

A Study on the Sound Warning System for Prevention of Roadkill Accident

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Abstract

The road-kill prevention system using sound is a system that detects animal movements around the road in advance by attaching radar and sound-generating devices to prevent road-kill, and puts the vehicle into protective operation mode while generating a warning tone. First, to identify wildlife approaching the road, a radar device that can detect movement across the entire front of the vehicle and the vehicle always detects data. The detection area of radars attached to the front of the vehicle is flexible and automatically distributed over the curved road to widen the radar detection area in both sides of the road and into the forest. If any animal is detected that is about to jump into the road by radar, it immediately fires warning sound frequencies and horns to stop the animal from moving. In other words, the roadkill prevention system is a system to prevent road-kill by pre-calculating the current speed of the vehicle and the anticipated collision point with the approaching wildlife, guiding the driver to the speed required to prevent collision, and generating alarm sounds such as threatening frequencies for animals. It is necessary to continually improve the roadkill prevention system to prevent the loss of animals due to future roadkill accidents.

Key Words: Sound, Roadkill accident prevention system, Vehicle, Warning sound, Radar device, Threatening frequencies

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1. INTRODUCTION

Every driver would have been surprised at a time by an animal popping up on the road. High-speed bus drivers, especially those who frequently drive on highways, often have roadkill accidents. Animals such as wild dove, pheasant, wildcat and elk often run into the windshield or front bumper of a fast bus that runs, or die on wheels. The same goes for cars. Such a road kill accident can sometimes be dangerous enough to damage the car's glass or cause a major accident while quickly braking or changing its lane to avoid animals. Road kill accident should also be prevented to protect the lives of animals, but urgent measures are needed to protect people's lives. Roadkill accidents are a civilized accident that occurs because humans divide the animal's place of life for their own convenience, set up a road, set up a facility, and drive on a car to make a loud noise. Surprised animals often cross the road and cross the road to find their territory before it was built. If people had considered the animals' territory well and designed roads that fit their characteristics, then there would be far fewer road kill accidents. Above all, if animals registered as natural monuments or endangered species are involved in accidents, they will have to work harder to prevent the roadkill accidents, which will result in serious damage to the Earth. Therefore, this paper proposed a roadkill prevention system using sound.[1]

2. ROADKILL ACCIDENTS

Roadkill is an accident in which an animal is killed by a car while crossing a road. It is a repeat of the roadkill because animals are not only unable to detect the speed of the car but also are not trained in the fact that they could die when they hit it. In Korea, there are many kinds of animals that are sacrificed in roadkill, including wild animals such as roe deer, water deer, raccoons, and pets such as dogs and cats. According to a government and local government report for 30 months since 2006, there are as many as 5,600 animals killed near Mt. Jiri and 1,000 others are loaded on only 3,000 kilometers of road over two days. Therefore, countless animals are killed on 100,000 kilometers of roads nationwide. Roadkillers often occur during May, the time to find food in the sea ice age, and during November when people go hunting for food to prepare for the winter. Streets on the back of the city or the residential area are often created regardless of the season. Recently, an asiatic black bear was injured in a roadkill accident on Mount Jiri on May 5, 2018, and an endangered species of mountain goat was killed in a roadkill accident in Uljin, North Gyeongsang Province on May 6. The number of animals killed by unknown roadkill in the country or around the world is also expected to be numerous as there are two cases that have been reported in the news in two days. The animal most affected by the roadkill in Korea is the water deer. Of the Roadkill dead animals in the last five years, water deer accounted for an overwhelming number of 9,078 animals. There were 1,088 raccoons, 198 wild rabbits, 142 wild boars, 113 wild boars, 102 badgers and 58 ferrets. Other birds also have accidents while flying low or sitting on the road. Also, on city roads and on the back roads, pet animals such as dogs and cats are often road killed due to caregivers' careless protection.

Table-1. Status of roadkill accidents in the last 6 years

Road \ Years	2012	2013	2014	2015	2016	2017
General National Road	3,174	7,452	8,727	9,563	12,867	15,436
Express high-way	2,360	2,188	2,039	2,545	2,247	1,884

Since an average of 50 billion insects die a year on major roads in Korea, it is time to think about the seriousness of the fact that the roadkill caused by cars plays a huge role in destroying life on Earth.[2][3]

**a. Deers exposed to roadkill****b. Bears exposed to roadkill****c. Bird's families exposed to roadkill****Figure 1. Animal cases of Roadkill accident**

3. EXISTING ROADKILL PREVENTION METHOD

The driver cannot slow down all sections of the road to prevent roadkill accidents. Instead, it is better to habituate your defensive driving and fulfill your set speed duty even in areas with signs of warning. If wild animals are found while driving on the road, honking their horns during the daytime, and warning signs are issued at night, with the headlamps turned off and the emergency light turned on, reducing their speed as much as possible. If you turn on the headlamps or the uplight at night, you should stop the sight of wild animals momentarily, so they can stop or attack rather than run away. so we should be switched off and honked out. The reason for turning on the emergency light is to warn subsequent vehicles of an emergency ahead. If wild animals suddenly jump on the highway, sudden braking or drastic turnovers can cause

secondary accidents. If a wild animal is found while driving at high speed, it should slow down as fast as possible within the extent that it is not a threat to passengers and the car behind them. There is a possibility that a sudden stop in embarrassment or a sudden change in the lane may collide with the car that was following or driving in the next lane. Sometimes, if you turn the steering wheel to the left to avoid the animal while driving on the first lane, there is a big accident that crashes into the opposite car. Those who are affected by the roadkill accident can not only lead to wild animals but also to the second and third follow-up accident, raising concerns over a major accident that could cause human casualties. In order to prevent roadkill, the Ministry of Land, Infrastructure and Transport, and the automobile industry as well as environmental and animal rights groups continue to do much research. Currently, each road has a warning sign called a wildlife sanctuary or a roadblock, while large-scale roads have ecological passages or fences that prevent animals from jumping into the dangerous roads.[4]

3.1 Warning sign

In order to prevent highway roadkill accidents, the National Territory Management Department and the Road Management Department under the government installed a sign of the "Wildlife Outing Area" to alert drivers in areas where roadkill occurs frequently. Animals live not only in their own living space but also in the way they make their way around. To mark their territory, wild animals sometimes bury their unique body odors in trees, grasses, or streets, or often mark the path to urine or feces. Humans have cut the way animals walk through, but animals cross the road in the belief that it is connected like a habit. Animals keep walking around without knowing the danger because they are their territory and their way. So, where there are frequent roadkill accidents, there can be continuous roadkill accidents.



Figure 2. Warning signs to prevent roadkill accidents

Likewise, animals continue to use their path by instinct. However, people cut their path and made it into a road and enjoy civilization. Therefore, preventing roadkill should be done by humans who have hurt them. For that purpose, people have installed signs of wildlife or warning signs that roadkill can occur frequently. Drivers can reduce the frequency of roadkill accidents if they turn on the emergency light each time these signs appear.

3.2 Moving passage

There are many reasons for frequent road accidents, but first, the animals cut off their living areas and built roads and cut off their paths. Second is the driver's speed and carelessness. Speedy driving and careless driving make it difficult for drivers to find animals running on the road in advance, and even if they find them and slow them down immediately, they often have to collide.



a. Land bridge path



b. Tunnel ecological corridor



c. Roadkill prevention fence

Figure 3. Roadkill prevention walkway

First of all, the most fundamental cause of the road accidents is that humans have blocked the animals' radius of activity to develop cities and roads, but have failed to

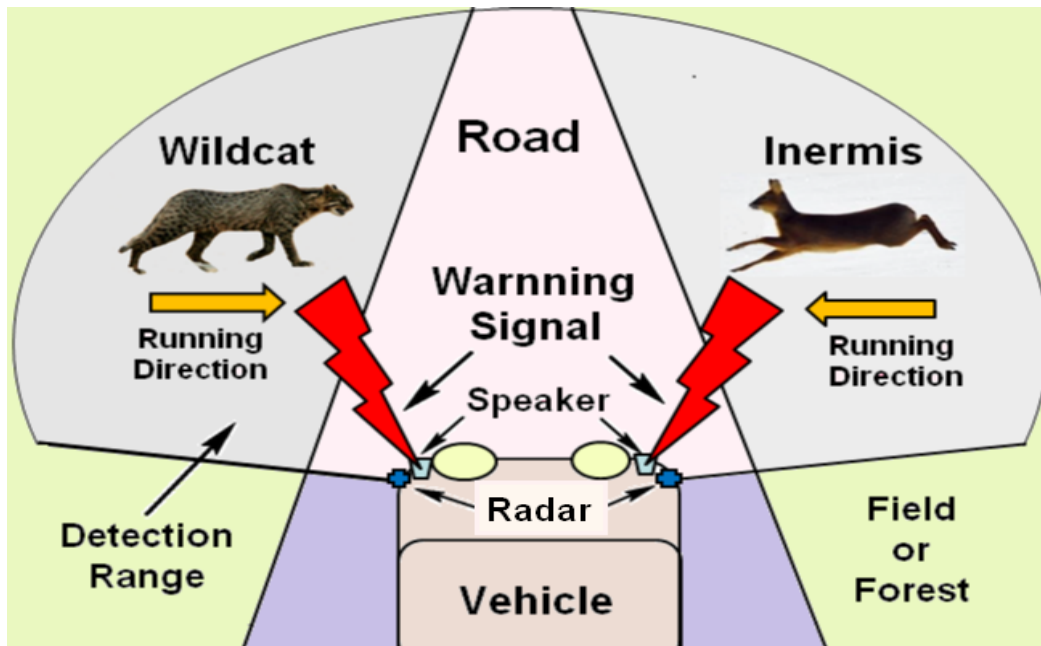
create transportation routes as an alternative. To address this problem, the Land, Infrastructure and Management Department of the local autonomous governments and the road management department have installed land bridge passageways, tunnel-type ecological channels, and roadkill prevention barbed wire entails to prevent road accidents. Figure 3 A's land bridge passageway is a passage that allows animals to look at their favorite routes and cross over onto the road. B is a passage that makes it possible for animals to walk down the road. c is a roadblock to create and build fences to guide animals into other roads to prevent them from jumping into the road. These are more aggressive ways of preventing roadkill than warning signs.

3.3 Roadkill handling method

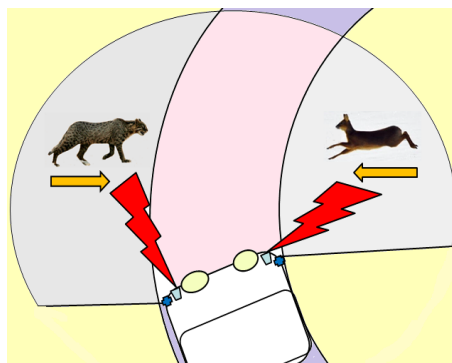
Efforts to prevent roadkill are important. However, it is also important to deal with the accident after a road accident. This is because it can cause a second or third accident while in a hurry or panic. The method for handling road kill accidents should be understood with the measures to prevent road kill accidents. On the road, cars race very fast, so it is very dangerous to attempt to directly dispose of animal carcasses caused by a roadkill. If a road accident occurs while driving on the highway, the car should be safely parked on the side of the road and a tripod or flashing signal 50 to 100 meters behind to inform subsequent vehicles. Then, immediately report to Korea Highway Corporation (Tel: 1588-2504) the details of the road kill accident. The government decided to transfer the roadkill investigation, which was carried out by the Ministry of Environment and the Ministry of Land, Infrastructure and Transport, to the road management institution for unification. The highway will be managed by the Korea Highway Corporation, the National Roads will be managed by the provincial government, and the provincial roads will be managed by the local government. In addition, road management is continuously carried out to prevent road-kill accidents, including distribution of location-based apps for drivers to use. Currently, the government is sending information about animal accident information in real time using "Good Road," a location-based app developed by the Green Union.[5][6]

4. ROADKILL PREVENTION SYSTEM USING SOUND

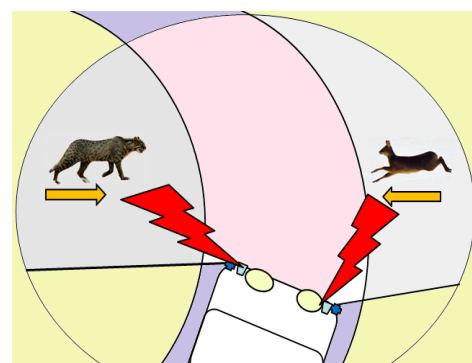
If the Roadkill sign is for drivers, the passage is for animals. Despite these efforts, however, the number of road kill accidents continues to increase. If both the driver and the animal can be warned at the same time, it could be a more effective way to avoid roadkill. In that sense, we studied the roadkill prevention system using sound.



a. Straight road



b. Right-hand bend



c. Leftt-hand bend

Figure 4. Roadkill prevention system using sound

A roadkill prevention system using sound is a system that alerts both the driver and the animal by sending a warning signal at the same time. A sound-based roadkill prevention system can be used to locate radar on the vehicle and detect the behavior of animals moving in the fields and woods on either side of the road. This system provides the driver with a reminder of the behavior of animals rushing towards the road and a warning tone to prevent them from approaching. The radar range was automatically adjusted on both fields and forested animals on straight roads as well as on winding roads. Sound alarms are a way of shooting sound frequencies that animals dislike and should continue to study more and more powerful frequencies in the future.[7][8]

4.1 Apply radar system

Radar is an abbreviation of Radio Detecting And Ranging. It emits electromagnetic waves of microwave to an object in a radar transponder, receives electromagnetic waves reflected from the object, and finds distance, direction, and speed with the object. It is a wireless monitoring device. It measures the movement of an object by measuring the time to the time of receiving the reflected wave by using the directivity of the radio wave. The principles applied to radar are related to the Doppler effect. The Doppler effect is applied to sonar equipment and speed guns that measure the depth of the ocean in 1842 as the principle of sound discovered by Christian Doppler. SONAR(sound navigation and ranging) is a system for acoustic navigation and distance measurement. It is a system for detecting and identifying targets such as fishery detection and torpedo detection in traps and submarines. However, it can be useful if you use it well in the air. Since the microwave applied to the radar has a long wavelength and has the same straightness as the light and is not reflected by the ionosphere, the emitted radio wave travels straight to the target and then reflects back.

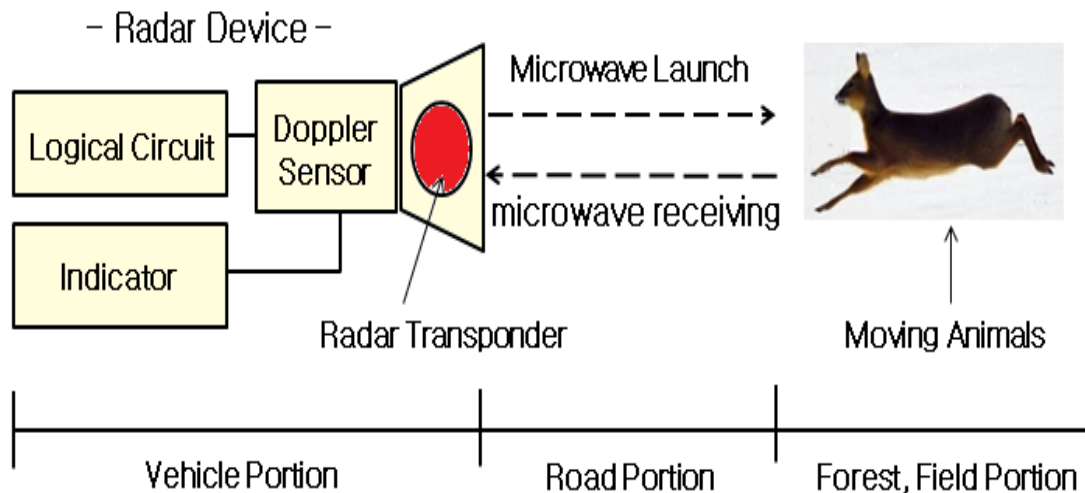


Figure 5. Radar device in load-kill prevention systems.

4.2 Research on frequency of animal access control

The frequency of animal access control was studied for applicability using spectrum currently used as a dangerous dog-fighting sound. An animal eradication sound should be chosen in the frequency band that animals feel most sensitive. Dog fighting sound is a sound that can be applied and developed as a sound model for the eradication of various animals. Studies of these frequencies should be tested and developed on a variety of animals. New sounds should also be developed continuously to counteract the learning effects of animals.[11][12][13]

Table-3 Contents of sound information

Sound information classification	Contents of sound information
The substance of sound	The collected sound is compared with the accumulated sound data and informed by the accumulated sound data.
The environment of sound	The environment of the sound is informed and accumulated as data by converting the data which constitutes a lot of informative and various sound entities.
The movement of sound	When the actual information of the sound and the environmental information of the sound are established, the information of the movement of the sound such as the distance, speed and direction of the sound entities in the environment of sound is informed and accumulated as data.

4.2.1 Time Domain Analysis of dog fighting Sound

Dog fighting sounds are used as a way to continuously fire in pairs with three distinctive sounds. This frequency is more sensitive to animals with a wider range of audible frequencies than to humans and will be more effective in warning tones. Animals that were running from fields and forests near the road to the road would stop or become nervous as soon as they heard the sound and go back in the opposite

In the waveform analysis, the energy of the time domain components was analyzed to verify the realness of the input sound and the result was obtained.

$$Time_energy = \frac{1}{N} \left[\sum_{n=1}^N (E_1(n) - E_2(n))^2 \right]$$

Equation (1) is the energy of the time domain.

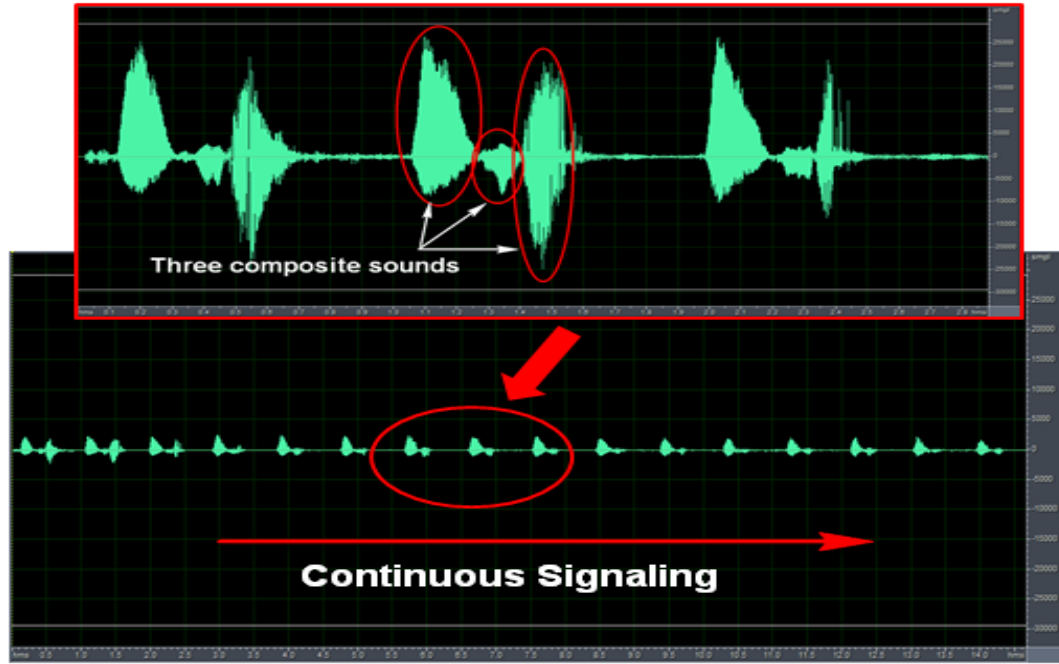


Figure 6. Time domain graph of dog fighting sound

Figure 6 shows a time domain graph of frequencies analyzed based on sound frequencies for dog fighting. In order to fight animals off, it should be a warning signal that makes animals nervous and run away by making some sounds in pairs rather than just using sounds. As you can see in the graph above, the dog-fighting sound is a unique sound that is continuously generated by a single sound forming three rhythm waves. This is because animals are so simple that they approach again when their sounds stop. It is important to continuously generate warning tones to track animals, as shown in the time domain graph above. A constant warning should be given time for animals to recognize and escape.

4.2.2 Spectrogram Analysis of Dog fighting Sound

Spectrogram is a graph that analyzes energy by frequency of sound. We analyzed a spectrum graph of dog fighting sound. A spectrum of dog-fighting sound is creating a vertebrae-shaped graph. It has a lot of energy at various frequencies and these sounds combine to stimulate, tension and escape animals.

$E_h(n)$ is the data after the conversion of the input sound, and $E_2(n)$ is the energy value of the sound information.

The similarity of each frequency component was measured by the following equation.

$$Frequency_energy = \frac{1}{N} \left[\sum_{n=1}^N (FE_1(n) - FE_2(n))^2 \right]$$

The difference of each frequency component was analyzed by the above equation and sound information was measured.

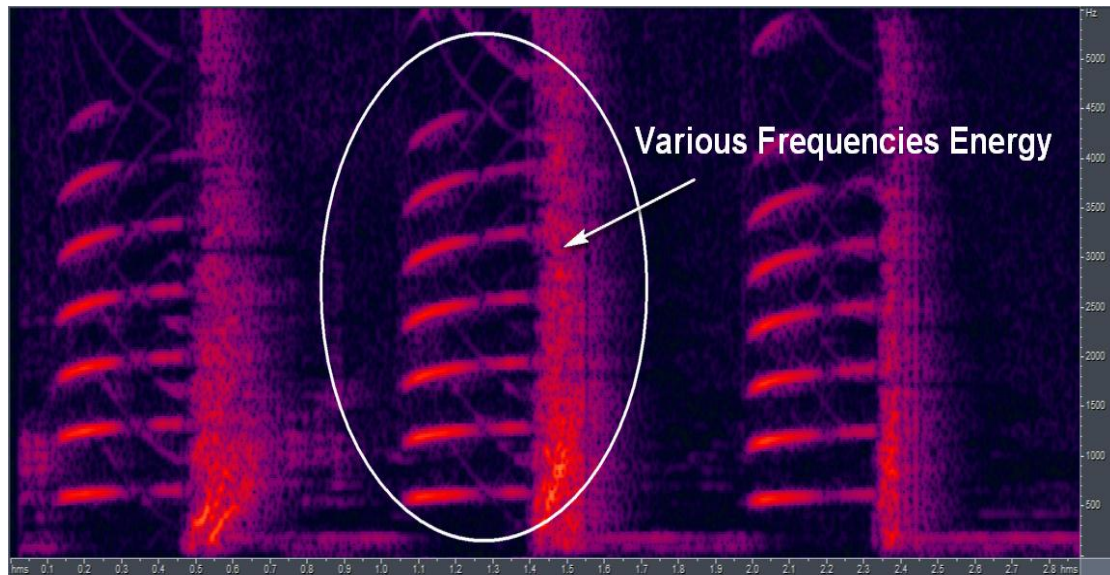


Figure 7. Spectrogram graph of the dog fighting sound

Figure 7 shows a unique form of noise frequency energy. The audible frequency domain of dogs is said to be 15 Hz to 50,000 Hz, among which 500 Hz to 5,000 Hz are the most sensitive. Thus, dog-fighting sound is generated by generating high-energy frequencies at intervals of 500 Hz to approximately 1,000 Hz, and combining low-frequency and ultra-high frequency sounds with audible frequencies above. Many native animals such as elk, wild boars, and raccoons have hearing frequency areas similar to dogs and are instinctively threatened by the extremely low frequencies emitted by carnivorous animals such as tigers and lions. Therefore, it should be used well for warning sounds to fight off not only dogs but also many other animals.

4.2.3 Spectrogram Analysis of Dog fighting Sound

If we have checked the continuity of sound in a time domain graph and analyzed the energy of sound in a spectrum graph, we should analyze the distribution of the total average frequency of sound in a spectrum graph. In this paper, the representative sound of sound to warn or chase animals is extracted from the currently on the market, dog-fighting sound system. Animals have slightly different auditory frequency bands from one another. Some animals are good at listening to ultra-low frequency band, while others are not good at ultra-low frequency band. Dog fighting sound used the principle of emitting large amounts of energy to the most sensitive frequency band of the dog's auditory frequency domain. Although other animals may have different minimum and highest audible frequency bands, it is believed that frequency bands

that react sensitively are common to each other.

Equation (2) is a formula for converting sound information into data.

The frequency-converted data of the input sound is called FE1 (n), and the FFT converted value of the sound information is called FE2 (n).

The information of each sound was measured by the following equation.

$$D_{LS} = \sqrt{\frac{1}{2\pi} \int_{-\pi}^{\pi} [10 \log_{10} \frac{P(\omega)}{\hat{P}(\omega)}]^2 d\omega}$$

$P(\omega)$: Original signal, $\hat{P}(\omega)$: Created signal

Equation (3) is a formula for measuring the spectral difference using Log-spectral distance.

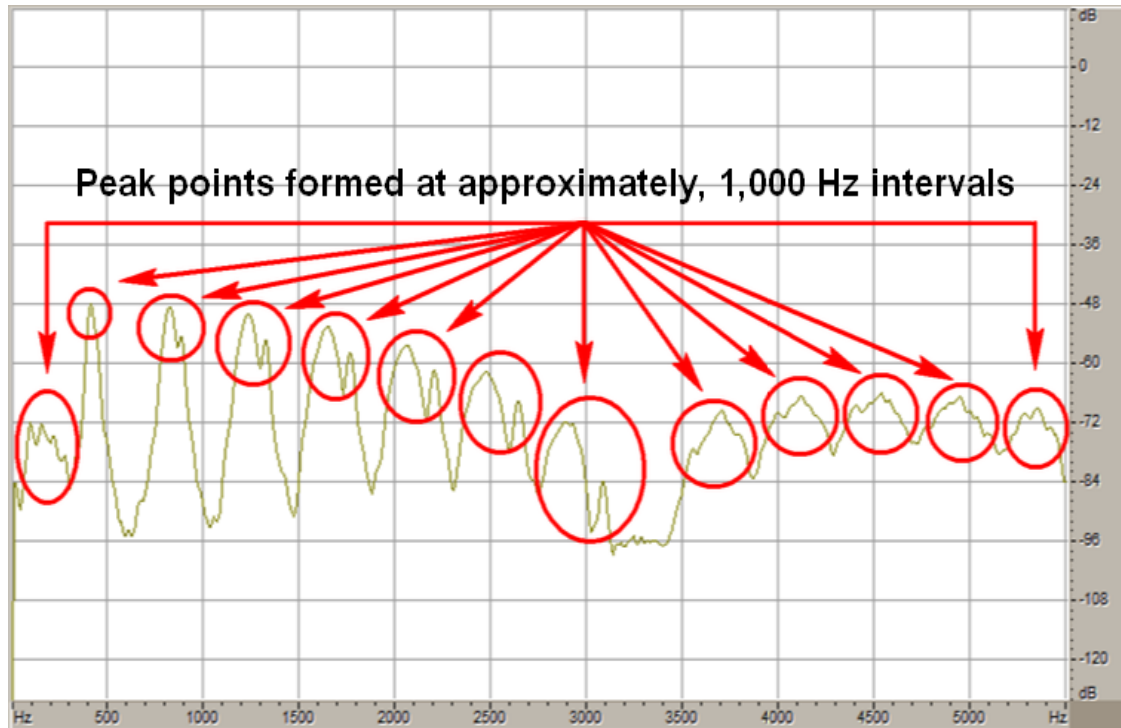


Figure 8. Spectrogram Analysis of Dog fighting Sound

Figure 8 shows the shape shown in the dog-repelling spectrum graph, with a peak occurring at approximately 1,000 Hz between 500 Hz and over 5,000 Hz. In other words, the critical frequency band in which dogs react sensitively uses the principle of strong peaks that warn dogs and eventually run away. The shapes of the peaks also vary, slowly becoming a pair from the 500 Hz band to the one, and then briefly halts

to the 3,500 Hz section to form a similar known peak in a band over 3,500 Hz. This is a way to make dogs nervous and run away by making them hear various frequency sounds strong. With this principle, it is necessary to find and retain a variety of frequency modules that can also be tested on water deer, wild pig, raccoon and others to warn animals. A powerful frequency module will be mounted in a sound warning system to prevent animal roadkill accidents and will play a major role in protecting animals from roadkill accidents.

5. CONCLUSION

The importance of life is given equally to animals as well as to humans. Humans have destroyed the living space of animals by damaging nature, including opening roads and developing cities to pursue the convenience of life. It is important to remember that an environment where animals cannot live will soon become an environment where humans cannot live. Perhaps the roadkill accident is a premonitory accident resulting from human greed, and the victims are all animals. Now, humans should stop being selfish and try to create a world that can co-exist with animals. If there is a place that has cut off the animal's livelihoods, we should build an underground passage. Also, if there is a destroyed environment, it should provide a place for animals to settle down. If you can't build underground passageways, you'll have to build a bridge, and if you can't do both, you'll have to put a barbed wire high so you won't have to cross the road dangerously. Even if all these best actions are taken, continuous human efforts are needed to prevent roadkill. As part of that, I proposed a system to attach to a car to detect animal movements and prevent roadkill by sounding warnings to drivers and animals. Roadkill prevention system that uses sound is a system that detects movement around the road in advance and switches to a defense operation mode while generating a warning tone. First, to identify wildlife approaching the road, a radar equipment is attached to the entire front of the car and animal movement is detected. Second, it detects the movements of wild animals and pre-calculates the vehicle's current speed and the predicted impact point with the approaching wild animals to guide the driver to the speed required to prevent a collision and to emit threatening frequencies or hon. We should think of the various animals living in our country as family members living with us, and we should work together not only with the driver, but also with the government, the National Territory and the road management department. We need to make efforts to develop sound warning system to prevent roadkill and to create an environment where animals live together in the future.

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