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Animal Detection: Techniques, Challenges and Future Scope

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Abstract: ***Departments of transportation all across the world are concerned with ever increasing number of Animal-Vehicle Collisions as they cause thousands of human and animal causalities along with billions of economic losses every year. This is one of the few areas of transportation that safety is not improving. As more roads are being built, the areas that animal inhabit is shrinking and thus causing more crashes between vehicles and animals. The human fatalities and injuries, animal fatalities and injuries, and material costs of these crashes emphasize the need for a solution to this problem. Through this paper, new research directions and combination of technologies which are suitable for covering the research gaps are presented.***

Keywords: Animal Detection, Animal Vehicle Collision Accident Prevention, Sensors, Road Safety

I. INTRODUCTION

Road accidents cause around 1.25 million deaths every year across the globe. These accidents include vehicle to vehicle collision, vehicle to animal collision, vehicle roll over etc. According to an annual report published by government of India [1] 3611 accidents were recorded in year 2017 which involved collision with animal resulting in death of around 1400 people. VDOT (Virginia Department of Transportation) spends four million dollars per year to remove about 55000 deer carcasses from its roadways [2]. On the other side, with increase in industrialization and depletion of natural resources (water, land, clean air etc.) the whole ecosystem of earth is endangered. It is alarming to take preventive measures to save our ecosystem and hence to save the wildlife which is being destroyed by either poaching or killed by hit by vehicles on roads. To turn down this scenario, effective animal detection algorithms are required. These algorithms can be a part of in-vehicle collision avoidance systems or can be embedded in on-road collision avoidance systems to signal the driver about the presence of animals ahead. This raised the need to explore all the possibilities in which a vehicle can hit an animal and how that can be avoided.

Animal-Vehicle Collision (AVC) can be classified as:

1.Direct collision with animal
2.Indirect collision with animal

When the vehicle hits the animal directly, it is called direct collision. In direct collision also cases are different (depending on speed of vehicle and motion of animal) as the animal may get hit and gets thrown to road-side. In comparison to other scenarios this may be less critical but loss will be there. Figure 1 shows the scenario.

Another case can be if after the collision, the animal gets raised and hits the windshield of the vehicle. This is very dangerous and cause loss of lives of both the animal and the driver of the vehicle. Figure 2 illustrates this scenario.

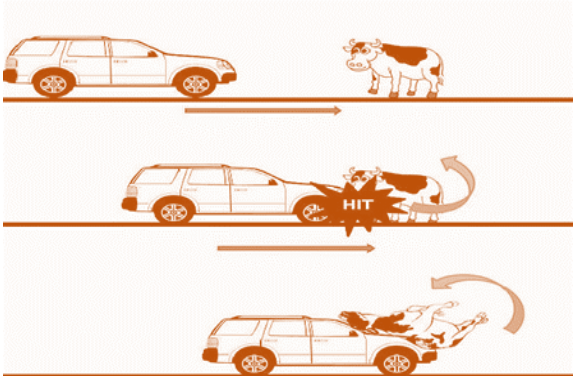

Fig. 1 Direct Collision- Case 1[3]

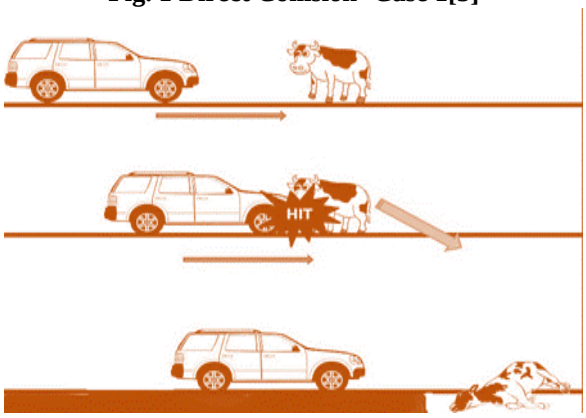

Fig. 2 Direct Collision- Case 2 [3]

In direct collision it is also possible that upon hitting the animal, the vehicle turn upside down on the animal. This scenario is pictorially represented in Figure 3. This is also very critical and can cause causalities on both the sides.

On the other side in indirect collision, the vehicle does not hit the animal directly but may hit any other vehicle while avoiding the hit with the animal.

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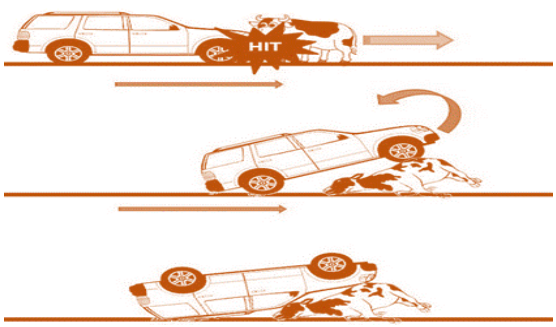

Fig. 3 Direct Collision Case 3 [3]

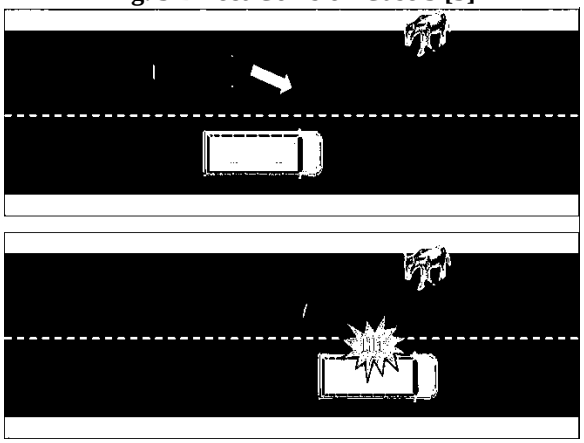

Fig. 4 Indirect Collision [3]

Lots of methods are used across the world to prevent the animals to enter road side. Fencing, passive signs, active signs, speed limit, sensors etc. are examples of such methods. Passive signs do not work effectively as they are static boards installed on roadsides with same words written irrespective of whether the animal is present or not. Fencing is effective but it is very expensive and difficult to maintain. Sensors designed to detect animals and signal the driver to slow down or take needful action to prevent the accident can be an effective method. All such systems and algorithms to detect animals are explored in the subsequent sections.

II. CLASSIFICATION OF ANIMAL DETECTION SYSTEMS

Animal detection systems can be classified based on their operation: 1) Area Cover Systems 2) Break-Beam Systems [4]

Animal Cover Systems use passive radio, Infrared or active radio (microwave) sensors to discover the presence of animals in a specific area. On the other hand, break the beam systems use laser or transmitters and receivers. Such systems are activated when the signal is blocked by an animal. Animal detection and warning systems developed in late 90s are developed using the later technique ([5],[6],[7],[8]) are examples of these. For Example, RADS is a break the beam systems which works on radio frequencies, was the first system of its kind to be deployed in Florida. It works on solar powered sensors to detect the presence
of wildlife animals like panther or moose near the highways. It alarms by illuminating LEDs connected to it at six sign boards along the road to communicate the driver about an animal approaching nearby. Following figure illustrates the RADs installed on US highway 191.

Fig 5 Illustration Break the Beam System [9]

LAWDS (Large Animal Warning and Detection System) is an area-cover system for detecting animals. Following figure illustrates an area cover animal detection system.

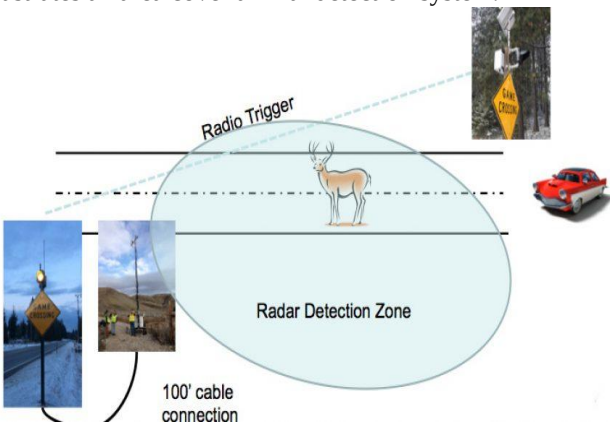

Figure 6 Illustration- Area Cover System [10]

III. COMPARISON OF VARIOUS ANIMAL DETECTION SYSTEMS AND ALGORITHMS

Intensive survey of literature brought forward many exciting systems/algorithms for detecting animals. Though the number of publications done on this particular subject are lesser as compared to vehicle detection (another significant part of road safety), we came across variety of algorithms for animal detection. Following figure represents various techniques used for detecting animals so far. It includes detecting animals for wild life monitoring and surveillance.

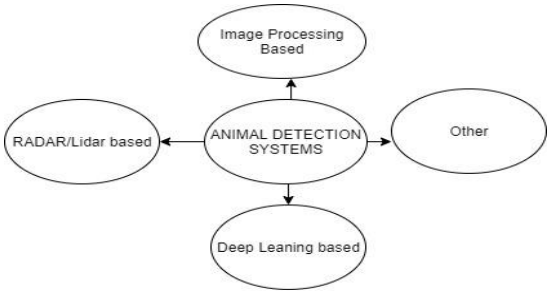

Fig. 7 Various Animal Detection Methods

All of these methods have their own limitations and significance. Image processing-based systems require heavy processing of live data to give real time processing and their performance degrades during night hours.

Deep Learning based algorithms require training on a dataset to detect specific object. RADAR/LiDAR or other optical sensors provide good results in terms of accuracy and computational load having their own limitations.

The countries like US etc. has deployed some animal detection systems on roads where wild animals cross the roads frequently and get hit by vehicles causing loss of lives on both the ends. To reduce such mis happenings, systems like RADS, LAWDS, ALERT and LASER TRIPWIRE has been developed.

Table 1: Comparison of Various Animal Detection systems

System	Technology used	Operation/Pros	Limitations
RADS (Roadside Animal Detection System) [11]	solar powered sensors	Decreased number of vehicle-animal collisions	Frequent downtimes results in large false negatives
[12]	HOG (histogram of gradient), Cascaded classifier A computer vision Technique	82.5% accuracy in detecting animals	Works for vehicles moving at speed up to 35km/h Detects only cows Works in daytime only
LASER TRIPWIRE [11]	Laser Powered by solar panels and back-up batteries	Reduces number of collisions form 11 in 5 years to 1 in 4 years	System gets triggered by false alarms i.e. rain/vegetables Alarms for 3 minutes only, after that even if the animal stays there it won't trigger any alarm.
LAWDS (Large Animal Warning and Detection System) [11]	RADAR	Detects large animals and reduces number of collisions	Overall speed of the traffic slows down
A.L.E.R.T (Animal Location Evasive Response Technology) [13]	optics, infrared illumination	Detects the moving animals and alarms	-
Buried Cable Roadside Animal Detection System [2]	Fiber optic cable sensor	Detects Animals and warns	Fiber optic cable network faulty communication
[14]	Thermal cameras for UAV technology	Good in terms of accuracy	Complex
[15]	LiDAR Sensor	Low computational speed, high accuracy	Does not work in rain, fog or bad weather.

Table 2: Algorithms for detecting animals

[16]	Foreground-background segmentation and object verification	Detects animals in highly cluttered videos.
[17]	Fusion of deep learning and HOG features	Robust algorithm Detects animals in highly cluttered natural images
[18]	Deep CNN with machine learning	Accuracy of 91% and works for both daytime and nighttime

[18] outperformed other two methods by giving an accuracy of 91.623%.

IV. CHALLENGES IN ANIMAL DETECTION

1. A lot of work on animal detection has been done for wildlife scenes and the results are quite promising but when it comes to animal detection on highways or roads, animal detection gets complicated as the background is never static.
2. Another major challenge in detecting animals is that many systems has been developed which focus on detecting a particular animal species only. This is because animals don't follow any pattern or symmetry when it comes to their body size, color and shape, which makes the animal detection process even harder.
3. It is not necessary that animals will face the camera or any other vision sensor in one pose only they may stand in any direction in any way which is another hurdle in detecting the animals through vision-based sensors.

V. DISCUSSION

Effectiveness of Systems

RADS

Based on the values of false negatives and false positives [19] RADS successfully detected the presence of 97% animals in its area of detection. This stat meets the required minimum standards for reliability and robustness of the animal detection systems. However, these figures are after excluding the downtime (when the beam is not operational) of the system. If we include the system downtime then it gives large number of false negatives (animal was present but was not detected).

This concludes that the system may perform up to the mark if the system does not go down so frequently. In [19] to evaluate the effectiveness of RADS the researchers used horse, sheep and llamas to represent moose, small Deer and Deer respectively. The study was conducted in an enclosure.

LAWDS

In [20] Large Animal Warning and Detection System has been analyzed. This system was designed to detect large animals such as moose and dear. LAWDS consists of radar scanning 360° stretch of highway. This provides year-round continuous highway monitoring, even in harsh weather conditions. LAWDS outperforms existing animal detection systems in terms of false alarm rates. Also, it is capable of working in poor weather conditions without going down frequently.

Another benefit of LAWDS is that it required no clearing of vegetation as required for break the beam systems. Also, it provides more area coverage than break the beam systems.

LAWDs helps in reducing the speed of vehicles to an average of 15% which is sufficient enough for the drivers to take needful action to avoid a possible collision.

Following table summarises the reduction in speed of vehicles depending on whether the beacons are ON/OFF thus reducing the possible collisions.

Table 3: Speed Reduction when beacons are ON [20]

Average Speed During	Signals ON	Signals OFF	Reduction in Speed %
Night	93.58	110.11	15.0
Day	89.30	105.58	15.4

Increasing number of vehicles and absence of any intelligent road safety system is the major reason for increasing number of on-road killings. Speed reduction is also a major concern.

Performance of algorithms

[16] [17] and [18] focused on animal detection for wild life monitoring based on videos recorded from motion trap cameras.

Results of all the three are enlisted in the table 4.

Table 4: Performance comparison of algorithms in [16][17] and [18]

Study	Year	Method	Precision	F-score
Zhi Zhang et al. [16]	2015	Ensemble graph cuts for object classifier as foreground-background segmentation followed by object verification	0.8293	0.8695
Zhi Zhang et al. [17]	2016	Combination of deep learning and HOG features	0.8209	0.8398
Animal Detection with deep CNN [18]	2017	Deep CNN features with machine learning	0.91625	0.9476

VI. CONCLUSION

In this paper, we came across many animal detection systems having their own advantages and disadvantages. Yet in a country like India, there is no practical implementation of such systems despite the increasing number of accidents with stray animals. Future research must prosper to develop a system which will be capable of detecting animals in daytime, nighttime and also in fog. None of the existing systems promised the detection of animals in foggy weather. Furthermore, in urban environments majority of AVC happen when dogs or cows hit the vehicle so we need to focus on detecting animals like dogs and cows instead of moose or giraffe.

Effectiveness of a system depends on two factors: Detection accuracy and signaling the driver regarding the presence of animal. In terms of detection accuracy, technologies/algorithms studied above confirm that a rained DCNN has performed quite well by giving an accuracy of nearly 91%, true positives of range 91-93 % and false positive rate of 6-10% [18]. It worked well for both daytime and nighttime. Furthermore, RADAR has the capability to work in harsh weather as well. Fusion of these two can be extended further to make it work for highways (background keep on changing) and in real time. To communicate the driver, most important fact is to inform well in advance so that the driver has enough time to take the action. All these requirements have made a large room for further research in the field of animal detection and warning system to implement them on a large scale.

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