remove the shadows. The method that used to remove shadow is based on HSV color space.

3. Moving object detection and tracking Using Convolutional Neural Networks

Shraddha Mane [3] proposed a novel CNN based object tracking algorithm which is used for robust object detection. The proposed approach is able to detect the object in different illumination and occlusion. The proposed CNN based moving object detection algorithm consists of two phase: Object detection and tracking.

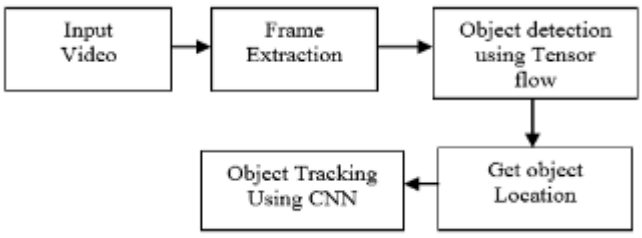

Figure 2. Block Diagram of the proposed system

In this system, the video is taken as an input. Frames are extracted for further processing. The two main algorithms object detection and object tracking is process through deep learning methods therefore Tensor flow based object detection algorithm has been used. After object detection, their locations are important to start the tracking process. Here Convolutional Neural Network (CNN) based tracking algorithm is used. In this approach first load the weights of the pre-trained model. The model is capable of incorporating the temporal information. Rather than focusing on the objects in the testing time, the pre-trained model which is trained on large variety of objects in real time. This lightweight model has ability to track the object at the speed of 150 frames per second. Also it is able to remove the barrier of occlusion. In this approach, the object locations obtained from the TensorFlow based object detection algorithms are passed to the CNN based object tracking algorithm. The initial positions are learned by the model and the same points are search in the net frames by testing process of CNN model.

4. A Vision Based Traffic Light Detection and Recognition Approach for Intelligent Vehicles

Ziya Ozcelik, Canan Tastimur, Mehmet Karakose, Erhan Akin [4] proposed a method which is divided into two sections. Each of these parts requires hardware. The first part requires a camera to get the image. The other part requires a computer to process the received images. In the proposed method, images have been taken using CCD camera. Image processing techniques are performed step by step to detect the traffic lights in the received image through the computer. When traffic lights are detected, the received RGB image is converted into HSV. By performing a color based segmentation process on the obtained HSV format image, the locations of traffic lights in the image are easily detected.

The color of the traffic light is easily determined through the SVM (Support Vector Machines) classification model, which is a machine learning algorithm. After the detection of the objects (circle) on the image, the detection of the states of the traffic lights detected is performed. Machine learning is used to determine the state of the traffic light therefore they have been categorized into three traffic lights (Red, Yellow and Green).Here, the number of groups to be classified is three because of the traffic light conditions. In order to create the SVM model, training is carried out using approximately 8000 frames of image obtained in the traffic. During training is characterized by a 3D color histogram method, which contains 8 boxes per channel respectively. After characterization, the method returns a feature vector of size $D = 8 \times 8 \times 8 = 512$. The obtained feature vector is used for modeling. For each image, the SVM model is created by performing the mentioned method. After the SVM model has been created, the model obtained is combined with image fragment within the boundaries of the object (circle) on the image to check the traffic light status.

5. Traffic Light Detection and Recognition based on Haar-like Features

Sang-Hyuk Lee, Jung-Hawn Kim, Yong-Jin Lim and Joonhong Lim [5] proposed an algorithm for traffic light detection and recognition based on Haar-like features. Here Haar-like features are used to learn about the traffic light image and detect the candidate area based on the learning data. The detected candidate image is verified by the pre-learned SVM (Support Vector Machine) classifier, and binarization and morphology operations are performed on the verified candidate image for detection of the traffic light object. The detected traffic light is divided into respective signal areas to determine the current on/off status of traffic lights. The signal signs in the respective areas are defined by regulation and the sign of traffic lights can be recognized by recognizing on/off of the signals in the respective areas.

6. Traffic Light Detection During Day and Night Conditions by a Camera

Chunhe Yu, Chuan Huang, Yao Lang [6] create a method to detect traffic light in day and night condition real time using camera., the algorithm of traffic lights detection 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: a CCD camera, an image acquisition card, and a PC.

The proposed method includes three steps: object extraction by color, rule based traffic light verification, and then extract the signal of the traffic light. The color segmentation is performed using RGB color model. They use color model element range and threshold to determine traffic light candidates. Red traffic light candidate must have R element bigger than G and B with a certain threshold, green traffic light candidate must have G element bigger than R and B with a certain threshold, and yellow traffic light must have R and G element bigger than B component with a certain threshold. Based on RGB color space, the algorithm extracts red, green, and yellow objects in the image firstly; For the purpose of eliminating disturbance in the environment, the features of traffic lights are used to verify the object identity, and then the types of traffic signals are judged.

7. Traffic Light and Sign Detection for Autonomous Land Vehicle Using Raspberry Pi

Priyanka D, Dharani K, Anirudh C, Akshay K [7] proposed a new method based on Raspberry Pi. Automatic recognition of traffic signs is also important for an automated intelligent driving vehicle or for a driver assistance system. This is a visual based project i.e., the input to the system is video data which is continuously captured from the webcam is interfaced to the Raspberry Pi. Images are pre-processed with several image processing techniques such as; Hue, Saturation and Value (HSV) color space model technique is employed for traffic light detection, for sign detection again HSV color space model and Contour Algorithm has been used. The signs are detected based on Region of Interest (ROI). The ROI is detected based on the features like geometric shape and color of the object in the image containing the traffic signs.

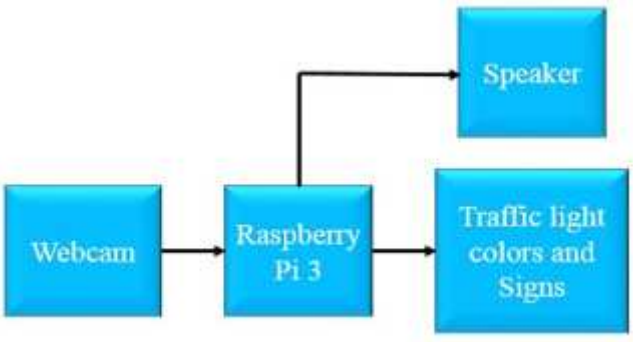

Figure3. Proposed Block Diagram

In the proposed work, Raspberry Pi 3 is the heart of the system. Raspberry Pi 3 is a compact computer which has many ports to which Camera, Speaker, etc., is interfaced. With the help of Raspberry Pi, the Image processing is done through OpenCV using Python. The maximum resolution of the Webcam is 1280x720, in which the resolution of the processed image is 680x680 and the Line of Sight (LOS) is 600 - 1200. The operating range of the camera is 40cm to 130cm and with Raspberry Pi camera the range is 50cm to 400cm. When a sign or traffic light is detected audio command is played through the speaker.

8. Segment-Based Traffic Sign Detection from Mobile Laser Scanning Data

Ying Li, Lingfei Ma, Yuchun Huang [8] proposes a segment-based traffic sign detection method using vehicle-borne mobile laser scanning (MLS) data. This method has three steps: road scene segmentation, clustering and traffic sign detection. The non-ground points are firstly segmented from raw MLS data by estimating road ranges based on vehicle trajectory and geometric features of roads (e.g., surface normal and planarity). The ground points are then removed followed by obtaining non-ground points where traffic signs are contained. Secondly, clustering is conducted to detect the traffic sign segments (or candidates) from the non-ground points. Finally, these segments are classified to specified classes. Shape, elevation, intensity, 2D and 3D geometric and structural features of traffic sign patches are learned by the support vector machine (SVM) algorithm to detect traffic signs among segments. The proposed algorithm has been tested on a MLS point cloud dataset acquired by a Leador system in the urban environment. The results demonstrate the applicability of the proposed algorithm for detecting traffic signs in MLS point clouds. The proposed algorithm is illustrated in the figure given below.

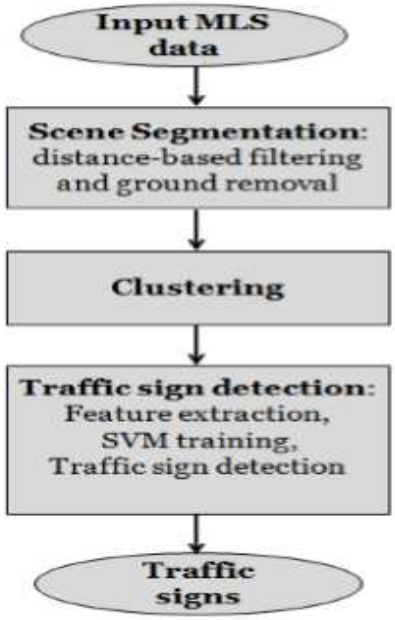

Figure4. Flowchart of the proposed traffic sign detection

9. Traffic Sign Detection and Classification using Colour Feature and Neural Network

Md. Abdul Alim Sheikh [9] proposed a new method based on neural network. The algorithm contain three main stages: 1) Preprocessing 2) Detection 3) Recognition and Classification. The system takes static color images as input taken from World Wide Web. The main steps of the proposed methodology are shown in Fig. 5. The output of the system is the name of the recognized road sign. In the detection module, the region of interest from the image is extracted based on color segmentation and make them ready for the recognition stage. The second module, artificial neural network is used to carry out the recognition and classification job.

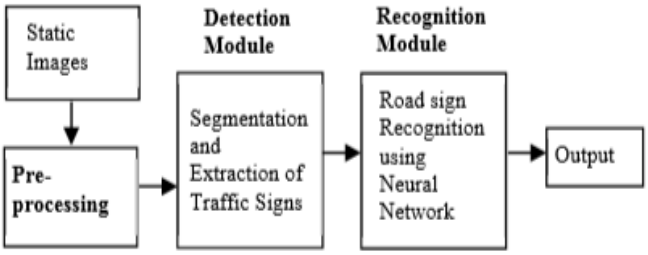

Figure5. Stages of the Proposed Method

10. Traffic Light Color Identification for Automatic Traffic Light Violation Detection System

Pasit Wonghabut, Rujchai Ung-arunyawee, Watis Leelapatra [10] proposes a software technique based on HSV (Hue, Saturation, Value) color model to eliminate difficulties in red light detection and is able to identify all colors of traffic light. Automatic traffic light violation detection system relies on color detection of traffic light appeared in video frames. The proposed system mainly includes three methods.

Method 1: Convert video frames to grayscale image, then followed by thresholding which yields binary images. All three colors of traffic light are compared with predefined pattern to determine which one is on. If there are more than one color of traffic light found to be on, the threshold value is adjusted and the process is repeated and this method uses pixel threshold value of ROI to judge whether the lights are switched on or not.

Method 2: Convert video frames from RGB to HSV color system, then compare value of hue to determine color of traffic light this method utilizes HSV color model to analyze ROI.

Method 3: Combine result of above methods. The color of traffic light is produced when the results from two methods are identical.

Three methods are combined to identify traffic light color. The conditional analysis is a process used to handle ambiguity of traffic light using predefined pattern as shown in Fig.4. This process makes decision whether the algorithms should output red, yellow or green. To verify correctness of algorithm, the number of times each color of traffic light switched on is counted manually by human and use this result as reference.

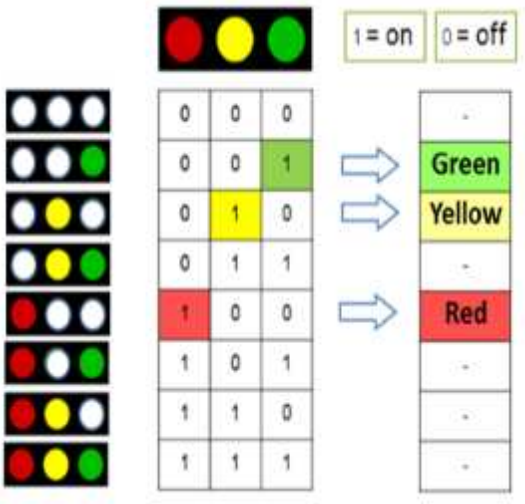

Figure6. Traffic lights decision pattern

CONCLUSION

Various methods to detect and recognize the traffic lights and signs are analyzed. Each of them works with different schemes. Each scheme varies on the convolution layers used and also their application used. A Deep learning system that classifies the traffic light is considered. The system consists of an ensemble of CNNs with post processing neural network that combine the predictions from the CNNs with traffic lights metadata. In the field of self-driving cars or autonomous driving, the use of Faster R-CNN Inception-V2 model via transfer learning improves the accuracy which makes the system reliable for real time application

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