RADAR BASED ANIMAL DETECTION SYSTEM FOR ROAD SAFETY

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Abstract:

The major issue that all the developed nations are confronting today is road accidents. Due to these road accidents, some of the people died and most of the people injured. Nowadays, accidents are increasing day by day and mostly happen on highways due to an increase in automobiles and a lack of alerting systems. Most of the accidents occurred due to rash driving, drunk and drive, animal-vehicle collision, etc. in this paper we mainly concentrate on animal-vehicle collision. Here we proposed a method using Doppler radar, which is used to reduce animal-vehicle collisions by alerting the driver.

Key word: Doppler radar,Thermal camera,Animal vehicle collision,Horn antenna.

Introduction:

In our area on the national highway 67, from Ballari to krishnapatnam port , the buffalo-vehicle collisions are increasing day by day. Most of the individuals drive their vehicles fastly, particularly on highways. If the buffalos suddenly enters on highways, the vehicle speed cannot be controlled at that time. It results in buffalo-vehicle collisions. Due to these collisions, not only human beings but also a large number of buffalos have died and some are injured. In this highway, the buffalo-vehicle collisions happen regularly and 100's of buffalos have died. So to avoid these collisions, here we implement animal detection systems along highways. These systems can alert the driver about animal detection. So the driver controls the speed of the vehicle. By controlling the speed due to animal detection, we can avoid buffalo-vehicle collisions.

Animal detection systems are designed to detect large animals especially buffalos, as they approach the road. When an animal is detected, the amber flashlight turns on. It warns the drivers that the large animals on or near the road. Animal detection systems have been installed in various places in Asia,Europe and North America. Some of these systems are reliable and helps in reducing animal-vehicle collision and some are abandoned due to technical problems, management problems.

If the animal detection system works effectively, then it reduces the number of animal-vehicle collisions. But most of the animal detection systems suffer from "false negatives" and "false positives". If the animal is near or on the road, but the system fails to detect, then it results in a false negative. If the system reports the presence of an animal, but no animal is present then it results in false positive. The animal detection system is efficient and reliable only when the false positives and false negatives are minimum. According to the warning system, the response of the driver is also important to minimize the animal-vehicle collisions. The results of the warning system is to increase the driver alertness and to reduce the speed of the vehicle.

Detection System:

The detection system is placed along the highways at various locations. The detection system consists of Doppler radar along with directional antennas, thermal [8] camera and data processing, and storage unit.
The Doppler radar, thermal camera, and directional antenna are mounted on the 7.5 poles.

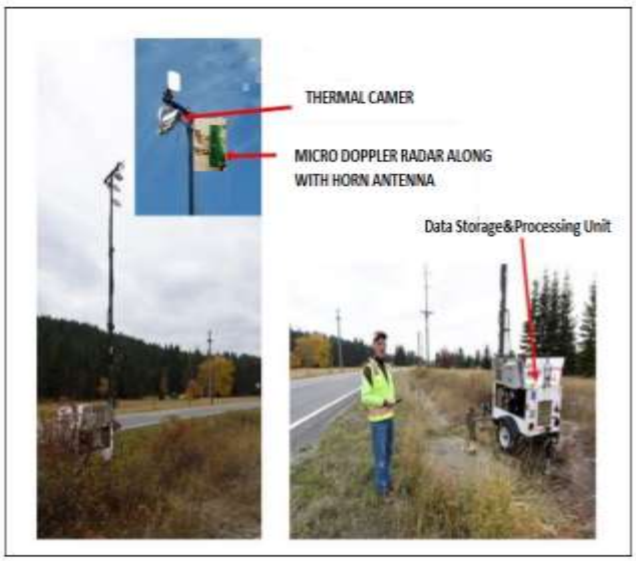


Figure 1. Detection system

The Doppler radar is used to detect large animals like buffalos on the highways and beside the road. Here the thermal camera is used to know whether the animal is present or not. The entire recorded data is stored in the data processing and storage unit, which is placed near the pole.

When the detection system detects the buffalo or any large animal, then the warning signs are activated. The warning system displays “animal crossing” (always visible) and the amber flashlight is on. In highways, we place the poles at every 700m which displays “animal crossing” along with an amber flashlight. The amber flashlight activates only when the detection system detects the animal. If the detection system detects buffalo, the amber flashlight is on, and the light is on for 40 sec from the detection. Within this 40sec, again it detects buffalo then again the light is on for 40sec. The activation of amber flashlight warns the driver about buffalo crossing. The distance between the two detection systems and two warning systems is 700m. The data will be recorded and stored only when the detection system detects the buffalo or any large animals.

Figure 2. The warning signs

The detection system not only detects the animals but also detects the human who was walking on the road. Here the thermal camera is used to know the reliability of the detection system.

Measurements of Targets:

The detection of targets is based on the change in the Doppler shift. The Doppler shift is the change in the frequency of a carrier by the objects. By using micro-Doppler radar, we can differentiate humans from animals. The micro-Doppler radar calculates the limb motions. The motion of limbs is not the same in animals and humans. In the time domain, the Doppler signal is represented as s(t) and the short-time Fourier transform is expressed as

$$s(t, f) = \int s(t^1) e^{-(\frac{t-t^1}{2\sigma^2})} e^{j2\Pi f(t-t^1)} dt^1 = |\chi| e^{j\phi}$$

Where σ is the time width of a Gaussian window. In short time fourier transform (STFT), the frequency-domain resolution and the size of the time window are inversely proportional to each other. By using spectrogram of moving targets we can differentiate animals from human [1],[2]. We measure a few targets under various situations. The different types of targets are humans, buffalos, dog and cars. By using Doppler radar, we measured eight distinct targets of each type. Human beings, buffalos, dogs, and cars are moved at different speeds in the realization. The related spectrograms are shown in the figure. The micro doppler radar clearly differentiates humans from dogs, buffalo, and cars. The main intention of the system is to discriminate humans from animals.

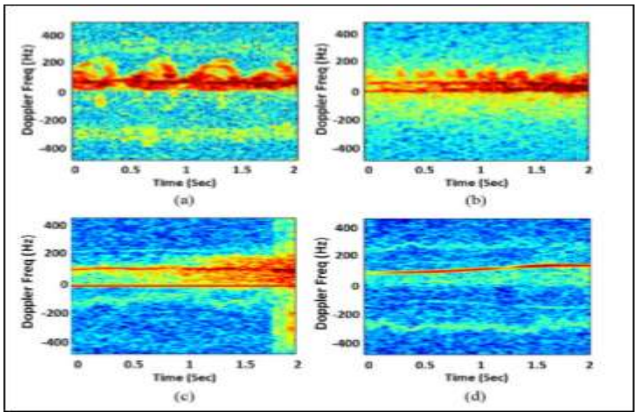


Figure 3.Spectrogram of moving targets (a) human (b) Buffalo (c) bicycle (d) car

If we properly set the noise threshold value, we can take out the noise and simple to remove the doppler data. At the point when the sign is in A/D converter, we utilize the versatile clamor limit to take out the symphonious parts. The versatile commotion limit is set as an exponential capacity of the pinnacle estimation of the got signal. The spectrogram images of noise eliminated is shown in the figure.

Characteristic Extraction:

If we detect the buffalo using radar information, special features can be observed from the spectrogram. Researches are done on the shape of micro-Doppler radar to distinguish the target is human or animal [3],[5]. Based on the size and movement of targets, the shape of the micro-Doppler radar is varying. Even though the shape of the micro-Doppler radar gives low accuracy in a real-time environment, but based on the spectrogram images, we classify the targets [4]. The humans walking style is unique and the length of the human leg is longer than animals. The limb motion and speed of humans are faster than animals. The Doppler frequency is maximum when the human leg has high speed, this is shown in fig4.

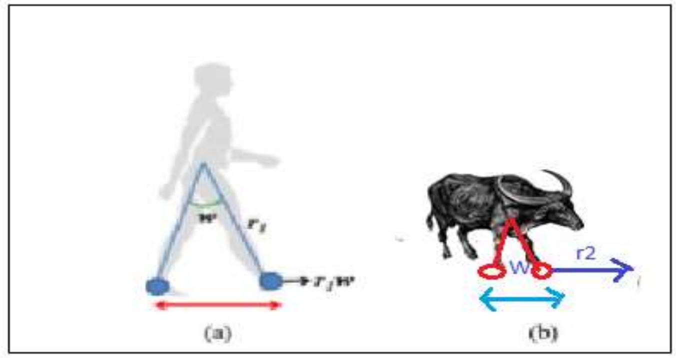


Figure 4. moving limbs (a) human (b) small animal

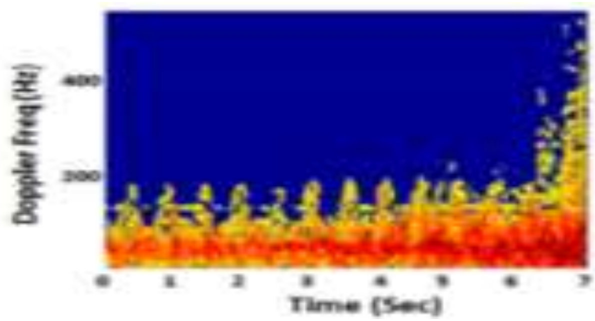


Figure 5(a) spectrogram of the micro Doppler

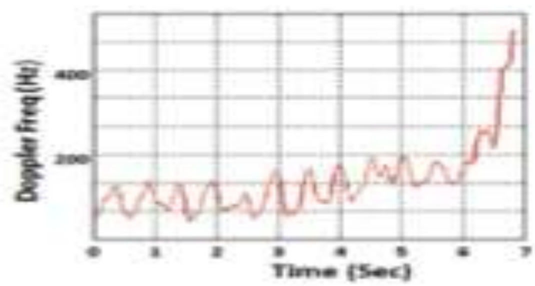
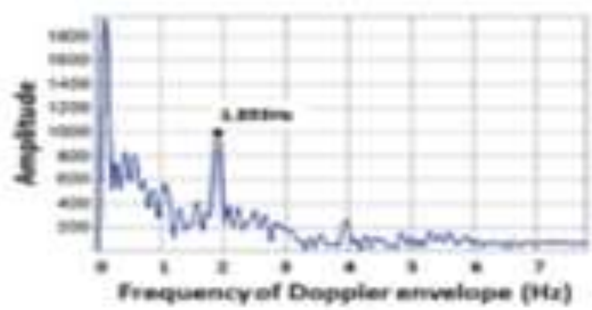
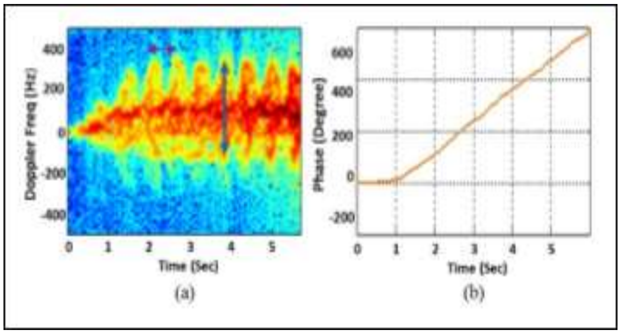


Figure 5 (b) detected envelope of the micro-doppler



Figure(c) frequency of the limb motion by the fourier transform

The proposed system highlights the limb motion, the data transfer capacity of the Doppler signal and sign quality conveyance of the Doppler signal. In the proposed domain, the human moment has unique. The features regarding this topic are explained below.



Figure(6). (a) description of the target features (b)change in phase

(A) Frequency of Limb Motion:

The animal movements entirely depend on the motion of limbs. Micro dopplers are generated when the legs or arms of animals moves during running or walking. The micro dopplers' time duration is measured and demonstrated by the purple shading appeared in 5(a). By utilizing the time term of small scale dopplers, we can discover the recurrence of appendage movement. The objective species as well as we can identify the speed of the objective by utilizing the recurrence of appendage movement. The recurrence of appendage movement increments when the walk and speed of the objective increments. The recurrence of appendage movement is high in little creatures compared to humans.

In the spectrogram, we have to recognize the miniaturized scale Doppler envelope, for the estimation of frequency. The Doppler signal can be detected by using the adaptive noise threshold. Due to the inconsistency of the envelope, the period is not determined clearly, so the Fourier transform is utilized right now. By using second-order polynomial approximation, we can eliminate the low-frequency components. These low-frequency components create the dominant frequency of limb motion. So after the elimination of these low-frequency components, we apply Fourier transform. By using the least mean square error, second-order polynomial coefficients are calculated. Before applying the Fourier transform, from the original graph, the low-frequency components are deducted. The limb motion fundamental frequency is shown in fiqure-4.

(B) Stride of Target:

The stride of humans is unique due to the recurrence of appendage movement. The speed of the objective is the blend of the result of the objective and the recurrence of the appendage movement. In light of the tallness of a human and his/her strolling style, the strolling stride for the most part goes from 60 to 90 cm. The recurrence of appendage movement increments because of increments because of increments in the walk. In running condition, the walk ranges from 80 to 130cm. The scope of the human walk is totally unique in relation to creatures. From the got signal, by computing the stage change, we estimate the stride [6]. The phase angle is always from -180 to +180. The Doppler frequency signal with time is plotted and shown in figure 5(b).

(C) Bandwidth of the Doppler signal

The greatest Doppler recurrence is legitimately relative to the speed of the appendage movement. The speed of the appendage movement is an element of the length of the appendage and rakish speed. When contrasted with the little creatures, the human appendage length is a few times longer. Accept that the rakish speeds are the equivalent, and the Doppler recurrence of the human is a few times higher. At the point when the recurrence of the appendage movement builds then consequently the walk and greatest rakish speed increments so the most extreme Doppler recurrence increments. The data transfer capacity of the Doppler signal is legitimately corresponding to the most extreme miniaturized scale Doppler recurrence appeared in figure 6(a).

(D) Distribution of strength of the Doppler signal:

The strength of the Doppler signal is used to estimate the limbs of the target. Contingent upon the objective species, the radar cross-area (RCS) proportion between the middle and the appendages is extraordinary. The RCS of the limbs of humans is higher than the animals and vehicles. In a spectrogram, the standard deviation of the Doppler signal can indirectly represent the RCS ratio. In the spectrogram, we calculate the standardized difference in the greatness of the Doppler signal and we use it as a feature.

Results:

For the estimation of classification accuracy, we construct the data sets. This data set consists of the preparation and test information. For a solitary estimation, the highlights are removed multiple times with various introductory occasions. Here the all out number of estimations is 100, the quantity of coming about information is 300. For feature extraction, we use a 3-s time window. The features of the targets are investigated and listed in table1. In the table, we considered the strolling instance of people and bison, and the velocities of the bike and the vehicle are 2.5 and 5m/s individually. The speed of the human changes, the component esteems likewise shift and appeared in figure7. The recurrence of the appendage movement increments with expanding the walk, which empower its ID against different targets utilizing a classifier. The features of the buffalos are gathered in a different area.

Feature/Target	Human	Buffalo	Bicycle	Car
Frequency of the limb motion(Hz)	1.87	2.37	N/A	N/A
Target stride (cm)	76	35	N/A	N/A
Bandwidth of the Doppler signal(Hz)	245	197	78	21
Distribution of the signal (dB)	10.02	10.25	7.8	5.6

Table: Example of the feature values of the target

Estim/Actual	Human	Buffalo	Bicycle	Car
Human	97%	8%	0%	0%
Buffalo	4%	95%	0%	0%
Bicycle	0%	0%	78%	20%
Car	0%	0%	23%	78%

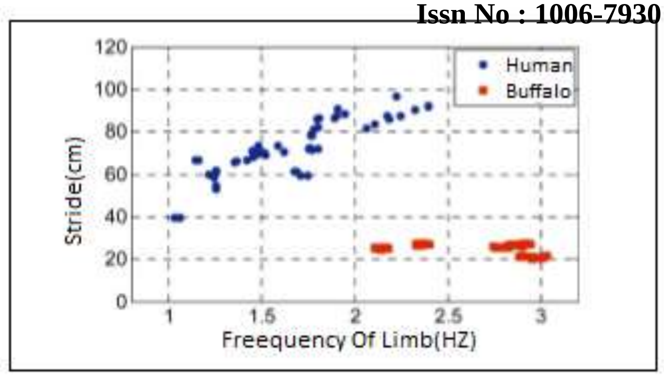


Figure7: Features of the human subjects and buffalos in the domain of frequency of limb motion and stride

Table2: Confusion matrix of the classifying result

By using the extracted features, we classify the targets by using SVM, which is one of the most impressive double classifiers [7]. The SVM is utilized to make a non-straight limit by applying a part stunt. By utilizing the Gaussian piece, we can control the sharpness of the capacity. The help vector parameters and the width of the Gaussian portion are utilized to expand the order exactness just as to diminish the computational unpredictability.

A multicase SVM is actualized by utilizing a tree structure since we utilize four sorts of targets. At the point when the objectives are little, the tree structure has high order precision. For the figuring of precision, a fourfold approval is utilized. The last precision of the approval set is 97% and appeared in table2.

Conclusion:

At finally we reduce animal vehicle collision rate by applying the Doppler radar successfully. Regardless of the location Doppler radar considering the objects and also it will fit for minimal mammals. In future we can overcome this by approaching advanced techniques. Regardless of the location and regardless of the time of the animal have to be detect. We sincere gratitude to my guide Mr N.Merrin Prasanna, and Brahmanapalli toll plaza.

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