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Ph.D. DISSERTATION DEFENSE

Candidate:	Daniel Kadyrov
Degree:	Doctor of Philosophy
School/Department:	Charles V. Schaefer, Jr. School of Engineering and Science /Department of Civil, Environmental and Ocean Engineering
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Title:	Vibro-Acoustic Signatures and Detection Algorithms for Stored Product Insects
Chairperson:	Dr. Raju Datla, Department of Civil, Environmental and Ocean Engineering
Committee Members:	Dr. Alexander Sutin, Department of Civil, Environmental and Ocean Engineering Dr. Muhammad Hajj, Department of Civil, Environmental and Ocean Engineering Dr. Richard Mankin, Agriculture Research Service, United States Department of Agriculture (USDA)

ABSTRACT

Stored products, such as grains and processed foods, are a staple in global diets and one of the most traded commodities but are susceptible to infestation by various pests, most notably insects. The early detection of insects throughout the supply chain is crucial to mitigate against qualitative and quantitative losses, ensure food safety, and prevent introducing invasive species to new environments resulting in further economic and ecological impact.

The Acoustic Stored Product Insect Detection System (A-SPIDS) was designed as a low- cost, non-destructive, alternative detection method that uses piezoelectric sensors to detect insect sounds and vibrations within an infested material. The system was used to record and analyze the vibro-acoustic signatures of various insects, including the *Callosobruchus maculatus*, *Tribolium confusum*, and *Tenebrio molitor*, in different materials. These recordings were annotated and organized into a dataset accessible through a developed database software package.

A normalization method was implemented using the ambient noise of the sensors as a reference to accommodate for proprietary, non-calibrated sensors and enable relative detection thresholds for unknown sensitives. The normalized envelope of the filtered signals was used to characterize and compare the insect signals by measuring the Normalized Signal Pulse Amplitude (NSPA) and Normalized Signal Energy Level (NSEL), parameters that apply the signal noise ratio (SNR) for pulse-based detection and averaged energy-based detection, respectively.

The physical insulation in the platform was shown to provide an average attenuation of 45 dB above 2000 Hz. The NSPA was applied as a detection metric resulting in a 99.4 % detection accuracy at 80 dB ambient noise levels when using a filter range of 1565 Hz to 6000 Hz. The external microphone integrated in the

system design was leveraged to identify and remove insect-like signals from the piezoelectric sensor recordings. This led to a 100 % detection rate with zero false alarms at noise levels exceeding 100 dB.