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United States Department of Agriculture
Project Initiation

Project Data for Accession Number 1032452

Project Title

Better trap design, identification automation, and spatial modeling for better stored product insect pest control

Project Details

Sponsoring Institution National Institute of Food and Agriculture	**Project Status** ACTIVE
Funding Source NIFA Non Formula	**Grant Year** 2024
Grant No. 2024-70006-42874	**Cumulative Award Amt.** $324,400.00
Proposal No. 2024-03517	**Multistate No.** (N/A)
Project Start Date Sep 01, 2024	**Project End Date** Nov 30, 2027
Program Code [ARDP] Applied Research and Development Program	

Project Director

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Recipient Organization

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Performing Department

(N/A)

Non Technical Summary

This research aims to tackle stored product insect pest trapping and monitoring problems in multiple stages of food processing, storage, and warehouses across the post-harvest supply chain. Pest control operators utilize past (historical) trap capture data as a starting point to make recommendations in response to active infestations. However, landscapes and pest pressures change throughout the year and geographical locations; therefore, the development of trapping and monitoring systems is crucial for preventing stored food losses. This project aims to improve stored product insect monitoring systems with improved trapping systems combined with automated pest identification methods to enhance the efficacy and efficiency of conventional monitoring methods. The specific objectives are 1) trap optimization for better population estimation and automated insect detection; 2) digital 2-D floor plan mapping of infested areas with improved traps, advanced sensors, and robotic technology; and 3) stakeholder engagement and beta-testing of automated modified traps. The developed technological solution will provide a cost-effective and simple

strategy for mitigating insect infestations since improved and automated pest monitoring can allow timely intervention, saving inputs resources of money, and time in remediation efforts. The project outcomes will be an optimized trap design for automated monitoring, a digital spatial insect infestation mapping system for location-specific trap data, and cost-benefit analyses for understanding the utility of a new monitoring system. These outcomes would allow deploying a novel technology that will help advance safer and more efficient storage of grain and grain-based products against pest infestation and attack. Our proposal includes researchers from Kansas and Tennessee, states which have increased interest in protecting stored products ranging from corn, wheat, hops, and more. Protecting these stored products is critical for food protection efforts as we enter a time of increasing pressure on protecting agricultural products, and addresses USDA Strategic Goals 2 and 4, which help to reduce health risk and environmental effects from pests and management strategies.

Animal Health Component

Animal Health Component: 0%

Research Effort Categories

Basic	0%
Applied	50%
Developmental	50%

Classification

Knowledge Area (KA)	Subject of Investigation (SOI)	Field of Science (FOS)	Percent
216	3110	2020	50%
503	5340	1130	50%

Knowledge Area

[216] Integrated Pest Management Systems

[503] Quality Maintenance in Storing and Marketing Food Products

Subject Of Investigation

[3110] Insects

[5340] Nonfarm structures and related facilities, including those used in marketing, storing,processing, and distributing functions, and for recreational uses

Field Of Science

[2020] Engineering

[1130] Entomology and acarology

Keywords

computer vision, insect traps, spatial mapping, storage pest monitoring, warehouse robots

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Goals / Objectives

The overall major goal is to combine redesigned and automated trapping techniques with real-time 2D spatial modeling to improve monitoring efforts in fixed storage structures such as processing, retail, and storage facilities. The detailed goals are as follows:optimize trapping methods for grain storage and processing facilities, including new automated, real-time and deep-learning based monitoring (i.e., insect detection, identification, and counting) system; develop digital tools combined with a 2D spatial mapping of indoor spaces and new automated traps for real-time evaluation of areas of concern in individual facilities; andinvestigate the benefits of automated and traditional monitoring and develop tutorials, outreach material, and trap prototypes for testing at a range of storage and processing facilities.

Project Methods

The employed methods are briefly discussed here:(a) Trap modification for monitoring:Research will be conducted in climate-controlled semi-field warehouses with interior dimensions of 2.8 x 5.9 x 2, W x L x H at the USDA-ARS in Manhattan, KS. A single trap, either the All-beetle or Dome trap, will be placed along the back wall of the warehouse approximately 139 cm from each wall and 4.8 m from the front door. Each trap will have the designated attractant based on manufacturer's instructions. Above each trap one video/photo recording device (GoPro Inc.) will be mounted and time-lapse video recordings will be conducted every 1 minute for the duration of each study.Data will be analyzed for each trap and a student's t-test will be used to determine significant differences between the two commercial traps. This baseline capture data will help determine points of modification in each trap design and rapid prototyping using a Computer-Aided Design (CAD) model, and 3D printing will follow keeping in mind accessibility of automated imaging systems .Both the modified trap and commercial traps will be visually inspected at a certain fixed interval.(b)Develop digital monitoring tools with modified trapsWe will capture large, diverse, and high-quality image data to train the model; we plan to collect image datasets both in actual storage environments and simulated or semi-field warehouse environments. This image-processing data would be used for building and training computer vision models for automated pest detection.The imaging system and computer vision models will be integrated and deployed on a single board computer or edge device (e.g., NVIDIA Jetson Board), which will be connected to the storage structure Wi-Fi network (if available), which would allow seamless data sharing without memory restriction with a central computer system where pest data would be viewed on GUI for real-time monitoring. Additionally, these digital pest sensing tools will be implemented on small autonomous ground vehicles to collect real-world data in a storage environment to develop digital pest infestation maps.(c)Cost-benefit analysis of traditional and automated monitoring and knowledge transfer through tutorials, trap prototypes, and demonstrations of new trapping and mapping tools.We plan to test a pair of local farm goods supply stores and two mills. The choice of these two types of facilities will promote a significant amount of diversity in floor plans, machinery, shelving, and usage. There will also be significant diversity in the timing of trap checking, deployment, and servicing because of the nature of a mill's schedule and the impact of retail store hours. For the paired facilities, one will serve as our "traditional" monitoring space, and the other will be our "automated" space. For the automated spaces, we will first develop spatial maps for the space and calculate square footage to develop a grid pattern for trap placement, taking into account the floorplan variation in our 2D models. The number of traps placed will be based on previous research for best deployment methods. Next, we will set our semi-autonomous or human-assisted robotic system to deploy traps to the preferred locations and take initial images. Traps will be assessed for six months total on an every-other-week schedule. Images will be collected for each trap, and species counts will be assessed using our automated image identification models. If insects within a trap have reached a pre-determined threshold (Campbell et al., 2010), we will set the prototype robot to replace the traps with a simple mechatronics system. Total time to do deployment, species identification, and bi-weekly checking will be recorded each day. For our traditional spaces, we will obtain floor plans from the owners or managers and develop a grid-based trap placement plan. We will then deploy our non-modified traps on the selected best deployment methods for square footage as above. We will also check these traps every other week by walking around the facility, opening the traps, recording the number of insects captured, and referencing threshold information to determine if a new trap should be deployed. Time to complete deployment and trap checking will be recorded as

above. Following the six months of trap checking and servicing at each location we will meet with management of the facility to discuss our results, including identification of high-risk areas and potential management suggestions. There will also be a cost analysis determined based on the time of each visit and the total number of traps used. Simulations will be performed based on trap captures to determine population growth over time in each facility with perturbations in the simulations to demonstrate effect of any targeted or facility-wide treatments. These simulations will be done in Python, using an iPython notebook with machine learning models based on population growth literature of the most common insects collected in the traps.