



# INSECT PEST IMAGE RECOGNITION AND MATURITY STAGES CLASSIFICATION USING FEW-SHOT MACHINE LEARNING APPROACH

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**Abstract:** The agricultural industry, pivotal for global food security and sustainability, grapples with a persistent challenge posed by insect pests wreaking havoc on crops. Identifying these pests and discerning their maturity stages are crucial for effective pest management and safeguarding crop yields. Traditional manual identification methods prove imprecise, time-consuming, and often inefficient, even for seasoned agronomists, due to visual similarities among insect species, especially at identical maturity stages. Notably, deep learning emerges as a prominent approach, albeit demanding extensive labeled datasets for effective training, a resource that remains scarce, demanding, and insufficient in addressing the wide-ranging variability within insect classes. Additionally, integrating pesticide recommendation systems could enhance pest management strategies, aiding in the selection of appropriate treatments for specific pests and crop types. This research proposes a solution to this problem using a few-shot learning approach as a solution to this predicament, delving into insect classification for pest management. A few-shot prototypical network is proposed based on a comparison with other state-of-art models and divergence analysis. Experiments were conducted separating the adult classes and the early stages into different groups, and at last recommending suitable pesticides that will help in the yielding of good crops.

**Keywords:** Few-shot learning; Insect pest classification; Insect maturity stages; Convolution Neural Network; Prototypical Networks.

## I. INTRODUCTION

Insect pest image recognition and maturity stage classification using machine learning and few-shot learning approaches represent a significant role in agricultural science and pest management. Insects play important roles within ecosystems, however, some species may turn into pests that destroy crops posing a threat to food security. Identifying causes by insects at an early stage as well as accurately determining the pests development periods is necessary for prompt actions towards control, repair of crop failures, and better farm practices. Machine learning has transformed the way pest management is done by making it possible to automatically and quickly identify insect pests from images. By employing deep learning algorithms, one can create strong models that are capable of accurately identifying various types of insects as well as their attributes. Such models trained on features such as body shape, color, size, and texture to differentiate between different kinds of pests while correctly classifying them according to maturity levels.

The lack of labeled training data is one reason that it is difficult to develop efficient insect pest identification and maturity stage classification models. Here is where the few-shot learning techniques come in picture. Few-shot learning refers to a division of machine learning which specializes itself on the exercising of models having limited labeled instances. This approach is especially useful for insect pests recognition, as collecting large data of labeled data for every species of pests and their stages can be problematic and time-consuming.

In summary, this application provides a good way to address agricultural pests' problems. These technologies enable farmers and other stakeholders in agriculture with useful means of early pest detection that eventually leads to sustainable and resilient food production systems.



## II. LITERATURE SURVEY

[1] This study focuses on a new mobile application of agricultural pests recognition using deep learning in cloud computing system. The paper proposes a new mobile application for recognizing agricultural pests using deep learning in a cloud computing system. The application utilizes a Faster Region-Based Convolutional Neural Network (Faster R-CNN) model to identify and classify pests from images captured by the user's mobile phone camera. The model is trained on a large dataset of pest images and deployed in the cloud, making it accessible to users with limited computational resources on their devices.

[2] This study focuses on crop pest classification based on deep convolutional neural network and transfer learning. This research paper proposes to building a deep convolutional neural network (CNN) for pest classification, pre-training it on VGG16 weights for faster learning. They gathered diverse pest images, resized and normalized them, then fed them through convolutional and pooling layers to extract features. Fully-connected layers analyzed these features and predicted pest categories. This efficient approach achieved high accuracy.

[3] This study focuses on the insect classification and detection in field crops using modern machine learning techniques. This paper proposes a new approach for insect classification and detection in field crops using modern machine learning techniques. A dataset of insect images is collected from various field crops, the images are preprocessed to improve the performance of the machine learning models. A machine learning model is trained on the preprocessed dataset. The authors use a convolutional neural network (CNN) model for this task. The trained model is evaluated on a held-out test set.

## III. SCOPE AND METHODOLOGY

### Scope

The aim of this project encompasses the development and implementation of a prototypical networks algorithm for insect pest image recognition and maturity stage classification using machine learning and few-shot learning approaches. The project involves collecting a diverse dataset of insect pest images, annotating them with species and maturity stage labels, and preprocessing the data for model training. The main objectives include designing and training a robust PNN model, evaluating its performance using validation metrics, conducting comparative analysis with other algorithms, and deploying the model for practical applications such as agricultural monitoring systems. The project aims to contribute to sustainable pest management practices by automating the identification and classification of insect pests, thereby assisting farmers and researchers in making informed decisions about pest control strategies by recommending pesticides.

### Methodology

A diverse dataset of insect pest images covers both early stage and maturity stage classes. After rigorous preprocessing, the data is split into training and test sets. The training set is used to train the model and test set evaluates the performance of the model. This datasets is used for image pre-processing in which it is applied to sharpen the images for better accuracy and image segmentation is applied. To make predictions in real time and to automate the process machine learning algorithm called prototypical neural network and few-shot learning approach is used. This algorithm is specifically designed for few-shot learning and image classification tasks. This is designed to classify new instances with a small number of labelled examples. Further, mapping is done in embedding space and calculates their mean value as the prototype of the category. Using euclidean distance as the measurement function for finding the shortest distance between mean values. For classification few-shot learning approach is being used in this. It selects random few set of labelled samples per classes rather than taking whole datasets. This will reduce time and rapid adaptation to new tasks. This will use query set and support set. Query set contains unlabelled examples and support set is to provide the model with relevant examples and information to learn and generalize classes during the training phase. Few-shot learning map the similarities between classes in the support and query set. This machine learning algorithm and approaches helps in image identification and pesticide recommendation for particular pest.

## IV. SYSTEM ARCHITECTURE

Our proposed system for insect pest classification using a few-shot machine learning approach with prototypical networks comprises several interconnected components designed to efficiently classify insect pests and recommend suitable pesticides. Initially, a diverse dataset of insect images is collected and preprocessed to ensure consistency and quality. Subsequently, a pre-trained convolutional neural network (CNN) is employed to extract discriminative features from the insect images. These features serve as the basis for training the prototypical network within a meta-learning framework, where the network learns to compute class prototypes based on support set samples from various tasks. During inference, given a query image of an insect pest, the trained prototypical network computes its feature representation and calculates the Euclidean distance to determine the closest class prototype, thus facilitating accurate classification. The system also



incorporates a pesticide recommendation module that accesses a database containing information about pesticides and their effectiveness against different insect pests. Based on the classified insect pest, relevant pesticides are retrieved from the database, considering factors such as insect type, severity of infestation, and environmental impact. A user interface is developed to enable seamless interaction with the system, allowing users to upload images of insect pests and receive classification results along with recommended pesticides. Evaluation of the system's performance is conducted using standard metrics, ensuring its effectiveness and reliability. Future work may involve enhancements such as incorporating additional data sources, refining the recommendation algorithm, or adapting to new insect pests and pesticides. Overall, the proposed system presents a comprehensive solution for insect pest classification and pesticide recommendation, contributing to improved pest management strategies in agriculture and beyond.

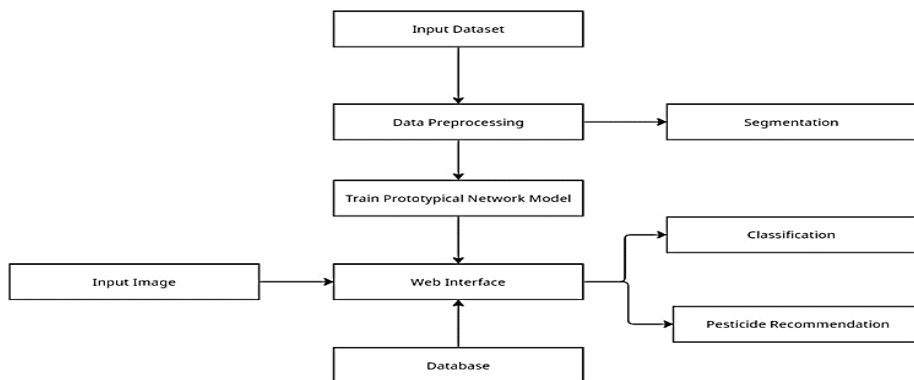


Fig. 1: System architecture

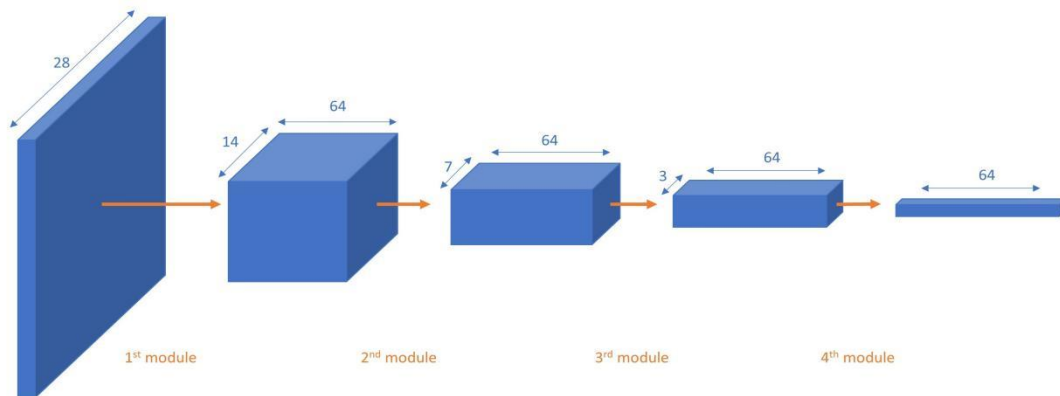


Fig. 2: The Embedding architecture

The embedding part takes a (28x28x3) image and returns a column vector of length 64. The image2vector function is composed of 4 modules. Each module consists of :

- A convolutional layer
- A batch normalization
- A ReLu activation function
- A 2x2 max pooling layer

## V. CONCLUSION

In conclusion, the integration of a few-shot machine learning approach for insect pest image recognition and maturity stages classification, along with recommending pesticides, represents a comprehensive solution to optimize pest management practices in agriculture. By leveraging innovative techniques in machine learning, this system offers farmers an invaluable tool to accurately identify pest species, classify their maturity stages, and make informed decisions regarding pesticide selection. The integration of pesticide recommendation capabilities enhances the system's utility by providing farmers with tailored solutions for pest control, like by considering factors such as pest species, maturity stage,



and environmental conditions, the system can suggest the most appropriate pesticides to optimize efficacy while minimizing environmental impact and ensuring crop safety.

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