Non-invasive detection of root feeding insects using Deep Learning

Presented by

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Outline

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Motivation

- India is the world's second-largest agricultural producer, it plays a vital role in the country's economy.
- However , farmers in India face numerous challenges.
- Soil-dwelling pests, particularly white grubs, pose a major threat to crops.
- Early detection of white grubs is crucial for implementing proactive pest management strategies.

Figure 1 : Yellowing of leaves due to white grubs.

Figure 2 : White grubs feeding on Roots.

Source : Internet

Motivation

- Currently, the lack of effective monitoring techniques hinders early detection and interventions.
- There is a critical need for cutting-edge technologies that address the challenge of white grub infestation and provide effective control measures.
- Developing advanced monitoring techniques can help overcome the challenge of early white grub detection.

Figure 3 : White grubs feeding on Roots.

Source : Internet

Introduction

Figure 4 : Grubs found under excavated site.

Figure 5 : Yellowing of crops.

Source: Internet

- One promising approach is the use of deep learning, a subset of artificial intelligence, for non-invasive detection methods.
- Deep Learning algorithms can analyse large amounts of data and detect patterns indicative of white grubs presence in soil.
- Integrating data from sensors, remote sensing technologies (satellite imagery and drones), and deep learning algorithms can enhance early detection capabilities and assist farmers in targeting their pest control efforts effectively.
- These techniques can provide farmers with timely and accurate information to implement proactive pest management strategies

Objectives

- To design Fractal dimension analysis to provide a semi-quantitative estimate of stridulation activity caused by the white grubs.
- Acquiring the audio from the stridulation activity of the white grubs and creating data set out of it.
- To implement deep learning techniques using (DNN) Deep neural network based classification for automatic detection of audio sections with stridulations.
- To quantify the density of the white grubs and provide a suitable solution to eradicate the white grubs from the rootlets of plants.

Literature Survey

Sl. No	Author	Title of the project/ paper	Remarks	Publishing Year
1.	H.M. Mahadeva Swamya and C.M. Kalleshwaraswamy	Arecanut white grubs Leucopholis species (Melolonthinae: Scarabaeidae: Coleoptera) morphological, molecular identification and phylogenetic analysis	• The species of white grubs are location-specific. • Shimoga- Leucopholis lepidophora • Mangalore- L. burmeisteri • Symptoms of root damage can be observed. • Presence of grubs in sandy rather than clay soil.	2019
2.	Görres and David Chesmore	Active sound production of scarab beetle larvae opens up new possibilities for species-specific pest monitoring in soils	The stridulations of the two species sounded similar, a stridulating second instar M. melolontha might not be distinguishable from a third instar M. hippocastani in areas where both species co-occur.	2019

Literature Survey

Sl. No	Author	Title of the project/ paper	Remarks	Publishing Year
3.	Kayuã Oleques Paim, Ricardo Rohweder	Acoustic Identification of Ae. aegypti Mosquitoes using Smartphone Apps and Residual Convolutional Neural Networks	• Advancing the state-of-the-art in mosquito tracking using smartphone apps. • Ae. aegypti mosquitoes from wingbeat sound recordings. • The CNN is designed to capture important features from the audio data, allowing for accurate identification of the mosquitoes.	2023
4.	Huang, Jingshan and Chen, Binqiang and Yao,	ECG Arrhythmia Classification Using STFT-Based Spectrogram and Convolutional Neural Network	• Two-step approach involving feature extraction and pattern classification. • 2D-CNN for ECG arrhythmia classification. • Average accuracy of 90.93% achieved.	2019

Literature Survey

Sl. No	Author	Title of the project/ paper	Remarks	Publishing Year
5.	R. W. Mankin and P. R. Samson	Acoustic Detection of Melolonthine Larvae in Australian Sugarcane	• Dermolepida albohirtum. • Antitrogus parvulus. • The acoustic method could help determine which samples would be best to excavate based on the density of high or intermediate based on cut-off value.	2009
6.	R. Hussain and Y. Saleh	Intelligent system for white grub monitoring through WSN	• The proposed method finds the instar of grubs that is most damaging stages in the grub lifecycle. • CO2 gas bursts released by grubs. • Based on EPN nematode methodology.	2017

Summary of Literature Survey

It is noticed that Deep Learning Techniques can be used to analyse density using audio data.

Features like Spectrogram serves best for audio data.

The CO_2 monitoring for white grub detection is not a feasible way.

As a consequence, the generalization of the overall solution is also limited.

Research Gap

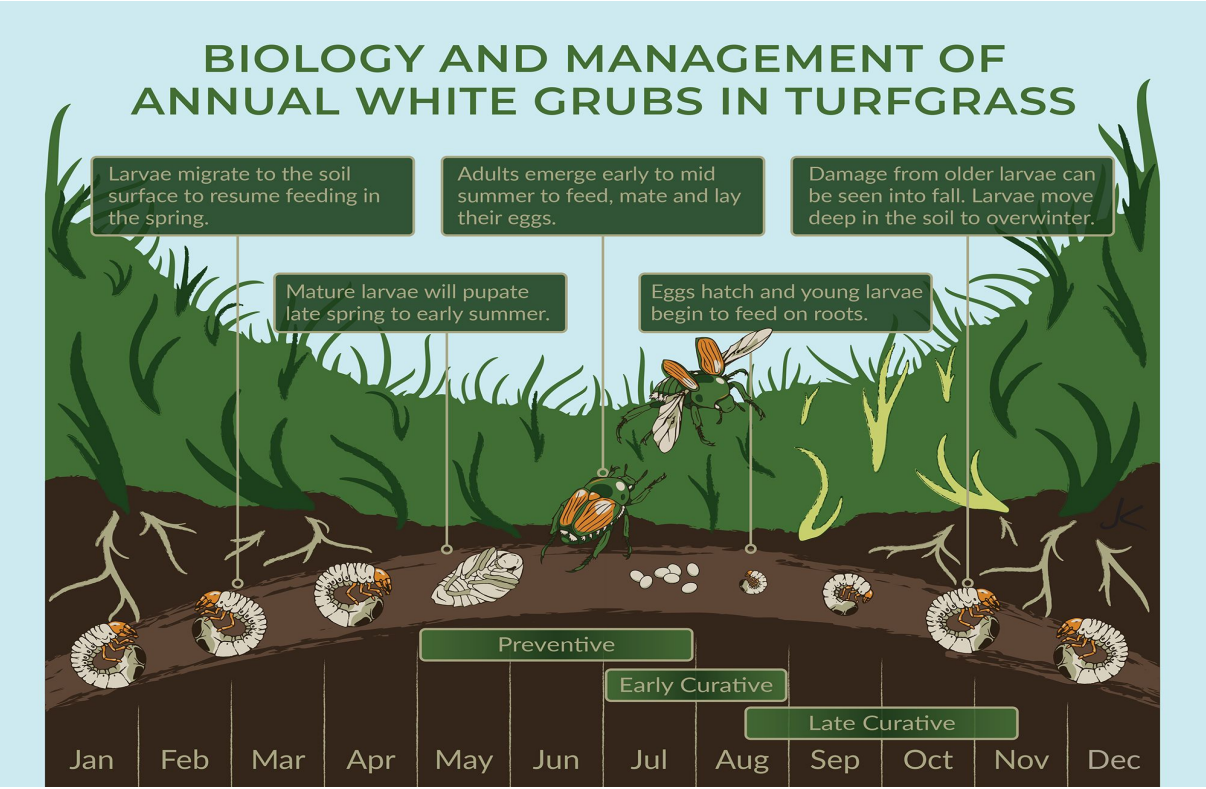


Figure 6: Life Cycle of White grubs.

Methodology

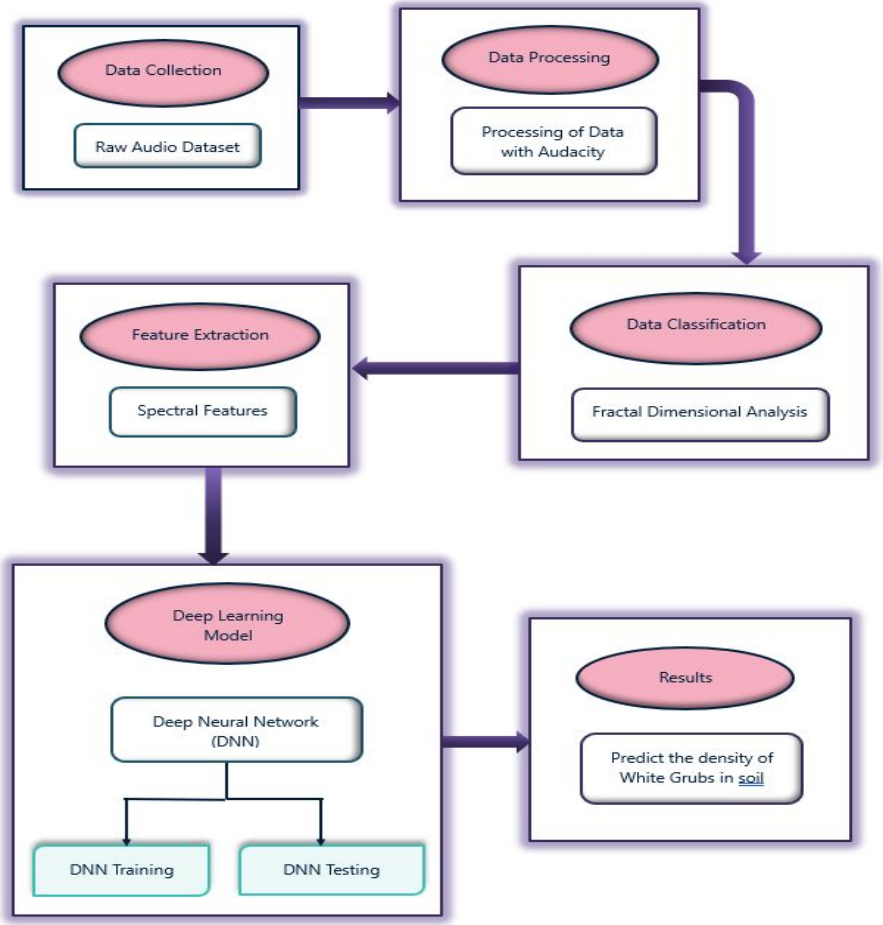


Figure 7: Block diagram of Proposed System.

Methodology

- **Data Collection** : In this experiment, the Raw audio dataset of M.hippocastani and M.melolontha species is used.
- **Data Processing** : Cleaning and normalizing of the data is done. The manual acoustic data analysis has been performed with the software Audacity using Band pass filter
- **Data Classification** : The quantitative estimation of the stridulation events in continuous audio recordings is obtained by Fractal Dimension analysis, which helps in detection of larval activity sounds.

Methodology

- **Feature Extraction** :
    - **Spectral features** : we have used Spectrogram to analyze and extract information such as frequency of the presence of white grubs.
- **Deep Learning Model** :
    - **DNN Training**
    - **DNN Testing**

Flowchart

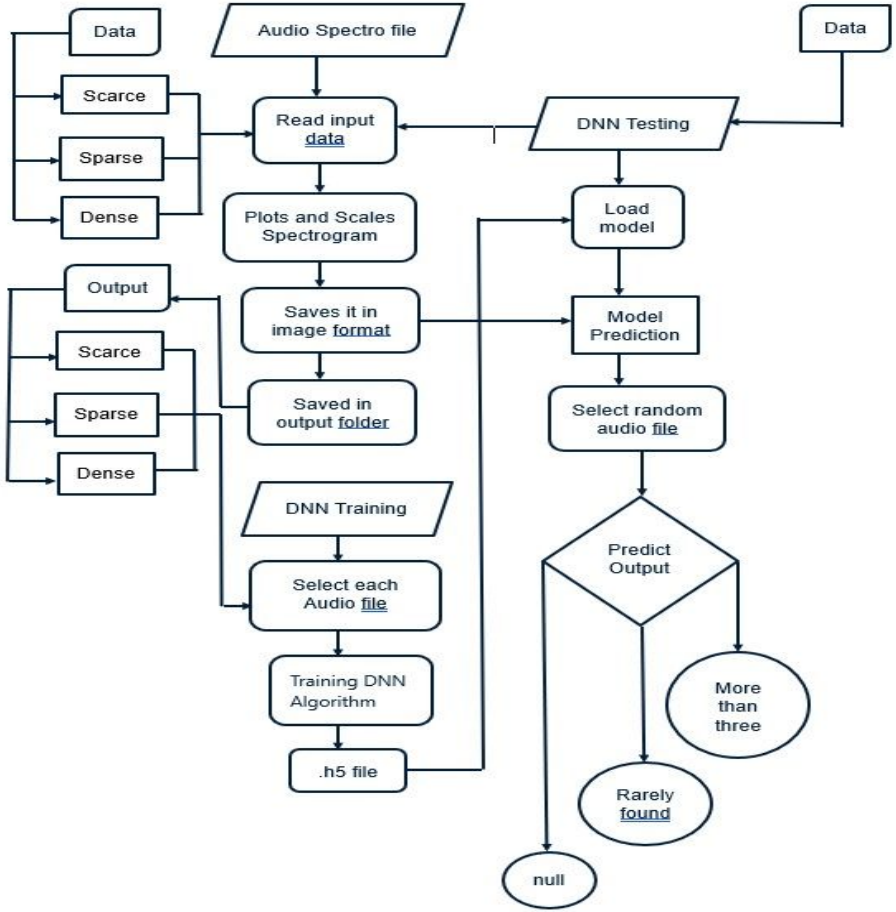


Figure 8: Flowchart showing the working of proposed methodology.

Algorithm - Pseudo codes

Audio Spectro -

- Read audio files from the input folder using api scipy.io.wav
- STFT (short time fourier transform) calculates the spectrogram of given audio files.
- log_scale_spec scales the spectrogram on logarithmic scale.
- Initially, Plot_audio_spectrogram function takes the path of input folder.
- Calculates spectrogram of each audio file present in the input folder using stft function.
- Scaling of the Spectrogram will be done using log_scale_spec function

Algorithm - Pseudo codes

Training -

- Convolutional Layer 1 - Applies a convolution operation to the input data.
- Convolutional Layer 2 - Applies another convolution operation to the previous layer's output. Followed by a ReLU activation function.
- Flattening Layer - Reshapes the output from the previous layer into a 1-dimensional vector
- Output Layer: Adds a dense layer with a number of units equal to the target classes (3).

Algorithm - Pseudo codes

Testing -

- Read audio files from the input GUI using tkinker.
- Load the Trained model form *.h5 file.
- Plot the spectrogram for the for the given audio file.
- Feed the model with the plotted spectrogram.
- Model will classify the testing audio to three categories

Software Description

Python

- Analysis, training and testing code is written in the python
- Major Library used :
  - NumPy - used for array calculations
  - Scipy - used to read the audio file (.wav)
  - Matplotlib - Used for the spectrogram pictorial representations and model curves

Software Description

- Ntpath - provides functions to manipulate file paths.
- Tkinter - Tkinter GUI used for import of the audio file.
- TensorFlow - Used for the deep learning model construction.
- OpenCV - Used for the spectrogram image extraction.

Software Description

Audacity

- Digital audio editing software called Audacity is free and open-source.
- Audio prepossessing and noise cancellation are done using Audacity.
- All raw audio files were subjected to bandpass filtering to retain only audio signals between 200 and 5000 Hz.

Results and Discussion

Fractal dimensional Analysis using R-code

- Stridulations count are noted from the output of the R code for each audio file.
- SFD is plotted against the time and if SFD crosses the threshold of -4.0, then it is considered as activity of the white grub.

Results and Discussion

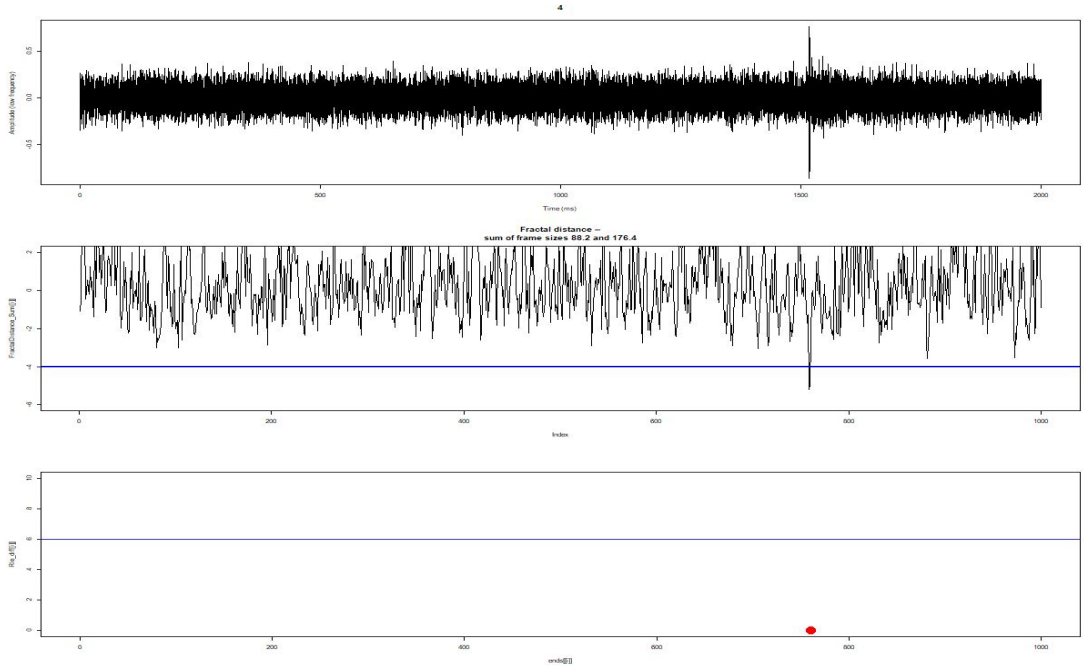


Figure 9 :Summed Fractal Distance (SFD) graph of a audio segment having 1 stridulation where threshold is greater than -4.0.

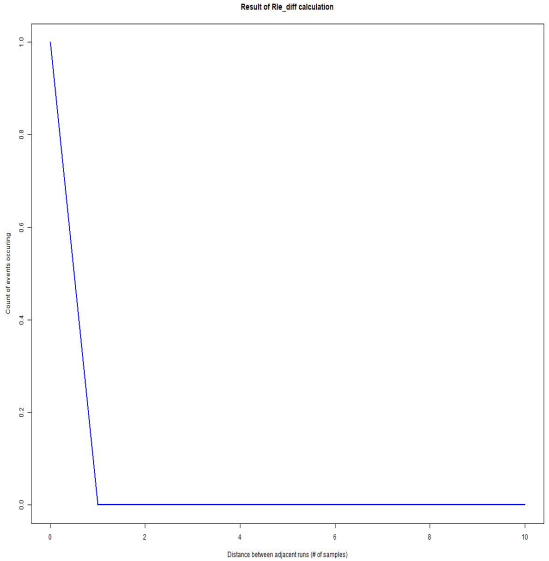


Figure 10 :Showing counts of white grubs in the complete audio files.

Results and Discussion

Spectral feature Results

- Spectrogram is calculated by finding the Short Time Fourier Transform (STFT) and transformed to the log scale
- For each audio files in the data folder, spectrum will be plotted and saved in the .png format in corresponding output folders.

Results and Discussion

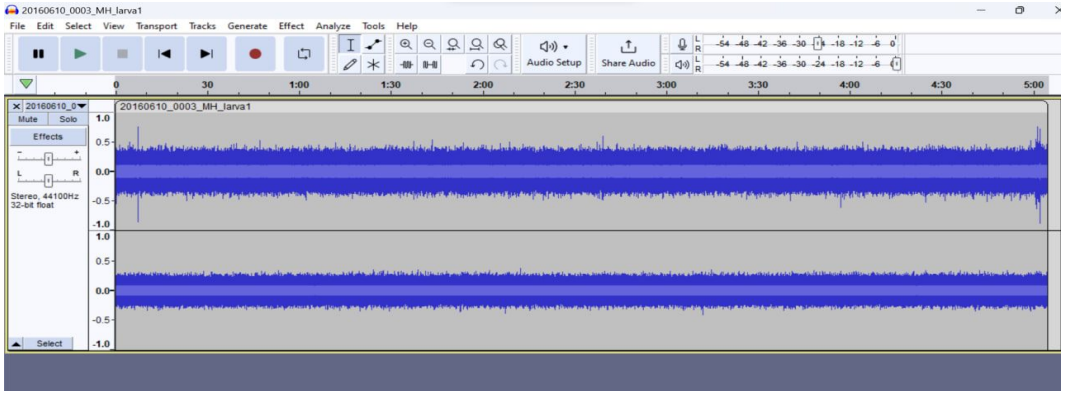


Figure 11 : Band pass filtered output in Audacity.

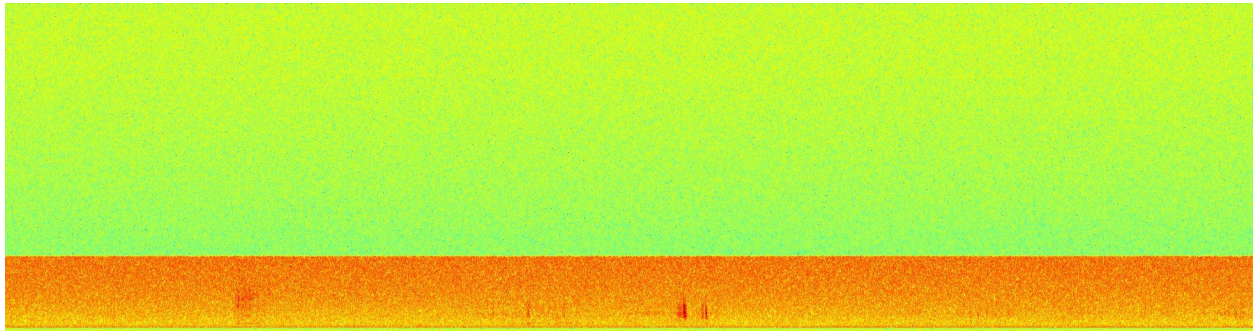


Figure 12 : spectrogram of the testing audio file.

Results and Discussion

Model Results

- The model serves as the spectrogram-based classifier for the input audio files.
- The model is giving upto 85 - 90 % accurate results.

Results and Discussion

DNN Algorithm classifies the results into the three category

Scarce - Null

- No action is required as there are no grubs, but it is suggest you to keep track once in a month.

Sparse - Rarely_Found - One_to_Three

- Larval activity could be a little lower. Application of powdered neem cake 1kg/palm, near the roots zone and also chlorophyriphos compound is useful.

Dense - More_Than_Three

- It is necessary to take precautions in accordance with the recommendations to use insecticides or manually remove the grubs by digging, hoeing, ploughing and expose them to predator birds and kill them directly.

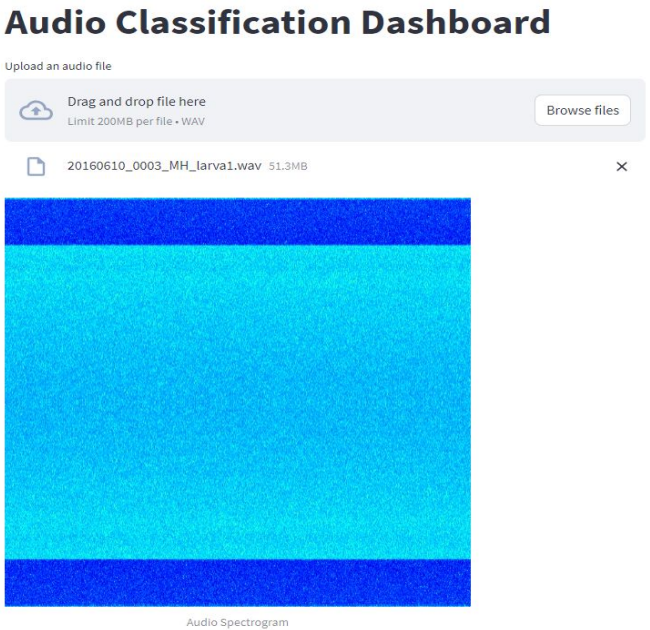
Results and Discussion

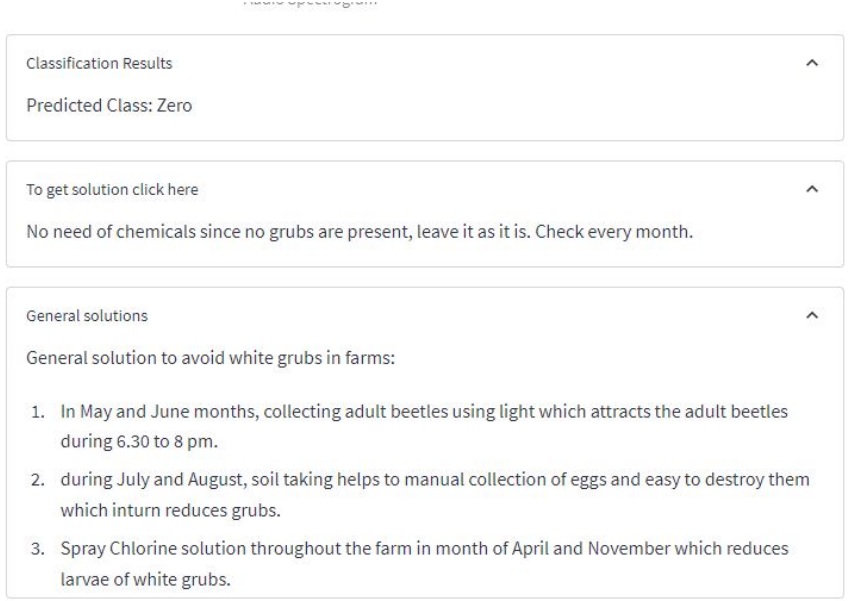
DNN Algorithm classified and given output as Null

```
>>>
============ RESTART: C:\Users\hmvee\Documents\Major\Testing_code.py ===========
Time bins:  1954
Frequency bins:  513
Sample rate:  44100
Samples:  999999
Unlabeled output saved as.png
20160627_0028_MH_larva1d.png
20160627_0028_MH_larva1d.png
1/1 [==============================] - ETA: 0s1/1 [==============================] - 0s 189ms/step
1
Given Audio Predicted is : Scarce - Null
>>>
============ RESTART: C:\Users\hmvee\Documents\Major\Testing_code.py ===========
Time bins:  3907
Frequency bins:  513
Sample rate:  44100
Samples:  999999
Unlabeled output saved as.png
20160610_0005_MH_larva3.png
20160610_0005_MH_larva3.png
1/1 [==============================] - ETA: 0s1/1 [==============================] - 0s 205ms/step
1
Given Audio Predicted is : Scarce - Null
>>>
```

Results and Discussion

DNN Algorithm classified and the results are shown with solution





Conclusion

- Acoustic behavior of white grubs is characteristic for the detection of the density of white grubs.
- Since fractal dimension analysis is a semi-quantitative analysis shifted to DNN for the qualitative analysis.
- The model is up to 85-90% accurate. Based on the output of the model best-suited recommendations are given for the farmers.

Outcomes

- By implementing advanced monitoring techniques, farmers can mitigate crop losses and improve agricultural productivity.
- Effective white grubs detection and pest management strategies contribute to food security in India.
- These technologies can empower farmers and help them make informed decisions to protect their crops from white grub infestations.

Plan of action

	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Literature survey for problem identification	✓							
Problem formulation	✓							
Literature survey for possible methods to address the problem		✓						
Design solution		✓						
Identification of platforms/tools/devices controllers			✓	✓				
Validate the design, analyze and interpret the results					✓			
Preparation of the report						✓		
Presentation of the work carried on symposium/Exhibition							✓	
Demonstration								✓

Future Work

- Cost efficient audio recording device has to be built.
- Need for automating the manual classification works.
- A portable and cost-efficient in-hand device, which has to be capable of recording and analyzing audio, and giving the recommendations.
- Test bed has to be setted up and device need to tested.

References

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[3] Mankin, Richard and Samson, P and Chandler, K. “Acoustic Detection of Melolonthine Larvae in Australian Sugarcane”, Journal of economic entomology, vol. 102, pp. 1523-35, Sept. 2009.

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[4] R. Hussain and Y. Saleh, “Intelligent system for white grub monitoring through wsn”, International journal of current advanced research, vol. 6, pp. 3816-3821, May 2017.

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[6] Huang, Jingshan and Chen, Binqiang and Yao, “ECG Arrhythmia Classification Using STFT-Based Spectrogram and Convolutional Neural Network”, IEEE Access. vol. 7, pp. 1-1, July 2019.


Thank You