Machine Learning for Classification of Disease-Causing Vectors

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Abstract

The aim of this work is to present machine learning tools for the classification of disease-causing vectors based on audio data. Wingbeat sound recordings of three classes of insects: fruit flies, house flies, and the male Aedes mosquitoes are analyzed using different features. Mel-frequency cepstral coefficients, Gammatone cepstral coefficients, Fourier analysis, and Spectrograms were used as feature detectors. We compare the performance these classification methods and analyze their applicability in wearable devices.

Introduction

Vectors are living organisms that can transmit infectious diseases between humans or from animals to humans. Malaria is a baffling vector-borne disease in over 97 countries, especially in the tropical areas where Anopheles mosquitoes can survive and multiply, and where Malaria parasites can complete their growth cycle in the mosquitoes [1]. Regional analysis of vector-borne diseases in relation to climate change can be found in [2]. Statistics show that more than 1,000,000 lives are lost each year to vector-borne diseases. In 2012, there were about 207 million cases of malaria and an estimated 627,000 deaths. Every year, an estimated 200,000 cases of yellow fever illness and 30,000 deaths are recorded. Similarly, in 2006, about 1,400,000 cases of Chikungunya were reported in India [3]. Different species of mosquitoes are vectors of numerous health problems such as malaria, encephalitis, dengue, and others. In Table 1.0, diseases caused by different Vectors are briefly described.

No	Vector	Diseases
1	Aedes aegypti	Dengue, Yellow Fever, Chikungunya, Zika Virus.
2	Aedes albopictus	Chikungunya, Dengue, West Nile Virus.
3	Culex quinquefasciatus	Lymphatic filariasis.
4	Anopheles	Malaria, Lymphatic filariasis.
5	Flies	African trypanosomiasis, Onchocerciasis.

Table 1: Overview of some Vector-Borne Diseases

The earliest works on the classification and analysis of insects by sound dates to 1945 at Cornell University Medical College [11]. The authors opined that the apparatus presented in their work would lead to the analysis of disease-carrying mosquitoes and consequently result in the development of effective control mechanisms. Similarly, the work done in by Gustavo Batista et al. [10] were motivated to make an impact in entomology using computer science. In truth, these early works have led to an active and valuable area of research in detecting vector species. For instance, the *HumBug* project hosted at Oxford University [6], involves key research areas such as habitat mapping, acoustic sensing, and vector modeling. In [10], the authors presented an inexpensive sensor system that captures data from flying insects and an algorithm for analyzing the data. In their work, they analyzed the amplitude spectrum of wing beat audio data and used a Bayesian approach for classification. The accuracy of this classification was very high. Yanping Chen et al. in [9] also presented a similar inexpensive, noninvasive pseudo-acoustic optical sensor system for the data collection of flying insect sounds and thereafter utilized a Bayesian approach for classification.

Classification of audio data is generally not a new problem. Elias Sprengel et al. in their work, [7], applied techniques from speech recognition and advances in deep learning for the identification of bird species. They applied novel preprocessing and data augmentation methods and trained a convolutional neural network on a publicly available dataset. Similar work was done by [8], to analyze recordings of songbird species during migratory periods. Their approach involved processing audio data to spectrograms and applying image processing filters before the final implementation of a classifier. Deep learning is arguably the most exciting area of research in recent times. In [14], it was noted that deep learning approaches haven't been extensively studied for audio data. Consequently, the authors introduced convolutional deep belief networks for multiple audio classifications of speech data. This approach was applied to speaker identification, speaker gender classification, phone classification, music genre classification and music artist classification.

This work is motivated by the desire to apply machine learning techniques to solving public health problems. In this work, audio data from previous work [15] were studied. The spectral properties of these recordings were extracted using four audio feature detectors: (1) Mel-frequency cepstral coefficients, (2) Gammatone cepstral coefficients, (3) Fourier analysis, and (4) Spectrograms images. Finally, image representations of these features are used to train a convolutional neural network (CNN) for classification of previously unseen audio data. The results of these three approaches are summarized and compared.

This paper is organized as follows: Section II formulates the methodology, describes the dataset, audio features used, and proposed machine learning algorithms. Section III presents the results obtained in our work and compares it with previous results. Finally, Section IV summarizes the research work and briefly highlights applications in wearable devices.

Experiments

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Results and Comparisons

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Summary and Conclusion

References