Agriculture: ML and DL-based Detection and Classification of Agricultural Pests

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Abstract – In the agricultural sector, automatic pest detection is quite helpful. To focus on the Indian context more specifically, the agriculture business has seen a loss of almost $12 billion simply due to pests. In this study, a methodical strategy is put forth that will allow using the combined strength of machine learning (ML) and deep learning (DL) approaches to identify agricultural pests early on and avoid more extensive damage later on. After extracting features from an image using a DL-based convolutional neural network (CNN) model, use ML classifiers to classify the pests. Using the best-performed CNN and ML models from analysis, attained an overall accuracy of over 95%. The resultant hybrid model may be used in the agriculture industry to detect pest spread news coverage early on. This method will overcome the issue of pests affecting the plants and benefit agricultural researchers to quickly know the issues and give treatment as soon as possible.

Index Terms—Machine learning, deep learning, convolutional neural network, hybrid model,accuracy.

INTRODUCTION

AI-based mock interview evaluators have become a game-changer for job seekers looking to improve their interview skills. These tools use Artificial Intelligence to provide realistic and unbiased assessments, helping candidates practice and refine their performance. Unlike traditional mock interviews, AI evaluators are available anytime, making it convenient for users to prepare at their own pace.

These AI-driven simulations closely resemble real interviews, including industry-specific questions that help candidates get a feel for what to expect. They don't just assess answers—they also analyze problem-solving skills, body language, and emotional cues. This well-rounded feedback helps users recognize their strengths and identify areas that need improvement.

What makes AI evaluators stand out is their fairness. Since they rely on AI, they eliminate human biases, ensuring objective assessments. Along with feedback, they often provide personalized suggestions and resources to help users sharpen their skills. Candidates can also track their progress over time, making it easier to measure improvement.

By allowing job seekers to practice repeatedly and receive constructive feedback, AI-based mock interview evaluators boost confidence and readiness. In today's competitive job market, they serve as a valuable tool to help individuals perform their best in real interviews.

Motivation

The impetus for starting this research stems from the crucial need to address the persistent threats posed by agricultural pests to global food security and sustainable farming methods. Agricultural pests threaten crop production, degrade food quality, and increase the economic burden on farmers and agricultural systems worldwide. The need for novel and ef fective pest detection systems grows as the global population grows and climate change exacerbates pest-related difficulties. Traditional pest detection methods, which rely mainly on physical labor and visual examination, must meet accuracy, scalability, and speed expectations. These methods are time consuming and limited in detecting pest infestations quickly, resulting in considerable crop losses. Fig. 1. displays different pests affecting plants.

Fig. 1: Different kinds of Pests

Contribution

• Investigation of different types of pests in agricultural plants.

• Analysis of the ML and DL-based CNN models.

• The hybrid model is implemented to identify 12 distinct categories of pests from their images.

Organization

In this article, we follow a structured approach, beginning with an exploration of diverse methodologies. Section II provides an extensive literature review on the detection and recognition of agricultural pests. We delve into the application of both machine learning and deep learning techniques, and subsequently, in the context of ML models, we investigate various articles related to the identification of agricultural pests in fruits and leaves. In Section III, we introduce our proposed model, offering a detailed explanation of its architecture and components. Section IV is dedicated to presenting the key f indings of our research. To wrap up our paper, we present our conclusions in Part VI. Finally, in Section VII, we ex press our gratitude and acknowledgments for the support and contributions that have made this work possible.

LITERATURE SURVEY

1. Paper Name: Agricultural Pest Detection System Based on Machine Learning.

Author: Shanshan Zhang, Junsheng Zhu, Nianqiang Li

Abstract: This paper designs an agricultural pest detection system based on machine learning. The system consists of pest detection algorithm and PC terminal system. The algorithm uses resnet50 as the backbone network, uses Feature Pyramid Network (FPN) to extract features, and optimizes them by Stochastic Gradient Descent (SGD) and Non-Maximum Suppression (NMS). Finally, the method is implemented by HAL CON machine vision software. The PC side uses C as the development language and C / S three-tier architecture for development, which is realized by visual studio 2015 combined with MySQL database.

2. Paper Name: Pest Detection on Leaf using Image Processing.

Author: Harshita Nagar, R.S. Sharma

Abstract : A survey report showed that 70depends on agriculture sector. Numerous heteroge neous diseases and various kind of pests affect the production of crops which leads to quality and quantitative loss. Automatic in-field pest detection using computer vision technique is an important topic in modern intelligent agriculture but suffers from serious challenges including complexity of wild environment, detection of tiny size pest and classification into multiple classes of pests.

3. Paper Name: A Comprehensive Survey on Pest Detection Techniques using Image Processing.

Author: Harshita Nagar, R.S. Sharma

Abstract : Agriculture is an essential source of sustenance. In India, this sector has tremendous opportunities of large-scale employment for villagers. A survey report illustrated the dependency of the Indian population on agriculture i.e. nearly 70crops depending on the climatic nature. However, most of the Indian farmers are still unaware of technical knowledge such as what kind of crop suits their farmland. Numerous heterogeneous diseases affect the production of crops and result as a profitable loss. This paper illustrates the pest diseases specifically with their impact on the current production of the crop. In addition, it shows the survey reports based on several detection techniques of image detection.

4. Paper Name: Pests detection system for agricultural crops using intelligent image analysis.

Author: A. G. Mazare, L.M. Ionescu, D. Visan, N. Belu

Abstract: The paper proposes an intelligent method for real time monitoring of the evolution of pests in an agricultural crop. The system consists of a pheromone trap, a camera that periodically fetches frames with trap and a data transceiver module where the frame is encapsulated with the date and station id. The data arrives at a server where they are retrieved and analyzed using two deep learning artificial neural networks. One determines the type and number of pests and the other identifies the evolution of the pest population. The system has been experimented with an apple tree culture in order to early identify pests and combat them

PROBLEM STATEMENT

To challenge in agriculture is to detect and classify pests accurately and efficiently to mitigate crop losses. There are numerous types of agricultural pests, and each affects crops differently. Identifying and distinguishing between them is crucial. Early detection of pests can significantly reduce the damage caused to crops. The solution must be scalable to different types of crops and farming. High accuracy in detection and classification is essential to ensure that the right countermeasures are taken.

OBJECTIVES & SCOPE OF PROJECT

❖ OBJECTIVES

• Detect pests early to prevent widespread infestations and minimize damage to crops.
• Help farmers take timely actions to protect crops and reduce yield and quality loss due to pest damage.
• Enable the application of specific treatments or biological controls that target identified pests, reducing the use of broad-spectrum pesticides.
• Assist inefficiently using pesticides, water, and nutrients by ensuring they are only applied where needed, reducing costs and environmental impact.
• Promote sustainable pest management by minimizing the use of chemical pesticides and encouraging eco friendly alternatives.
• By controlling pests effectively, farmers can improve crop quality, boost yields, and maintain food security.

RELEVANCE

• To optimize field-level management concerning crop farming.
• To accurately identifying and classifying agricultural pests, farmers can take timely actions to prevent crop damage, leading to increased crop yields.
• To Proper pest management can help in optimizing the use of pesticides and fertilizers, thereby reducing costs and environmental impact.
• DL provide data-driven insights that can aid in making informed decisions for better crop management.
• To Early detection and management of pests contribute to sustainable farming practices, preserving the ecosystem.

PROPOSED WORK

Agricultural pest management is a critical issue affecting crop yields and food security. Pests can cause severe damage if not detected and controlled in time, leading to significant losses for farmers. The proposed work aims to develop an intelligent pest detection and management system using advanced technologies such as DL. By deploying smart model in the field, the system will continuously monitor crop health and environmental conditions, identifying potential pest infestations early. Integrated image recognition algorithms will use data to accurately classify pests, providing a data-driven approach to pest identification. The system will be connected to a cloud-based platform, where deep learning models will analyze the collected data to predict outbreaks based on environmental factors such as humidity, temperature, and crop health. The system will also integrate for aerial surveillance and ground robots for closer inspection, enhancing detection accuracy. Farmers will receive alerts and actionable insights, allowing them to make informed decisions on pesticide application and pest control, reducing unnecessary pesticide use and minimizing environmental impact. This technology-driven approach to pest detection is expected to bring significant benefits, including early detection, reduced crop losses, and cost savings for farmers. The system's scalability will allow it to be adapted to various crops and field sizes, offering a solution that promotes sustainable agriculture while improving overall productivity.

METHODOLOGY

The methodology for agricultural pest detection using deep learning (DL) begins with problem definition, where specific pests and crops are targeted, along with establishing clear objectives like early detection and species classification. Next, data collection occurs, which involves capturing a large dataset of images featuring crops both with and without pests, followed by annotating these images to identify pest species and their locations. The collected data undergoes preprocessing, including normalization of pixel values and data augmentation techniques to enhance diversity and robustness, before being split into training, validation, and test sets. In the model selection phase, appropriate deep learning architectures, such as Convolutional Neural Networks (CNNs) are chosen for image classification tasks. The model training process involves training the selected model on the training dataset while adjusting hyper parameters for optimal performance. The model's efficacy is evaluated during the validation phase and later tested on a separate dataset to assess accuracy, precision, recall, and F1 score.

SCOPE OF PROJECT

- To Develop a Convolutional Neural Network (CNN) model to detect and classify various agricultural pests from images.
- Collect a comprehensive dataset of images representing different types of agricultural pests.
- Trained and validated CNN model capable of detecting and classifying agricultural pests with high accuracy.

HARDWARE & SOFTWARE REQUIREMENT HARDWARE REQUIREMENT

Processor : Pentium-IV

RAM : 512 MB (min)

Hard Disk : 40 GB

Key Board : Standard Windows Keyboard

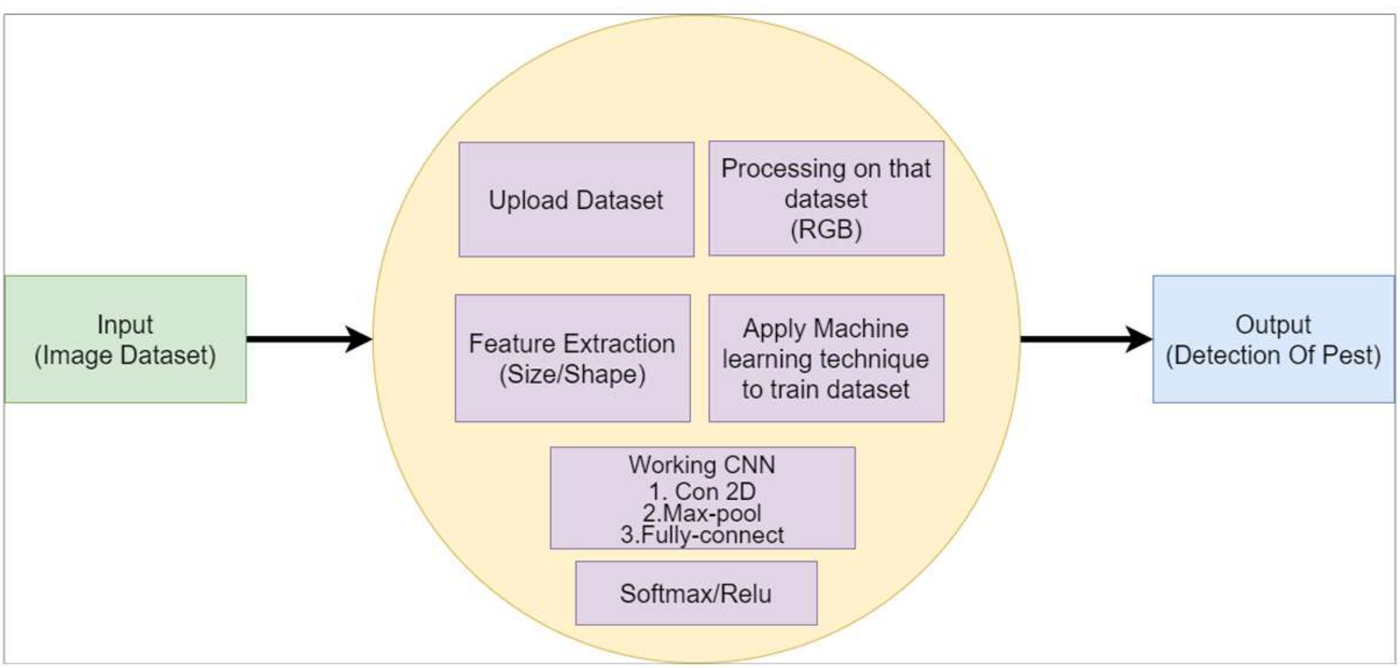
SOFTWARE REQUIREMENT

DATE Coding Language : Python

Operating System : Windows 10

IDE : Spyder

SYSTEM ARCHITECTURE



EXPECTED OUTCOME

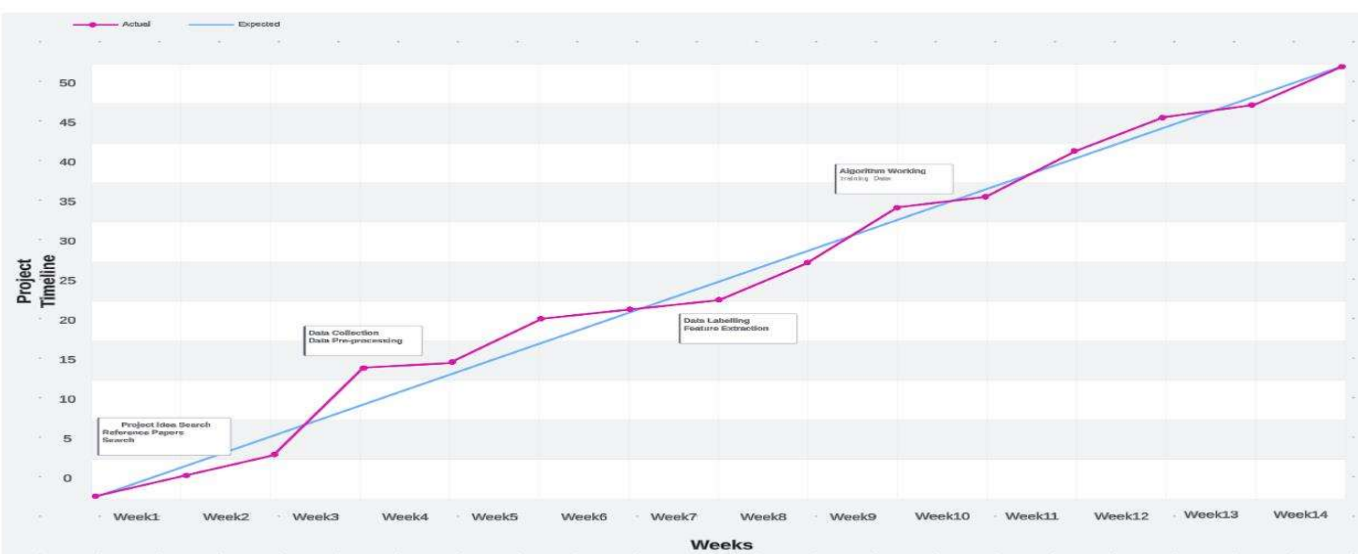
Expected outcome:

- Timely identification of pest infestations helps farmers to take corrective action before the pests spread, reducing crop damage and improving productivity.
- Accurate pest detection can significantly minimize the loss of crops by enabling the implementation of targeted interventions.
- By identifying the specific types and locations of pests, farmers can apply pesticides more strategically, reducing overuse and minimizing environmental harm.
- Early detection and precise pest control reduce the need for large-scale pesticide applications, leading to savings in both pest control costs and crop production costs.
- With pests under control, farmers can achieve higher yields and better-quality crops, which can lead to increased revenue.
- A pest detection system supports sustainable farming by reducing pesticide overuse, protecting beneficial insects, and minimizing harm to the ecosystem.

APPLICATIONS

- Pest detection systems, integrated can continuously monitor crops for signs of pest activity. This monitoring allows for early detection and timely intervention, reducing potential damage.
- With accurate identification of pest species and locations, farmers can apply targeted pest control measures rather than blanket pesticide application. This approach reduces chemical use, cutting costs and minimizing environmental impact. In precision agriculture, pest detection data can guide decisions on where and when to apply specific treatments, ensuring efficient use of resources.
- By detecting pests early and controlling them efficiently, pest detection systems help to preserve crop health, which leads to better yields. Pest damage is one of the major contributors to yield loss, and automated systems that catch infestations early can significantly reduce this loss.

WORK PLAN



CONCLUSION

The windows application of Deep Learning (DL) techniques, particularly Convolutional Neural Networks (CNNs), has proven to be a robust approach for the detection and classification of agricultural pests. To study demonstrates that CNNs can effectively learn and generalize from a diverse dataset of pest images, leading to high accuracy in identification and classification tasks. The implementation of CNNs not only enhances the speed and efficiency of pest detection compared to traditional methods but also minimizes human error, providing farmers and agricultural professionals with timely and precise information for pest management. This technological advancement can significantly contribute to sustainable agriculture by enabling targeted interventions, reducing pesticide use, and improving crop yields.

FUTURE SCOPE

The future of agriculture pest detection lies in more sophisticated, connected, and intelligent systems. As these technologies evolve, they will not only improve pest control efficiency but also contribute to greater sustainability, food security, and resilience to environmental challenges. Integration with other precision farming tools and advancements in DL will define the future of pest detection in agriculture.

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