Deer Clear: The Solution to Pennsylvania's Car Crashes Involving Deer

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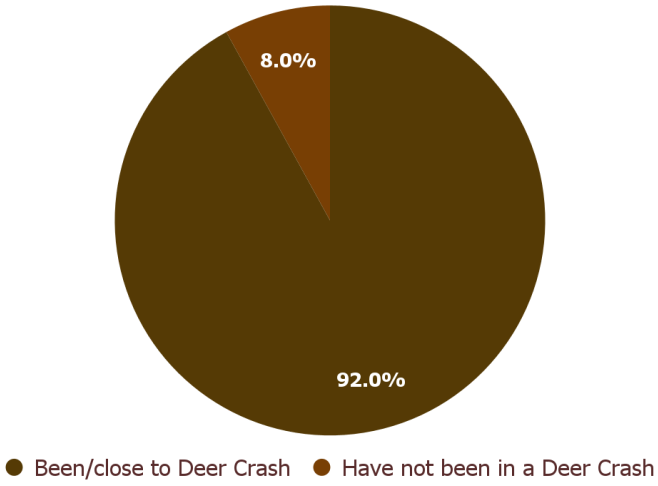
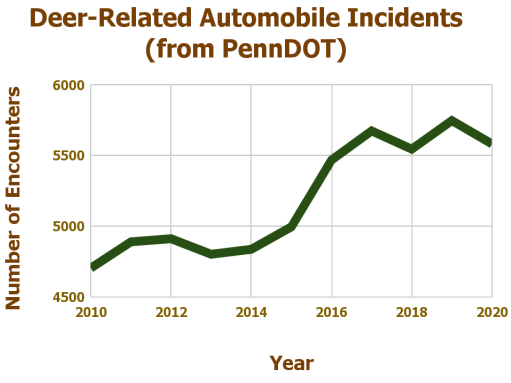
Pennsylvania: The Deer State

As of 2021, Pennsylvania ranks third in the country for the greatest number of deer collisions (Source 9). Deer cause over 1 million motor vehicle accidents in the U.S. each year, resulting in more than $1 billion in property damage, 200 human deaths, and 29,000 serious injuries. Pennsylvania has approximately 1.5 million deer, averaging 30 deer per square mile (Source 4). This ranks Pennsylvania in the top five states for the amount of deer per square mile.

Because of their abundance, deer have been known to travel on highways and various roads, increasing the potential risk of crashes. In fact, there is just over a 1/100 chance of an automobile-deer collision every outing. Moreover, Pennsylvania is infamous for being the state with the most average deer crashes, with over 142,000 such incidents (Source 7). In fact, in our conducted survey, 92 percent of respondents had stated they have been or been close to a car crash, demonstrating the dire need for such a device to reduce the risk that comes with driving on Pennsylvania roads.



With the average cost of an automobile collision involving deer being between 2,500 and 6,000 dollars, a crash is costly and requires many resources to account for one incident (Source 3). Insurance agencies have been inclined to pay a total of 4 billion dollars to this issue nationally where 36 million of this stems from Pennsylvania, demonstrating the monetary damage of such accidents (Source 1). Furthermore, collisions not only cost money but also cost lives: over 200 people nationwide die and over 29,000 are injured annually (Source 9).



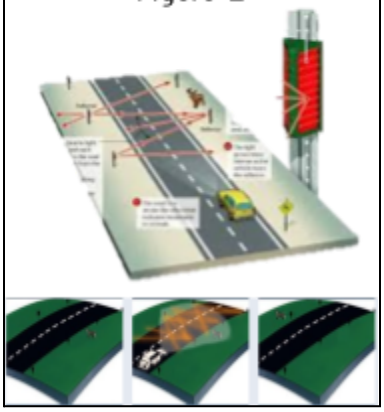
Previous Attempts at Solution

There have been very few attempts to resolve the issue, including fencing, repellents, and the deer horn. However, these solutions have been proven inadequate, whether it be due to their expense or their effectiveness (Source 6). Despite the short-term success of repellents, deer are able to adapt to the scents or odors emitted by such products, eventually to the extent that the repellents do not affect the deer (Source 5). Fencing is designed to function merely within the parameters of the structure. Though it is effective in small-scale scenarios, fencing increases in cost as the area it is meant to protect expands, and this same drawback applies to other types of modifications of fencing.

Figure 1

A product made in 2010 called Deer Deter (see Figure 1 on the right) is a prime example of the fencing technique. This device detects the presence of deer through a sensor and then plays various sounds combined with reflective lights. Costing over 10,000 dollars per mile, this product is only effective on chosen roads rather than automobiles.

Figure 2



Another solution that utilizes the fencing technique is called Strieter Lite (see Figure 2 on the left). It is a series of reflectors mounted on posts that reflect headlights to create an optical illusion of a fence and alert deer of oncoming vehicles. The total installation cost with reflectors, posts, equipment, and labor is $10,000 to $15,000 per mile. Further, the strobe lights can be a potential annoyance, especially in suburban, residential areas (Source 8).

The deer horn (see Figure 3 on the right) is a product placed on a vehicle that emits a whistle from the wind when the vehicle reaches a speed of at least 35 mph; though it was cheap, studies have proven its inefficacy and that its sounds and frequencies do not sufficiently affect deer. As a result, it was deemed as more of a nuisance than a solution (Source 10). Thus, there is an evident need for a practical and efficient approach to solving this problem.

Figure 3

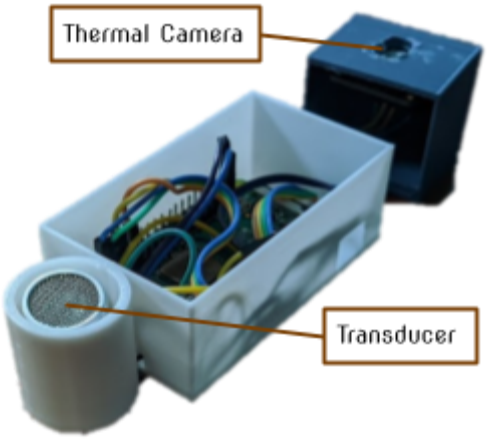
Partnership

To better understand our application to deer and how they may be impacted, we worked with Dr. Tim Nuttle, a deer and environmental biologist employed at CEC Pittsburgh. He educated us on the behavior of deer and how they interact with their environment, offering insight into the construction and effectiveness of our proposed solution. He described to us that deer have the tendency to adapt to stimuli that initially pose a threat, which made us concerned about whether this trend would occur with our product, but Dr. Nuttle described that the passing of a car would be a suitable threat to keep the deer alert and wary of the sounds created by the device.

He explained the 2-step process deer take in order to determine how they should respond to a threat. If a deer hears an alarming sound (first stimuli) - for example a twig snapping - it will initiate the alert response, and the deer will remain in place and maintain its vigilance while scanning its surroundings for threats. If a deer does identify a threat (second stimuli) - such as seeing a coyote - it will trigger a flight response in which the deer will run in the opposing direction of the danger.

Applying the same logic to our solution, we proceeded to create our prototype using the method of sound as the first stimuli and the passing of the car as the second stimuli. We chose sound as our means of the first stimuli because Dr. Nuttle discussed with us that deer's sense of sight and smell is not as powerful as their sense of hearing. For one, deer's eyesight is weak, and although they have a sharp sense of smell, we do not want to create a repelling device that will equally affect deer, humans, and others in the environment due to its high irritability especially to humans. He stated that sound is a great method to reach deer due to their heightened sensitivity in hearing compared to humans, inspiring us to utilize the sound approach.

Our Solution



By utilizing computing power alongside thermal imaging and ultrasonic speakers, Deer Clear is an effective solution to Pennsylvania's deer collisions. First, there is a thermal camera that maps heat to detect deer. Upon detection, the device plays a randomized sequence of varying high frequency sounds (see diagram on the right).

There is additional complexity in the device due to the 2 ways to trigger the transducer: detection of deer through the thermal camera or our prediction algorithm. This algorithm would function by taking the driver's longitude and latitude and searching within a one-mile by one-mile region centered around the driver's location. Then it would look at population data and DVC data to determine the likelihood of the driver potentially being involved in a DVC; if it is of a high enough possibility, the alarm will sound. This would serve to be a greater preventative measure, keeping drivers safer while also compensating for lapses with the thermal camera.

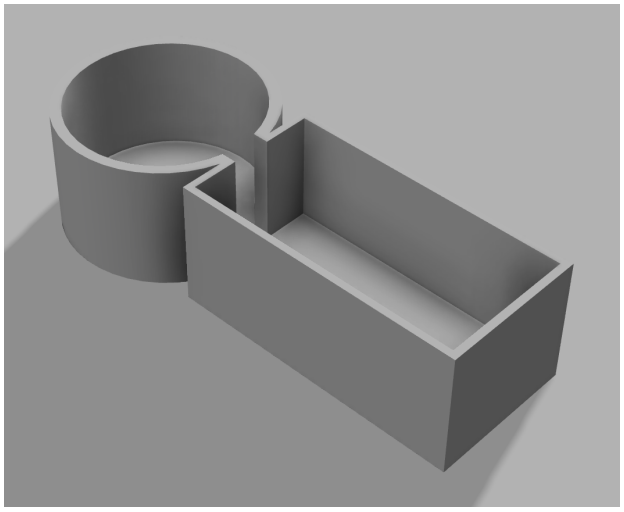
When connected to a vehicle, the device is constantly active and on standby, without needing another power source. The thermal sensor detects deer along roads, activating an ultrasonic sound that deters deer. This sound is tuned to be in the deer's range of hearing, while being outside the average human's range, eliminating audible disturbances to drivers, passengers, and pedestrians (Source 2). The sound is created in a random pattern to create an alarming noise for the deer, compelling them to remain alert; this prevents deer from sporadically jumping on roads, keeping drivers safe as well. Adaptability is a downfall to monotone alarms as deer become habituated to and ignore the alarm, so we resolve this by playing varied high frequency sounds that the deer will not adapt to. Furthermore, by making it a portable device, installments on roads will not be necessary, allowing for more convenience while also significantly reducing expenses.

Deer Clear effectively deters deer from roads while being humane, cost-effective, and human-friendly, ensuring the safety of Pennsylvania's drivers and the deer. Deer Clear combines these features into a small, expandable form factor for every automobile, rather than specific roads. The development of such a product would greatly benefit Pennsylvanians by creating safer driving conditions and saving lives as well.

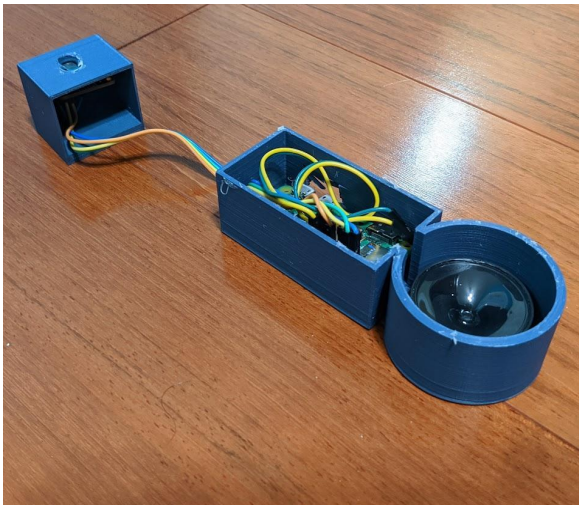
Prototype

The device has been tested, and in each instance, the device successfully deterred the deer. The prototype combines the hardware items of a Raspberry Pi 0w, AMG8833 thermal camera, a 40 kHz transducer, and Python code to operate. The Raspberry Pi 0w constantly receives data from the attached camera, runs through conditionals in the code, and operates the ultrasonic speaker after passing the conditionals. The device was made in two stages, prototypes one and two. Model 1 included our first transducer which we found to be low in decibel output and as a result, we created Model 2 with a smaller, louder transducer.

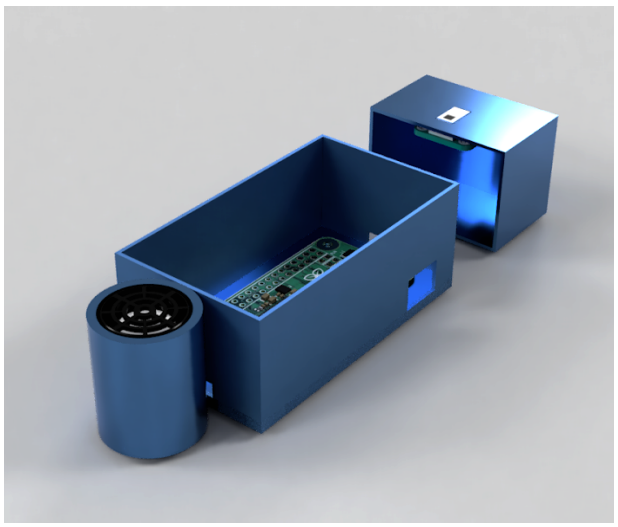
Images of the Prototype



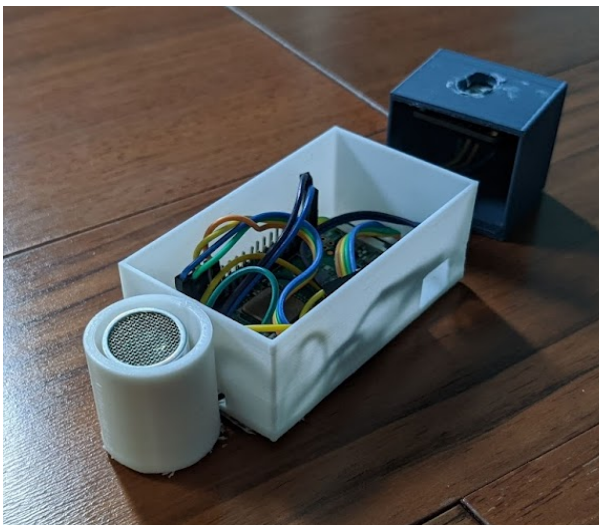
3D Model of Case in Stage 1



Isometric View of Prototype 1

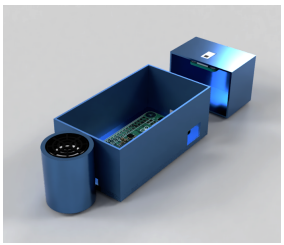


Prototype 2 Render

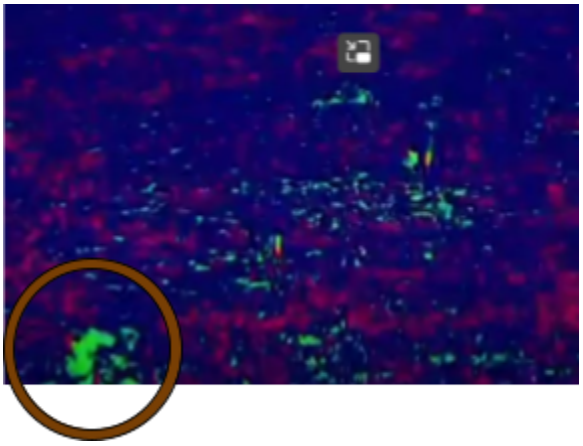


Prototype 2

Materials

Component	Image	Description
Raspberry Pi 0w		It is responsible for all computations and is the “brain” of the system. It also compiles information from the camera and communicates with the transducer.
Transducer		It creates ultrasonic sounds at 40 kHz that deter deer.
Thermal Camera		It maps heat which is used to detect deer.
Wires		It connects the devices to the Raspberry Pi.
Case		It protects the hardware from weather and organizes the components.

Demonstration

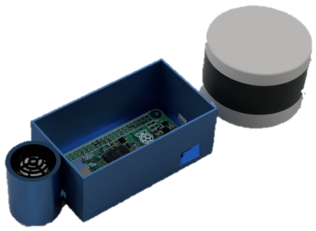
Step Number	Explanation of what Happens	Image
1	Deer is Identified Using Thermal Camera	
2	Ultrasonic Sound is Played (Deer is Startled)	
3	Deer Runs Away	

Budget

Component	Quantity	Cost	Quantity	Cost
Raspberry Pi 0w	1	$2.00	1000	$1500.00
3D Printed Case	1	$0.13	1000	$130.00
Wires	6	$0.55	6000	$176.49
Transducer	1	$8.00	1000	$320.00
Thermal Camera	1	$35.00	1000	$500.00
Total: Deer Clear	**1**	**$45.68 for Prototype**	**1000**	**$2.63 per unit if Scaled**

Future Plans

In the future, we plan to expand the usage of the device to encompass data compilation. As of now, we are heavily depending on the crash and collision data obtained from third-party companies such as PennDot. This data is necessary for the function of the prediction algorithm, which inputs the location, time, and date of the crash and processes the data to predict if deer can potentially be found at that location again. In the future, we will switch the data collection system from third parties to the device. Since detecting deer triggers the device, it records the necessary information about the deer sighting. It is the same type of detail that the prediction algorithm intakes, allowing it to be a reliable and up-to-date source of information. Furthermore, this collected data could be uploaded to a spreadsheet accessible to other models of this device where it can be accessed and referenced. As this data collection progresses, a more precise "map" of deer encounters can be made, and the device will be able to more accurately predict when to sound an alarm based on the frequency of deer sightings in an area.



We are currently relying on thermal cameras to detect deer; however, mass implementation of thermal cameras is not an optimal solution. This is because of the large amount of heat data in the environment, such as humans and other cars. As a solution to this issue, we can implement Lidar sensors in the future. As of now, the sensor's price is above the allotted budget, but as the budget increases, we can implement these sensors. Lidar sensors will offer the ability to detect the general shapes of the surrounding objects they scan, so it can still be used to detect deer. Moreover, Lidar can be used in conjunction with thermal imaging to more accurately determine which objects are the general size of a deer, reducing the number of times the device plays the alarm and records false data. This would work by the thermal camera picking up a significant amount of heat, then it would cross-reference this general area with the Lidar to see if it takes the shape of a deer-sized organism. If it does, then the alarm will sound and data regarding the encounter will be uploaded to the spreadsheet. These future plans would lead to greater accuracy in detection and alerting, reducing unnecessary sounding and improving the prediction power of the device.

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