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New Algorithm for Road Boundary Marking and Highlighting of Road Tracks with Object Removal

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Abstract - In the current era, sensing the surroundings is salient development area in the field of autonomous self-driving cars. Aptness of sensing the surrounding helps to determine the travelable area on the road. Various types of road round boundary extraction techniques were available. However, these are not enough for making road boundaries in the unstructured format. In this study, a robust algorithm to detect the road boundaries for both structured and unstructured in different situations is proposed. The objects on the road are also detected in this method that can assist the driver to ensure safe driving. This method is capable of detecting the road and segment the travelable part of the road along with generation of bounding boxes around the detected road objects. The algorithm proposed in this paper is divided into three modules namely Canny module, YOLO v5 module and Hough Transform (HT) module performing three different tasks. The model is robust in boundary detection and road segmentation because the novel architecture that is used exhibits more efficient and reliable results for driver assistance with high accuracy. The NVIDIA RTX 5500 hardware has been used to build the road boundary detecting system. The proposed technique is trained and validated through different sets of images from a data set. The dataset used in making this model is in high-complex non-linear form contain the road images of various situations at different weather conditions. The experimental mean accuracy achieved in this model is 93.45% on both structured and unstructured road. The experiments show that the proposed algorithm can accurately detect the road boundary and segment the travelable road.

***Key Words*:** Road Boundary Detection, Road Segmentation, YOLO5, Hough Transform, Autonomous vehicle

1.INTRODUCTION

Nowadays, due to the increase in fatalities from road accidents throughout the world, traffic safety has become an important subject of research. To ensure road safety, advanced technologies like Advanced Driver Assistance Systems (ADAS) and self-driving cars are embedded with Lane keeping, Blind spot warning and automatic parking system. However, getting informed about the road boundaries is required for smooth driving. This study, addresses the issue of knowing road boundaries and road segmentation using novel algorithm. Most of the proposed methods to solve these problems using external stereo-typic hardware making the system more complex [30]. Many LiDAR based techniques follow the conventional mechanism that is highly depending on the sensing quality []. In this methods Region Of Interest (ROI) is delineated from and processed. The computation required for this analysis is very high. Other learning-based models are also proposed for this task. The large portion of learning-based systems utilize Support Vector Machines (SVM) and Convolutional Neural Networks (CNN) for training and accurately classifying roads []. However, these classic systems are not robust to different conditions. The performance of these methods is highly relied on the training dataset that is used [5]. SegNet [13] is other approach proposed for road segmentation using the Kalman filtering technique. Wang et al. [27] proposed lane line detection using HT. This HT based module is based on the road boundary and tangent relationship. Moveh Samuel et al. [28] compared various edge detection algorithms. The analysis of HoG techniques given in [28] show that they cannot be used for the road boundary detection because of the high complex data. Satish Kumar Satti et al. [29] used Sobel operator for edge detection. The sobel filter are not able to extract the features of the boundaries of the road and the inference of these encodings are not effectively preserved. Nevertheless, the discussed works have not performed boundary detection on the unstructured roads that are usually there in urban areas as well as the road segmentation. Motivated by these research works, a

novel and efficient algorithm is presented here to detect boundary of road along with identification of road area with detection of objects present on the road. The dataset used for making the proposed algorithm is taken from KITTI Road_Seg data set [30]. The variation and bias in this dataset are genetic, thereby overfitting or underfitting the data cannot be done. Canny and Hough Transform modules present in the network are used to segment the road and boundaries with different colours. Instead of the edge-based analysis, the proposed algorithm works on the colour based and pixel-based analysis. Using the pixel level classification techniques, the road is segmented and pixels with similar intensity value are stored in buffer and highlighted with one colour for segmenting the travelable road region. Later using the same approach, the sudden change in pixel intensity and the pixel depth values from stored values in buffer space are identified as road boundary by different colour. Extended Hough Transform is applied to predict different types of roads either straight as well as curved. It performs interpolation of the detected road boundary, once the object is detected by YOLO v5. The YOLO v5 module present inherently in the network works simultaneously with Canny module for object detection by using the bounding box around detected objects. This technique performs simultaneously for detection of any object on the road. In this way, the proposed algorithm is able to identify the road boundary and segment the travelable road that can help the driver. This work can also be extended as the alarming system when the vehicle is moving out of the detected road boundaries.

The roads in the cities are constructed in a structured way. So, the detection of road boundary is comparatively easy from detecting road boundaries from urban roads. The basic structure of road is similar everywhere that includes plane linear design curve design, and colour. Due the vehicle moments the parameters like driving speed, turning radius, banking angle changes. The video captured by the camera is changed into a frame of images

2. Algorithm

The proposed algorithm is robust to the edges of the road. Since many proposed models works only on structured road format. In the urban roads, the structured and planned roads are not available. Hence, the novel architecture of using the canny edge detection module along with extended Hough Transform model makes the detection of unstructured road plausible as shown in Fig. 2

This experiment is performed on the data set KITTI road_seg data [30] with 12000 images as input along with additional test frames from live video. The technique proposed in this paper is implemented on the basis of three basic phenomena. First, Edge Detection along with smoothing of image for noise removal which is performed with the help of Canny Edge Detection Algorithm. In this paper, we have not only detected the road edges but these boundary edges are highlighted along with road segmentation. Second, along with Canny, YOLO5 is used for detection of object on the road. For clear and uninterrupted boundary detection, removal of objects present on the road is very necessary. Using YOLO5, the proposed technique has achieved the object detection and removal of object from road. Later the image is passed through Canny again for pixel wise classification. Third, in case for curved roads Hough Transform is used for detection and marking of the road boundary even though the visibility of road is minimal due to the curved structure, it detects the boundary by interpolation. It even does the road segmentation based on similar pixel intensity phenomena and boundary marking based on sudden pixel intensity change phenomena. Initially the input image is passed to Canny Edge Detection. Canny can detect strong as well as week edges. As it follows multi-step approach, it itself performs smoothing of image and removal of noise. Fig.1(a, c, e) are the input road images that are passed to proposed model. In this process, input images segmented from the video are first divided into grids, by traversing through grid, pixel differentiation is performed. Similarity between the adjacent pixels is identified and tracked. Pixel position with similar characteristics are stored in the buffer memory. One by one the sliding window traverses through the image grids and the buffer memory gets filled with similar colour pixels. Sudden colour change in image is identified and pixels are grouped together to be treated as a same object. All the similar identified pixels are highlighted with the same colour (pink) Fig.1(b ,d ,f). After the process of road pixels highlighting is completed, sliding window once again traverses through the grid but instead of traversing this time from the initial grid it starts traversing through the pixel for which sudden change in intensity values is detected. Such pixels are marked with different colour (green) Fig.1(b, d, f) which can be identified as boundary of the road. Hence prominent road boundary is detected along with road area detection in different colour. This is done with the help of Canny and Hough Transform. Hough

Transform produces a cosine curve[25] on the curved road image. Curve of a road is detected by transforming the image space into hough space. With the help of this a line in image space is converted to a point on hough space. In the hough space, line is turned into a point [13]. As for vertical lines the slope goes to infinity, hence polar coordinates are used. Concurrently, YOLO5 algorithm works for object detection on road images. Compared to R-CNN, YOLO5 is extremely fast [11]. This algorithm divides the image into N number of grids with same dimension. Each of these N grids is responsible for the detection and localization of the object. Image localization along with the image classification is applied to every grid. It creates bounding boxes and calculate object class probabilities. While checking for presence of car image inside the input road training image the Probability considered (Pc) is set to 1 and 0 according to presence and absence of car image inside the bounding box. It adds bounding boxes [11] using single neural network around the detected object (red colour bounding box) Fig. 1(b, d, f). It even detects multiple objects, present in an image as represented in Fig.1(f) where, two cars are represented by bounding box by finding centroid of each object individually. As YOLO5 works simultaneously with Canny, the object detected image is passed through Canny again for boundary detection and highlighting along with road segmentation. Object pixels are hold and the edges are detected again. Sliding window concept is also applied on the object detected image so that the road can be identified and marked with single pixel colour. In this way road region and boundary can be identified by removing any obstacles present on the road. This is a simple approach (Fig. 2) and not time consuming also. In this paper, a novel approach of boundary detection is proposed that can be easily implemented in real time. The proposed algorithm is compared with the existing works which can detect road boundaries. The results of the comparison are given in Table 1. The accuracy comparison graph of various model with the proposed model

3. CONCLUSIONS

In this paper, a new method for image-based road boundary detection is proposed. Beside road boundary detection, object finding and road area identification also the major outcome of this method. This method is developed by incorporating three very popular algorithms like Canny Edge, YOLO5 and Hough Transform. The method is efficient and effective for autonomous vehicles. The algorithm designed here, can successfully produces the expected results, which confirms the validity of the proposed method.

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