AI and IoT-Based Model for the Detection and Treatment of Sweet Potato Pests and Diseases in Precision Farming

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Abstract

Pests and disease detection and treatment at an early stage are essential in agriculture to ensure food security in Africa. Farmers face various challenges when identifying and controlling pests and diseases. In this work, a pests and diseases detection and treatment system, using Artificial Intelligence (AI) and Internet of Things (IoT) will be developed. Pheromone will be used to monitor and capture sweet potatoes farm pests especially Cylas puncticollis. Images of sweet potato virus diseases (Ipomoea batatas (L.) and sweet potato chlorotic stunt virus gotten online will be used to train the AI model using Convolutional Neural Networks. Data augmentation and pre-processing will be done. To test the performance of the developed AI model in real time, an (IoT) device will be built and set up on the farm to monitor and capture the pests and disease parameters. The IoT will send the parameters to the AI model deployed to the cloud for prediction.

Introduction

Cylas brunneus Fabricius and Cylas puncticollis Boheman are responsible for 50% of the yield loss in Nigeria. Weevils severely damage sweet potato roots, vines, stems, and leaves during every step of their life cycles, from the egg to the adult making market to be undesirable. Roots that have been infected have a bitter flavor and should not be used as food or as animal feed. Fewer roots are produced by infected stems; if the infestation is severe, the plants may not take root. The number of acres lost due to weevil damage is not known with precision. Recently, farmers have found it challenging to quickly, proactively, and visibly identify these pests and illnesses from a distance. This makes them to make frequent trips to their farms to check on the moths, which is highly expensive and stressful. As a result, the suggested system will be able to capture photos of pest species, detect diseases and accurately identify and classify them using a trained AI model, and relate the species to farmers for visualization via mobile phones.

Specific Objectives

The aim of this research is to develop an AI and IOT-based model for the detection and treatment of sweet potato pests and diseases in precision farming for recognising *Cylas puncticollis* and other sweet potato diseases in real-time. The objectives of the research are to:

1. Gather large datasets of the pest *Cylas puncticollis*, sweet potato feathery mottle virus SPFMV, sweet potato chlorotic stunt virus SPCSV, soil parameters such as temperature, humidity, and PH for the proposed AI model training.
2. Deploy deep learning, fine-tune, and argument it for Cylas puncticollis, sweet potato feathery mottle virus SPFMV, sweet potato chlorotic stunt virus SPCSV, and soil parameters detection using a convolutional neural network.
3. Develop an IoT System hardware integrated with sensors, controllers, and communication technology that will be mounted on the sweet potato farm, for sensing, and capturing the parameters in the farm.
4. Evaluate the performance of the AI model using appropriate metrics.

The datasets of images of healthy and diseased sweet potatoes will be collected online from the Kaggle repository and pre-processed. While that of the pest will be collected with pheromones mounted at different positions on the farm. IoT sensors will also be used on the farm to monitor the soil parameters such as temperature, humidity, and PH values. These datasets will be used to train the AI model using the convolutional neural network (CNN).

Methodology

The proposed AI - IoT model will be tested using an IoT system equipped with sensors for the measurement of target biotic parameters. The model will be developed using deep learning. It is expected that the dataset will contain large biotic parameters values gotten from three (3) segments of the sweet potato farm that has been planted already.

A smart sweet potato App will be developed, to assist farmers to monitor and visualize the activities going on in their farm. The infrastructure as a service (IaaS) will be deployed. To make the proposed AI system robust, the AI model will be deployed on an Edge device and integrated into the IoT system to perform the prediction offline when the network fails and send short message services (SMS) to the end users. When the network is restored, the IoT system sends it to the cloud.

Economic Impact and Damage of C. Puncticollis

The two most significant pests of sweet potato in all of the major sweetpotato-producing nations in Africa are the sweetpotato weevils, C. puncticollis and C. brunneus. Yield losses are significant and can exceed 100%, particularly during protracted dry seasons. Roots that have been infected have a bitter flavor and should not be used as food or as animal feed. Less roots are produced by infected stems; if the infestation is severe, the plants may not be able to take root.. (Okonya, 2016). Adult sweet potato weevils consume the skin of leaves and vines. Additionally, it damages the storage roots' outer surfaces by making rounding feeding punctures. These punctures can be distinguished from opposition sites by their greater depths and the absence of a fecal plug, as shown in Fig. 1. The weevil's developing larvae tunnel in the vines and storage roots, causing serious harm. The tube fills with flint. Storage roots respond to harm by producing poisonous terpenes that make them inedible even at low concentrations and minimal levels of physical damage.

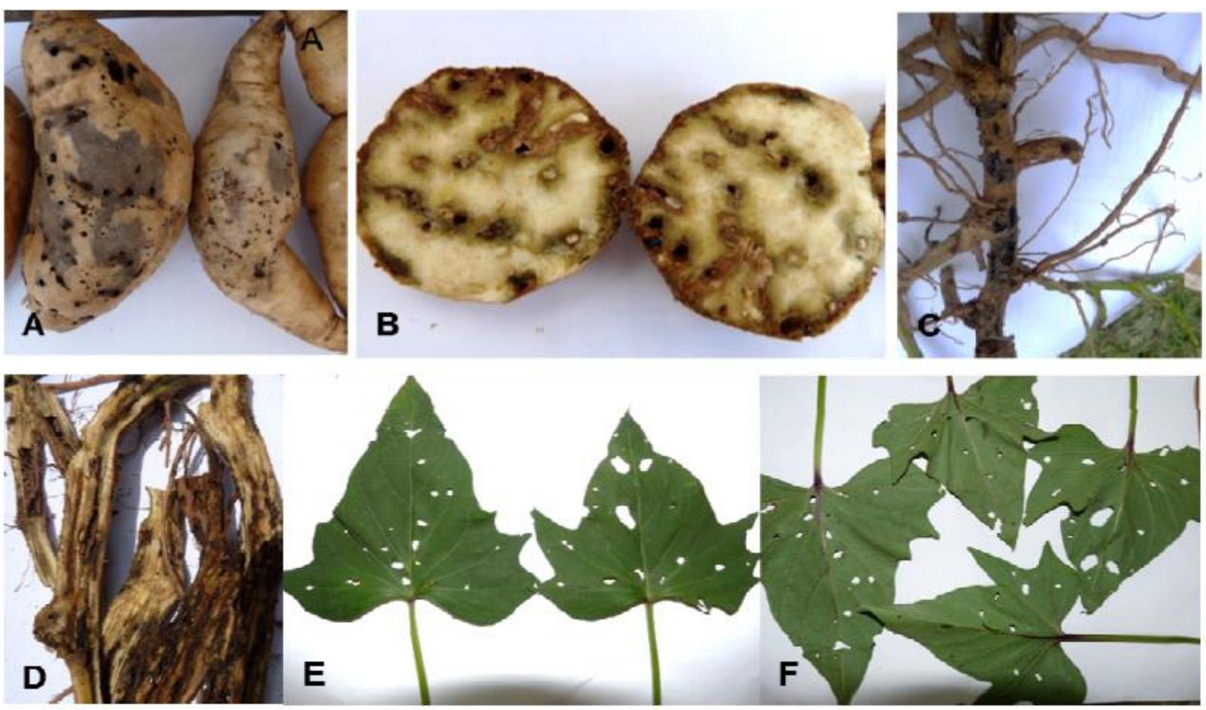

Fig. 1. Symptoms of sweetpotato weevil, Cylas puncticollis: A, B larvae and adult damage on roots, C, D larvae damage on stems, and E, F adult damage on leaves (Okonya, 2016)

Review of related work

Harvey, et al., 2019 presented a CNN model acquired using an unmanned aerial vehicle UAV, they trained a convolutional neural network CNN model on lower resolution sub-images, achieving 95.1% accuracy on a separate test set of sub-images. The CNN model was utilized to generate interpretable heat maps of the original pictures, which indicated the sites of possible lesions. The ability to detect lesions at a precise spatial scale opens the door to unprecedented high-resolution disease detection for plant breeding and crop management techniques.

Oppenhiem, 2017 put forward a convolutional neural network to identify picture patches of diseased potatoes into four disease classes and one uninfected class. The trained CNN model categorized 2,465 pictures that differed in capture device and circumstances. The results show that the classification method is robust enough to handle uncontrolled acquisition situations. The results show that the right classification ranges for fully trained CNN models. from 83% for the model trained on the least amount of data to 96% when trained on 90% of the data.

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