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Animal Vehicle Crash Mitigation System For Intelligent Vehicles In Indian Scenario

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ABSTRACT

Traffic accidents are a major cause of death and injuries world-wide. The collision of an animal with the vehicle on the highway is one of the reasons for road accidents. In this paper a simple low-cost methodology for automatic animal detection on roads for preventing animal vehicle collision (AVC) using computer vision techniques are proposed. A camera mounted on the vehicle to take the picture of the animal on road. The system is trained with the images of commonly found animals in our road like cats, dogs, cattle and elephants. Feature extraction is done by HOG (histogram of oriented gradients) and classification of animals by K Nearest Neighbor (KNN) classifier. Approximate distance of the animal from the test vehicle is also estimated so that the driver can get enough time to prevent a collision.

Keywords:*Animal vehicle collision (AVC), Histogram of oriented gradient (HOG), KNN Classifier, Distance calculation, Mitigation.*

1. INTRODUCTION

Traffic accidents are a major cause of death and injuries world-wide, but while they are declining in many parts of the developed world, fatalities are still on the rise in many developing countries including India. One serious road accident in the country occurs every minute and 16 die on Indian roads every hour. 1214 road crashes occur every day in India. In Kerala 4,199 lives were lost and 31,611 persons grievously injured in road accidents in 2018. Road accidents are increasing due the increased number of vehicles, pedestrians and animals at the roads and due to the lack of any intelligent road safety and alert system. The collision of an animal with the vehicle on the roads is another reason for such road accidents. The speed with which the vehicle is coming and hitting the animal also plays a critical role in deciding the impact of the collision. In Kerala accidents due to the collision of vehicles with dogs and cattle are increasing day by day [1].

Automatic collision mitigation systems are intended to assist drivers in animal detection and avoidance .Animals can arrive from a scene from various directions and in different sizes, poses, and color. Animals in front of the vehicle can be detected and the distance between the two be measured by image processing techniques. The system is trained with the images of commonly found animals in our road like cats, dogs, cattle and elephants. Cameras are mounted on the vehicle to take the picture of the animal on road. If any animal is detected on the road the automatic system will alert the driver so that he can stop the vehicle to prevent a collision.

The paper is organized as follows: Section II summarizes the literature review, Section III describes the feature extraction with HOG, and Section IV introduces KNN classifier model for animal vehicle collision avoidance system. Section V describes the calculation of the distance between the vehicle and the animal and finally Section VI gives the result analysis with discussion and conclusion.

2. RELATED WORK

Animal to vehicle accidents on road is becoming a significant area of research to reduce human loss, economic casualties, loss of animals and environmental damages [2]. Large animal detection in the automotive context has not received great interest from the researchers, despite the existence of some AVC mitigation architectures [3]. In fact, almost all these papers present some countermeasures that are mainly used to prevent collisions; but they do not address the detection algorithms of AVC systems. A contour-based HOG-

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SVM method is developed to detect dears [4]. Haar-like features and AdaBoost algorithms are used in [5] to detect lions. The detection of the pedestrians in near, mid and far scales was developed using HOG-SVM algorithm employing two identical Cameras [6]. Binocular camera based obstacle detection and segmentation, obstacle tracking and recognition,

and vehicle reversing speed control algorithm are also are being widely used for avoiding vehicle to animal collision [7].

The major challenges and issues faced during animal detection on Indian highways are Blurring of Image, Lighting/Illumination Conditions, and Animal Detection Accuracy etc. The on-board camera mounted in vehicle may give the blurred image due to vibration of the camera when the vehicle is moving fast or running on a bumpy road or while making a turn. The light of the outdoor environment varies and uncontrollable since it changes different time of a day, different seasons, and different weather conditions. The light will naturally affect the video quality, which may cause problems in catching our target. Some of these systems were inefficient due to excess in "false negatives" and "false positives" images of animal detection. False negative happens when the system is not able to detect or identify animals moving or crossing the roads even when the animal is present in the scene. False positive happens when the system generates an alert signal (false warning) without any animal present in the scene, which can distract and disturb drivers in their driving task.

3. BRIEF OVERVIEW AND ADVANTAGES OF HOG AND KNN CLASSIFIER

Histogram of Oriented Gradients (HOG) is used in image processing applications for detecting objects in a video or image, which by definition is a feature descriptor [3], proposed by Dalal and Triggs who used their method for pedestrian detection. Figure 1 and 2 shows the block diagram and block normalization scheme of HOG feature extraction.

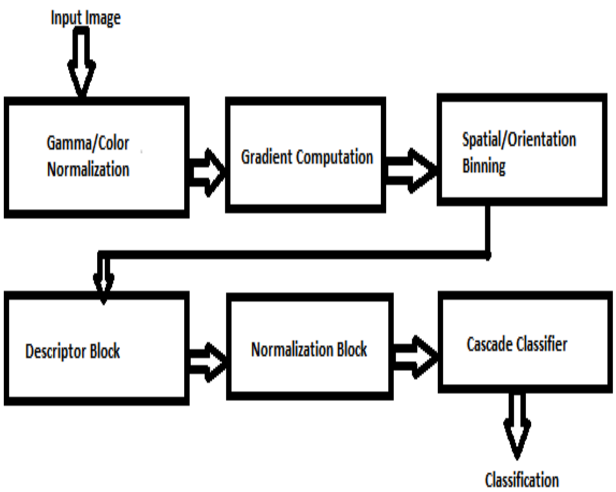

Fig. 1. HOG algorithm.

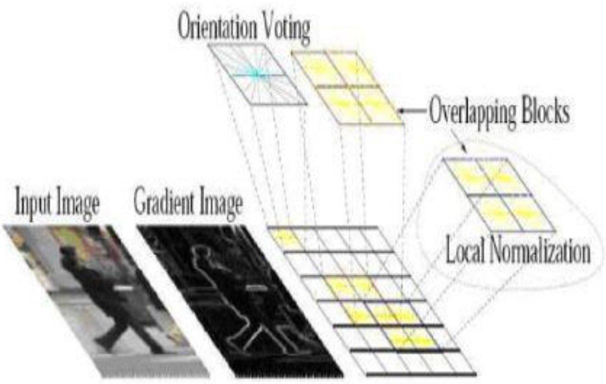

Fig. 2. Block normalization scheme of HOG [2]

As shown in figure 2, the input image is given to gamma and color normalization block. Color normalization is used for object recognition on color images where it is important to remove all intensity values from the image while preserving color values. After color normalization, the next step involves gradient computation. The values by applying 1D centered point discrete derivative mask in both vertical and horizontal directions. Specifically, this approach involves filtering the gray scale image with the following filter kernels:

Cell Histogram and Feature Vector Generation

$$D_x = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix} \; and \; D_y = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$$

So, given an image *I*, we obtain the x and y derivatives using a convolution operation:

$$I_x = I * D_x, I_y = I * D_y$$

Then the magnitude of the gradient is given by:

$$|G| = \sqrt{I_x^2 + I_y^2}$$

and orientation of the gradient is given by:

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$$\theta = \arctan(I_Y / I_X) .$$

After gradient computation, the next step is to create the histogram of the cells. Within the cell, each pixel casts a weighted vote for an orientation-based histogram channel based on the values found in the computation of the gradients. The cells are rectangular, and the histogram channels are uniformly spread over 0 to 360 or 0 to 180 degrees, depending on whether the gradient is "signed" or "unsigned". As for the vote weight, pixel contribution can be the gradient magnitude itself, or the square root or square of the gradient magnitude. The gradient strengths need to be normalized locally in order to account for changes in contrast and illumination, which basically involves combining/grouping the cells together into larger, spatially-connected blocks, which is the next step. The HOG descriptor is then the vector of the components of the normalized cell histograms from all the block regions. These blocks overlap and each cell contributes more than once to the final descriptor (Fig. 2). Normally two block geometries are present and used i.e. rectangular R-HOG blocks and circular C-HOG blocks. R-HOG blocks are square grids and represented by three parameters: the number of cells per block, the number of pixels per cell, and the number of channels per cell histogram. Different methods for block normalization are also there. Let v be the non-normalized vector comprising all the channel histograms in a given block, $\| v\|$ k be its k-norm for $k = 1, 2$ and e be some constant (value of e is small as experimented and discussed by Dalal and Triggs in [3] and does not affect the results). One of the following normalization factors can be used:

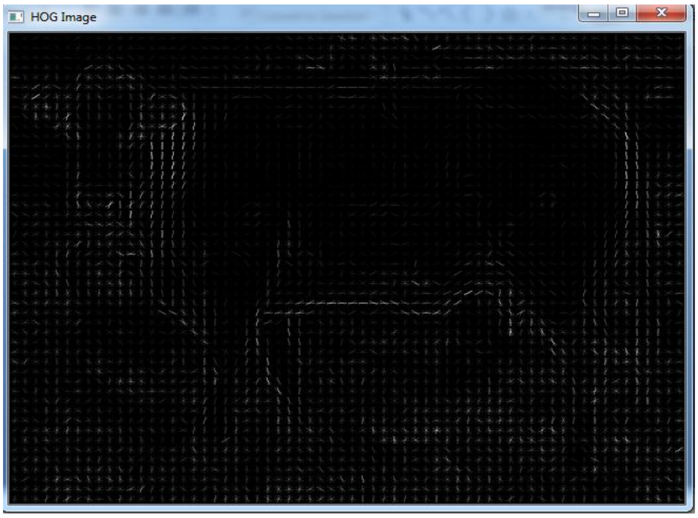
L2-norm: $$f = \frac{v}{\sqrt{||v||_2^2 + e^2}}$$

L1- norm: $$f = \frac{v}{||v||_1} + e$$

L1-sqrt: $$f = \sqrt{\frac{v}{||v||_1}} + e$$

The maximum value of v is limited to 0.2 as experimented and discussed in [2-3] to improve the performance. Finally, the image goes to KNN classifier for classification of the object. Figure 3 shows an original animal image and the image after applying HOG algorithm. Note that the presence of an animal indicates the outline in the HOG image.

(a) Original image



(b) After applying HOG algorithm

Fig. 3. Original (Initial) image and image after applying HOG algorithm for an animal image.

In figure 3, each "-" represents a cell with nine bins and the magnitude of this bin is shown or given by the luminance of each direction vector. HOG descriptor is suitable for animal detection in video or images due to some key benefits compared to other descriptors. Firstly it can describe contour and edge features exceptionally in different objects such as cars, bikes and animals such as cow, elephant, etc. Secondly, it works on local cells, so it is invariant to geometric and photometric transformations which helps and allows various body movement of animals to be overlooked if they maintain a roughly upright position. Cascading is a concatenation of different classifiers (group based learning). Classification algorithm in machine vision and image processing is that of determining whether or not the input image contains some particular object (human-face, pedestrian, animal, traffic sign, etc.).

Once we have the features used to describe the image in detail, an algorithm is needed to justify whether it is target image or not. The algorithm has two main effects, the first is to process the image feature in training step to generate the classifier based on the image database and the second is to analyze the input image and detect the target. Knn classifier is used. K-Nearest Neighbors (KNN) is one of the simplest algorithms used in Machine Learning for regression and classification problem. KNN algorithms use data and classify new data points based on similarity measures (e.g. distance function). The data is assigned to the class which has the nearest neighbors. Step by step compute KNN algorithm is given:

- Determine parameter K = number of nearest neighbors.

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- Calculate the distance between the query-instance and all the training samples.
- Sort the distance and determine nearest neighbors based on the K-th minimum distance.

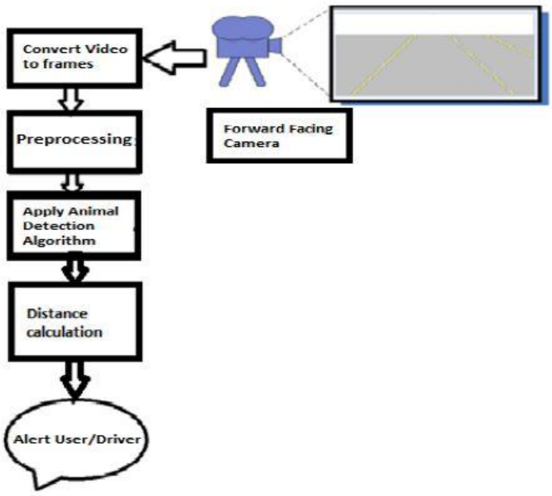

Fig. 4. Block diagram of automatic animal detection and collision avoidance system.

4. PROPOSED RESEARCH METHODOLOGY

Fig.4 shows the architecture of the proposed automatic animal detection and collision avoidance system. Referring to figure 4, a video is taken from a forward facing optical sensor (camera), which is going to capture the objects in front of vehicle, which may have target animal present along with other stationary and non-stationary objects. This video is stored in the computer system and then converted into different frames. As the road side video and images are noisy and blurry, we need to perform some preprocessing steps such as denoising, filtering to enhance the image etc. Following the same these frames are fed to the Animal detection system for feature extraction and learning of the system. We are using a combination of HOG and K Nearest Neighboring classifier for animal detection. All the image processing techniques are implemented in OpenCV software. Once the animal gets detected from the video, the next step is to find the distance of the animal from the vehicle and then alert the driver so that he can apply the brakes or perform any other necessary action, which is displayed on command prompt as a message.

A. Animal Detection System

The research methodology adopted for building an automatic animal detection and collision mitigation system based on image processing and computer vision techniques (figure 5). Once the animal gets detected in the video (frame), next important step is to find the distance of the detected animal from the camera mounted on the testing vehicle. The driver gets an indication of distance of animal from the vehicle and accordingly can apply brakes or take other corrective actions to prevent animal-vehicle collision.

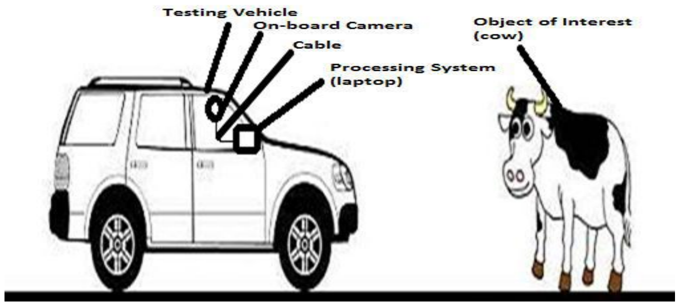

Fig. 5. Camera mounted testing vehicle with the processing

(i) Procedure for Training and Testing the KNN Classifier/System

India has more varieties of animals found in different states of India. We have collected and added varieties of animals and different images as database for training the system.

Following are the proposed procedure for training and testing of the data base for animal detection:

1. Collect all positive images (different views) in the data folder (figure 6 and 7).
2. Generate the visually selection regions of interest of the obstacle instances in any given images.
3. Create sample i.e. generate .vec file.
4. Train data and generate XML file. Table 1 shows the Parameters used /set during training of the system.
5. Testing

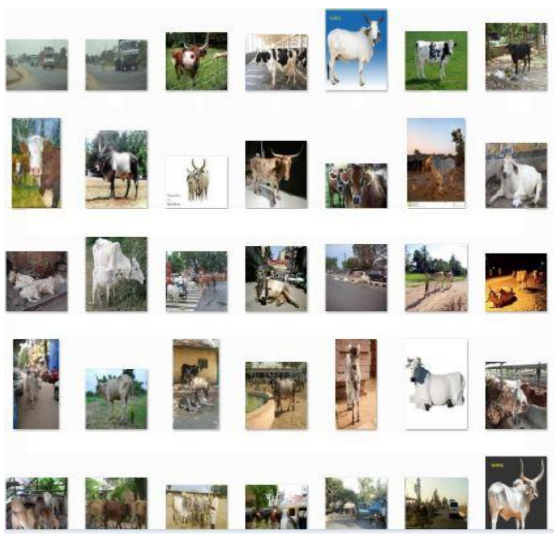

Fig. 6. Positive sample dataset of animals.

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In order to optimally utilize the specifications of the classifiers we need to have positive as well as various animal view database. Immediately after creating database of images and videos, create two different folders in the database i.e. positive sample images database folder and negative sample images database folder. In order to have better detection accuracy, the animal videos/images collected from non-stationary vehicles are to be under different weather conditions and also should cover different postures of the animal. A positive sample image database of more than 1200 animal images with different views, as well as the front, and rear view of the animal facing the camera mounted vehicle is created. Figure 6 shows some of the positive sample images of the animals.

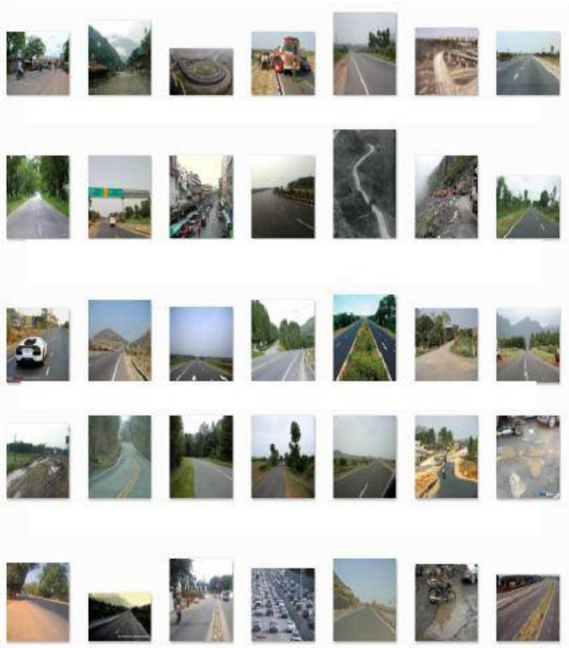

Fig. 7. Negative sample dataset of animals.

A negative sample image database of more than 700 background images is created for this research work. Figure 7 shows some of the negative sample images. A negative sample image means it is an image where the target animal is absent. Detecting the obstacle in the particular environment such as driving on the road, a real negative sample database can certainly enhance final detector's performance. It is also important that in order to detect the animal in real time scenario, the background can be anything like road, vegetations, city areas etc. So negative sample image should contain them as well as to make the target detection more effective and accurate.

TABLE-1 : Parameters set up during training animals of the system.

Parameters	**Value/Type**
numPos (number of positive samples)	1200
numNeg (number of negative samples)	700
numStages (number of stages in KNN)	15
feature Type (feature type for extraction)	HOG
Sample Width (width)	70 pixels
Sample Height (height)	40 Pixels

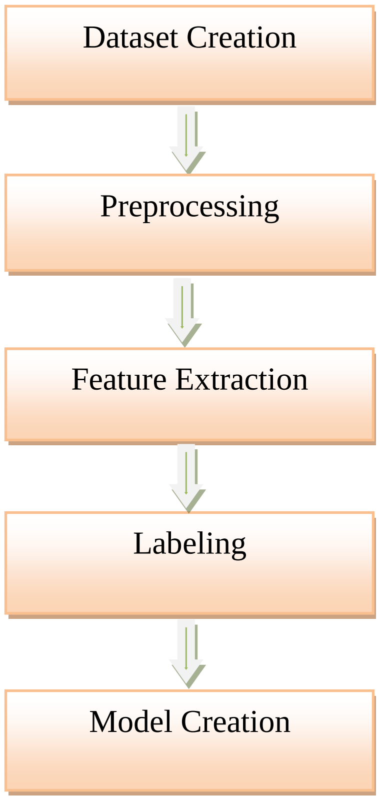

Fig. 8. Training Procedure.

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Fig 8 shows the training stage in the animal-vehicle collision avoidance system. First, collected the images of various animals with different views from sources like internet etc. These images can be either positive or negative. These images are stored as data set images. Then it is pre-processed and then its features are extracted using HOG. According to this extracted feature, a model is created. Various labels are given to these created models. This trained model is used for further coding and processing using the system.

ii) Method for Approximate Distance Calculation of the Detected Animal from the Test Vehicle

Once the animal gets detected in the video (frame), next step is testing and calculating distance of the identified animal from the camera mounted on the vehicle so that the driver is aware of how far or near the animal is from the vehicle and when to apply brakes or take same actions to prevent an animal to vehicle collision.

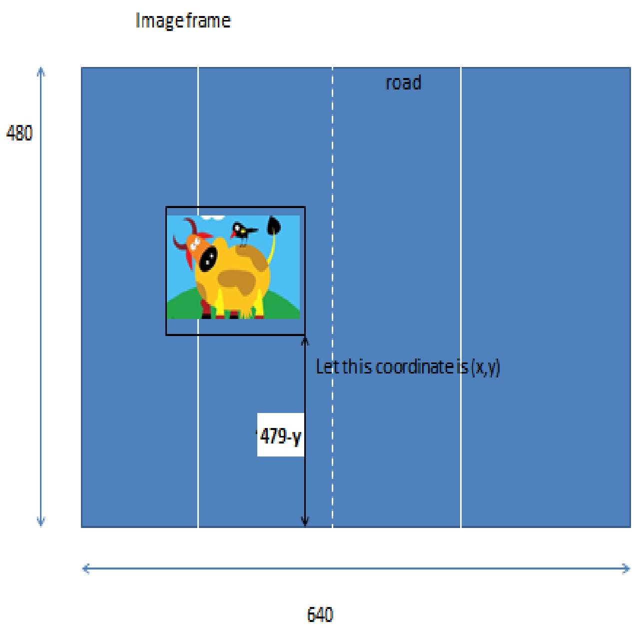

Fig. 9. Distance calculation.

As shown in figure 9, a video is taken and converted into frames. The procedure for calculating the distance of the detected animal from the camera-mounted vehicle in pixels is:

1. Image resolution is 640 × 480
2. X range is 0 to 639
3. Y range is 0 to 479

Let the right bottom coordinate of the detected animal be (x, y). Then the distance of animal from the lower edge (car/camera) is 479 – y. The above method of distance calculation works well with the flat ground surface. Suffers a bit if the ground surface is not perfectly flat.

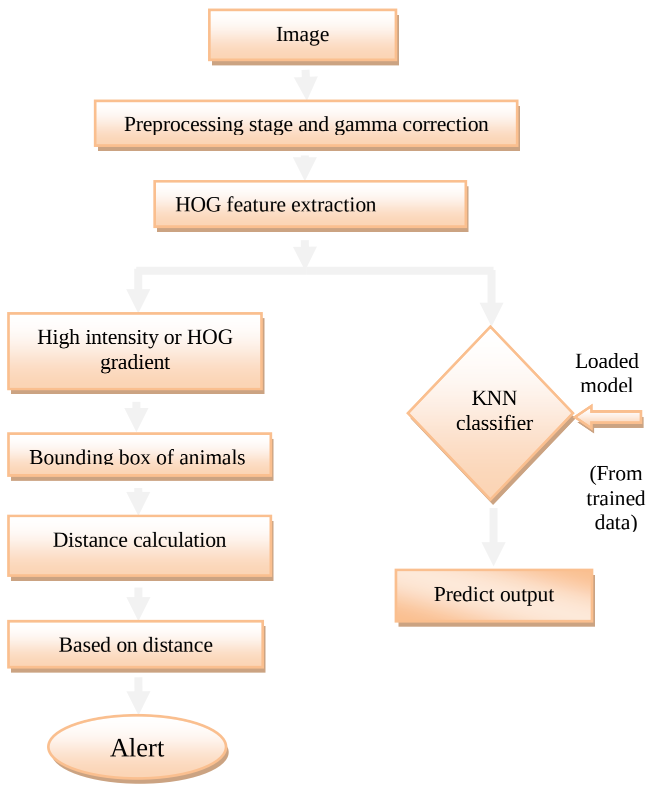

Fig. 10. Flow chart of testing and distance calculation.

The relationship between the depth of the object in pixel and depth in real world units from the camera mounted vehicle, the object gets detected in the frame. As the depth of the object in meters from the camera mounted vehicle increases the size of the object decreases and as the depth in pixels also increases and vice versa [5]. Fig 10 depicts working of the testing and distance calculation stage in the animal to vehicle collision avoidance system. Initially, we take the videos using a camera with frame rate 30 fps. Then by decreasing the frequency of these frames to make it images. Thus our first step is to convert the video taken into images. This image is given to the pre-processing stage and gamma correction. The gamma correction value is set as one. Next step is to give these images to HOG feature extractor for feature extraction. The output of the HOG feature extractor can be used for both testing and distance calculation. For distance calculation a high intensity gradient image is taken and the gradient value is calculated. This value is extracted as pixels. Again this pixel is converted to meters using mathematical equations.

$$Y = 0.0323x^2 + 22.208x + 1.3132 \qquad (1)$$

Where y is the depth in pixels and x is depth in meter.

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Then it is given to a bounding box of object and we can calculate the distance of the animal from the vehicle using the polynomial equation for y. Based on these distance an alarm can be programmed for an alert to the driver. And also the HOG feature extractor is used for testing of the image using a KNN classifier which includes some trained data. The upcoming data is compared with the trained data in the classifier. Thus the most similar characters are considered and then label is given to the given data. This will be the predicted output.

5. RESULT AND ANALYSIS WITH DIFFE RENT VEHICLE SPEED AND DIFFERENT DISTANCE OF ANIMAL

In our implemented animal detection system, we took 640 frames in which 105 frames are showing animal detected, i.e. marked rectangular box, even though there is no animal present in those frame at those places. So, false positive in this case turns out to be 105 and true negative turns out to be 535. Similarly out of 640 frames, 125 frames are showing no animal detected i.e. no rectangular box even though animals are present in that frame. So false negative turns out to be 125 and true positive turns out to be 515.

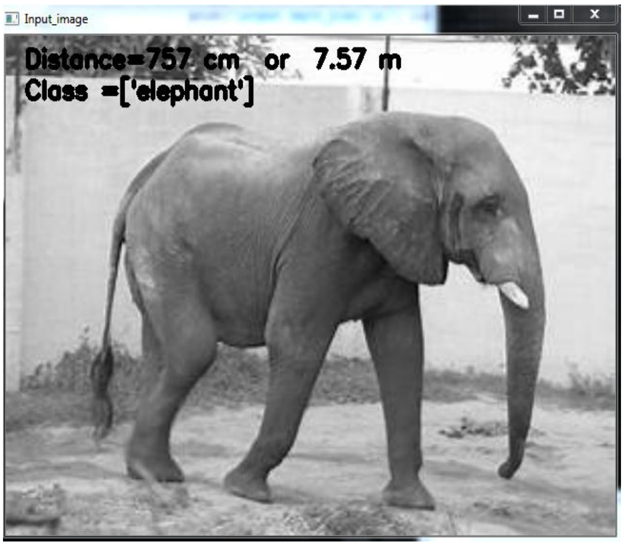

Fig. 11. Output of the distance calculation animal from the vehicle.

Fig. 11 indicates that the distance between the vehicle and the animal is 7.57 m and the class of the animal is elephant for the speed of the vehicle between 30 to 35 kmph. As the speed is low and the distance between the vehicle and the animal is 7.57 m the driver will get some time to apply brakes and can avoid a collision.

6. CONCLUSION

The necessity and importance of automatic animal detection system on roads is established and presented an approach/algorithm based on HOG and KNN classifier for automatic animal detection and ranging. The algorithm can detect an animal in different distance on highways. Implemented an animal detection and collision avoidance system using computer vision technique. Dataset are collected from the internet (9 class of animals and 1200 images). HOG feature extraction is used - HOG descriptor is mainly suitable for pedestrian or animal detection in video or images. KNN Classifier is used for training and testing. Finally predicted the approximate distance of animal and identified the class of the animal from the video collected from the camera mounted on the vehicle.

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