HISC Coqui Frog Detector Final Report

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Introduction

The coqui frog, *Eleutherodactylus coqui*, is a small arboreal amphibian native to Puerto Rico, and has become a notable invasive species in Hawaii. Initially introduced via horticultural trade in the late 1980s, the coqui frog has spread across several Hawaiian Islands, particularly on the islands of Hawaii. There are small pockets found on Maui, and Oahu, and if not kept at bay can spread to other parts of the Island and the rest of the Hawaiian archipelago. Infamous for its distinctive, loud mating call, which reaches up to 100 decibels, the coqui has had significant ecological, economic, and social impacts. Ecologically, the frog's voracious insectivorous diet disrupts local ecosystems, outcompeting native species for food and altering invertebrate populations. Economically, the infestation of coqui frogs in residential and agricultural areas leads to increased pest control costs and devaluation of property due to noise pollution. Socially, the persistent nocturnal calls have led to community disturbances and contributed to a decline in quality of life for affected residents. A solution of 16% citric acid has been approved as a pesticide for the control of the coqui frog. However, the dense foliage of the Hawaiian forests, the size of the area the frog has established, and the local backlash has made it unreasonable to spray citric acid. Therefor an early detection system is essential for developing approaches to mitigate its spread and mitigate its adverse effects in Hawaii before the population gets out of hand.

Project Objectives

1. Create a machine learning model to detect coqui frog sounds
2. Package it in a housing that can withstand the Hawaiian climate
3. Ensure the product does not produce any false positives

Project Outcome

OBJECTIVE 1: We developed a prototype utilizing an Arduino Nano microcontroller to detect the presence of coqui frogs through advanced machine learning techniques. By collecting and analyzing over 1000 samples of coqui frog calls, we employed Mel-Frequency Cepstral Coefficients (MFCC) to convert these audio signals into a more compact and informative format. MFCC is widely used in speech and audio processing because it effectively captures the phonetic characteristics of sounds, making it exceptionally effective for recognizing the unique calls of coqui frogs, which fall within the human speech frequency range of 2 to 4 kHz. Our algorithm enables the microcontroller to activate only upon detecting a coqui frog call, akin to the activation of an iPhone with the "Hey Siri" command. This significantly conserves energy, allowing the system to run efficiently on four AA batteries for up to three days.

OBJECTIVE 2: We soldered the Arduino into a compact package with precise dimensions of 2 inches by 2 inches by 3.5 inches, subsequently encasing it within a custom-designed 3D-printed housing. This housing, akin to a building, designed with a low hanging roof endure Hawaii's wet climate, effectively preventing rain from entering and safeguarding the internal components. To enhance its waterproof capabilities while maintaining acoustic transparency, we adhered a high-quality waterproof camping tarp over the housing's windows. This innovative approach allows sound to pass through seamlessly while ensuring complete protection against water. The entire assembly boasts an impressively lightweight design, weighing less than 3 ounces, and maintains a remarkably compact footprint with dimensions under 5 inches by 4.5 inches by 3.5 inches. Allowing the device to be hung safely from a tree in the forest or to be place discreetly in plant nurseries or ports of entry.

OBJECTIVE 3: Given the device's application as an early detection warning system, it is crucial to minimize false positives. Increasing the number of samples used in the machine learning training phase enhances the device's ability to accurately differentiate between the distinct calls of the coqui frog and other acoustically similar sounds. Presently, the AI system has been trained with over a thousand sound samples, resulting in an impressive accuracy rate exceeding 99%. Despite this high level of accuracy, there remains a need for further refinement. At 99% accuracy, the system would theoretically produce an error approximately every 25 seconds, considering it analyzes sound at a frequency of four times per second. To further mitigate the risk of misidentification, the device leverages the characteristic repetitive nature of coqui frog calls. Upon detecting an initial call, the device is programed to wait for a subsequent call within a 30-second window to confirm the authenticity of the initial detection. If no secondary call is detected within this specified timeframe, the device disregards the initial call, thereby significantly reducing the likelihood of false detections. This innovative approach not only enhances the reliability of the early detection system but also underscores the critical importance of accuracy in monitoring invasive species.

CONCLUSION: The distinctive and piercing call of the coqui frog is almost impossible to ignor. This auditory signature not only signifies the presence of these amphibians but also provides a unique opportunity for proactive environmental monitoring. Leveraging Artificial Intelligence, we have developed a detection system capable of identifying the presence of coqui frogs in previously uninhabited areas with remarkable precision. The machine operates by capturing and analyzing the specific frequency range of the coqui frog's call, distinguishing it from other environmental sounds. This early detection capability is crucial as it allows for the immediate implementation of control measures before the frogs establish a breeding population. Preventing establishment is significantly more effective than trying to manage an already established population, which can grow exponentially and disrupt local ecosystems. By utilizing this technology, we can effectively monitor and mitigate the spread of the coqui frog.