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Automated Vehicle Collision Avoidance and Navigation Using Raspberry Pi

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Abstract:

This paper presents vehicle detection and road detection is done which are adopted in intelligent vehicles. Vehicle detection and tracking is done using the Haar cascade method to identify the vehicles which are present on road. This detects the stationary as well as the movable vehicles on road. Haar like features are implemented in the system to get a clear edge of the vehicle ahead. The road detection is the free space estimation on the road in which the system in the vehicle provides a safer path to navigate. HSV method is mainly used for colour extraction. The road detection uses HSV colour space algorithm to track the real-time changes on the road. In this research vehicle detection and road detection is done at the sane time. The research process is on-going and many algorithms are being found to reduce the problems faced on road today.

Keywords — **obstacle detection, raspberry pi, camera, ultrasonic sensor**.

I. INTRODUCTION

Over the past few years on road vehicle detection is the key technique to help driver assistance in intelligent vehicles and it's been in practical use. This paper demonstrates this problem, proposing Haar cascade algorithm and also a cost-effective method. Along with the advancement of transportation and up growth in Automotive field, navigation in intelligent vehicles is interesting, fascinating and is a successful swing in the real world today. Vehicle detection being one of the most important task under the research of intelligent sensing vehicles works along with system like ADAS. In vehicles drivers significantly prefer advanced driver assistance system for a safe and comfortable journey. Vehicle detection in intelligent vehicles is progressed in two different techniques: motion based method which identifies motion regions using a sequence of images, while appearance based method uses video frames or images to identify vehicles [5]. Though multiple techniques and features are raised, Haar like features and HSV are chosen and preferably installed in vehicles [3]. P.Viola and M.Jones developed the Haar like feature algorithm. The key advantage of Haar like features over other features is the fact that it is cost-effective, easy to work with, gives errorless result and fast computation, and used in the detection of vehicles. The haar like feature brings forth a successful and satisfactory result in vehicle detection. The two popular sensors: a monocular camera along with millimetre wave radar is used for vehicle detections [1]. The root idea in this work is to eradicate the haar like features from the vehicle ahead of the system [7].

The road detection is a main component of this work. In the past ages, numerous techniques have supported intelligent vehicles to avoid vehicle collision and navigate in a safer obstacle free zone. Structured road and unstructured road are the basic two different types of roads. Road detection can also be attained by detecting the marking on the structured roads. Nevertheless, detection techniques are developing time to time [18]. The system must only handle with certain natural environmental problems as defined by the DARPA associates [16]. One of the hypercritical controversy in intelligent vehicle navigation is the detection of road [15]. The free space ahead of the vehicle is brought out processing the improved camera image. The available space ahead of the system is move the vehicle to prevent from a collision [17]. Exclusively only a few image pixels are considered from the image frame to improve processing speed, to conclude the edges are adapted has an outline either by curves or straight lines [23]. Road segmentation service senses the frames, histogram correlation method is utilized in a RGB picture to detect lane marking. RGB image is converted to HSV colour space to extract shadows [26].

II. METHODOLGY

The main aim of this work is to design a cost-effective solution for low end cars. The work mainly describes about the technology of vehicle detection and free space extraction. This work uses a monocular vision system for the detection. The cost of the system is low and works efficiently. This is used for the advancement of the navigation system in

intelligent vehicles. This work is designed for safe driving especially on highway roads which accounts in avoiding collision.

The system components consists of a laptop and the raspberry pi. The raspberry pi is connected to the laptop by the ethernet cable through which the data or information is transferred. The power to the raspberry pi is provided by the laptop by a cable. The images from the laptop are loaded to the raspberry pi. The raspberry pi stores the raw images from the laptop. These images are then taken for further processing. The images are then converted to digital images. There are two methods which are used, they are:

1. Vehicle Detection using Haar cascade method.
2. Road detection using HSV colour space method.

2.1 Vehicle detection using Haar cascade method:

The vehicle detection is done using the cost-effective system. There are many vehicle detection algorithms such as the HOG, SVM and the Haar cascade. This work is done by using real time images for processing. It is mainly used in intelligent vehicles. The vehicle is detected using the haar cascade method for the given images. The Haar cascade algorithm is provided with a pre-loaded data of the vehicles. Haar cascade uses feature extraction and classification for the detection purpose. Haar cascade are with low calculation cost and with high recognition rates. The algorithm also detects the boundary of the vehicles. It has a reliable detection result as it uses feature extraction technique. Thus by the given procedure the vehicles are detected and recognized. The vehicle is recognized by a rectangular box over it. The comparison result shows that this algorithm is very fast, which detects vehicles in real-time and has a higher performance than the other algorithms.

2.2 Road detection using HSV colour space method:

The road detection system is a challenging system as there are different type of road scenarios. The system is used to find the optimal drivable region of the road surface.. This algorithm is used to extract the road surface and show the drivable region for the vehicle. The road detection is done using HSV algorithm. Digital image is converted to multiple segments called superpixels. The given image is converted into superpixel image in which the image is partitioned. Each pixel is coloured as desired. The partitioned pixel are separated and the desired pixel is taken as an input which given to the HSV color space. The desired pixel color is extracted and the road is detected from the image. The superpixel segmentation technique is done using matlab and the real time image HSV color space is done using python programming in the raspberry pi. The region of colour can also be extracted. This algorithm has better performance than other algorithms as it is cost effective when compared.

III. SYSTEM DESCRIPTION

The system in figure: 1 describes that the images which are stored are loaded to the raspberry pi for the processing. The system component consists of a personal computer and a raspberry pi board. The raspberry pi board is connected to the computer by the ethernet cable. The power to the raspberry pi board is supplied from the computer to work.

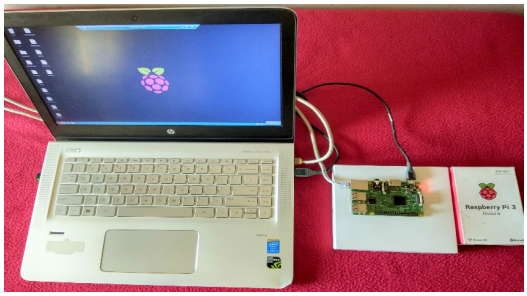

Figure.1 System components

The Raspberry Pi is a small computer chip which have the capability of the laptop and used for many applications in real time environment. Python software are programmable codes which is well suitable for this board. The board has GPIO pins through which it can be processed. The Raspberry Pi contains Broadcom. The board consists of 512 MegaByte of RAM. It has a quad-core processor which is used for fast processing. The Raspberry Pi is a low-cost device for researchers for developing many applications.

OpenCV is a computer vision library. It is found by Intel. OpenCV using C++ programming software. The image captured is segmented into pixels and so each pixel is processed by this programming technique. Algorithms related to machine learning is also possible with OpenCV. Python and C++ are languages which are supported in OpenCV, The Open CV can run on windows. OpenCV runs on a variety of platforms and it is easily programmable. The OpenCV is dumped in the raspberry pi for the programming purpose.

3.1 Block diagram:

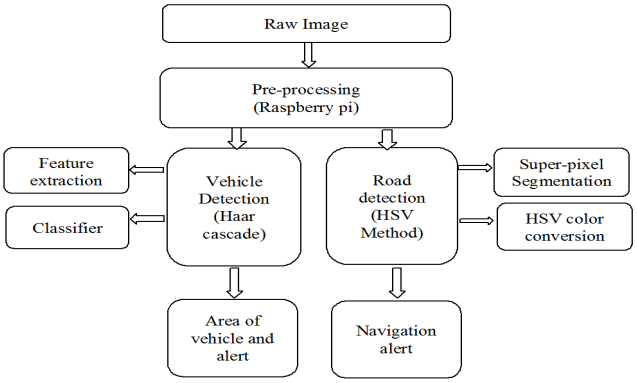

Figure: 2 Block Diagram

The image taken from the frames which are used directly for processing are called as the raw image or the original image. These images are processed for the detection of vehicles as well as road surface. These images are given as the input to the Raspberry pi, so as to process the image. The vehicle is detected by the Haar like feature algorithm which is

one of the fastest algorithms. An alert is to be provided as the vehicle is detected.

The road is detected by conversion of the color space from BGR to HSV. This is converted by giving values to the HSV and the surface of the road is extracted. The free space is thus provided by the system which results in a better navigation. An alert is provided in this method for easy and safe navigation of the vehicle.

Raw image is the image captured by the camera which is stored in the system in a viewing format. Many images are taken and stored in the system. The image is further taken from the system and given as the input to the raspberry pi. The raspberry pi further processes the image. The raw image has to be converted to digital image to be processed in the raspberry pi for detection purpose.

Raspberry pi is necessary for pre-processing. The pixelate information from the image or the picture is processed by the raspberry pi. The library files are downloaded to the raspberry pi as per the requirements to obtain the desired output. Overall vehicle detection and road detection is done by the raspberry pi at the same time.

Vehicle detection is to be done from the given image using Haar like cascade algorithm. Haar like cascade algorithm is used for detection of the vehicles. The Haar cascade method is provided with positive and negative images of the vehicles. This method which further does feature extraction and classification for detecting vehicles ignoring other obstacles such as trees and buildings. The haar algorithm is used as it is having a high performance characteristics.

Feature extraction used by Haar-cascade:

Feature extraction along with classifier training is done. The value of two rectangular features is the difference sum of the pixels within two rectangular regions. This method is used in this work. The three rectangular features are computed by taking the sum of two outside rectangles and then subtracted with the sum in a center rectangle. This rectangular feature is used for more complicated tasks. This feature is useful to obtain the haar like edges of image.

Classification:

Classification process comprises of positive images and negative images through which it is trained. Ada-boost technique is used for training the images for classification purpose. This process is mainly used to differentiate the image features. The trained images are classified for different types of vehicles. The Ada-boost classifier is a fast and reliable method used for detection and recognition purpose. The feature extraction and classification process is done for the end result of detecting the on road vehicles.

The road detection is done using Hue Saturation Value algorithm. Digital image is converted to multiple segments called superpixels. A superpixel is an image patch which is better aligned with intensity edges than a rectangular patch. Superpixels can be extracted with any segmentation algorithm, however, most of them produce superpixels, with widely varying sizes and shapes. The given image is converted into superpixel image in which the image is partitioned. Each pixel is coloured as desired. The partitioned pixel are separated and the desired pixel is taken as an input which given to the HSV color space. The desired pixel color is extracted and the road is detected from the image.

3.1.1 Vehicle Detection Block (Haar Like Feature):

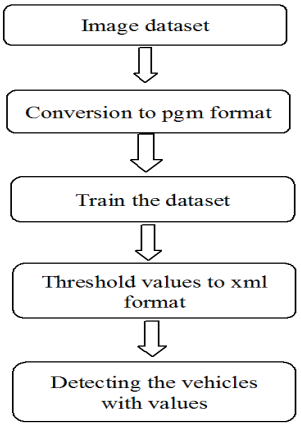

Figure: 3 Haar-like feature

The vehicle detection method uses the Haar like feature algorithm for detecting the vehicle. Haar like features are mostly used for vehicle detection and pedestrian detection. All the images from dataset are arranged together and the pictures are converted to pgm file format. The dataset consists of positive and the negative images of the cars. The trained images produce the threshold values. The values are produced for each image in the dataset. The values which are extracted from every image is stored and converted to xml format. The xml file consists of the dataset. The xml file is added to the program and if the vehicle appears, the algorithm detects the vehicles by drawing a rectangular box over the image.

3.1.2 Road Detection Block:

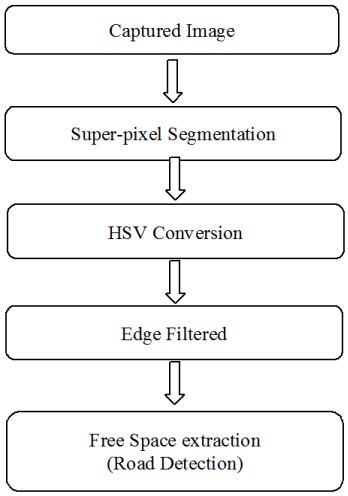

Figure: 4 Flow diagram of road detection

The above shown flow diagram in figure: 4 represents the road detection method. The original image or the captured image is taken as the input to the system. The input image is

given to the raspberry pi for proceesing and collecting information from the image. The system splits or groups the images into different kind of pixel called as superpixel. The superpixel image is a randomly created pixels according to the edges and other features of the image. The superpixel segmentation is done to the image. After converting to superpixel image, HSV values are given to the desired area or the superpixel. HSV is the hue saturation value where each of these contain separate values which help in differentiating the image. The HSV is the main method which is used for the extraction of the required parameter. The dilation and erosion is done to the image to have a clear output. The desired portion of the image is taken as the output. The edge filtering is done to the image so as to get a good view of the needed details from the image.

The following two procedures are detailed in the following:

i) Super-pixel segmentation

ii) HSV conversion

i) Super-pixel segmentation block:

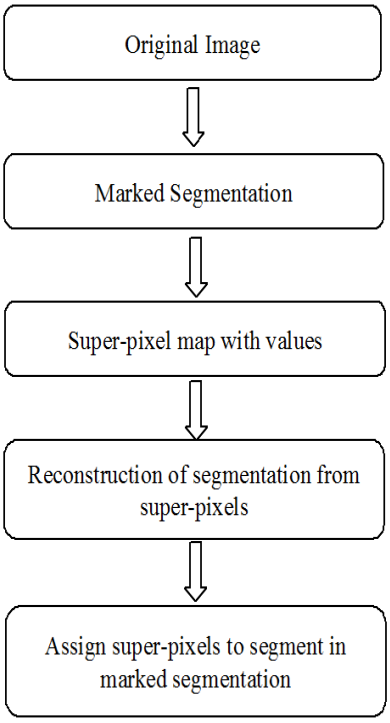

Figure: 5 Flow diagram of super-pixel segmentation

The above shown flow diagram in figure:5 represents the superpixel segmentation. The original image or the captured image is taken and given as input to the processing system. The edges of the image is detected by using edge detection technique. The superpixel segmentation is done by beginning with the marked segmentation. The pixels are separated as per the edges in the image. The pixels formulated are marked. The marked segmentation consists of values which is used to form the superpixel map. The superpixel map with the values is generated. The values are generated and the reconstruction of the segmentation from the superpixel is done.

ii) HSV conversion block:

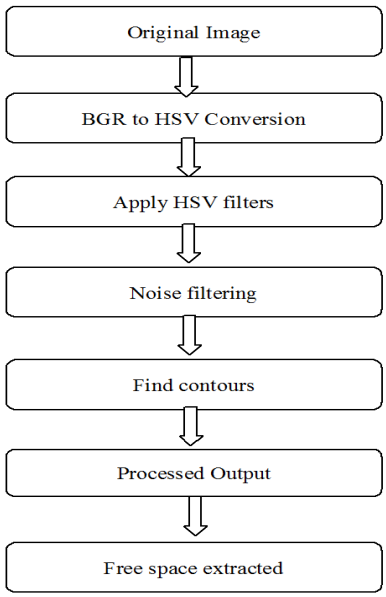

Figure: 6 Flow diagram of HSV color space

The above shown flow diagram in figure:6 represents the HSV conversion in the image for road detection. The Hue, Saturation, Value is the last step of conversion for the free space in the road to be extracted. The original image or the captured image is given as the input to the system. BGR is converted to HSV by formulation procedure. The HSV filters are applied to every segment and the noise filtering is done. Noise is produced when the filtering is done. The noise is removed and the contours are found using contour measurement technique. The dilation and erosion operation is done for further betterment. The output is processed after these procedures and the free space in the road is extracted using HSV method.

IV. RESULTS AND DISCUSSIONS

4.1 Result of Vehicle Detection:

The raw image is taken. The vehicle detection is to be done to the image, so Haar cascade technique is used. The Haar cascade uses feature extraction and classifier methods to detect vehicle. The image data is pre-loaded to the system to easily detect or classify the vehicles. The right image shows that the vehicle in the image is detected and recognized with a rectangular box showing a better result of the vehicle detection technique. The result is as expected and the performance of the Haar cascade algorithm is high and efficient. There is a small percent of error as the algorithm also detects many particles which are unnecessary, so it must be further rectified.

Figure: 8 Result of vehicle detection using Haar cascade

The below shown table: 1 shows the calculation of the vehicles detected in the image. The false and true value are noted in the table. The false detections are more as they are used for testing and providing alert about the vehicles.

Images	False	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Image 1	34	35	37	39	44	45	49	50	52	57	687
Image 2	26	29	30	34	37	54	60	69	72	90	1056
Image 3	25	26	28	30	32	34	57	65	76	80	475
Image 4	22	22	34	36	37	56	59	76	98	99	643
Image 5	21	23	26	33	35	41	45	52	55	60	652
Image 6	21	22	28	31	32	34	41	53	102	110	238
Image 7	20	21	23	24	26	29	35	36	52	70	195
Image 8	23	30	42	45	49	78	80	87	104	126	148
Image 9	21	23	24	34	46	54	62	63	66	71	403
Image 10	20	21	26	34	37	44	52	60	74	78	198

Table: 1 Vehicle detection rate

4.2 Result of Super-Pixel Segmentation and HSV In Matlab:

The raw image is taken and converted to superpixel image using superpixel segmentation technique. This method is done using the matlab software. The superpixel image is taken and each pixel in the image is given a color according to our requirements. The desired color pixel is extracted using HSV extraction is done thus by extracting the free space estimation of the road excluding the other parameters. The result of the above experiment is as expected. In this method, the road is detected without any false detections. The vehicle is not considered in this technique and the super-pixel is to be further refined.

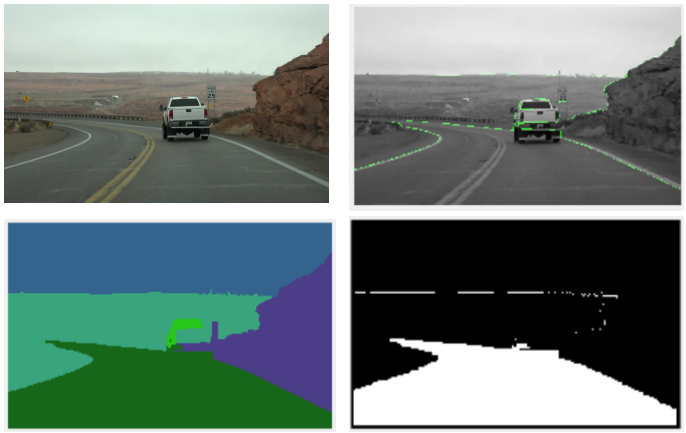

Figure: 9 Result of the road detection using super-pixel segmentation

4.3 Result of Road Detection:

The raw image is taken. The road detection is to be done with the given image. The HSV valves according to the color of the road is noted by changing the values till the colour of the road is obtained. The noted values are applied to the HSV algorithm, with which the road is detected. The result of the road detected is shown in the above figure. The figure clearly shows the extracted figure of the road. The other parameters are ignored when the extraction is done. road detection or the free space extraction is done to detect the edges and to find out the free space available for the navigation of the vehicle. The results of the HSV algorithm shows that the performance of this technique is high. The detected edge of the road is further processed to reduce errors thus making the technique cost-effective and successful.

Figure: 10 Result of the road detection using HSV technique

V.CONCLUSION

Based on the results it can be concluded that vehicle detection technique which uses the Haar like feature algorithm provides faster and better results than other methods. The experimental results show depth analysis of the technique. The road extraction method has also proved that it is better by the super-pixel and the HSV method in which the errors are minimal and the result is as expected. This entire work has been performed in Open CV by adopting python as the programming language.

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