Poster: A Low-cost Elephant Localization System

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Abstract

The human-elephant conflict is affecting the day-to-day life of villagers and farmers of rural Sri Lanka. To protect humans from elephants, reliable mechanisms to identify the presence of wild elephants around human habitats are necessary. In this work, we present the design and preliminary results of our elephant localization system that is based on infrasonic emissions from wild elephants.

1 Introduction

The rural villagers and farmers in Sri Lanka are continuously exposed to the human-elephant conflict that claims the lives of both elephants and humans. The root causes of this conflict are human settlements in elephant passages and the conversion of elephant feeding grounds to farm lands. Meanwhile, the density of the elephant population in Sri Lanka is significantly higher than in the other countries in the region where Asian elephants live. This has intensified the conflict [4]. In order to minimize the encounters between elephants and humans, it is necessary to locate the elephants that roam around human habitats and farm lands.

Elephants use low frequency sounds (infrasonic) to communicate among each other [3]. Compared to audible sounds, infrasonic waves travel long distances without facing significant attenuation by obstacles. This property makes elephant infrasonic emissions a promising candidate to detect the presence of elephants. Researchers have studied different methods to automatically identify infrasonic emissions of elephants [6]. Utilizing infrasonis signals to localize elephants is, however, unexplored.

In this work, we present a low cost infrasonic localization system for rural Sri Lanka. The goal of the system is to get information about the locations of elephants with sufficient accuracy to minimize human-elephant encounters.

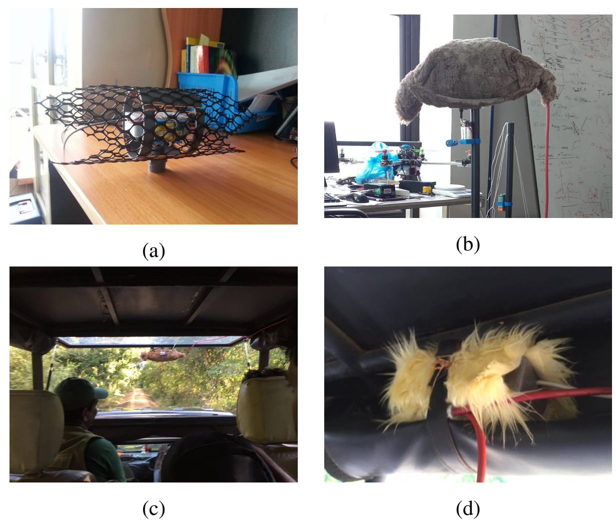

Figure 1: (a) The microphone together with the pre-amp circuitry is placed inside a sealed plastic box and then put inside the wire-frame with shock mounting. (b) Wire-frame covered with a soft material to cancel wind noise. In (c) and (d), two microphones are mounted in the front and back of a vehicle for field experiments.

2 Low-cost Infrasonic Detector

In our previous work, we used an infrasonic detector that was designed for detecting seismic activities [2]. However, these devices cost thousands of dollars making them unsuitable for a low-cost elephant localization system. Therefore, we design a low-cost infrasonic detector from off-the-shelf hardware.

The heart of our infrasonic detector is a Panasonic WM-61A omnidirectional back electret condenser microphone [1]. A small preamplifier circuitry is connected to the microphone inside a sealed plastic container. Such an infrasonic microphone unit is sensitive to the infrasonic noise from the environment making it difficult to pick the weak infrasonic signals from elephants. Therefore, we developed a wind barrier around the microphones to protect them from wind noise as shown in Figure 1. Our localization algorithm requires two infrasonic detectors to be time synchronized while recording data. Therefore, we connect a pair of detectors to a single board computer so that the data acquisition of both infrasonic detectors is performed exactly at the same time and then we processes the data on-board.

The total cost of a setup that consists of a pair of infrasonic detectors and the single board computer with proper housing is about US $73. $73 is affordable for rural villagers who want to deploy our system in their premises to become a part of the localization system.

3 Localizing Elephants

We use a simple, well-known technique based on time difference of arrival (TDOA) to locate infrasonic sources. The basis of this technique is presented by Kim et al. [5] for localizing humans by the sounds they make. In their scheme, the infrasonic sounds emitted by a source arrive with a time difference to a pair of detectors. This time difference is used to calculate the angle to the source.

Figure 2 illustrates the complete process of locating an elephant using the infrasonic data. In the first step, two detectors capture infrasonic data in a time synchronized manner and we sample and quantize their output. In the next step, we break the data sets of the two channels into multiple windows of equal sizes to get multiple data samples from the original recordings. Then we take each corresponding window pair from the two channels and calculate the cross correlation between them (Step 3). The number of sample points (*i.e.,* the lag) to the peak of the cross correlation is the phase shift that we compute in the fourth step. Using this value, we calculate the angle to the infrasonic source for each sample window in Step 5.

Since we have multiple windows, we get multiple angles to the infrasonic source which may not necessarily be the same value due to the noise in our recorded data. As Step 6 of Figure 2, we plot the distribution of the calculated angles for multiple windows for a known sound source. In the next step, we take the statistical mode of the distribution as the most representative angle that represents the actual angle towards the sound source. Our eventual goal is to deploy multiple pairs of microphones. In Step 8 we can then perform triangulation based on the angles calculated using each node pair to compute the position of the elephant in Step 9.

4 Preliminary Evaluation and Future Work

We performed experiments to evaluate the accuracy of calculating angles to the infrasonic source using our hardware setup with both artificial infrasonic sources and real elephants. Figure 3 illustrates the relationship between the real angle and the calculated angle in these experiments and the behavior of the error in the calculation for different angles. We are planning to perform further experiments to evaluate other aspects of the system such as the energy consumption of the hardware.

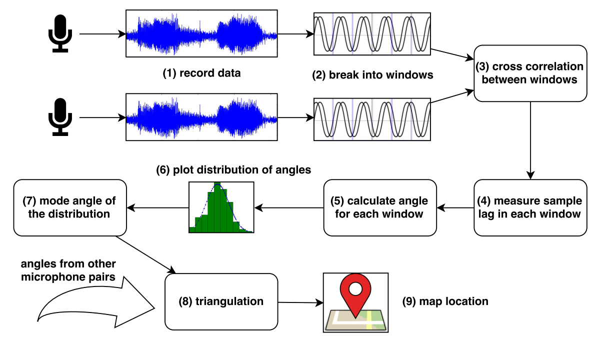

Figure 2: Process of calculating the location of an elephant. A pair of infrasonic detectors capture elephant sounds.

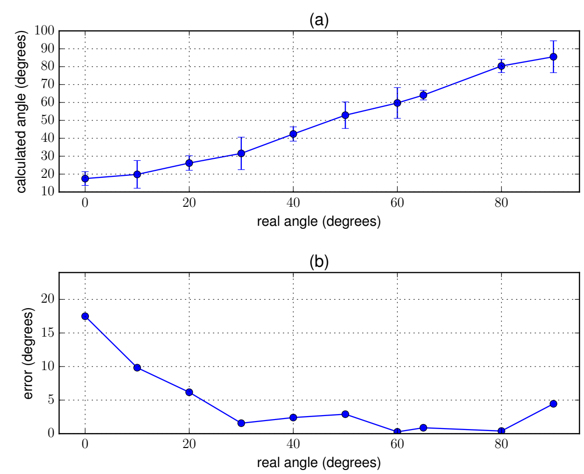

Figure 3: Accuracy of calculating the direction to an infrasonic source. The top figure shows the relationship between real and respective calculated angles while the lower figure shows the variation of the error in calculation. For angles above 30 degrees the error is low.

5 References

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