Developing an automated and digital tool for integrated bird pest management in fresh produce fields

Summary

Birds carry foodborne pathogens and pose a significant food safety risk in fresh produce fields. Birds get habituated to current fixed frequency–based bird deterrent methods, and they lack species-level identification and target displacing all birds, including beneficial species. Therefore, we propose developing a digital tool integrating sensors, electro-mechanical systems, and machine learning to perform real-time bird surveillance and autonomous deterrence. The system will identify bird presence and species, allowing targeted deterrence of high-risk species. By combining multiple dispersal methods with intelligent and random triggers, the proposed approach enhances the effectiveness of conventional deterrent tools in solving bird habitation problems. A prototype digital toolbox will be developed and later integrated into a solar-powered, autonomous robotic platform. This project outcome will help reduce food contamination and crop damage, benefiting fresh produce and specialty crop growers with a cost-effective, sustainable bird management solution.

Objectives

1. Develop a machine learning model to identify bird presence and species (i.e., digital surveillance) through sound in the produce field.
2. Integrate multiple bird dispersal methods (e.g., visual and auditory) to develop a bird deterrent toolbox.
3. Evaluate the digital tool or platform in fresh produce fields for effective bird deterrence and management.

Methods

A prototype mechatronic system was developed for bird surveillance, consisting of a microphone, Raspberry Pi, and other electronic components (**Fig 1**). Bird species identification is achieved using BirdNET, an AI model developed by Cornell University that detects bird species through their calls and vocalizations. The operational flow of the digital tool is illustrated in **Fig 2**, beginning with bird sound recording, followed by an audio conversion process that generates a spectrogram. This spectrogram is then fed into the BirdNET model, which outputs the detected bird species along with a confidence score. The system was preliminarily tested in a laboratory and controlled environment to assess the accuracy of the digital surveillance tool. The toolbox was fed recorded calls of various bird species (commonly found in the Tennessee region) in a lab environment from 1-meter and 2-meter distances, and its performance was evaluated. Additionally, the toolbox was deployed near a bird feeder (at 1 meter) to observe its effectiveness under real-world conditions.

Results to Date

- Preliminary results suggest a digital toolbox is capable of identifying major bird species (**Table 1**).
- Model confidence score is highly dependent on bird call frequency or pitch (**Fig 3**).
- The toolbox would serve as a low-cost device to monitor bird habitat to answer critical ecological questions.
- Environmental noise is identified as one of the challenges that influence toolbox performance.

Benefits to the Industry

The potential impact of this digital tool technology on the produce industry includes:

- Avoid the loss or damage of costly produce caused by birds
- Avoid the risk of food contamination or spillover by safeguarding the produce field from birds
- Cost saving with low-cost, practical, and effective bird deterrent method

The physical outcome will be a simple, low-cost bird deterrent toolbox with digital surveillance and trigger capabilities for bird deterrent methods. The long-term outcome would be harnessing an emerging technology to provide a long-term, simple, and effective solution to restrict or limit the potential pathways of avian food-borne pathogen spillover to mitigate the contamination risk without jeopardizing the bird's ecosystem benefits or conservation.

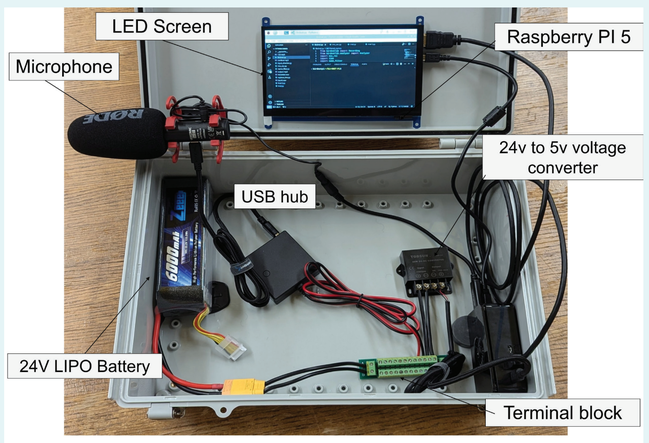

Fig1: Physical toolbox of the system and its components

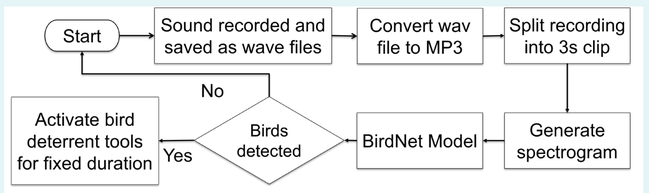

Fig 2: Flow chart of code that runs the digital surveillance system

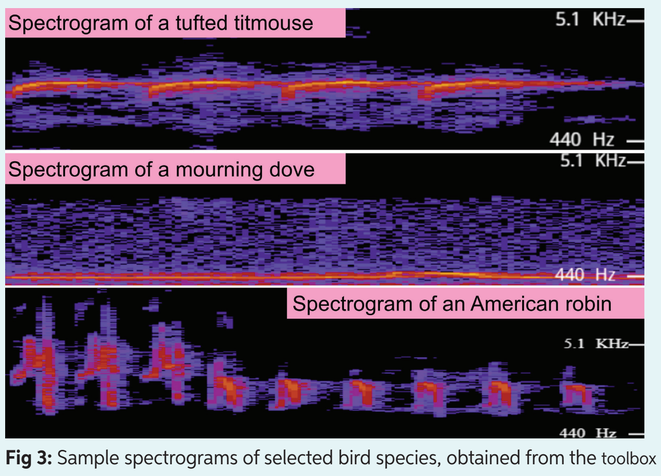

Fig 3: Sample spectrograms of selected bird species, obtained from the toolbox

Table 1: Preliminary lab testing demonstrating the performance of the developed toolbox

Common bird species in Tennessee	1 meter		2 meters	
	Detected	Confidence score	Detected	Confidence score
Northern cardinal	Yes	38.30%	Yes	20.89%
Tufted titmouse	Yes	87.07%	Yes	85.50%
Carolina chickadee	Yes	87.55%	Yes	81.63%
Blue jay	Yes	31.05%	Yes	16.98%
Eastern bluebird	Yes	70.29%	Yes	57.55%
White-breasted nuthatch	Yes	95.88%	Yes	36.86%
American robin	Yes	69.44%	Yes	31.99%
Mourning dove	No		No	
European starling	Yes	88.91%	Yes	88.60%
American goldfinch	Yes	36.18%	Yes	11.98%

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