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Pest Detection Using Artificial Intelligence

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Abstract: ***A dollar saved is more than a dollar earned; the same approach can be applied to solving food scarcity problem we are facing today. About 30% of crop is wasted due to pests and AI can help us solve this problem in a novel way by early detection and elimination of pests, resulting in reduced damages to crops, vegetables and fruits.***

Keywords: AI, Pest, Agriculture, Deep Learning, Visual Recognition, Smart Agriculture, Smart Farming, Keras-RetinaNet, Image Detection, Pest Detection, Pest Density

1. Introduction

AI is one of the most profound technological advancement in human history and the driving force behind fourth industrial revolution. To quote Google CEO Sundar Pichai "AI is more profound than fire and electricity". What makes AI different from other technological advancements is that all others didn't challenge human cognition.AI has the capability to impact humans in ways unimaginable.

The importance of agriculture is known to mankind from the start of early human civilization, whereby farming and use of domestic animals created food supplies to people which helped humans to settle and cities to develop. Since the late twentieth century, there has been an exponential rise in human population due to industrialization and medical advances, increasing the demand for fruits and vegetables beyond our supply capacity. Considering the wastage factor of modern agriculture, early detection of pests in crops using artificial intelligence can hugely benefit in preventing its spread to neighboring crops.

Pests are organisms living and growing where they are not wanted and can cause damage to plants, humans, structures, and other creatures.Some of the most common pests are insects, bacteria, and fungi. They are responsible for two major kinds of damage to growing crops. First there is the direct injury they cause to the plants as they feed on the tissues. Secondly there is the indirect damage, where the insects do little direct harm, but either transmit or allow entry of fungal, bacterial or viral infections.

Transboundary plant pests and diseases can easily spread to several countries and reach epidemic proportions. Their spread has increased dramatically in recent years, causing significant losses to farmers and threatening food and nutrition security.Globalization, trade and climate change, as well as reduced resilience in production systems due to decades of agricultural intensification, have all played a part.

1.1 Confirm the Opportunity

Human population is growing at an exponential rate compounding the food problem that we are facing today. It is estimated that, by 2050, we will have to grow food for ~10B people whilst using fewer natural resources. At the same time, findings by Indian Council of Agricultural Research estimates that about 30-35% of the annual crop yield in India gets wasted because of pests.

This presents an immense opportunity to increase our yield by deploying novel AI solutions to tackle this problem.If pests are detected early, suitable measures can be taken to protect the cropby appropriateand reduced pesticide use, thereby boosting farm yield. Generally, these pests are eradicated by manual inspections and using techniques such as black light traps and sticky trapswhich are laborious, time consuming, cost intensive and ineffective especially in large fields. Sometimes these pests may go undetected by the labourers as they are hard to locate during nighttime.So, as a preventative measure, farmersspray pesticides in bulk which is not only harmful for the crops but also harmful for the environment.Additionally, insects and bugs become resistant to pesticides with continuous exposure, resulting in heavier pesticides usage. Extreme use of pesticides can result in severe water & soil contamination and can also intoxicate plants with harmful chemicals. Other methods such as genetic seed manipulation can prove effective but aren't economically viable.

This presents the need to have an automated solution to detect pest infestation and classification which can be deployed at scale. Although work has been implemented in this domain using Internet of things-based sensors and trap capture pest control alerts,they are yet to be effective. We suggest here an innovative approach to overcome these barriers by using a combination of artificial intelligence and image processing techniques to solve the problem at hand. This helps farmers to produce more with less land, keep food affordable, reduce waterborne and insect transmitted diseases,conserve the environment, transforming developing countries into food producers and ensure bountiful harvests.Figure 1 depicts the reasons for crop losses due to pest attack.

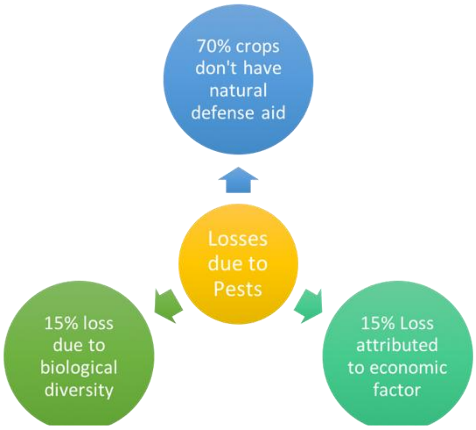

Figure 1: Numbers for the crop losses due to pests

2. Characterize the Problem and Profile the Data

The problem dealt is timely and automatic detection and identification of pests. Activities which foster healthycrops growth and help fight pest are - fertilization, pruning, weeding, loosening the soil, irrigation, removal of crop residues from fields, crop rotation, and other works of tillage.

Farmers also need to choose the best location, which should be sunny and airy and where humidity does not retain for long; plant varieties resistant to most diseases; regularly suppress weeds and keep an eye on conditions that favor disease and pest development.Since there are a lot of factors at play -use of fast, efficient and reliable technological tools for early detection and elimination of pests is of seminal importance.

2.1 Profiling the data

We haveselected 4 most commonly found pests - Tutaabsoluta, Melanacanthusscutellaris, Fifth-instar nymph andThrips(refer Figure 2). Most of the dataset for this POC is self-createdvia field visits and collectinghealthy and pest infestedcrop pictures, whilst others were collected by crawlingthe web using Google and Bing searches for each of these pests.Online images were manually vetted to confirm their legitimacy.The dataset was then split into train, validation, and test, for training and evaluating the model.Next, we created annotation files for the images.

We have used ImgLab as an image annotation tool to annotate images and extracting xml files for each image.

Figure 2: Pests identified by our model

3. Architect and Deploy the Solution

3.1 Process Flow

The project is divided into five stages: dataset collection, pest detection using Keras-RetinaNet, pest density calculation, SMS alert, and email alert with the attachment of the pest identified.

Figure 3: Process Flow

3.2 Solution Deployment

3.2.1Training the Model

With the growing success of deep learning for visual recognition, we used a Keras-RetinaNet as the model to recognize pest images.

1) Keras-RetinaNet

Keras-RetinaNet by Facebook AI Research (FAIR), is an one-stage detector with ResNet+FPN as backbone for feature extraction, plus two task-specific subnetworks for classification and bounding box regression, which achieves state-of-the-art performance, and outperforms Faster R-CNN, the well-known two-stage detector.

2) Transferable Features for Image Recognition

In recent years, it was observed that using pre-trained networks and transferring those to other datasets provided a significant boost to performance than training new models from scratch. This was due to the ability of the models to learn general features applicable to severalcomputer vision tasks. We have used pre-trained modelwith ResNet50 backbone on COCO dataset and trained it on our custom dataset. We used weights “resnet50_coco_best_v2.1.0.h5” to train our model. During the course of this project, we have tried several models, and updated them as we found betterperforming model.

3.2.2Model Features

1) PestDetection:
Detects pests through Keras-RetinaNet object detection model. (As explained above)

2) Pest Density:
Model counts the number of pests detected in each image. It gives an idea of how much pests are there on a leaf and is a parameter to gauge the amount of damage that has already been done.

3) SMS Sending:
SMS is sent to the user notifying the Pest detection. Using this API https://www.fast2sms.com/dev/bulk platform, the alert messages are delivered to the farmer as soon as pest is detected.

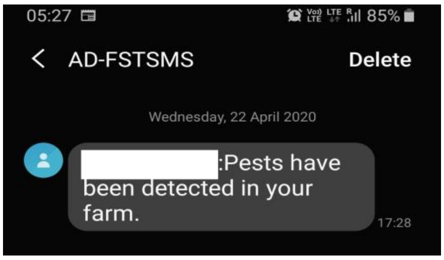

Figure 4: Sample SMS notification

4) Email Sending
Model goes through all the images on the cloud server and collects images which have pest detected and sends it to the registered users as attachments detailing types of pest detected and the maximum pest density calculated by our model. We have used smptlib module and email package using python.

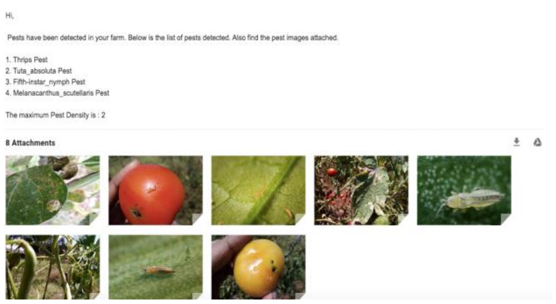

Figure 5: Sample Emailnotification

4. Evaluate for Business Value

India is an agriculture-based country, where more than 50% of the population is dependent on agriculture. As urbanization increases, many rural farm employees are switching jobs and commuting to cities and huge towns, reducing labor available for farming activities, resulting in shortage of food supply anddriving up farmer suicide rates. Increasing population puts a lot of emphasis on smart production of vegetables and fruits.

Pests on the other hand, have always been considered a serious threat that affects crop production negatively. Pests can destroy the entire farm in a matter of days if they go undetected by the farmers at the initial stage. Our model allows farmers to automatically detect pests, identify pest density and notifies the farmers with a SMS and an Email as soon as the pest is detected.

4.1 Model Benefits

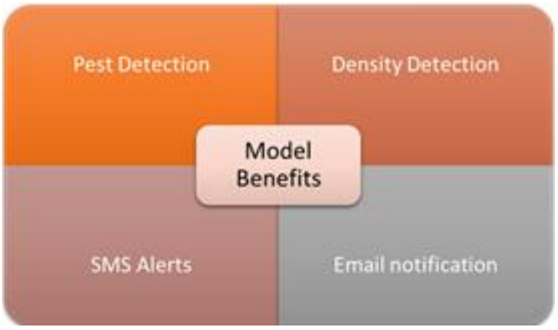

Figure 6: Model Benefits

1) **A stitch in time saves nine:** Early detection helps to drastically reduce infestation and increase yield, resulting in enhanced social and economic wellbeing.
2) **Quantifying Damage:** Pest density allows the farmer to gauge extent of damage, allowing them to calibrate pesticides dosage for healthier crops and elevated human health.
3) **Notifications:** SMS and Email Alerts provide a quickest way to reach the farmer. Additionally, the image in email alert enables the farmer to know the details of the pest outburst.
4) **Global Applicability:** This will be beneficial to farmers all around the world as the cost of manual labour will significantly decrease.
5) **Efficiency Boost:** Enables the farmers with ample time to work on other important taskswhich need more attention leaving space for innovation.

5. Scale Up the POC

A working model would have a camera installed in the farms to continuously capture images. These images would be sent to the cloud server with the help of Raspberry Pi. Our AI algorithm would then read data from the server and run the analysis to detect and classify pests. If pests are detected, relevant notifications will be sent to the farmer to take appropriate actions.

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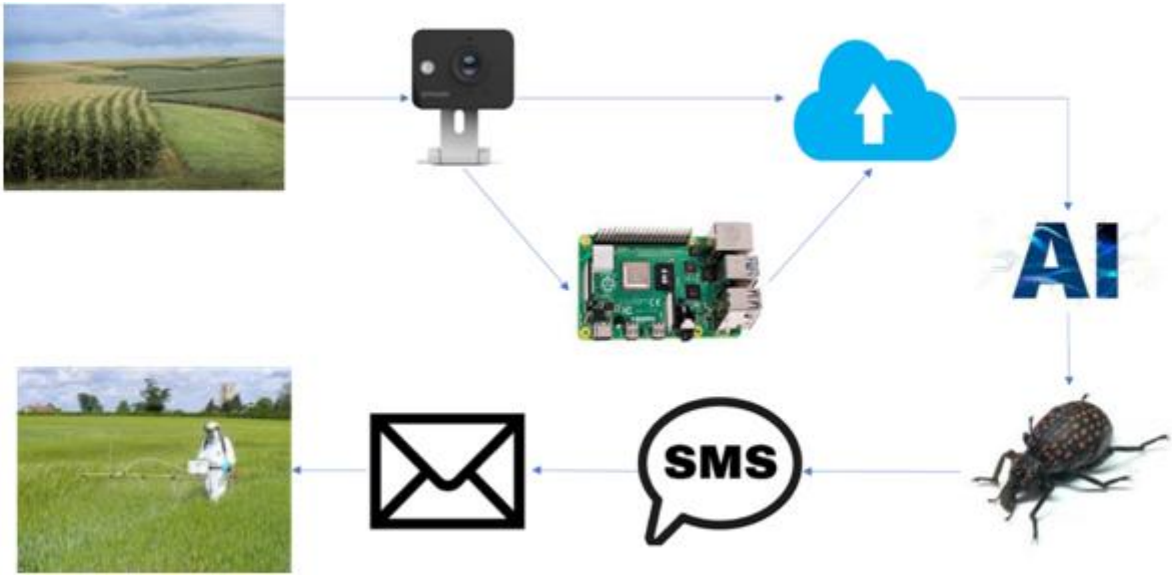

Figure 7: System Architecture

1) Installing raspberry pi (RPi3):
The next phase of our project would be to install a raspberry pi (RPi3) system connected to two cameras via Bluetooth or Wi-Fi depending upon the coverage area. The cameras will be placed above and below the crops and will cover entire field expanse by moving along the cultivation trails, enablingimages to be takenwith wider surface area for accurate analysis.

2) Cloud Data Storage:
Image data captured from farms can be stored in a cloud server which can hold huge number of incoming images. Images would be cropped andprocessed before feeding into the model to compute their respective outputs. (As discussed in the Figure 8 below)

3) Image Processing
Images would be Cropped, Resized and Rescaled automatically before being fed into the model to compute their respective outputs

Figure 8: Image Processing

4) LED Setup
Green and RedLED's could be setup along the trails to make it easy for the farmers to identify pest infected plants. Whenever a pest is detected in a region, the signal will be passed to the Red LED indicator, else the signal would be passed to the green LED. (Red LED– Pest Detected, Green LED– No Pest)

5) Model Extension
Model can be trained with a wider data set and to include other pests,enabling the system to work well during all seasons. This will make our model more generic, enabling the automated task to work at its best in different farming regions.

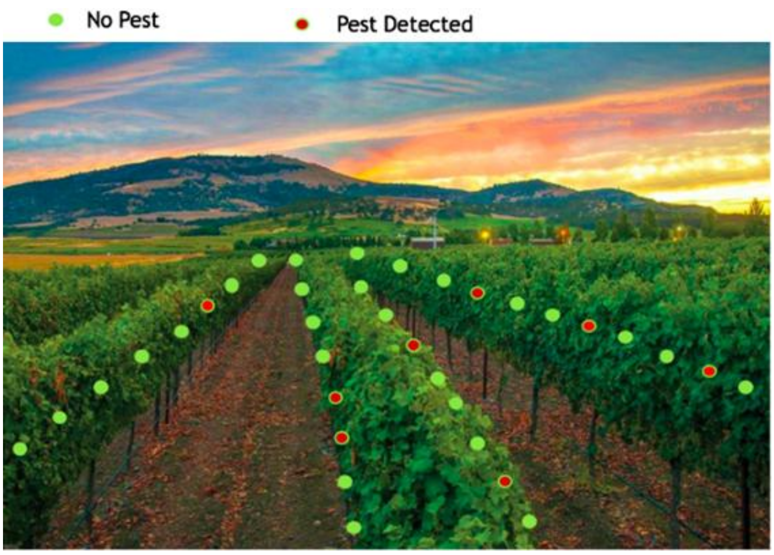

Figure 9: LED Setup

6. Other Applications

Some of the other potential applications of artificial intelligence in pest detection are as follows:

1) Warehouse pest control
2) Pest control in food security reserve grain stocks
3) Insect monitoring in food plants
4) Pest control in food manufacturing

7. Acknowledgment

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