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Identification of Beetles in Wheat Grain by the use of Noise filter

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Abstract

In this paper, an effective approach to increase the sound level of the recorded acoustic signal from beetle (Triboium confusum) in wheat grains is presented. The signals were received on sensor from adults located at 10cm away. IIR and FIR bandpass filter was applied on the received signal. The signal processing were performed using MATLAB software.

I. Introduction

As the world's population grows, so do worries about pesticide usage and over-exploitation of natural resources, as well as the increase of global commerce, and as technology improves, so does agriculture. Digital technologies are used to boost productivity and optimise the management of natural resources and agricultural inputs at the same time as this revolution occurs [1]. As a result of this rising need for food, most governments have implemented strategies to increase agricultural productivity, land usage, and population control. However, the crucial problem of post harvest loss is rarely given the attention it deserves. To put it another way, postharvest loss includes both direct physical losses and quality losses that lower the crop's economic worth or render it unfit for human consumption [2]. Most developing nations' diets are built around grains like wheat, rice, and maize, which is often, considered the world's most popular food crops. Post-harvest losses are responsible for 19% of the total losses for cereals [3]. One resource-efficient strategy to promote food security, alleviate hunger, reduce agricultural acreage required for production, rural development, and improve farmers' livelihoods is to minimise grain losses along the supply chain.

The food supply chain relies heavily on storage, and multiple studies have shown that the greatest losses occur during this process. Crops are planted seasonally, and grains are preserved as food and as seeds for the next year in most areas. Many studies have shown a correlation between the amount of grain that is kept in traditional buildings and the amount of grain that is consumed at the household and farm level in developing nations like India. Because, the native storage structures are composed of locally accessible materials such as grass and wood among others, they cannot be guaranteed to safeguard crops from pests for an extended period. Other storage structures made from Polypropylene bags resulted in losses of up to 59.48 percent of maize grains after 90 days of storage. According to [4], 21.99% is the post harvest storage loss in wheat.

Insect pests are regarded to be the most significant biotic factor, causing losses of 30 to 40 percent in grains [5]–[7]. About 6,700 beetle and moth species assault and destroy food storage facilities across the world [8]. Contamination of food products by insects and other pathogens is a major source of quality control issues for the food manufacturing industry. Insects in food are strictly prohibited in the majority of developed nations [9]. Effective pest control in storage facilities begins with quick and accurate pest identification and treatment.

There are several ineffective and time-consuming techniques that is used to identify pests in grain storages (e.g., silos) such as visual examination, sifting and Berlese funnels. CO2 and uric acid measurement, near-infrared spectroscopy, and soft X-ray have all shown significant promise in the laboratory. Nevertheless, the majority of these devices are prohibitively expensive and need elaborate operational procedures and calibrations [10].

An acoustic approach for detecting insects in the grain bulk is a promising one. In spite of the fact that it's been around since the 1950s (Adams et al. 1953), it has just been extensively investigated in recent years. Due to advancements in audio technology, this has become increasingly commonplace. Reliability and effectiveness of acoustic pest detection has been considerably boosted in the past few years as a consequence of the development of new acoustic instruments and signal processing techniques [11].

As insects fly, feed, lay eggs, or move about, they produce sound that may be used to identify them. Acoustic based systems for detection of pest that include bio acoustic signal processing [12], machine learning approaches [13]–[16], wireless network [20], using microphones [17], digital signature [18] are proposed in the literature. Noise filters may be used to boost the acoustic signal captured from a beetle in wheat grains, according to this article. This kind of work is unique in its own right since it has not before been treated in the literature.

The remainder of the paper is laid out as follows: The acoustic system is described in detail in Section 2, along with the experimental approach. Results and discussions are provided in Section 3. Finally, the paper is concluded in Section 4.

II. System Description

Rather of using a standard piezoelectric sensor, this one has been adapted to pick up low-level sounds like the insects buzzing. Having a robust boost circuit for sound pre-amplification was vital to the sensor's performance when it came to converting very low acoustic sound intensities into audible noises. Using a computer to store audio signals and reduce background noise from the surroundings is possible thanks to the amplifier circuit's architecture. There are two types of amplifiers (first floor transistor and second floor operational amplifier) included in the sensor's specs, as well as an output audio connection that may be connected to a computer system or speaker. The database that has been built into the device may then be used to identify the pest sounds. A MATLAB software is used to store and analyse the majority of the data, as well as perform other data-related tasks (Figure 2). In order to reduce the impact of noise, many noise reduction methods were incorporated into the signal processing unit.

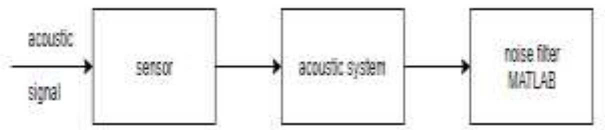

Figure 1: An acoustic signal noise filtering system

To conduct this experiment, we used wheat that had a moisture content of 13 percent. Insect proliferation was carried out in a little dish of wheat seed in order to create a suitable number of adults and larvae. From 8 a.m. until 6 p.m., the trials were conducted. An adult insect was put in the test tube the day before the test, and it was coated with wheat grain so that the insects could get familiar with their new surroundings. Prior to opening the test tube, it was filled with pest-free wheat grain to a height of 10 centimetres. Before putting wheat grain into the test tube, a very thin veil was placed within the tube to prevent insects from reaching the upper layers. Grain mass surface and insect population were put 10 cm apart in order to begin the experiments. Digital signal processing software was used to capture the noises of adult beetles for 30 minutes, which were then relayed to a computer and an integrated signal processing circuit. The received sounds are saved in 30-second files by the sound recording software and played back later. Test tubes were filled with a thin coating of wheat grain and multiple wheat grains, each with several larvae, were put on top. The first step was to fill the test tube with wheat grain to a distance of 10 centimetres (no need to use separator veil, because the larvae is inside the kernel without any movement). After inserting the separator veil, a tiny layer of flour beetle-infested wheat (both larval and adult stages) was put in the test tube, and the test tube was then filled with insect-free wheat. Additionally, sound sensors were fitted at the correct heights. In the same way as the prior recordings, the sound recordings were made. All tests were carried out with the use of a temperature control system that kept the test rig's temperature at about 20°C. Figure 2 depicts the signal analysis architectural flow diagram.

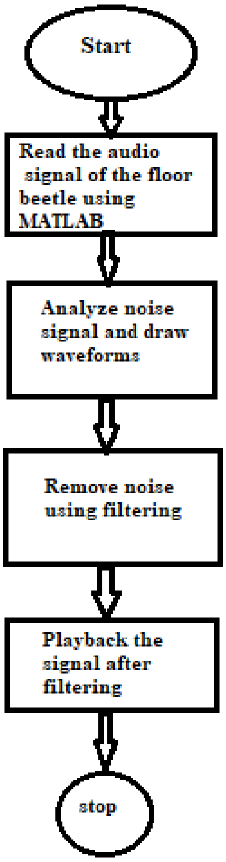

Figure 2: Architectural flow diagram of acoustic signal detection and signal analysis

III. Results and Discussions

When performing the larval stage test, MATLAB software was used to evaluate recorded acoustic frequencies. Some of the recorded noises exhibited multiple sound pressure peaks because to the rapid activity of numerous larvae. As seen in Figure 3, the larvae's peak intensity in the frequency domain may be seen. For the most part, larval sounds are found in the range of 1 to 7 kHz, with the most intense sound occurring at 0.3kHz. This frequency range is almost identical to the range of frequencies that are audible to the human ear. A greater range of amplitude can be detected in the noise waveform compared to the original one. In the background, you may hear the sound of the surrounding area. As a consequence, the waveform is smoother and the audio stream clearer as a result of the filtering process. Figures 4 and 5 show the results of the FIR and IIR band pass filtering.

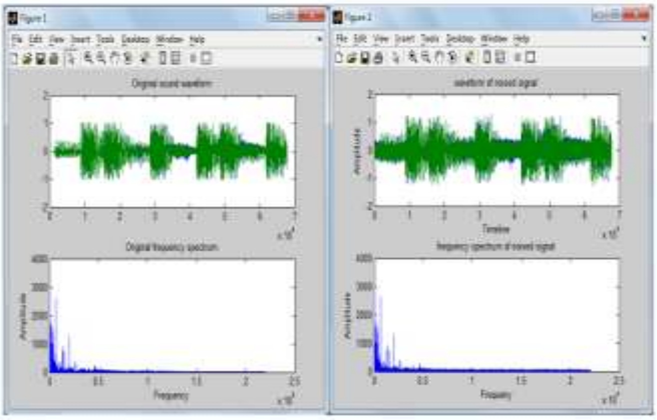

Figure 3: Spectral analysis of the acoustic noise

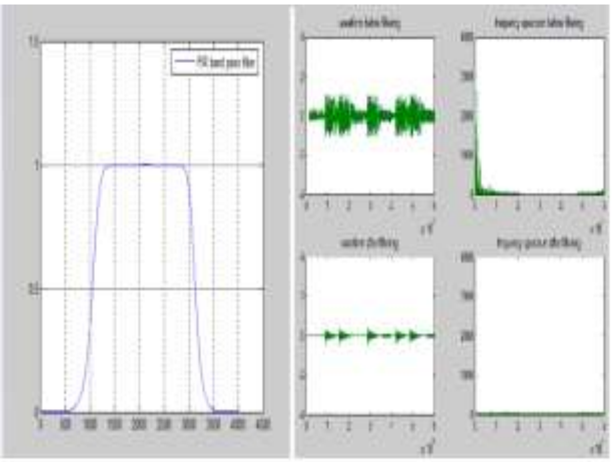

Figure 4: FIR band pass filter applied to remove noise

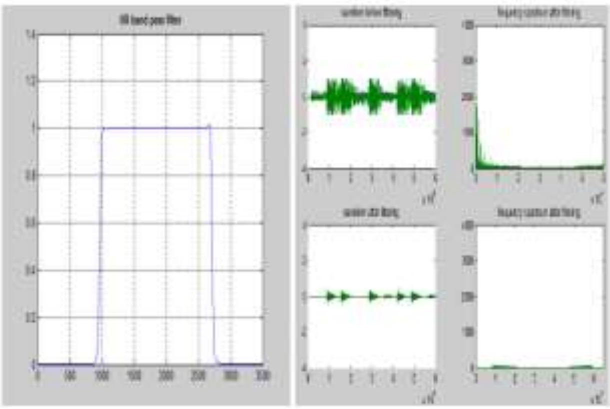

Figure 5: IIR bandpass filter

IV. Conclusion

In this paper, an effective approach to increase the sound level of the recorded acoustic signal from beetle (Triboium confusum) in wheat grains is presented. The signals were received on sensor from adults located at 10cm away. IIR and FIR bandpass filter was applied on the received signal and shows that about 10dB increment in the sound level of the received audio signal was achieved.

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