Lecture Notes in Networks and Systems 938

Mohamed Ben Ahmed
Anouar Abdelhakim Boudhir
Rani El Meouche
İsmail Rakıp Karaş *Editors*

Innovations in Smart Cities Applications Volume 7

The Proceedings of the 8th International Conference on Smart City Applications, Volume 2

Springer

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Preface

The content of this Conference Proceedings volume comprises the written version of the contributions presented at the 8th International Conference on Smart City Applications 2023.

This multidisciplinary event was co-organized by the ESTP in the partnership with Mediterranean Association of Sciences and Sustainable Development (Medi-ADD) sponsored by the digital twins' chair of construction and infrastructure at ESTP.

The contents of this volume delve into recent technological breakthroughs across diverse topics including geo-smart information systems, digital twins of construction and infrastructure, smart building and home automation, smart environment and smart agriculture, smart education and intelligent learning systems, information technologies and computer science, smart healthcare, etc.

The event has been a good opportunity for more than 110 participants coming from different countries around the world to present and discuss topics in their respective research areas.

In addition, four keynote speakers presented the latest achievements in their fields: Prof. Jason Underwood "Imagining a digital competency management ecosystem approach to transforming the productivity of people in the built environment", Prof. Isam Shahrour "Smart city: why, what, experience feedback and the future/challenges", Dr. Ihab Hijazi "Integrating system dynamics and digital twin for the circular urban environment", Prof. Mohammed Bouhorma "Challenges of cybersecurity in smart cities", Prof. Filip Biljecki "Advancing urban modelling with emerging geospatial datasets and AI technologies", Prof. Ismail Rakip Karas "Background of Smart Navigation".

We express our gratitude to all participants, members of the organizing and scientific committees, as well as session chairs, for their valuable contributions.

We also would like to acknowledge and thank the Springer Nature Switzerland AG staff for their support, guidance and for the edition of this book.

We hope to express our sincere thanks to Pr. Janusz Kacprzyk and Dr. Thomas Ditzinger for their kind support and help to promote the success of this book.

November 2023

Rani El Meouche
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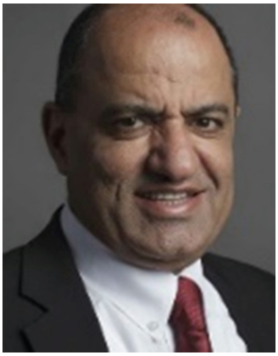
Smart City: Why, What, Experience Feedback and the Future/Challenges

Isam Shahrour

Lille University, France



Prof. Isam was a graduate from the National School of Bridges and Roads (Ponts et Chaussées-Paris); he has been strongly involved in research, higher education and partnership with the socio-economic sector. During the period of 2007–2012, he acted as Vice President “Research and innovation” at the University Lille1. He is a distinguished professor at Lille University with about 35 years of intensive academic activity with strong involvement in the university management as well as in both socio-economic and international partnership. His research activity concerned successively: geotechnical and environmental engineering, sustainability and since 2011 Smart Cities and urban infrastructures. Associate Editor of Infrastructures Journal (MDPI).

Imagining a Digital Competency Management Ecosystem Approach to Transforming the Productivity of People in the Built Environment

Jason Underwood

University of Salford, UK

Prof. Jason Underwood is a Professor in Construction ICT & Digital Built Environments and Programme Director of the MSc. in Building Information Modelling (BIM) & Digital Built Environments within the School of Science, Engineering & Environment at the University of Salford. He holds a BEng (Hons) in Civil Engineering from Liverpool John Moores University, a Master's in Psychology from Liverpool Hope University and a PhD from the University of Salford. His doctoral thesis was on "Integrating Design and Construction to Improve Constructability through an Effective Usage of IT". He is a Chartered Member of both the Institution of Civil Engineering Surveyors (MCInstCES) and The British Psychological Society (CPsychol) and a Fellow of the Higher Education Academy (FHEA). He is actively engaged in the digital transformation of the UK construction industry. He is the present Chair of the UK BIM Academic Forum and Director of Construct IT For Business, an industry-led non-profit making collaborative membership-based network.

Challenges of Cybersecurity in Smart Cities

Mohammed Bouhorma

UAE University, Morocco

Prof. Bouhorma is an experienced academic who has more than 25 years of teaching and tutoring experience in the areas of information security, security protocols, AI, big data and digital forensics at Abdelmalek Essaadi University. He received his M.S. and Ph.D. degrees in Electronic and Telecommunications from INPT in France. He has held a Visiting Professor position at many Universities (France, Spain, Egypt and Saudi Arabia). His research interests include cyber-security, IoT, big data analytics, AI, smart cities technology and serious games. He is an editorial board member for over dozens of international journals and has published more than 100 research papers in journals and conferences.

Advancing Urban Modelling with Emerging Geospatial Datasets and AI Technologies

Filip Biljecki

National University

Prof. Filip is a geospatial data scientist at the National University of Singapore where he had established the NUS Urban Analytics Lab. His background is in geomatic engineering, and he was jointly appointed as Assistant Professor at the Department of Architecture (College of Design and Engineering) and the Department of Real Estate (NUS Business School). He hold a PhD degree (with highest honours, top 5%) in 3D GIS from the Delft University of Technology in the Netherlands, where he also did his MSc in Geomatics. In 2020, he has been awarded the Presidential Young Professorship by NUS.

Integrating System Dynamics in Digital Urban Twin

Ihab Hijazi An-Najah

National University and Technical University of Munich

Dr. Hijazi is an associate professor of Geographic Information Science at Urban Planning Engineering Department, An-Najah National University in Palestine. Also, he is a senior scientist at the chair of Geoinformatics at Technical Uni of Munich. He worked as a postdoc scholar at the chair of information architecture, ETH Zurich. He was a researcher at ESRI–the world leader in GIS and the Institute for Geoinformatics and Remote Sensing (IGF) at the University of Osnabrueck in Germany.

Background of Smart Navigation

Ismail Rakip Karas

Karabuk University, Turkey

Prof. Ismail Rakip Karas is a Professor of Computer Engineering Department and Head of 3D GeoInformatics Research Group at Karabuk University, Turkey. He received his BSc degree from Selcuk University, MSc degree from Gebze Institute of Technology and PhD degree from GIS and remote sensing programme of Yildiz Technical University, in 1997, 2001 and 2007, respectively, three of them from Geomatics Engineering Department. In 2002, he involved in a GIS project as a Graduate Student Intern at Forest Engineering Department, Oregon State University, USA. He has also carried out administrative duties such as Head of Computer Science Division of Department, Director of Safranbolu Vocational School of Karabuk University. Currently, he is the Dean of Safranbolu Fine Art and Design Faculty in the same university. He is the author of many international and Turkish publications and papers on various areas of Geoinformation Science.

Contents

Smart Agriculture

Plant Disease Classification and Segmentation Using a Hybrid Computer-Aided Model Using GAN and Transfer Learning

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Abstract. Plants are essential for life on earth, providing various resources and are helpful in maintaining ecosystem balance. Plant diseases result in reduced crop productivity and yield. Manual detection and classification of plants diseases is a crucial task. This research presents a hybrid computer aided model for plant disease classification and segmentation. In this research work we have utilized PlantVillage dataset with 8 classes of plant diseases. The dataset was annotated using a Generative Adversarial Network (GAN), four transfer learning models were used for classification, and a hybrid model is proposed based on the pretrained deep learning models. Instance and semantic segmentation were used for localizing disease areas in plants, using a hybrid algorithm. The use of GAN and transfer learning models, as well as the hybrid approach for classification and segmentation, resulted in a robust and accurate model for plant disease detection and management in agriculture. This research could also serve as a model for other image classification and segmentation tasks in different domains. Proposed hybrid model achieved the promising accuracy of 98.78% as compared to the state-of-the-art techniques.

Keywords: plant disease · classification · segmentation · hybrid model · Generative Adversarial Network (GAN) · Convolutional Neural Network (CNN)

1 Introduction

External factors can alter a plant's physiological processes, making it more susceptible to infection and causing changes to the plant's structure, development, functions, or other features. Depending on the kind of the causal agent, plant diseases can be classified as infectious or non-infectious. Depending on the disease's etiology, type, and impact site, the symptoms can change. The prevalence

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of diseases brought on by bacterial, fungal, and viral infections has significantly increased recently. Plants in various stages of agricultural production have been impacted by these diseases. Plant diseases, whether contagious or not, significantly reduce agricultural output, leading to financial losses as well as decreased crop quality and quantity. Examining the extensive effects of plant diseases on global agricultural productivity is the goal of this study [18]. It is crucial to take prompt action in developing effective disease management plans to safeguard global food security and ensure a sustainable food supply for the world's growing population [28]. Environmental aspects and production resources, including temperature, humidity, and labor, in the agricultural process must be taken into account if agricultural output is to be increased. Plant disease, on the other hand, considerably lowers agricultural productivity by 20–30%, making it the primary factor in the global agricultural industry's decline in production and economic value. In order to prevent the spread of disease and make effective treatment possible, monitoring plant health conditions becomes an essential duty [5].

Many systems have been proposed for plant identification based on leaf images [2,8,9]. Deep learning approaches achieved high accuracy while classifying plants based on leaf images [4,12,19]. Proposing systems based on the AI can help farmers to quickly and accurately identify infected areas of their crops, leading to more efficient use of resources and improved crop yields.

In this research work eight classes of PlantVillage dataset are utilized but the images may contain noise, which can negatively impact the model's performance. To address this, the researchers applied denoising using a generative adversarial network (GAN) [3] and data augmentation techniques. For classification, three different convolutional neural network (CNN) [20] architectures were evaluated, and a hybrid model was built using all three, resulting in higher accuracy. For segmentation, two different approaches were evaluated: instance and semantic segmentation. We have utilized Mask-RCNN [7], VGGSegnet [10], and Unet [6], and a hybrid algorithm was created by combining the strengths of these approaches, resulting in more accurate segmentation of plant diseases. The proposed hybrid model can help farmers to quickly and accurately identify infected areas of their crops, leading to more efficient use of resources and improved crop yields. Additionally, the use of GAN for denoising and data augmentation further enhanced the quality of the images, and the proposed hybrid model for segmentation can effectively localize and segment the disease areas in an image.

2 Related Work

The increasing prevalence of rice plant diseases has caused significant agricultural, economic, and communal losses. Researchers have been exploring image processing techniques to diagnose and identify these diseases. Some literature review was conducted on studies published between 2020 to 2023, which focused on the development of disease detection, identification, and quantification methods for a variety of crops. One of them Anjnaa, Meenakshi, Pradeep [26] worked an automated system to detect and classified the plant disease in 2020. The paper presents an automated system for early detection and classification of plant diseases, specifically for capsicum plants. The system uses k-means clustering to identify the infected area of the plant and GLCM features to analyze its texture. The type of disease is then classified using various classifiers, with KNN and SVM providing the best results. The proposed system achieved an accuracy of 100% on a dataset of 62 images of healthy and diseased capsicum plants and their leaves. The research emphasizes the importance of early analysis and classification of plant diseases to improve crop production. The article by Prabira, Nalini, and Amiya [22] discusses the current advancements in the diagnosis of rice plant diseases, specifically highlighting the use of image processing techniques for disease identification and quantification. While acknowledging the potential of these methods, the authors also highlight the challenges faced in accurately classifying certain diseases due to the need for high-quality images. They suggest that further research is necessary to address these limitations and enhance the accuracy of these methods in diagnosing and identifying rice plant diseases. Parul, Yash, and Wiqas [23] investigated the use of segmented image data to train CNN models to improve automated plant disease detection. They compared the performance of a CNN model trained using full images to one trained using segmented images and found that the segmented model had significantly higher accuracy of 98.6% when tested on previously unseen data. They used tomato plants and target spot disease as an example to demonstrate the improvement in selfclassification confidence of the segmented model compared to the full image model. Kamal KC et al. [14], have investigated the impact of background removal on convolutional neural networks (CNNs) for in-situ plant disease classification. They have contributed to the field by proposing a novel dataset of in-situ plant images with annotated ground truth, which they have used to evaluate the performance of different CNN architectures with and without background removal. They have also investigated the effect of different background removal techniques on CNN performance. Their results show that background removal can significantly improve CNN performance for in-situ plant disease classification, and that a combination of segmentation-based and color-based background removal methods can achieve the best results. The framework of the model proposed in this study is given in the Fig. 1. Azim, Khairul, and Farah [5] proposed a model in 2021 for detecting three common rice leaf diseases: bacterial leaf blight, brown spot, and leaf smut. The model uses saturation and hue thresholds to segment the disease-affected areas and extract distinctive features based on color, shape, and texture domains. They tested several classification algorithms and found that extreme gradient boosting decision tree ensemble was the most effective method, achieving an accuracy of 86.58% on the rice leaf diseases dataset from UCI. The class-wise accuracy of the model was consistent among the classes, and it outperformed previous works on the same dataset. The paper emphasizes the importance of accurate segmentation and feature extraction for effective disease detection in plants. The authors [15] in this paper propose an automated project for leaf segmentation to detect the

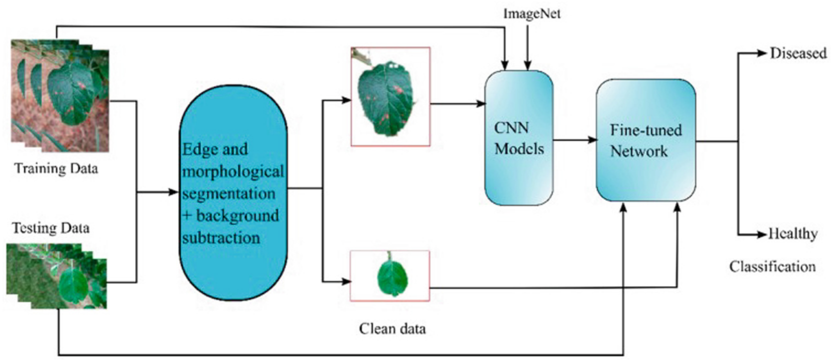

Fig. 1. Framework of the proposed method

classification of disease. They use a deep convolutional neural network based on semantic segmentation for the classification of ten different diseases affecting a specific plant leaf, specifically tomato plant leaves. The model successfully identifies regions as healthy and diseased parts and estimates the area of a specific leaf affected by a disease. The proposed model achieved an average accuracy of 97.6% on a dataset of twenty thousand images. The study conducted by Raj, Anuradha, and Amit [16] found that 70% of machine learning-based studies used real-field plant leaf images, while 30% used laboratory-conditioned plant leaf images for disease classification. For deep learning-based approaches, 55% of studies used laboratory- conditioned images from the PlantVillage dataset. The average accuracy attained with deep learning-based approaches was 98.8%. The authors, Pooja and Shubhada [13] discuss in their paper different methods that have been developed for plant disease detection using image processing. They also explore the use of machine learning algorithms such as neural networks and decision trees to improve the accuracy of disease detection. In their paper, Jinzhu, Lijuan, and Huanyu [17] provided a review of the latest CNN networks for plant leaf disease classification. They discussed the principles and challenges of using CNNs for this task, as well as future directions for development. They also collected plant datasets from Kaggle [24] and BIFROST [25], and their proposed model achieved high accuracies of 91.83% on the PlantVillage dataset and 92.00% on their own dataset. The general steps adopted in majority of the related research studies is given in the Fig. 2. The literature suggests there is a gap in plant disease detection, and the proposed research aims to address this gap by proposing a method for the segmentation and classification of plant diseases. The goal of this study is to create a hybrid model for segmenting and classifying plant illnesses to precisely identify and control them for sustaining agricultural yield and halting the spread of disease. In this research work we have utilized the PlantVillage dataset, and considered 8 different classes of plant diseases. Four transfer learning models are utilized for categorization. A stable and accurate model that can be a useful tool for plant disease identification and

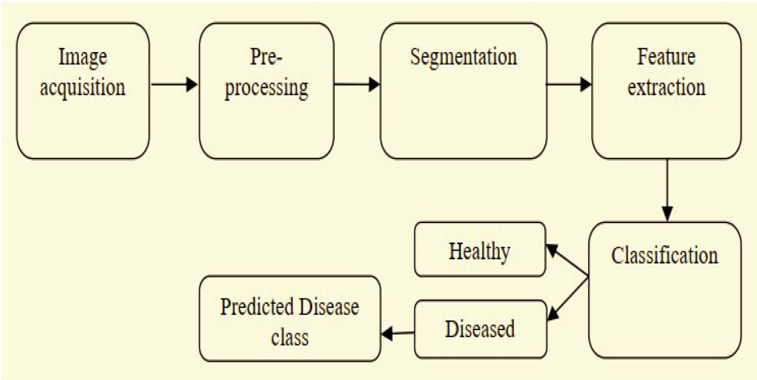

Fig. 2. General steps involved in the disease prediction system

management in agriculture was created by using GAN to generate the dataset and combining transfer learning models, instance and semantic segmentation, and other techniques.

3 Proposed Methodology

Data collection, data preprocessing, picture segmentation, feature extraction, model training and testing, model assessment, and deployment are the main phases in the approach that we present in this research work. Figure 3 gives the visual representation of the workflow of proposed method. The major phases of proposed method are described in the following section: The proposed method is

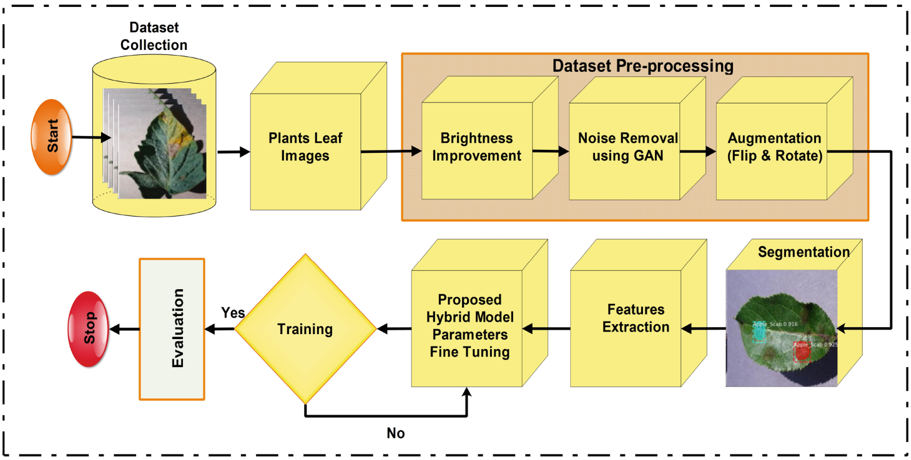

Fig. 3. Working methodology of proposed method

based on the following steps: Collecting data from the PlantVillage dataset, pre-processing images, segmenting leaves, extracting features, training and testing deep learning model, evaluating the model's performance using metrics such as accuracy, precision, recall, and F1-score, drawing conclusions from the results and discussing future work to improve the model's performance. The algorithm of our proposed method framework is as presented in the Algorithm 1:

Algorithm 1: Enhanced Hybrid Model for Plant Disease Segmentation and Classification

Input: $PlantVillage\ dataset$,
$segmentation\_models : MaskR-CNN, UNET, VGGSegNet$,
$Pretrained\_models : DenseNet, ResNet,\ andEfficient-NetB1$

Output: Preprocessed_Dataset,Hyb_Seg_Model: Ensemble hybrid model for disease segmentation, Hyb_classification_Model: An Ensemble model for classification

Load PlantVillage dataset;
Perform data annotation and augmentation;
foreach *image in PlantVillage_dataset* **do**
  Perform preprocessing using Generative Adversarial Networks (GAN) to enhance input data quality and diversity;
  Save *Preprocessed_Dataset*;
end
foreach *segmentation_model in segmentation_models* **do**
  Train *segmentation_model* on *Preprocessed_Dataset*;
end
Perform segmentation using *Hyb_Seg_Model*;
foreach *pretrained_model in pretrained_models* **do**
  Train *pretrained_model* on *Preprocessed_Dataset*;
end
Perform segmentation using *pretrained_models*;
Perform classification using *Hyb_classification_Model* ;
Evaluate accuracy for segmentation and classification;
Assess effectiveness in localizing disease areas;
Analyze results and Compare with state-of-the-art techniques;

We also followed a timeline for our methodology:

1. Data collection: The PlantVillage dataset will be used for this project, which contains images of plant leaves affected by different diseases and pests. The dataset will be downloaded from the Kaggle [22] website.
2. Data pre-processing: The images will be pre-processed to remove any noise and improve the overall quality of the images. This will include color space conversion, image enhancement, and image cropping.
3. Image segmentation: The leaves in the images will be segmented using a suitable segmentation algorithm. This will involve separating the leaf from the background, and isolating the leaf from other parts of the image.

4. Feature extraction: After the segmentation step, features will be extracted from the segmented leaf images. These features will include color, texture, and shape features.
5. Model training and testing: A machine learning model will be trained using the extracted features. The model will be trained using a suitable algorithm and fine-tuned using hyperparameter tuning.
6. Model training and testing: CNN model will be trained using the appropriate hyperparameters.
7. Model evaluation: The performance of the model is evaluated using metrics such as accuracy, precision, recall, and F1-score.
8. Deployment: The model will be deployed in a web or mobile application, which can be used by farmers and researchers to detect diseases in plants.

3.1 Data Augmentation

The practice of intentionally introducing random modifications to already-existing images is known as data augmentation. Its goal is to decrease overfitting and increase the generalisation of the model. The Keras ImageDataGenerator class is used in this project to apply data augmentation to the training pictures before supplying them to the GAN. The class supports a variety of enhancements, including random rotation, turning the view horizontally or vertically, and zooming in or out. The model may be exposed to a larger variety of picture changes thanks to these enhancements, which can also increase its resistance to different kinds of noise and image fluctuations. The generator may learn to denoise the pictures while also becoming more accurate by adding data augmentation to the images before entering them into the GAN. Sample output of this phase is given in the Fig. 4.

Fig. 4. Sample Output of Data Augmentation Phase

3.2 Dataset Preprocessing

A crucial phase of image processing is data preparation. In this context, generative adversarial networks (GANs), advanced deep learning models composed of a generator and discriminator network, are used to improve images with noise.

The generator network learns to produce images similar to the input data, whilst the discriminator network develops its capacity to distinguish real images from fake ones. The GAN model is used to successfully remove noise from photos after training. The output of this phase is given in the Fig. 5.

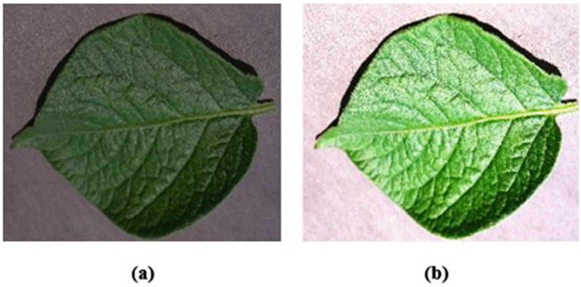

Fig. 5. Sample Output of preprocessing phase

3.3 Leaf Segmentation

Segmentation is the process of dividing an image into multiple regions, each representing a different object or part of the image. Semantic segmentation is a technique that associates each pixel in the image with a label representing the object or region it belongs to. This process involves feeding an image to a neural network model that generates a probability map for each pixel in the image, representing the likelihood of that pixel belonging to a certain class or segment. The probability maps are thresholded to obtain a binary mask for each class, and these masks can be combined to obtain the final segmentation mask representing the different segments or regions in the image.

Fig. 6. Segmentation Output

Segmentation is important for various computer vision applications such as object detection, image recognition, and medical image analysis. In this research work we have utilized both instance and semantic segmentation techniques to detect and segment individual objects and different regions in an image. The Mask R-CNN model is used for instance segmentation and generates bounding boxes around each object, while the semantic segmentation model combines the VGGSegnet and UNet models to classify the segmented objects into different classes. The resulting segmented image can be used for various tasks such as object detection, classification, and localization in different applications. Sample output of the segmentation phase is given in the Fig. 6.

3.4 Model Building

A hybrid model was created by combining DenseNet, ResNet9, and EfficientNetB1 for the purpose of classification and segmentation of plant diseases using preprocessed and segmented images. The model input was preprocessed images of $256 \times 256 \times 3$ dimensions. The paper uses the DenseNet121 architecture as the base model for plant disease classification and segmentation. The model is built using the Keras library and is trained on a dataset of plant disease images. In this project a hybrid model is created using three different architectures: DenseNet121, ResNet9, and EfficientNetB1, which are chosen for their ability to classify images with high accuracy and extract features effectively. The model is created by concatenating the output of the three different architectures and passing through fully connected layers. The Adam optimizer is utilized in this research work. The hybrid model is effective in extracting features and classifying images with high accuracy by combining the strengths of each architecture.

4 Experiments and Results

4.1 Dataset

In this research work PlantVillage dataset [11] is utilized. The PlantVillage dataset is a large-scale dataset used for plant disease recognition and classification. It contains over 50,000 images of healthy and diseased plant leaves belonging to 14 crop species, such as tomato, potato, corn, and grape. The images were collected from various sources, including field surveys and plant clinics. Each image is annotated with the corresponding plant species and disease class label, making it a valuable resource for developing machine learning models for plant disease detection and diagnosis. The classes used in this research work are given in the Fig. 7.

The dataset is publicly available and has been widely used by researchers to evaluate the performance of their algorithms. Some sample images of the dataset are given in the Fig. 8.