Obstacle Detection of Vehicles under Fog

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Abstract **- Obstacle detection of vehicles is important for driver safety. If there is any obstacle in the road it may cause accidents as well as it affects the traffic flow of vehicles. To prevent such accidents, it is important to study detection of obstacles in real time. But it is difficult to analyze due to factors related to shadow and/or sudden changes in the environment and obstacles ahead of the vehicle. Fog is one of the important environmental changes that can cause vehicles not to identify the object in-front. This paper aims to design a new approach for obstacle detection which is based on moving objects. This approach is more useful for identifying the different and the minute obstacles in which the fog covers the object, so that driver assistance is provided and acquires more safety. We focus on factors such as: i) classification of fog (dense fog, moderate fog and high fog), ii) how long the distance the driver can see nearby vehicle or obstacle and iii) under each types of fog how much would be the maximum distance of visibility. The vehicle to vehicle visibility distance measurement and obstacle to vehicle distance measurement can be calculated using visual aids.**

Keywords - OBSTACLE, ADAS, ITS, GLCM, SVM

I. INTRODUCTION

The obstacle detection technologies and fog detecting technologies are increasing in our day-to-day life. The accidents are increasing due to this. Hence for the better awareness of driver there is a better choice for driver assisting system with Intelligent Transportation System. The benefit of all these technologies is that driver can interact with the GPS system and become aware of upcoming obstacles that is coming in-front.

Fog is the water droplets which can be seen in the earth surface. It is mainly influenced by the near-by bodies of water, based on the features of earth surface and climatic conditions. The term “FOG” and “CLOUD” can be differentiated according to the moisture content. The visibility of fog is more compared to mist, snow, dew etc. because of the moisture content being more in fog.

The accidents occurring due to fog is more. As per the survey in 2016-17, the occurrence of death due to fog accidents is reduced by 50% in North India [27]. But the accidents that occurred are more due to dense fog which affects the visibility of driver. Further it reveals that the snowfall also leads to more accidents as well as it affects the visibility too. As per this, the driver could not see the vehicle in-front or obstacle in-front. 80% of the places show that the accidents have occurred due to dense fog.

Table I. shows some parameters which change the road accidents and change over the previous year [28].

TABLE I. COMPARISON TABLE OF ROAD ACCIDENTS IN 2015-2016

Road Accidents and change over the previous year			
Parameter	2015	2016	% change
Total accidents	501423	480652	-4.1
Killed	146133	150785	3.2
Injured	500279	494624	-1.1
Accident severity*	29.1	31.4	7.9

*Number of persons killed per 100 Accidents

There are number of research studies that reveals about the driver safety related to vehicles. The driver must interact with Global Positioning System (GPS) continuously while driving. This creates a diversion to the driver which causes severe accidents. The approach which is presented in this paper is more useful for driver’s safety and improves accuracy and performance.

The major questions arrived at are:

1) Without introducing to GPS how the driver can assist their own safety?
2) What are the main disadvantages of GPS while driving?
3) Will only the image processing technique will be useful to this driver assistance system?
4) What happens if the system or approach fails to detect the obstacles?

In this approach there are several considerations. According to fog, the user must understand about the visibility distance properly. If the fog content is dense, then the drivers can’t move over speed. So the interaction between the vehicle, driver and the environment should be user friendly. Drivers will not look back for finding the obstacle. The driver has to understand from that screen for upcoming obstacles. In this paper the main aim of the obstacle detection is to decrease the number of road accidents and give much more awareness to driver safety.

The Advanced Driver Assistance System (ADAS)plays an important role in the safety of drivers as well as vehicles. With the help of this system the driver can avoid accidents and can give more attention to the higher-level tasks. Here the term visibility comes as a main indicator to help the driver to drive safely. When the visibility reduces due to fog it can cause several dangerous accidents. As the fog density increases the visibility decreases. When the climate change is severely affected due to excessive speed, it will affect the vision of the driver. For this reason we are introducing a new approach which is capable of detecting obstacles in the presence of fog. With the help of image that is taken under real time, it is classified into categories of fog, obstacle in-front of vehicle and informing the driver about the maximum speed that they should travel on the road.

II. RELATED WORK

In this section the existing methods for fog detection and obstacle detection in terms of ADAS and Intelligent Transportation System (ITS).

Jeevanand Usha [1] describesthe system which detects the fog for a particular image with a goal of assisting the driver about the visibility distance to avoid accidents. They were computed on the basis of the horizon line estimation and inflection point estimation to detect the fog as well as finding the visibility distance.

RakeshAsery, Ramesh Kumar Sunkariaet al., [2] have analyzed about the fog by using Gray level co-occurrence Matrix (GLCM) based features and Support Vector Machine (SVM). The images are extracted on the basis of the optical characteristics. The GLCM Features are selected by using the box plot. The box plot differentiates the foggy images and non-foggy images, by considering the three parameters such as contrast, correlation and homogeneity which describes the SVM classifier. These parameters are suitable for the synthetic database as well as natural database.

Lima [3] implemented ADAS to restore the image visibility. They are using canny edge detector for edge detection, after estimation of horizon line and inflection point assessment ofwhether the fog is present in the image or not. If the fog is present in the image, then they are estimating the visibility distance, after that they are implementing a speed warning system to alert the driver about the speed. To get a fog free image under the fog classification and to estimate the fog density for deciding the maximum speed that a vehicle should travel is their main objective. ADAS algorithm is mainly used for detecting the presence of fog in the image and to measure the visibility distance and also to inform the driver about maximum speed.

Salma Alami, Abdelhak Ezzine and Fouad Elhassouni [4] had presented an approach for detecting day time fog based on the saturation and correlation between the components of the RGB (Red-Green-Blue) color space which can be computed for a region around the image. There are certain criteria to select the characteristics of fog: its purity color attenuation and an increase in white color. From these characteristics they are finding vanishing point. As per this vanishing point, fog detection is done.

SileaIoan and Miclea Razvan-Catalin[5] describes a system which is able to estimate the visibility distance and to inform the driver about safety driving and maximum speed as per the weather conditions. The model which is described in this paper has an input data as foggy images which contains the light sources and from that there is a link between the levels of fog and visual acuity. The very first analyzation of light source is LED (Light Emitting Diode) light, after that laser source was analyzed using power meter. From this they conclude that fog doesn’t influence the laser light but the fog can be detected by using LED light.

Vidhi R. Shah, Sejal V.Maru and Rutvij H.Jhaveri [6] describes about the obstacle detection technique which is based on the moving cameras and moving objects. Here they are considering road dimensions for identifying the different obstacles as well as overcoming the limitations of stationary object and stationary cameras. Their results show that the proposed method is robust and reliable than the previous approaches. This method includes the moving vehicle for detecting obstacles. At the time of detecting obstacles the user can notify about some actions that they can be performed to prevent accidents. Their system aims to the security of Vehicular adhoc Network (VANET)in ITS.

GowthamPrabhakar,et al., [7] presented a system which is associated with deep learning in which it uses a region-based convolution neural network which is trained in PASCAL &VOC image dataset which is mainly developed for the detection and classification of on-road obstacles. The implementation of this system is on a Titan X GPU which achieves a processing frame rate of at least 10 fps for a VGA resolution image frame. This frame rate uses a GPU that suites the system for highway diving of autonomous car. The variation in images (climatic change, iRoad images) will lead to various results.

A. S. Nitheeshand Dr. HemaMenon P[19] describes about the obstacle detection which is based on the contour vision. By using this, they are also estimating the depth of the images by extracting the contours. Using this contours of the images disparity of objects are found out and they are being compared the performance of execution by using a beagle-board and a personal computer.

Naveen Appiahand NitinBandaru [8] describes in his work about the obstacle detection by classifying the points in 3D space based on height, width and slope relative to the neighboring points. The obstacle points which are detected can be mapped to their corresponding projection planes for the planning movement. The process is tested on various outdoor settings and gives positive results. They were not described about the accuracy or performance. Though the performance was so poor the obstacle above the ground was considered for their work. But the advantage shows that the process will be worked for the potholes in the ground too. When a point inside the hole is considered then it will be considered as 3D space around that point. These points will be considered as an obstacle.

Huinhai Cui, et al., [9] presented an algorithm which detects the obstacles by using SONAR data from dual sonar sensors. In sonar model first the obstacle's features are described. After that a dynamic filtering algorithm is applied. It uses an orientation and trajectory information of the vehicles. The validity of this algorithm is applied through the test field in cross-country environment. Through Autonomous land vehicle (ALV) only the information is captured and mapping should be done through various on-board sensors. Some of the obstacle detection devices such as LiDAR, millimeter-wave radar, ultrasonic or infrared sensors can be installed on ALV. The algorithm performs high accuracy in cross-country environment.

GildasLefaix, T. Marchand, and Patrick Bouthemy[10] describes a technique which is based on image motion analysis. Here they are using dominant image motion by considering all the outliers in the dominant motion and detect the obstacles directly. They have added detection step as a tracking module which relies on a motion consistency criterion.

Dr. Mohammed Abdul Waheed and Soumyashree [11] defined a standard visibility index used to allow the fog into various categories, where the driver assistance system should recognize. Mainly they are implemented the system for the night time fog. The night time fog is classified based on their intensities. They have introduced 2 approaches here. The first approach is based on the scattered veil created by head lamps. The second approach evaluates the presence of fog due to detection of halos around the light sources ahead of vehicle. They have worked under real time images of fog.

Bansal et al., [12] describes about the video and image defogging algorithms. They have presented the detection and classification method of a foggy image. After that they have summarized the existing image defogging algorithms, image contrast enhancement algorithms, and fusion-based defogging algorithms. They have also implemented video defogging algorithms. They have compared the different defogging algorithms on manual approach as well as experimental approach. Finally they have summarized these approaches on the basis of image quality assessment.

Li, Qin, and Bin Xie [13] implemented a new method for visibility estimation by using a single image as input. By using the theory of radiation theextinction coefficient is calculated. On the basis of dark channel prior the ratio of extinction coefficient of clear and current atmosphere is calculated. After that multiplying the clear coefficient and ratio the extinction coefficient of input image is calculated and after that obtained a visibility value. The advantage of this method is there is no need of constraints and performs well in various types of scenarios.

KumarTarun, and Dharmender Singh Kushwaha [14] proposed the efficient and novel approach for the detection of moving vehicles as well as to estimate the speed of vehicles by using a single camera in daylight. They have implemented an approach which detects and tracks the vehicles that passed through a particular area. The vehicle tracking is mainly based on the relative positons of vehicles in consecutive frames. Here they have used Automatic Number Plate Recognition (ANPR) system for selecting key frames.When there is any wrong detection of images they are using cropping operation to minimize this.

Jasinski, Janusz, et al., [15] presented the detection of fog and stratus which is taken from the results of MODIS images. They have taken the high resolution images. These high resolution images contain the intensity of the images, its color, its brightness as well as its contrast. They have used various data diagrams and reflectance diagrams to describe the internal structure and properties of the images.

EktaChauhan [16] implemented a novel algorithm for fog removal or haze removal by using the combination of various methods. The methods are edge enhancement method, color adjustment method, adjustable empirical function, and Weiner filter. By using all these combinations the quality of possible outcomes is more. They have taken images that contain bad contrast as well as good weather images. The bad contrast images are got by bad weather. So when the light reaches through camera it is severely scattered throughout the whole atmosphere.

KumariChigullaLeela[17] presented a method which ismainly based on software implementation of obstacle detection and avoidance system for Wheeled Mobile Robot. The system consists of infrared sensors and microcontroller. In this system three infrared sensors are used for left, front and right. The reading is taken from infrared sensor and processed to avoid the obstacles. The main goal of this approach is to avoid the obstacles along its path and to determine the distance.

Peng, Yan, et al., [18] presented an obstacle detection and obstacle avoidance method. Here they have mentioned about the local avoidance techniques based on the sensors. The algorithm for obstacle detection and obstacle avoidance deals with 2-D lidar images. The algorithm has an advantage that good real-time performance with a simple mathematical model.

Mane Sunil B and SharanVhanale [20] described about the real time obstacle detection and avoidance algorithm using a kinect camera. The obstacle detection algorithm is mainly used to find the depth of image which is captured from the camera. The obstacle detection and avoidance can be used in both static as well as dynamic environment. They have proposed the images with a hardware called raspberry pi2. The advantages of the system are simple, robust and efficient.

Karunasekeraet al., [21] implemented a method to detect the negative obstacles from stereo vision on ground plane. They have used stereo camera for taking input images. The input image is fused with 3D transformation. The method can be improved by adding various parameters and also by efficiency of the system. The system was tested with roads and terrains.

Nair, Dinesh, and Jake K. Aggarwal [22] presented a system that detects moving obstacles and also estimated the motion of the object with respect to robot.They have used a single camera in structured environment. The goal of the system is to detect the obstacles to avoid the collision. They are considering only the obstacle in-front. The system is implemented with hardware.

Moon Hee Chang, Hong Chul Lee, and Jung Ha Kim [23] introduced a new obstacle detection approach based on vision and laser scanner for Unmanned Ground Vehicle (UGV). It is very difficult to fuse the sensor data. Because of this mono vision is used. But it has also certain disadvantages so that they are mapping the local data with scanner's data.

Yao Tingting, et al., [24] introduced warning system for the prevention of accidents. Already there so many systems related to the warning system are available based on the artificial intelligence, vision and sensor based. But they have proposed two methodologies such as a single thermal camera and ADA boost algorithm to detect the obstacle in the level crossing road and an artificial intelligence camera setup to find the landslides over the rail track.

Prashanth C.R et al. [25] described a novel based algorithm for obstacle detection. Image processing algorithm is used for processing the images. The camera needs to focus only on a particular image. When a lightning or sudden movement of images occurs happened the camera can't be captured. So that the algorithm fails in these conditions. To overcome this they have used IR cameras for capturing images. But the algorithm worked for negative obstacles as well as positive obstacles.

Savitha, G.P.S.Venugopal, and Niranjan Chiplunkar [26] implemented object detection which is based on the image processing algorithms. Binary image is given as input to perform the morphological operations. Foreground objects and background objects are differentiated by their intensity values. After segmenting the images objects are extracted using contour based technique.

III. SYSTEM'S OVERVIEW

In this work first we have to check whether there is a foggy image or not. If it is not a foggy image we can't proceed further. After that the detection of obstacle in foggy image is found out as well as the distance to that particular obstacle is also calculated. Here we are considering all the images at real time. The input is given as a video while output comes as images which contains obstacles with its visibility distance.

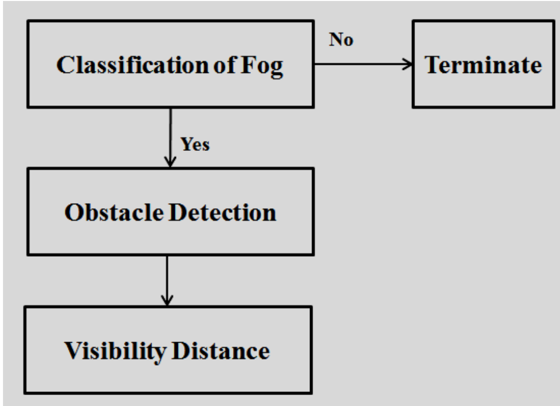

Fig 1: System Design

Fig 1 shows the working of system. First for an input image classification should be done (dense fog, moderate fog and high fog) after that finding whether there is any obstacle or not by training the system again and again. Finding the visibility distance with that obstacle is the last process.

A. Classification of Fog

The detection of fog and its classification can be undertaken by using GLCM features and SVM. For this first feature extraction should be done for each of the image for a particular video file.

A1. Feature Extraction

Finding out some special features from a set of sample data is called feature extraction. Here feature extraction is done for the input data for performing the GLCM and SVM.

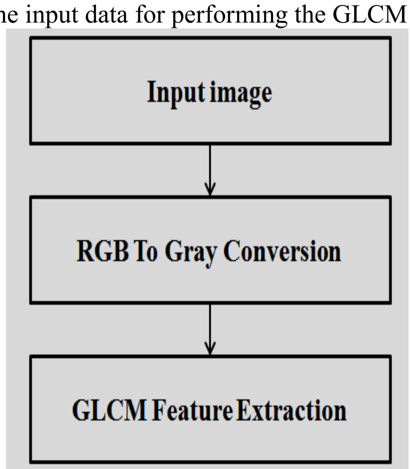

Fig 2: Feature Extraction.

Fig 2 shows how the feature extraction can be done using an input image**.** The feature extraction should be done

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while the GLCM Features and SVM is applied to the images. While performing this we can extract the special features from the input image.

A2. GLCM

Gray level co-occurrence matrix (GLCM) is one of the approaches for 2-point extraction technique. The2-point extraction is mainly used for representing the image in 2D analysis. The GLCM is calculated from the histogram of the image. But the image should be gray converted. The GLCM Matrix mainly depends on the number of gray levels in that particular image. GLCM has so many features such as Contrast, Correlation and Homogeneity [2].

a. Contrast

Contrast can be determined by the color difference and brightness of the object.

Contrast = $\sum_i \sum_j (i-j)^2 \ G(i,j)$

b. Correlation

Correlation is a measure of gray pixel with relative pixel in the image:

Correlation =$\sum_i \sum_j (i * j) \ G(i,j) \ \mu_i \ \mu_j / \ \sigma_i \sigma_j$

Whereσ_i and $\sigma_j$are the standard deviations of horizontal and vertical GLCM Matrix and μ_i and μ_j means relative to horizontal and vertical components of variance. The value of$\mu_i$and μ_j is in between -1 to 1 and 1 implies maximum correlated and -1 implies minimum correlated.

The variance:

$$\sigma_i^2 = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} G(i,j)\,(i-\mu)^2$$
$$\sigma_j^2 = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} G(i,j)\,(j-\mu)^2$$

c. Homogeneity

The uniformity of the pixel values of that image is homogeneity. If the pixel values are same then the homogeneity has maximum value [2]:

Homogeneity= $\sum_i \sum_j \frac{1}{1+(i-j)^2} G(i,j)$

It's value depends on [0, 1]. If there is a larger variation in image, homogeneity is lower and if there is no variation in image homogeneity is equal to 1.

A3. Support Vector Machine

It is a supervised learning technique mainly used for classifying data. It is a concept based on the decision planes which develops a model that assigns an observation into one category and others into other category. Support vector Machine (SVM) is mainly used for text and image classification.

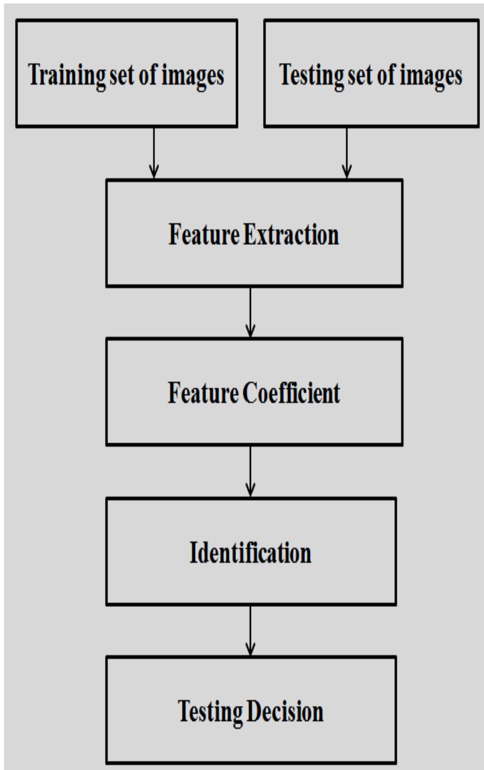

Fig 3: Classification of SVM

Fig 3 shows the classification system of SVM. The main idea behind the SVM is to classify the images into various categories and finally arrive at a decision that in which category this input set of images belongs to. First the input images are classified into 2, training set and testing set. After that feature extraction should be done on this 2 sets and finding a feature coefficient which leads to the identification of that particular decision.

The goal of SVM is to find best suitable hyper plane for the training data. The mapping of SVM Classifier is done by different types of kernel. Performance of SVM is affected by the selection of kernel.

B. Obstacle Detection

Algorithm

```
Input: Video
Output: Image containing obstacle with a bounding box
   1. Train the system
   2. Read the xml file generated as output from step1
   3. Read the video
   4. Initialize each and every frame of the video from 0,1,2,..n
   5. For i=0,1,........n
        read the video frame
        if obstacle is detected
              draw the bounding box
        else
              neglect image frame
        end if
```

Fig 4: Obstacle detection Algorithm

Fig 4 explains the algorithm of obstacle detection. For this the input is a video which is a sequence of images. For this first we have to train the system after that we have to find the xml file from the system which is trained. Then we have to read the video file and initialize frames for that video. If any obstacle is found in that video then a box is plotted around it.

B1. Training the system

This includes the outline of the obstacle detection. For training a detection system there should be a dataset. Here the dataset is the images of the vehicles which are under fog. The detection system is useful for all the images that contain fog. A detector function is used in this.

Fig 5 shows the obstacle detection in real time images. By using the cascade detgector function the system gets trained and by cascade classifier we are reading xml file. To see the output video we are using a function vision. cascade object detector system. object.

To identify the object in the video frame we have to train the system by using the CV ToolBox provided by the MATLAB R2017a.

The training stage requires the images that are taken as real time and applying a detector function to that particular image and obtain results as an xml file and can be used for detection.

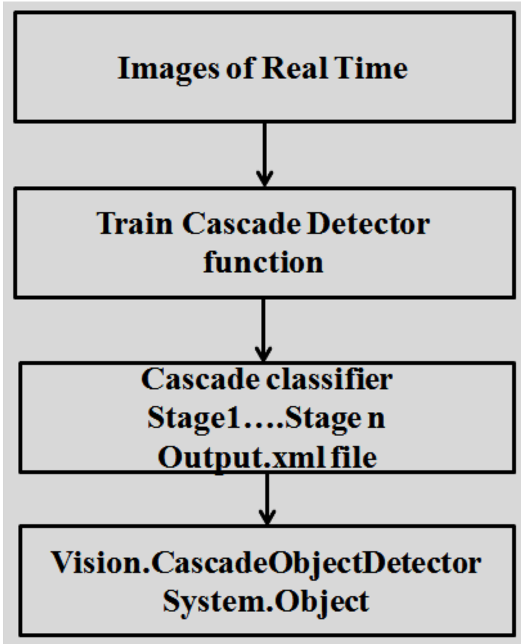

Fig 5: Obstacle Detection

B2. Detecting the Obstacle

This phase depends on the initial phase of system training. This phase works by reading the video and loading this video into the system. As the video is the sequence of images only, we have to convert the video into keyframes and for each and every frame training result is applied. The output is of the form of video which is having obstacle.

IV. VISIBILITY DISTANCE

The visibility distance can be calculated by using ADAS system. The visibility distance is the distance by which the driver can see the obstacle in-front. The visibility distance can be calculated after finding the inflection point and horizon line estimation from the image.

TABLE II. DISTANCE ESTIMATION TABLE

Visibility Distance	
Range	Categories of Fog
0m - 100m	Dense Fog
100m – 500m	Moderate Fog
500m – 1000m	High Fog

Table II shows the distance estimation table and its categories. On the basis of the distance we are classifying the fog categories into dense fog, moderate fog and high fog. When the intensity of the atmosphere is more the foggy situation is also complex.

V. RESULTS, DISCUSSIONS AND CONCLUSION

Input: Video File (Driving_in_Fog.png)

Fig 6: Frame of the Video File

Fig 6 shows one of frame of the above mentioned video file.

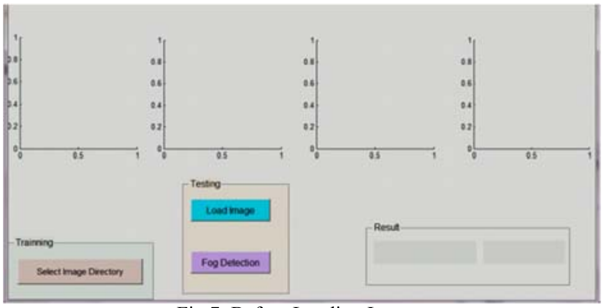

Fig 7: Before Loading Images

Fig 7 shows that when the frame is load first into directory there shows a command box that database is created successfully Fig 8.

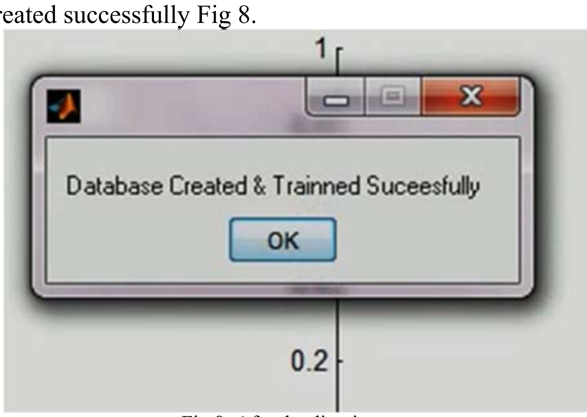

Fig 8: After loading images

After clicking ok in this command box we have to test whether the image contains fog or not. For that we have to click on the load image. For loading the images there are lot of images for a particular video file and select the frame.

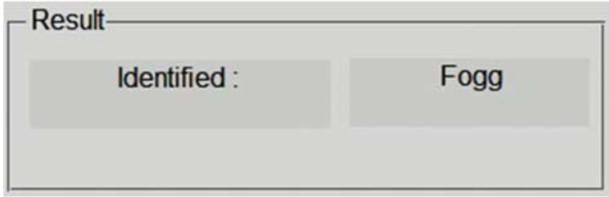

Fig 9: Classified Categories of Fog

After performing the classification of fog we have to find the obstacle in-front.

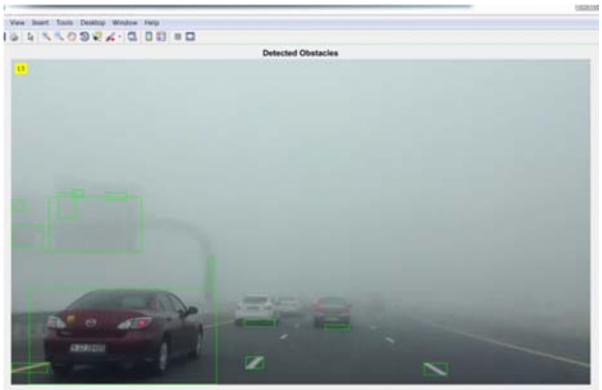

Fig 10: Detected Obstacles

Finally we have to calculate the visibility distance of the vehicles in-front as summarized in Table 2.

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