Enrollment No: 119997111011

Batch: 2011

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Specialization: Electronics & Communication Engineering

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- **Title of Research Work**

"Design and Development of Animal Detection Algorithm Using Image Processing"

- **Abstract**

Road crashes have been a major problem in India in recent times. The occurrences have increased considerably owing to the influx of four-wheelers and two-wheelers on Indian roads. The numbers of road traffic collisions have also increased due to the absence of automatic highway safety and alert systems on major roads connecting cities and towns. The interior roads connecting villages and towns have been instrumental in multiple animal-vehicle collisions. Although the figure is not too large compared to other causes of road-related injuries, they are significant in number. The associated number of fatalities and injuries are substantial too. Though numerous efforts have been in progress to solve and reduce the number of collisions, lack of practical applications and resources along with quality analytical data (for training and testing) related to animal-vehicle collision has impeded any major breakthrough in the scenario.

In our current work, we have proposed and designed a system based on histogram of oriented gradients and boosted cascade classifiers for automatic cow detection. The Indian cow has been the biggest obstacle compared to other animals on Indian roads. The distance between a cow and the vehicle is calculated prompting an alert signal to notify the driver for applying brakes or undertake any similar action. The method is implemented in OpenCV software and tested on various video clips involving cow movements in various scenarios. The proposed system has achieved an accuracy of almost 82.5% in terms of animal (cow) detection. The proposed system is a low-cost, highly reliable system which can easily be implemented in automobiles for detection of cow or any other animal after proper training and testing on the highway.

- **Introduction**

Today's automobile design primarily depends on safety measures, security tools and comfort mechanism. The approach has facilitated the development of several intelligent vehicles that rely on modern tools and technology for their performance. The safety of an automobile is of the highest priority according to a recent report [1]. The report commissioned by World Health Organization in its Global Status study on Road Safety 2013, revealed that the main cause of death for young people (15-29 age) globally is due to road traffic collisions. Even though various countries have initiated and taken steps to reduce road traffic collisions and accidents, the total number of collisions and traffic accidents remain as high as 1.24 million per year [2]. Road traffic accidents and injuries are expected to rise by almost 65% by the end of 2020 [3]. Due to road accidents, every year 1 out of 20,000 persons lose their life and 12 out of 70,000 persons face serious injuries in India [4]. India is also known for the maximum number of road accidents in the world [5]. According to the data given by National Crime Records Bureau (NCRB), India, there were almost 118,239 people who lost their life due to road accidents in the year 2008 [6]. A major percentage of these road crashes and accidents involved car and other vehicles.

The road accidents are increasing due to increase in number of vehicles on the road day by day and also the due to the absence of any intelligent highway safety and alert system. According to data given in a study [7], the number of people who lost their lives in India due to road accidents was almost 0.11 million deaths in 2006, which was almost 10% of the total road accident deaths in the world. According to the accident research study conducted by JP Research India Pvt Ltd. for the Ahmedabad-Gandhinagar region (cities of India), for the duration February 2014 to January 2015, total 206 road traffic accidents were recorded and these were influenced by three main factors i.e. human, vehicle, infrastructure or a combination of them [8].

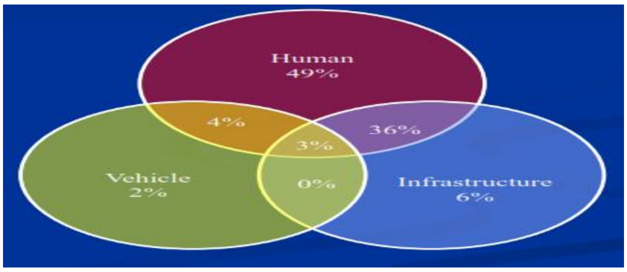

Figure 1. Influences on road traffic accidents [8]

The number in the figure 1 is percentage of the total number of accidents surveyed. According to the record, human factor influence on road traffic accidents was 92%, vehicle 9% and infrastructure 45%. Out of total 45% (91 accidents) infrastructure influenced road accidents, 6% (12 accidents) were due to animals on the road whereas out of total 92% (171) human factor influenced road accidents, 14% (24) were due to driver inattention and absence of any timely alert system for preventing the collision. Similar types of surveys were conducted for the Mumbai-Pune expressway and Coimbatore by JP Research India Pvt. Ltd. and the conclusions hinted at a significant percentage of road accidents resulting due to an object (animal) on the road, driver inattention and absence of an intelligent highway safety alert system.

- **Evidences of Animal-Vehicle Collision**

Below are some snapshot of the images with the sources which suggest that there are many challenges that the drivers are facing because of animals on the road.

Source: indianexpress.com/over-1600-stray-animals-injured. Source: newindianexpress.com/states/odisha/article596072.ece

Source: arrivesafe.org/road-accidents. Source: chandigarhtrafficpolice.org/situation.php

- **State of the Art**

Applications built on detection of animals play a very vital role in providing solutions to various real-life problems [9]. The base for most of the applications is the detection of animals in the video or image.

Many applications require human intervention. A recent study [10] revealed that human beings need to take the final decision during driving whether they can control their car to prevent collision with a response time of 150ms or no. The problem with this method is that human eyes get tired easily and need some rest consistently, which is why this method is not that effective. Some scientific researchers [11] have proposed a method that needs the animals to take a pose towards the camera for the trigger, including face detection. The problem with this technique is that face detection requires animals to see into the camera which is, not necessarily captured by the road travel video. Animals can arrive from a scene from various directions and in various sizes, poses and color.

Animals can be detected using the knowledge of their motion. The fundamental hypothesis here [12] is that the default position is stationary and can simply be subtracted. All blobs, which remain after the operation are considered as region of interest. Though this method performs fine in controlled areas, e.g. underwater videos, it does not work everywhere especially road or highway side videos. Researchers [13] used threshold segmentation approach for getting the targeted animal's details from background. Recent researches [14] also revealed that it is difficult to decide the threshold value as the background changes often. A method applicable to moving backgrounds (e.g., due to camera motion) is presented in subsequent studies [15] and [16]. The authors also state that other moving objects apart from the object of interest may be falsely detected as animal.

Researchers in [17] tried to discover an animal's presence in the scene (image) affecting the power spectrum of the image. This method of animal detection was also considered not appropriate since quicker results with this method would involve gigantic amount of image processing in a short period of time [18]. Researchers in [19] also used the face detector technique initiated by Viola and Jones for a specific animal type. After the animal face is identified, the researchers track it over time. The problem with this technique is that face detection requires animals to see into the camera not necessarily captured by the road travel video. Animals can arrive from a scene from various directions and in various sizes, poses and colors. Another method for animal detection and tracking that uses texture descriptor based on SIFT and matching it against a predefined library of animal textures is proposed in [20]. The problem with this method is that it is restricted to videos having single animal only and very minimal background clutter.

In Saudi Arabia, the number of collisions between the camel and a vehicle were estimated to reach more than a hundred each year. Authors in [21] implemented a deployable Camel-Vehicle Accident Avoidance System (CVAAS) and exploit two technologies GPS and GPRS to detect the camel position and then transmit that position to the CVAAS server consequently. The CVAAS server checks the camel position and decides to warn the drivers through activating the warning system if the camel is in danger zone. Authors in [21] do mention that cost of deploying such CVAAS in large scale is too much. Also the system suffers from many false negatives due to dependency on many parameters like width of dangerous zone, variation in camel speed and delay in receiving SMS message. Authors in [22] designed a system, which uses web cameras which are placed in the detecting areas from where the animal can cross their boundary. The videos are sent to the processing unit and then uses image mining algorithm, which identifies the change in setted reference background. If there is a change in the newly acquired image then authors are applying content based retrieval algorithm (CBIR) to identify the animal. The proposed method in [22] based on CBIR algorithm suffers from many issues like unsatisfactory querying performance- CBIR systems use distance functions to calculate the dis-similarity between a search image and database images. This process is often very slow and reply times in the range of minutes may occur for large databases. Low result quality—by using only general features for all types of images and asking the user to choose features leads to low quality retrieval result.

For finding the correct position of fishes in the sea, researchers [23] designed a technique using LIDAR (light detection and ranging). Using the micro-Doppler technique [24], researchers also tried avoiding risky animal intrusions in the housing area. Some of the above mentioned approaches and methods for animal detection have been discussed in [25] also.

- **Research Gap and Challenges**

    - Though various practical solutions for automatic lane detection and pedestrian detection on highways are available still research related to automatic animal detection on highways is going on.
    - Animal detection in wildlife (forest) videos or underwater videos (controlled areas) have been tried in past but the challenges are much more when detecting animals on highways (uncontrolled areas) as both animal as well as camera mounted vehicle is moving apart from other obstacles on the road which are also moving or stationary. There is no issue of speed (vehicle speed as well as animal speed) and detecting distance of animal from the vehicle in wildlife videos which is very important and critical in animal detection on highways.
    - The biggest challenge in detecting animals compared to pedestrians or other objects is that animals come in various size, shape, pose, color and their behaviour is also not quite predictable. While the basic size and shape of a human being is pretty standard (give or take a few inches and/or pounds), the same can't be said for non-human animals.
    - Though numerous efforts have been in progress to detect, solve and reduce the number of animal-vehicle collisions, lack of practical applications and resources along with quality analytical data (for training and testing) related to animal-

vehicle collision on highways has impeded any major breakthrough in the scenario.

- **Different Scenarios and Consequences of Animal-Vehicle Collision on Highways**

Animal-vehicle collision can be classified using two ways [26]:

1. Direct collision
2. Indirect/Secondary collision

Direct collision: It happens when the vehicle directly hits the animal. Following cases and outcome may occur depending on the speed of the vehicle and the speed of incoming or outgoing animal.

Case 1: Vehicle hits the animal and animal gets thrown to the side. This scenario may be less critical but damages will be there. Figure 2 shows the case 1 scenario.

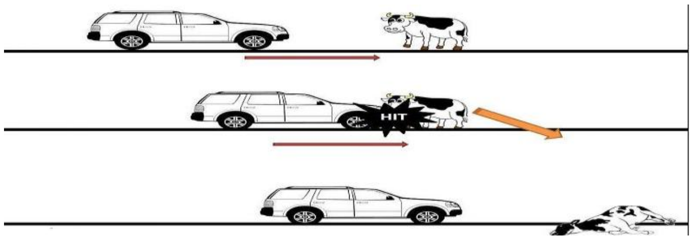

Figure 2. Case 1 scenario [26]

Case 2: Vehicle hits the animal and the animal jumps/ gets raised in air and again gets back or falls back on the bonnet or the windshield. This is quite critical and dangerous scenario and can cause death of the animal or even the driver of the vehicle. Figure 3 shows the case 2 scenario.

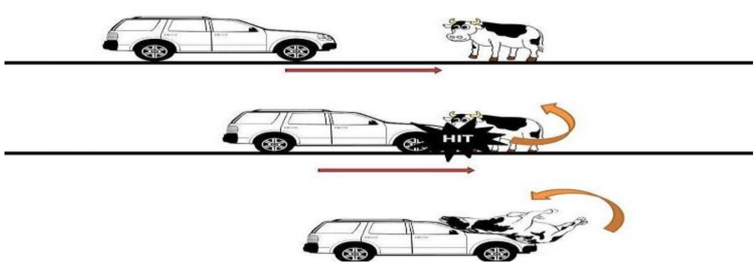

Figure 3. Case 2 scenario [26]

Case 3: Vehicle hits the animal and runs over the animal. In this case a definite injury will occur to animal. It may also happen that because of the impact of collision, vehicle may get overturn which can cause injury to driver. Figure 4 shows the case 3 scenario.

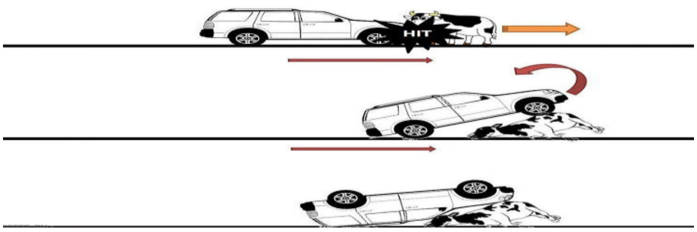

Figure 4. Case 3 scenario [26]

Indirect collision: In this case, accident occurs because of animal only but not directly. Driver of one vehicle finds an animal on the highway and tries to change the direction or the lane and collides with the vehicle which is running on the other lane. Figure 5 shows the indirect collision scenario.

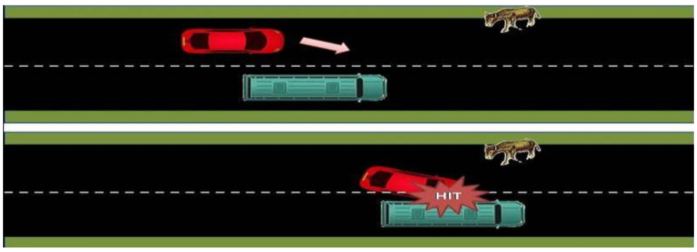

Figure 5. Indirect collision scenario [26]

In all the cases as discussed above, if the driver has some automatic animal detection and alert system in the vehicle, then it is possible to some extent to prevent injuries and collisions between vehicle and animal.

- **Objective and Scope of Work**

Intelligent highway safety and driver assistance systems are very helpful to reduce the number of accidents that are happening due to vehicle-animal collisions. With respect to Indian roads, two types of animals – the cow and the dog are found more often than other animals on the road. The main focus of the proposed work is on detection of animals on roads which can have potential application of preventing animal-vehicle collision on roads. Specific objectives of the research work are:

1. To develop a low cost automatic animal detection system in context to Indian roads.
2. Finding the approximate distance of animal from the vehicle in which camera is mounted.
3. To develop an alert system once the animal gets detected on the road which may help the driver in applying brakes or taking other necessary action for avoiding collision between vehicle and animal.

- **Specific Reasons for Animal (Cow) Detection**

According to the surveys and report given by [27] [28] [29] [30] [31] [32] [33] [34], number of accidents on Indian roads has increased due to increase in number of vehicles day by day and also due to presence of animals on the road (mainly two animal's dog and cow). Although the figure is not too large compared to other causes of road-related injuries like lane changing, drunk-drive or over speeding, they are significant in number. The associated number of fatalities and injuries are substantial too. Though numerous efforts have been in progress to solve and reduce the number of collisions, lack of practical applications and resources along with quality analytical data (for training and testing) related to animal-vehicle collision has impeded any major breakthrough in the scenario.

Specific reasons [34] behind developing automatic cow detection system in place of any other animal are:

1. India is mainly an agriculture based country where 70% of people depend on agriculture and 98% of them depend on cow based agriculture.
2. Cow is a sacred animal in India and nobody wants to hit a cow.
3. Cow milk is the most useful and compatible with human mother's milk than any other animal or so.
4. According to some surveys, cow's milk and cow dung has many medicinal benefits.
5. Cows as well as dogs are found quite often than other animals on the Indian roads.
6. As cow is a large (heavy) sized animal, the collision between a cow and vehicle will be very much severe. The collision between a small (less weight) sized animal like dog and vehicle won't be that much severe.

The speed with which the vehicle is coming and hitting the animal also plays a very important role in deciding the impact of collision.

- **Brief Overview and Advantages of HOG and Cascade Classifier**

A histogram of oriented gradients (HOG) is used in computer vision applications for detecting objects in a video or image, which by definition is actually a feature descriptor [35]. Figure 6.1 and 6.2 shows the steps and algorithmic implementation scheme of HOG.

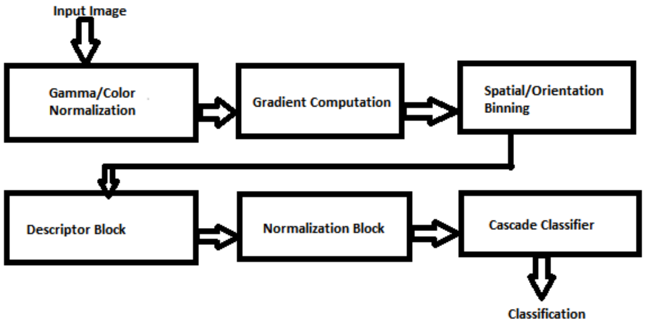

Figure 6.1. HOG algorithm [35]

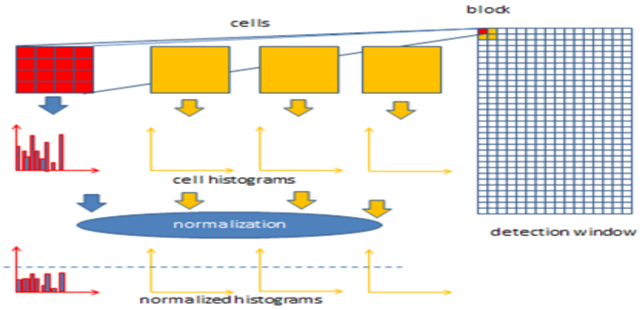

Figure 6.2. Algorithmic implementation scheme of HOG [36]

HOG descriptor is mainly suitable for animal detection in video or images due to some key advantages compared to other descriptors. First, it operates on local cells so it is invariant to geometric and photometric transformations. Secondly coarse (spatial) sampling, fine orientation sampling and strong local photometric normalization allow different body movement of animals to be overlooked if they maintain a roughly upright position [36].

Cascading is basically a concatenation of various classifiers (group based learning). The technique involves taking all the data collected from the output of the first classifier as a supplementary data for the next classifier in the group [37]. The key advantages of boosted cascade classifiers over monolithic classifiers are that it is a fast learner and requires low computation time. Cascading also eliminates candidates (false positives) early on, so later stages don't bother about them.

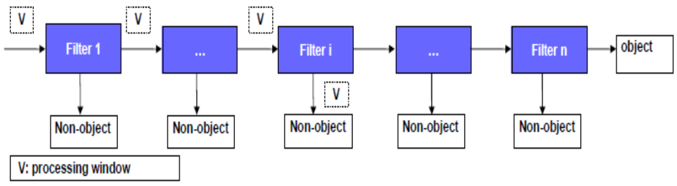

Figure 7. Boosted cascade classifier

As shown in the figure 7, each filter rejects non-object windows and let object windows pass to the next layer of the cascade. A window is considered as an object if and only of all layers of the cascade classifies it as object [38]. The filter *i* of the cascade is designed to

1. Reject the large possible number of non-object windows
2. To allow large possible number of object windows for quick evaluation

- **Methodology of Research**

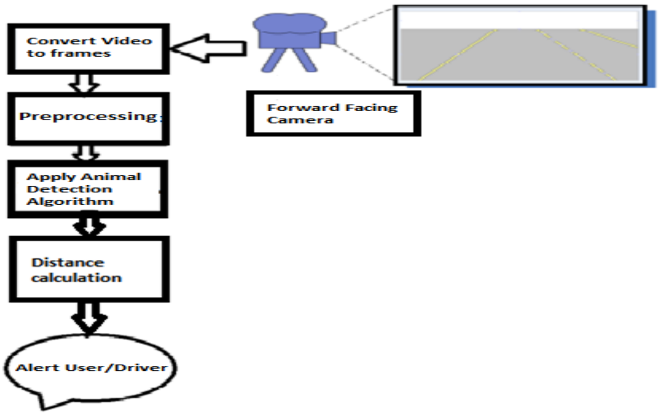

Figure 8. Block diagram of the proposed method

As shown in figure 8, video is taken from a forward-facing camera in which a moving animal is present apart from other stationary and non-stationary objects. This video is stored in the computer and converted into different frames. Then we are doing pre-processing steps to enhance the image. For feature extraction and learning of the system, we are using a combination of HOG and boosted cascade classifier for animal detection. All the image processing techniques are implemented in OpenCV software. Once the animal gets detected in the video, the next step is to find the distance of the animal from the testing 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.

- **Procedure for Training and Testing**

India has more than 20 varieties of cow found in different states of India such as Gir, Sahiwal, Red Sindhi, Sahiwal, Kankrej, Dandi and others. We have collected and added all the varieties of cow in the database for training the system. Following is the proposed procedure for training and testing of the data for animal detection:

1. Collect all positive and negative images in the data folder (figure 9.1 and 9.2)
2. Generate Annotation
3. Create sample i.e. generate .vec file (figure 10)
4. Train data and generating xml file (figure 11, 12). Table 1 shows the parameters used /set during training of the system
5. Testing (figure 13)

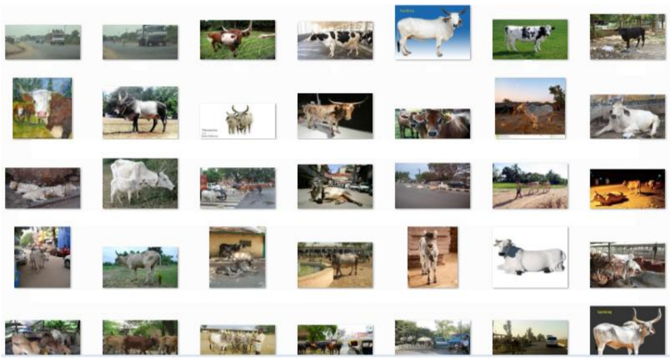

Figure 9.1. Positive samples

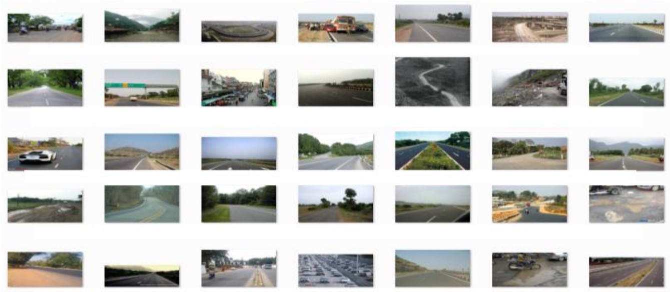

Figure 9.2. Negative samples

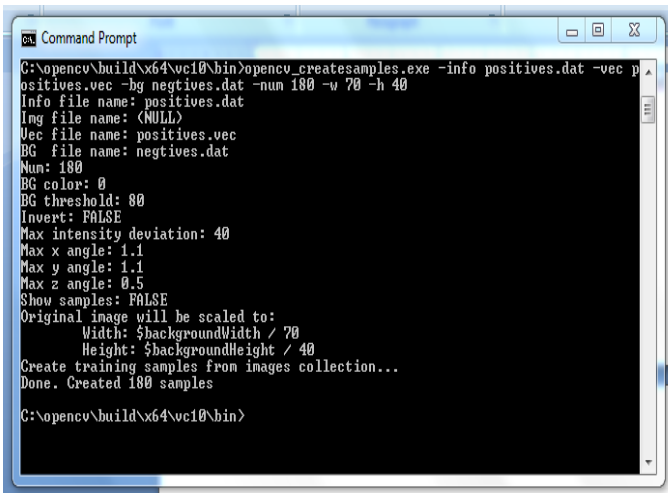

Figure 10. Create sample

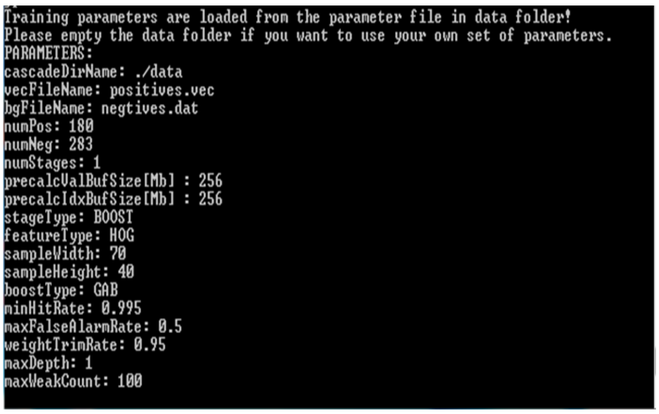

Figure 11. Train data

Table1: Parameters set up during training of the system

Parameters	Value/Type
numPos (number of positive samples)	700
numNeg (number of negative samples)	1500
numStages (number of stages in cascade)	20
stageType (type of stage in cascade)	BOOST
featureType (feature type for extraction)	HOG
sampleWidth (width)	70 pixels
sampleHeight (height)	40 pixels
boostType (type of boosting)	GAB (Gentle AdaBoost)
minHitRate (minimum hit rate of the classifier)	0.995
minFalseAlarmRate (minimum false alarm rate of the classifier)	0.5

Average time it took to generate a cascade on Intel(R) Core(TM) i5-2430M CPU 2.40GHz, 4GB RAM was almost 14 hours.


```xml
<?xml version="1.0" ?>
<opencv_storage>
- <cascade>
    <stageType>BOOST</stageType>
    <featureType>HOG</featureType>
    <height>70</height>
    <width>40</width>
  - <stageParams>
      <boostType>GAB</boostType>
      <minHitRate>9.9500000476837158e-001</minHitRate>
      <maxFalseAlarm>5.0000000000000000e-001</maxFalseAlarm>
      <weightTrimRate>9.4999999999999996e-001</weightTrimRate>
      <maxDepth>1</maxDepth>
      <maxWeakCount>100</maxWeakCount>
    </stageParams>
  - <featureParams>
      <maxCatCount>0</maxCatCount>
      <featSize>36</featSize>
    </featureParams>
    <stageNum>30</stageNum>
  - <stages>
      <!--   stage 0   -->
    - <_>
        <maxWeakCount>2</maxWeakCount>
        <stageThreshold>-7.4642084538936615e-002</stageThreshold>
      - <weakClassifiers>
        - <_>
            <internalNodes>0 -1 193 2.5299549102783203e-002</internalNodes>
            <leafValues>8.0689656734466553e-001 -8.8571429252624512e-001</leafValues>
          </_>
        - <_>
            <internalNodes>0 -1 205 2.3257724940776825e-002</internalNodes>
```


Figure 12 XML file

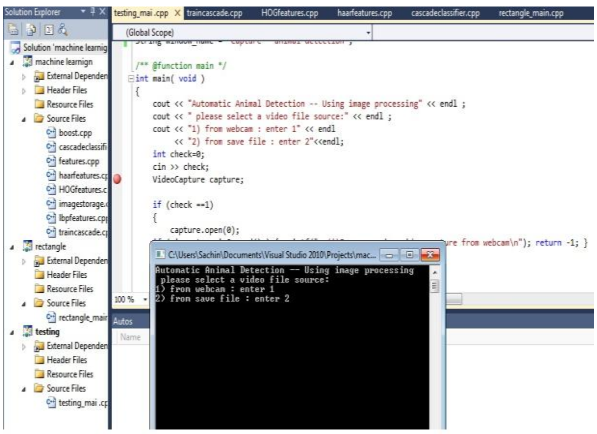

Figure 13. Testing

- **Distance Calculation of the Detected Animal**

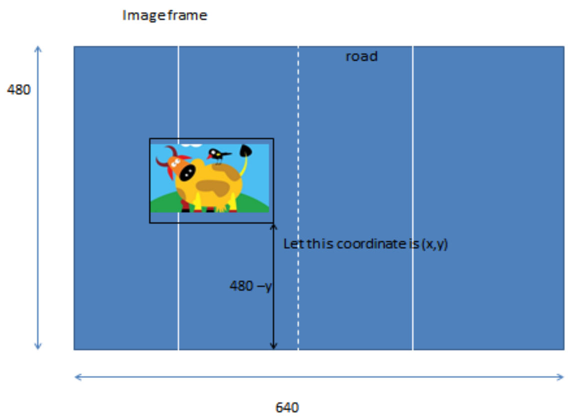

Figure 14. Distance calculation

As shown in the figure 14, video is taken and converted into frames (image of size 640 * 480). Following is the procedure for calculating the distance of the detected animal from the camera-mounted vehicle:

- Image resolution is 640 × 480
- X range is 0 to 640
- Y range is 0 to 480

Let the right bottom coordinate of the detected cow be (x, y). Then the distance of cow from the lower edge (car/camera) is 480 – y which is in pixels and needs to be converted into real world units like meter.

Note: The above method of distance calculation works well with flat ground surface. Suffers a bit if the ground surface is not perfectly flat.

- **Conversion from Pixels to Meters**

There is some direct relationship between the depth of the object in pixel and depth in real world units (meters) from the camera mounted vehicle once the object (animal) gets detected in the frame. As the depth of the object in meters from the camera mounted vehicle increases (size of the object decreases), the depth in pixels also increases and vice versa [39]. This hinted us to find a relationship between depth of object in pixels and meters. Once the camera position in the car and height of the camera from the ground was fixed (camera calibration done), we took different images of the same object kept at different depths from the camera center (figure 15). The depth of the object from the camera center in meters was known to us.

We then noted the corresponding depth of object in pixels. Table 2 represents relation between pixels and meters. Graph of depth in meters versus depth in pixels was plotted in excel (figure 16) and the best fitting second order polynomial equation is

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

where y is the depth in pixels and x is depth in meters.

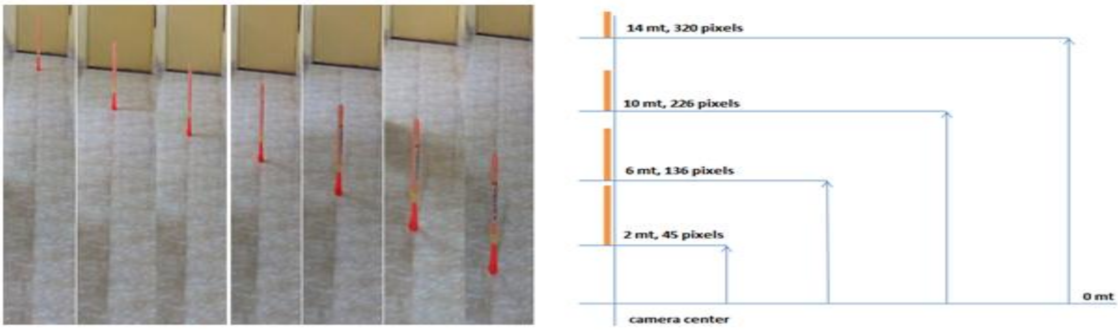

Figure 15. Same object kept at different positions (depth) from the camera center

Depth (mt)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Depth (pixel)	23	45	69	91	114	136	159	180	206	226	245	274	295	320

Table 2: Relationship between pixels and meters

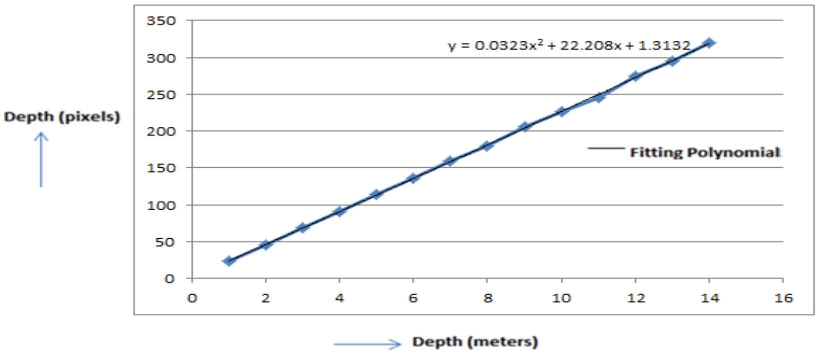

Figure 16. Graph of depth (meters) versus depth (pixels)

- **Testing of Actual Distance versus Calculated Distance**

As shown in figure 17, we took two images of cow in which we knew the depth of the cow in meters from the camera mounted vehicle. We then calculated the depth using the technique as mentioned earlier. Table 3 shows the results of actual depth and calculated depth. The error is very less (less than 2 percent).

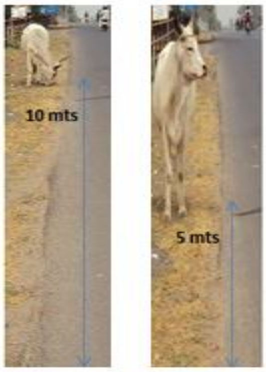

Figure 17. Testing images (depth in meters was already known)

Table 3: Actual depth versus calculated depth

Parameters	**Observation 1**	**Observation 2**
Actual depth (mts)	10	5
Calculated depth (mts) after converting from pixels to mts	9.85	4.95
Error in percentage (%)	1.5	1

- **Data Collection and Result Analysis**

We are using HOG descriptors which are feature descriptors and are used in computer vision and image processing for the purpose of object detection. For object classification, we are using boosted cascade classifiers. A good source for the animal images is the KTH dataset [40] and NEC dataset [41] that included images of cows and other animals. Some more animal images have been clicked for creating a healthy database of almost 2200 images consisting of positive images in which the target animal is present and negative images in which there is no target animal for feature extraction and for training the classifier. After the classifier is trained and the detection system is built, we tested the same on various videos.

Videos have been taken using a camera having a frame rate of 30fps mounted on the testing vehicle. Hardware used in our experiment is ASUS x53s, Intel(R) Core(TM) i5-2430M CPU 2.40GHz, 4GB RAM. Software used is Microsoft visual studio 10 professional, OpenCV 2.4.3, 64 bit operating running under Windows 7.

Parameters which are important for checking the performance of the test/classifier are Sensitivity (True Positive rate), Specificity (True Negative rate) and Accuracy which are given as

$$\textbf{Sensitivity} = \textbf{TP} / (\textbf{TP} + \textbf{FN}) \quad (2)$$

$$\textbf{Specificity} = \textbf{TN} / (\textbf{TN} + \textbf{FP}) \quad (3)$$

$$\textbf{Accuracy} = (\textbf{TN} + \textbf{TP}) / (\textbf{TN} + \textbf{TP} + \textbf{FN} + \textbf{FP}) \quad (4)$$

Here in above equations, TN stands for true negative, TP stands for true positive, FN stands for false negative, and FP stands for false positive. True positive (TP) and true negative (TN) are the most important and true parameters of classification. False Positive indicates that the animal is detected in the frame (video) even though animal is absent in that particular frame at that particular place. False Negative (FN) indicates that there is no animal present in the frame (video) even though animal is present in that particular frame.

In our implemented animal detection system, we took 640 frames in which 105 frames are showing animal detected i.e. 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 those frame. So false negative turns out to be 125 and true positive turns out to be 515. Substituting the above parameter values in equation (2), (3) and (4), we get sensitivity close to 80.4%, specificity close to 83.5% and accuracy of the classifier close to 82.5%.

Figure 18 shows the camera mounted vehicle setup. Figure 19, 20 and 21 shows true positive, false positive and false negative case. Some more results with different vehicle speed and different weather condition is shown in figures 22, 23, 24 and 25. Training and testing on large datasets will improve the detection rate and accuracy of the classifier.

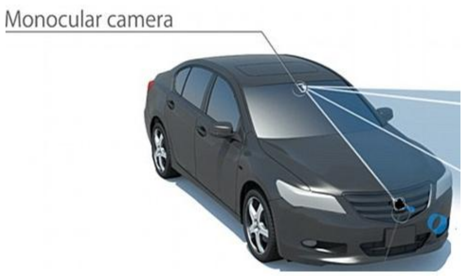

Figure 18. Camera mounted vehicle

Figure 19. True positive case

Figure 20. False positive case

Figure 21. False negative case

Figure 22. Animal detection at 0 kmph speed (morning condition)

Figure 23. Animal detection at 40 kmph (afternoon condition)

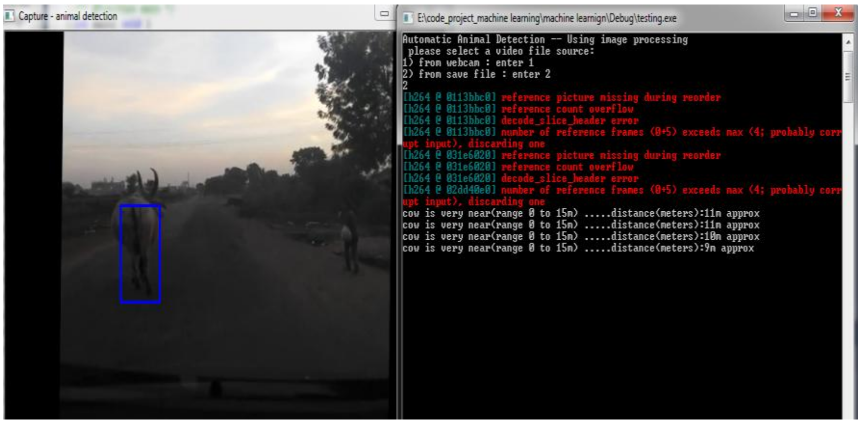

Figure 24. Animal detected at a distance of approximately 11 mts from the camera mounted vehicle with the speed of 60 kmph in evening time

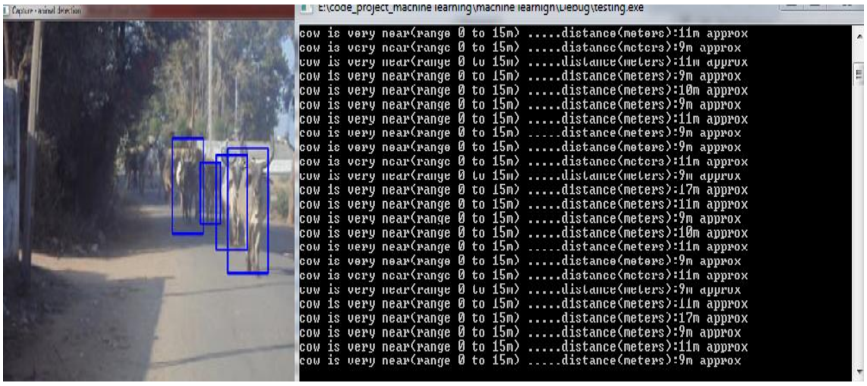

Figure 25. Multiple animals detected in one of the testing video (detecting distance of 17 mts)

Vehicle speed (kmph)	Approximate distance of detection from the camera mounted vehicle (meters)	Approximate time available for the response (sec)
0 (stationary)	20	Enough time to avoid collision as maximum speed of Indian cows is 3 to 3.5 kmph [42]
20	18	3.24
30	17	2.04
35	17	2.04
40	15	1.35
50	14	1.00
60	11	0.66

Table 4: Speed-distance relation

According to the article [43], the term **response time or brain-reaction time** of the drivers in traffic engineering literature is composed of mental processing time, movement time and mechanical response time. As per the **"two-second rule"** which is normally a rule of thumb suggests that a driver should ideally stay at least two seconds behind any object that is in front of the driver's vehicle [44]. The two-second rule is useful as it can be applied to any speed and provides a simple and common-sense way of improving road safety. So if we go with "two-second rule", clearly from table 4, it indicates that when the speed of the vehicle is between 30 to 35 kmph, driver gets some time to apply brakes and can avoid collision. Anything above this speed, though the alert signal is available but driver won't be able to avoid collision.

- **Comparison of HOG and HAAR**

Comparison of HOG with other feature descriptor (HAAR) is shown in table 5. ROC (receiver operating characteristic) curve, which is a graphical plot that illustrates the performance of a classifier system as its discrimination threshold is varied [45], is shown in figure 26 for hog-cascade classifier, haar-cascade classifier. The curve is created by plotting the true positive rate (TPR) against the false positive rate (FPR) at various threshold settings. Clearly our method based on hog-cascade gives good results compared to haar-cascade.

Table 5: Set of tests by cascade classifier

Feature descriptor	TP	FP	TN	FN	Sensitivity	Specificity	Accuracy	Average processing time
HOG	515	105	535	125	80.4%	83.5%	82.5%	100ms
HAAR	502	142	498	138	78.4%	77.8%	78.1%	150ms

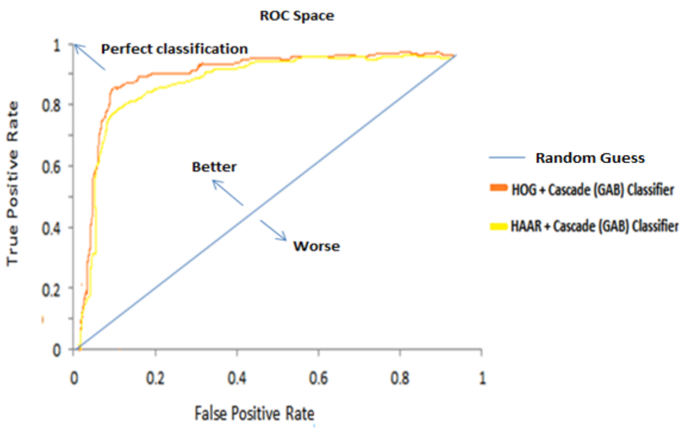

Figure 26. ROC curve

- **Achievements with respect to Objectives**
  - ✓ Algorithm developed is working properly and able to detect animal in different conditions on roads and highways.
  - ✓ Estimation of animal distance from testing vehicle is done. Maximum detecting distance of the animal from the camera mounted vehicle was found to be 20 mts.
  - ✓ Speed analysis (different speeds like 20, 30, 35, 40, 50, 60 kmph) is implemented and tested.
  - ✓ Alert signal to the driver is available.

- **Conclusion**

An efficient automatic animal detection and alert system can help drivers in reducing the number of collisions occurring between the animal and the vehicle on roads and highways. In this thesis, we discussed the necessity of automatic animal detection system and our algorithm for animal detection based on HOG and cascade classifier. The algorithm is able to detect animal in different conditions on highways. The proposed system achieves an accuracy of almost 82.5% in terms of animal (cow) detection. Estimation of approximate animal distance from testing vehicle is also done. Though the proposed work has been focussed on automatic animal detection in context to Indian highways but it will work in other countries also. The proposed method can easily be extended for detection of other animals too after proper training and testing. The proposed system can be used with other available efficient pedestrian and vehicle detection systems and can be offered as a complete solution (package) for preventing collisions and loss of human life on highways.

- **Limitations**

Though our proposed system is able to detect the animals (cow) on roads and highways as well as gives alert to the driver it has some limitations too. The proposed system is able to detect animal up to a distance of 20 mts only when vehicle is stationary. The system can prevent collision of vehicle with the animal when driving at a speed in between 30 to 35 kmph. Beyond this speed though animal gets detected but time is not sufficient to prevent animal-vehicle collision.

- **Future Scope**
  - Some means or method in increasing the detecting distance of the animal from the camera mounted vehicle needs to be done so that driver gets sufficient time for applying brakes or take any other action for preventing collision which may be solved using high end resolution cameras or radar.
  - No effort has been made to detect animals during the night, which is expected to be done in our future scope of study and research.

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Agent Number:

Sr. No.	CBR No.	Reference Number /Application Type	Application Number	Title/Remarks
1	16939	ORDINARY APPLICATION	4144/MUM/2015	AUTOMATIC ANIMAL DETECTION ON INDIAN ROADS.
2		E-101/49562/2015-MUM	4144/MUM/2015	Correspondence
3		E-2/2640/2015-MUM	4144/MUM/2015	Form2
4		E-3/3049/2015-MUM	4144/MUM/2015	Form3