Capstone Project : 400C

Towards Automated Detection of Tomato Leaf Diseases

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Introduction

- A web based intelligent system.
- Upload image for the identification of the tomato leafes diseases.
- Recommendation of pesticides.
- Visit website for detailed dietary summary.

Motivation

- Detect diseases in early stages.
- Prevention of diseases in early stages.
- Food security assurance.
- Time and cost saving.

Business Model Canvas

Key Partners

- Agro-Based Companies.
- Domain & hosting provider

Key Activities

- Best performance improve of our system
- Add as much as possible information of the plants disease and solution to the database.
- Get feedback from the field officers and farmers.

Value Propositions

- Detect diseases of different kinds of plants and tell how to prevent it.
- Farmers can post image of the infected plant in our website to identify the disease.
- Monitor the infected plant and get a detailed analysis of the disease and gives recommendation for the best pesticide in the market to prevent the disease.

Customer Relationships

- Long-term Personal assistance

Channels

- Website Application

Customer Segments

- Agro-Based Companies.
- Farmers and people who wants to know the name of disease that their plants are infected with and prevention method of it.

Cost Structure

- Development cost
- Engineers
- Server cost
- Advertisement

Key Resources

- Efficient algorithm
- ML engineers

Revenue Streams

- AdSense / Affiliate products commission from Agro-Based Companies.

Subscription

- Agro-Based Companies

Background

- Detecting tomato leaf diseases is a challenge in computer vision.
- Researchers has created automated methods to identify tomato leaf diseases.
- Deep learning algorithms have improved tomato leaf disease detection.
- Creating systems that are accurate, efficient, and accessible to farmers.

Related Works

ToLeD: Tomato leaf disease detection using convolution neural network.

Agarwal, M., Singh, A., Arjaria, S., Sinha, A., & Gupta, S. (2020). ToLeD: Tomato leaf disease detection using convolution neural network. *Procedia Computer Science, 167,* 293-301.

- The paper discusses a deep learning-based approach using a Convolutional Neural Network for accurate disease detection and classification in tomato crops.

- Dataset of this paper was collected PlantVillage and the size is 12,206.

- The disease was detected with the accuracy of 91.2%

Related Works

Tomato leaf disease detection using convolutional neural network with data augmentation

Kaushik, M., Prakash, P., Ajay, R., & Veni, S. (2020, June). Tomato leaf disease detection using convolutional neural network with data augmentation. In *2020 5th International Conference on Communication and Electronics Systems (ICCES)* (pp. 1125-1132). IEEE.

- This paper presents a deep learning-based approach using Convolutional Neural Networks (CNNs) for detecting six prevalent diseases in tomato leaves, using data augmentation and transfer learning with a ResNet-50 pre-trained model.
- Dataset of this paper was collected PlantVillage and the size is 54,306
- The disease was detected with the accuracy of 97%.

Related Works

Deep Convolutional Neural Networks for image-based tomato leaf disease detection.

Anandhakrishnan, T., & Jaisakthi, S. M. (2022). Deep Convolutional Neural Networks for image-based tomato leaf disease detection. *Sustainable Chemistry and Pharmacy*, *30*, 100793. .

- This paper proposes an automatic system for identifying tomato leaf diseases at an early stage using Deep Convolutional Neural Network (CNN)

- Dataset of this paper was collected PlantVillage and the size is 18,160.

- The disease was detected with the accuracy of 98.4%.

Research Questions

1. How will the proposed system benefit our farmers?

1. How it would be possible to detect tomato leaf diseases in the early stage and prevent it?

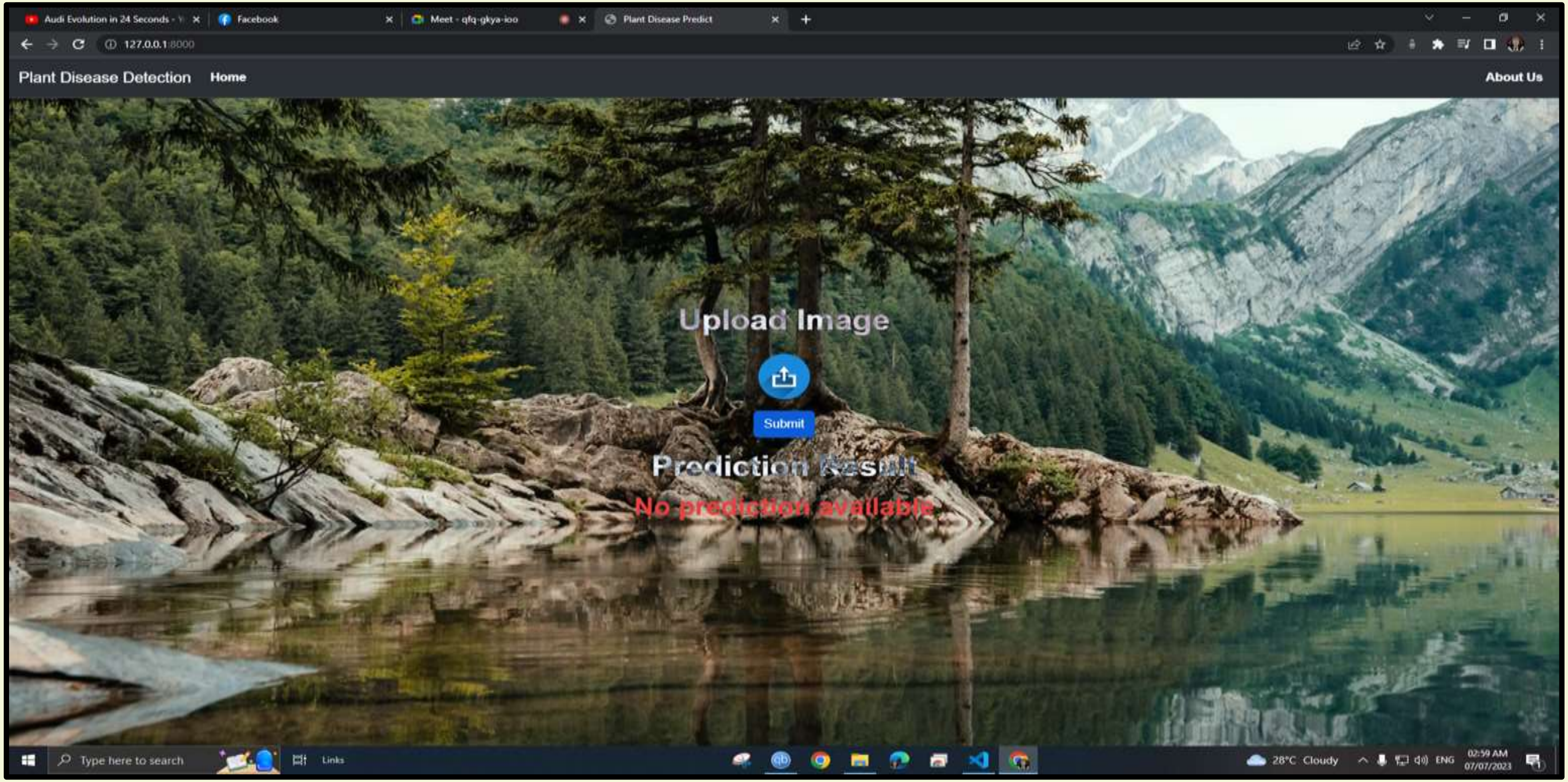
1. How can automated disease detection systems be used to improve disease management strategies, such as through targeted application of pesticides or other treatments?

System Requirements

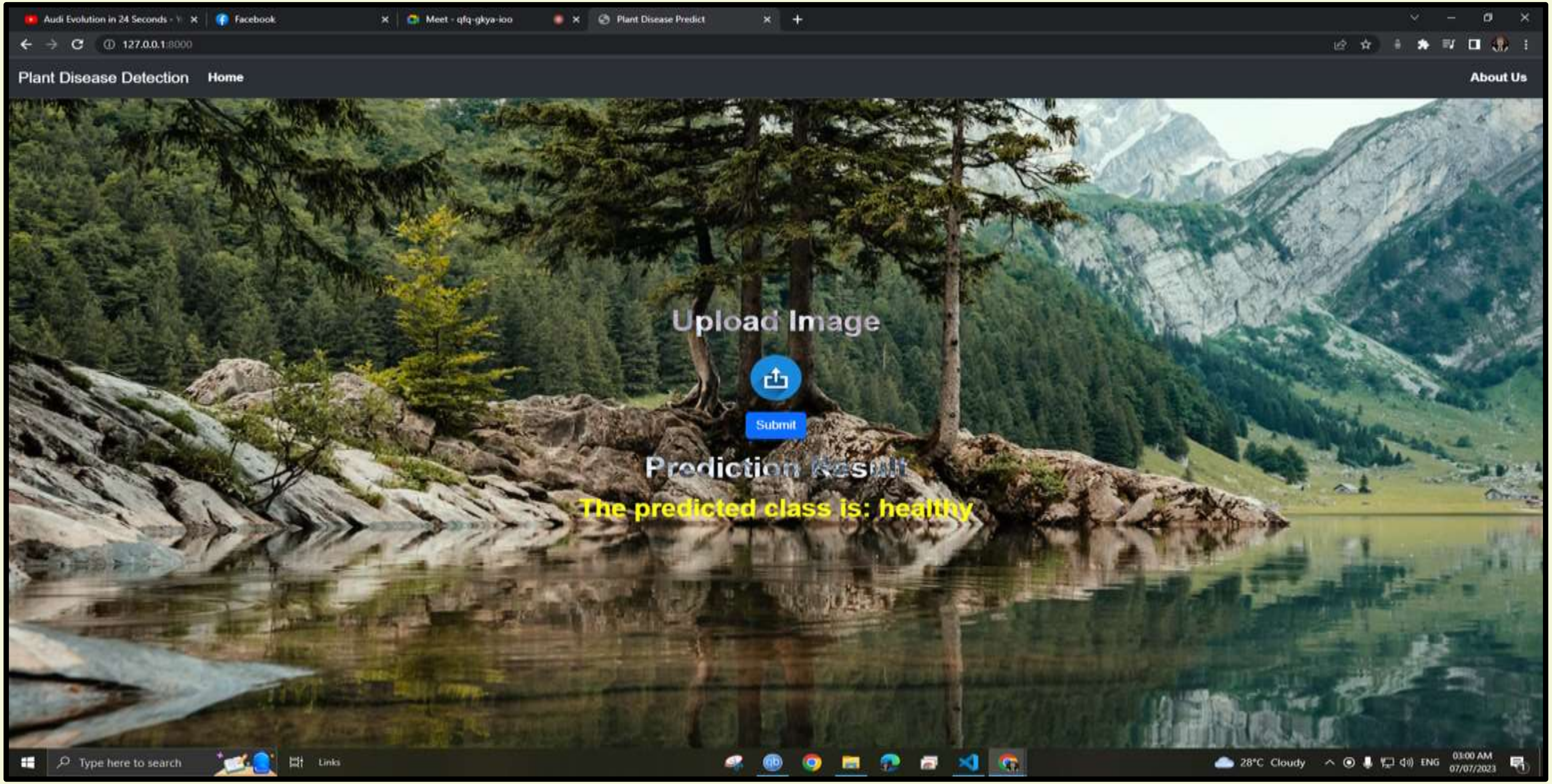
- ➢ **Functional Requirements:**
  - ✓ Sign-in and Registration
  - ✓ Image Upload
  - ✓ Prediction Result
  - ✓ Auto Save History
  - ✓ Generate Notes
  - ✓ Customer Feedback
  - ✓ Admin Panel

- ➢ **Non-Functional Requirements:**
  - ✓ Security
  - ✓ Performance
  - ✓ User friendly
  - ✓ Responsive
  - ✓ Reliability
  - ✓ Compatibility

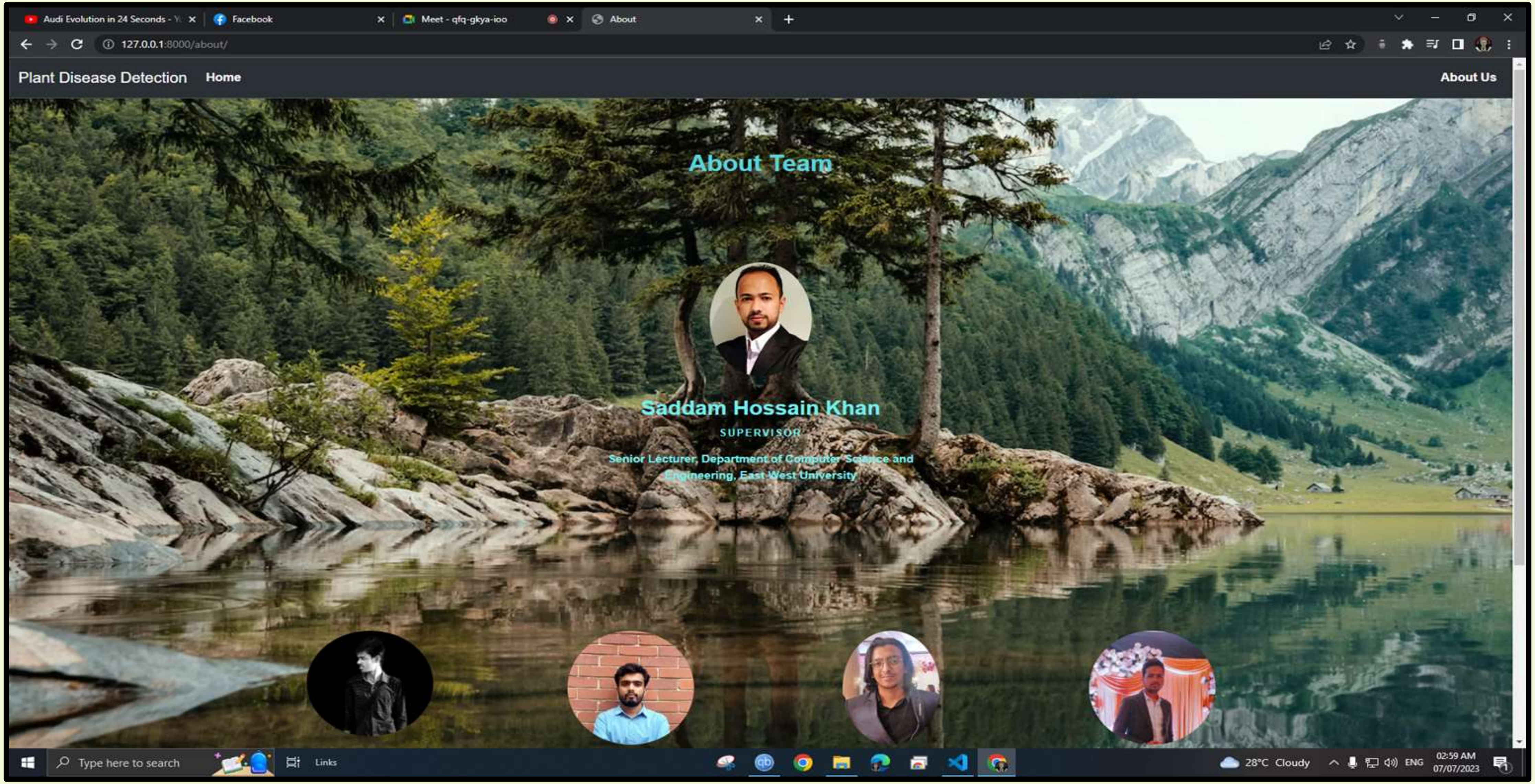
Web-based System



Web-based System

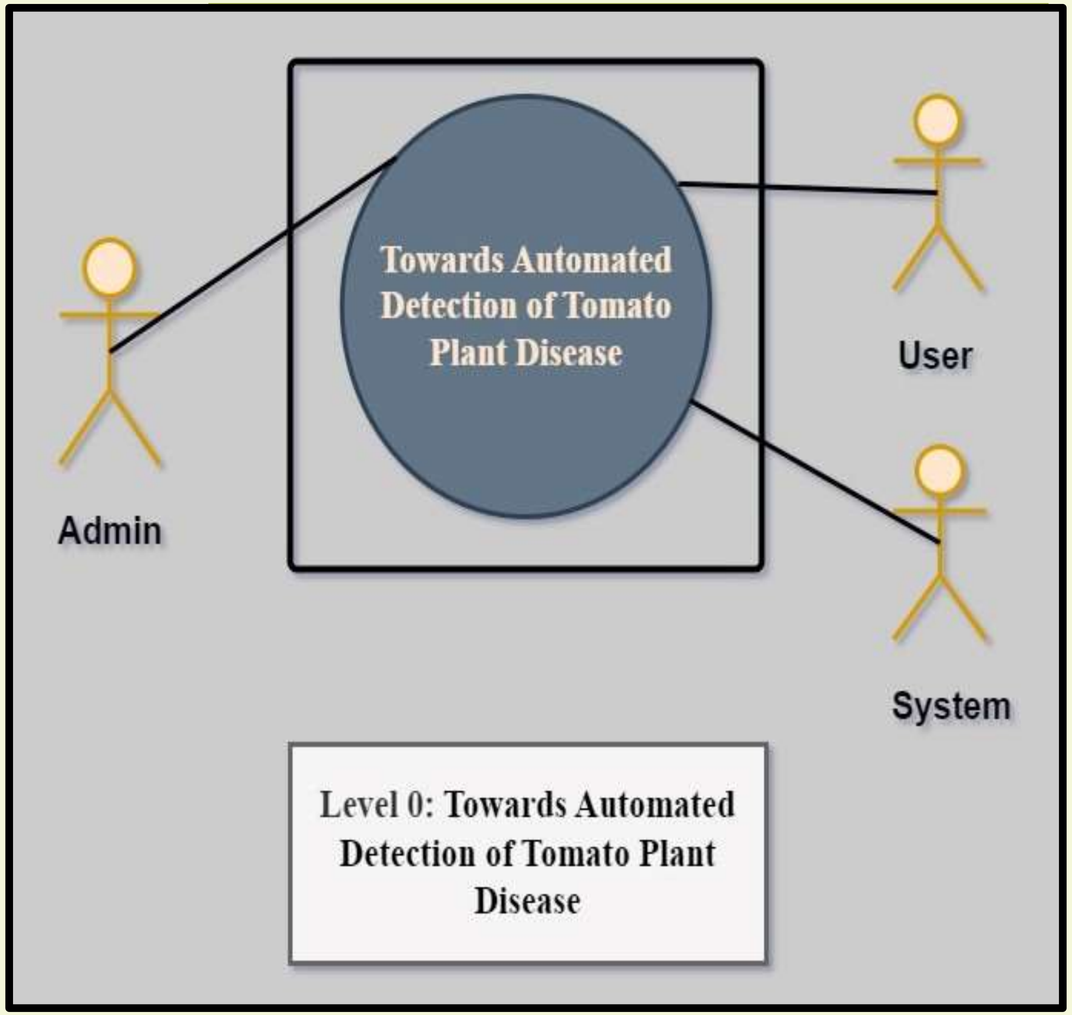


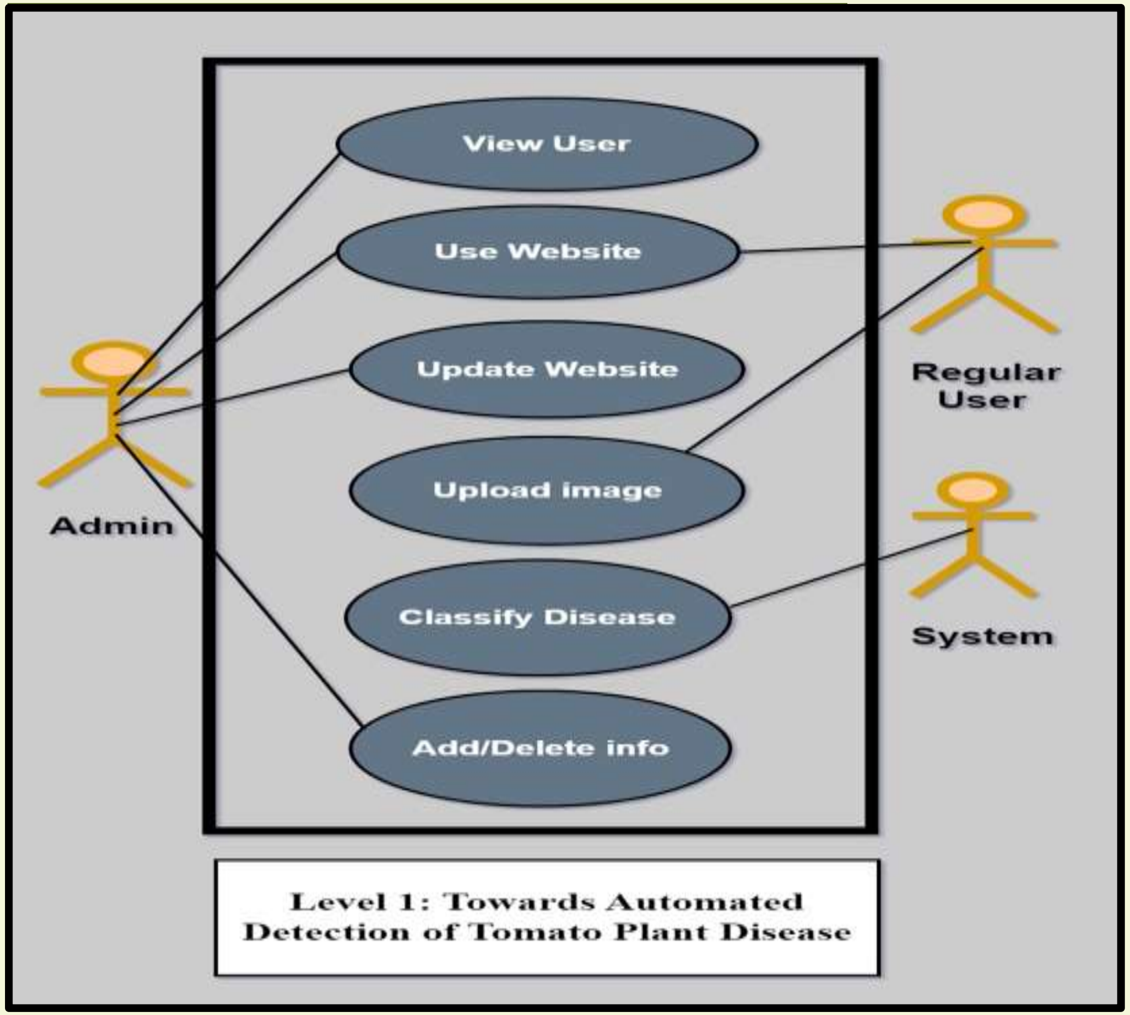
Web-based System



Diagrams

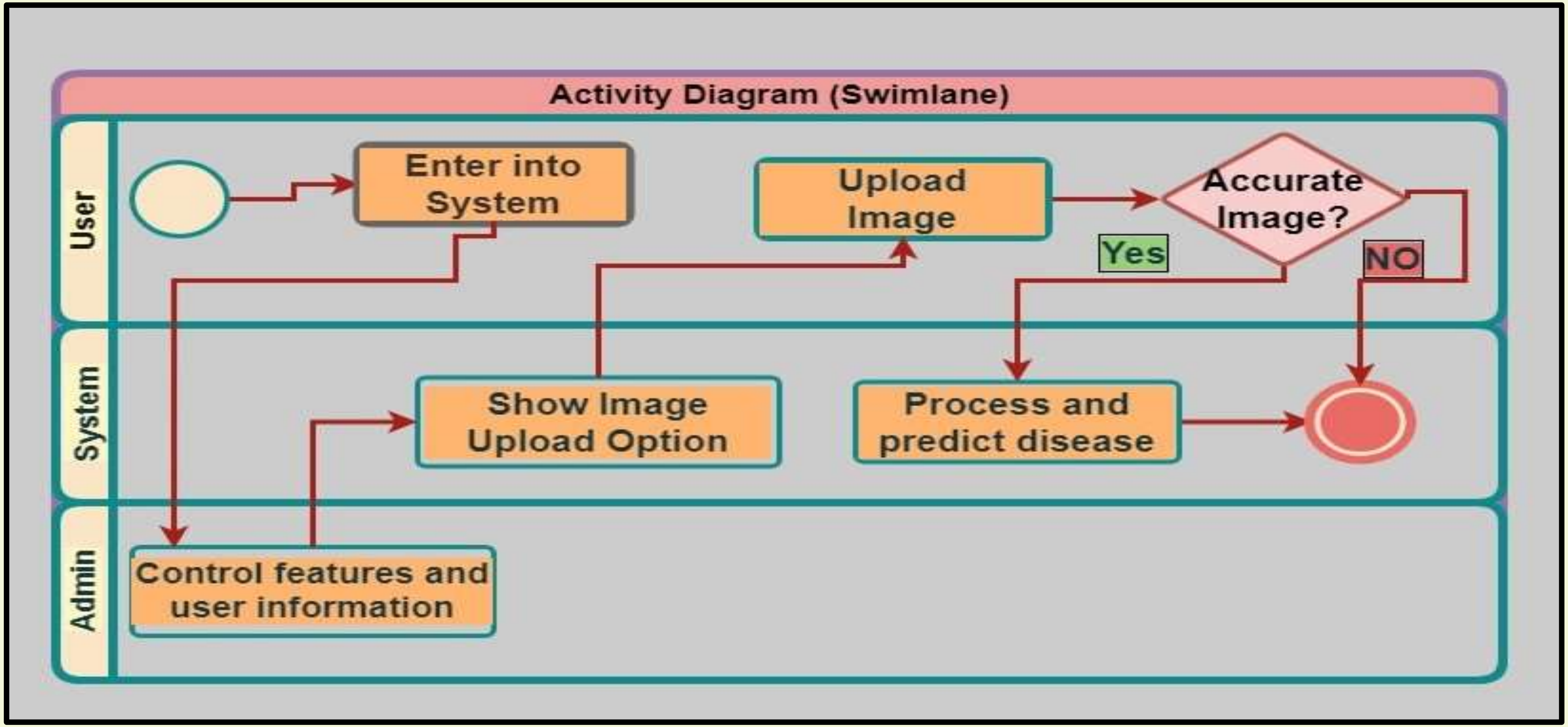
Use Case Diagram





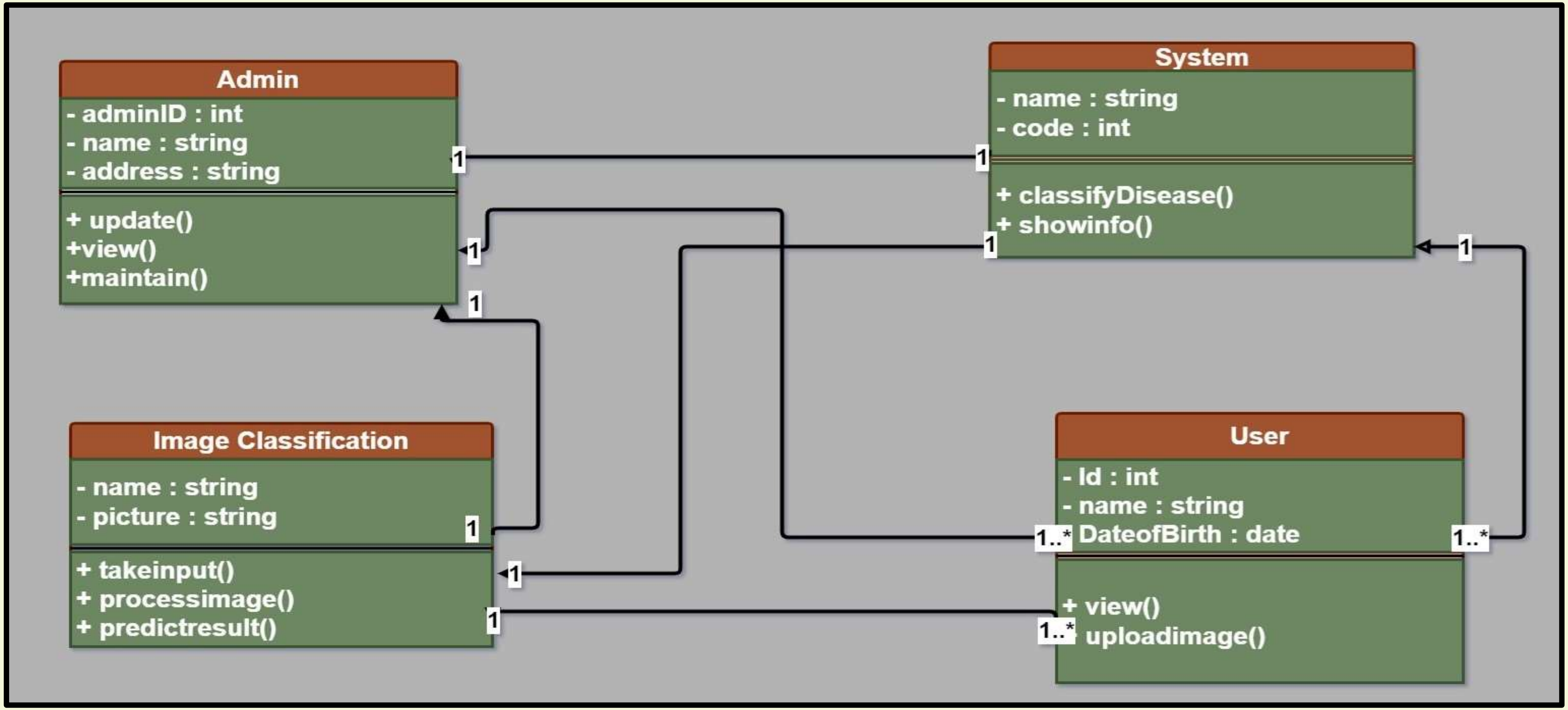
Diagrams

Activity Diagram (Swimlane)



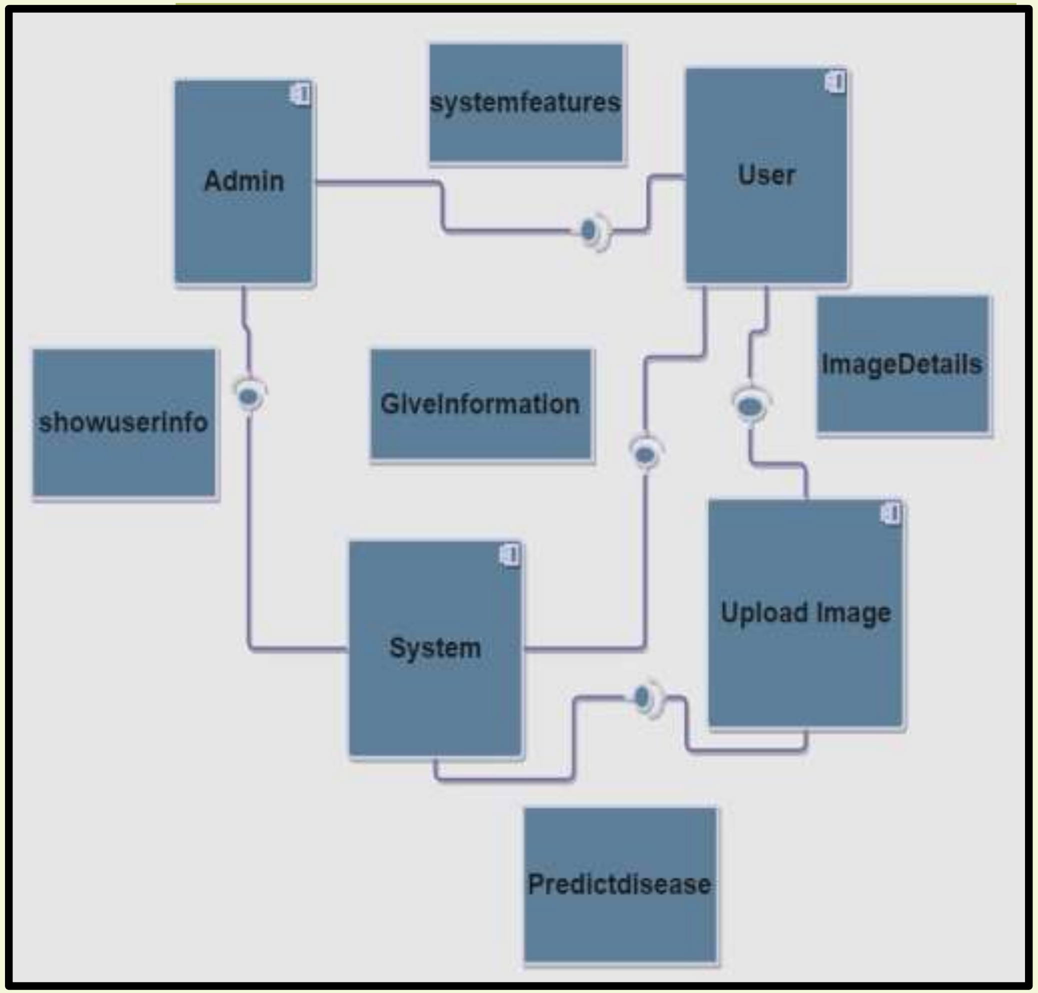
Diagrams

Class Diagram

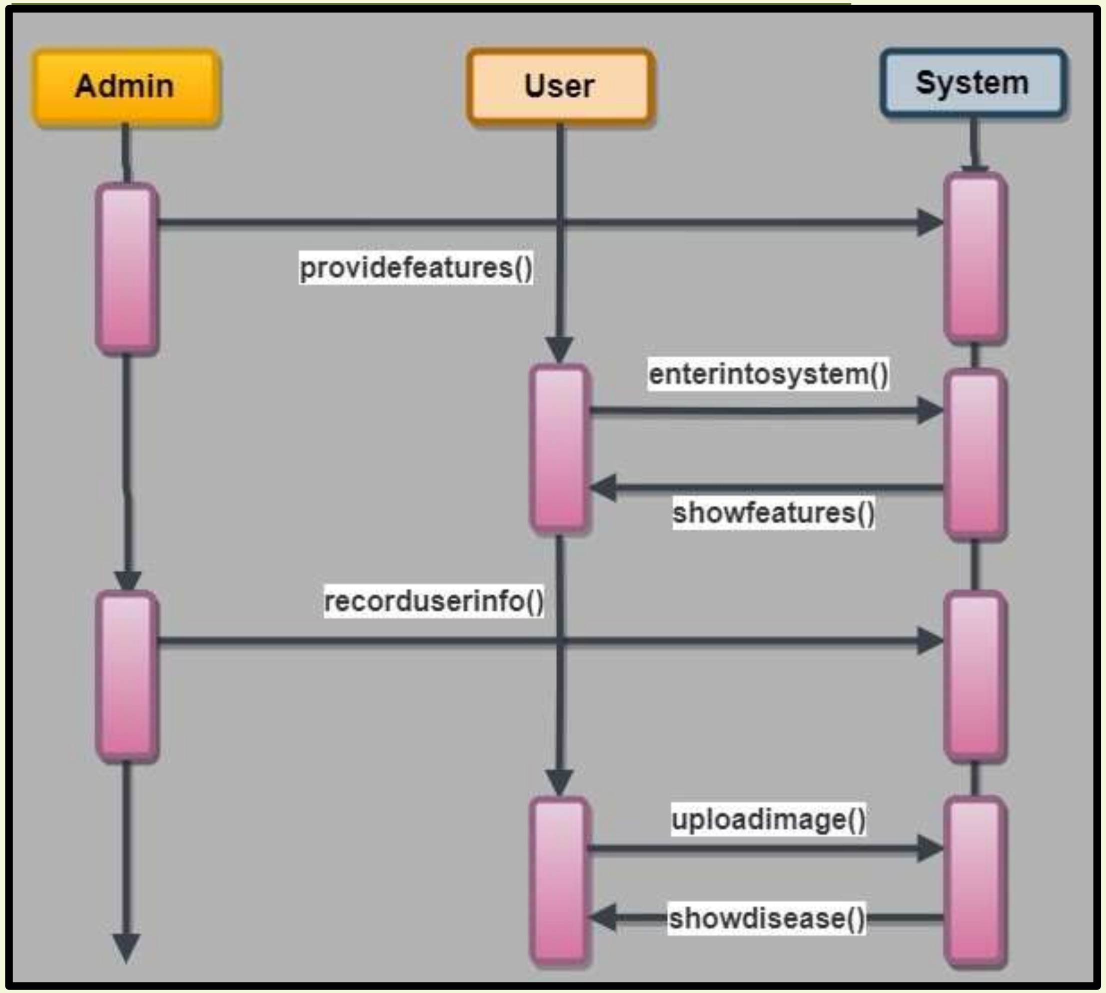


Diagrams

Component Diagram

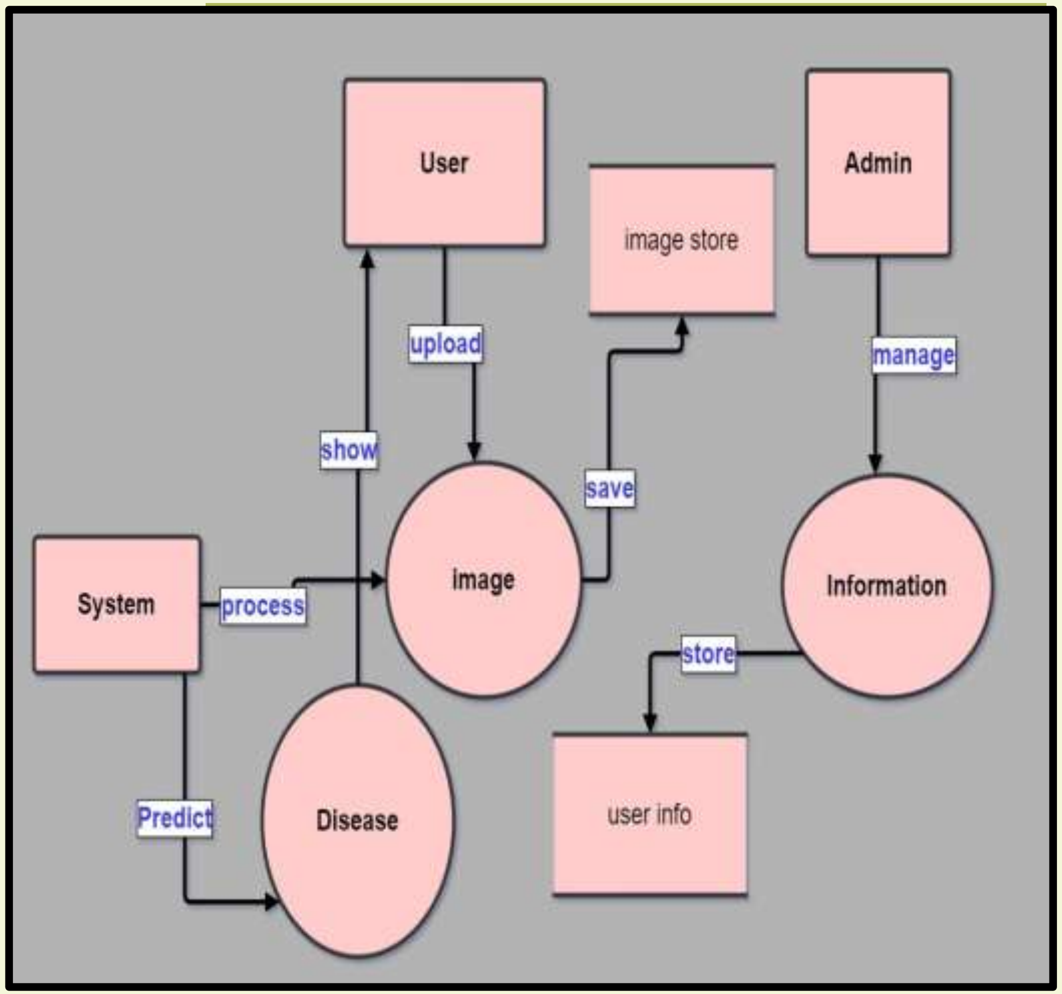


Sequence Diagram

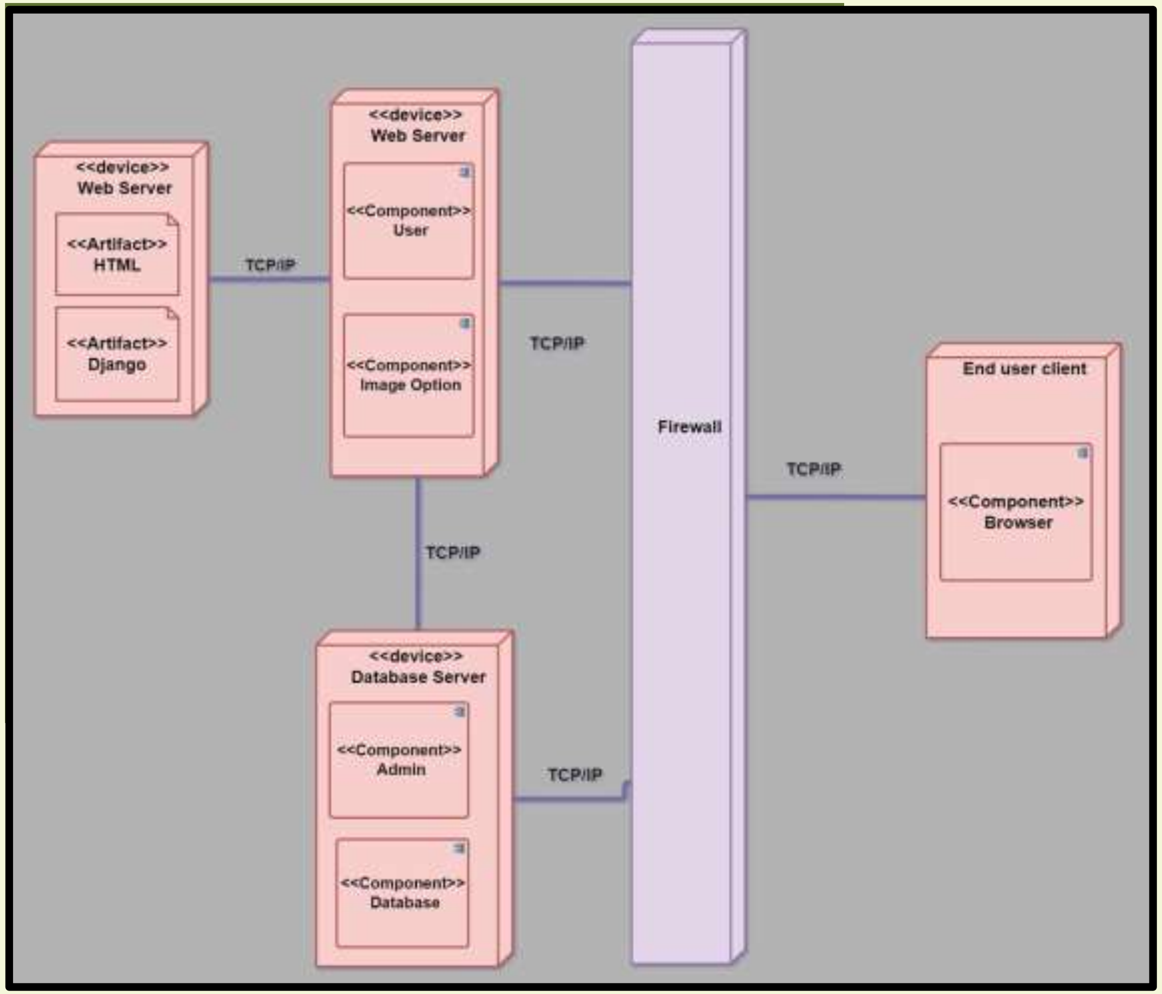


Diagrams

Data Flow Diagram



Deployment Diagram



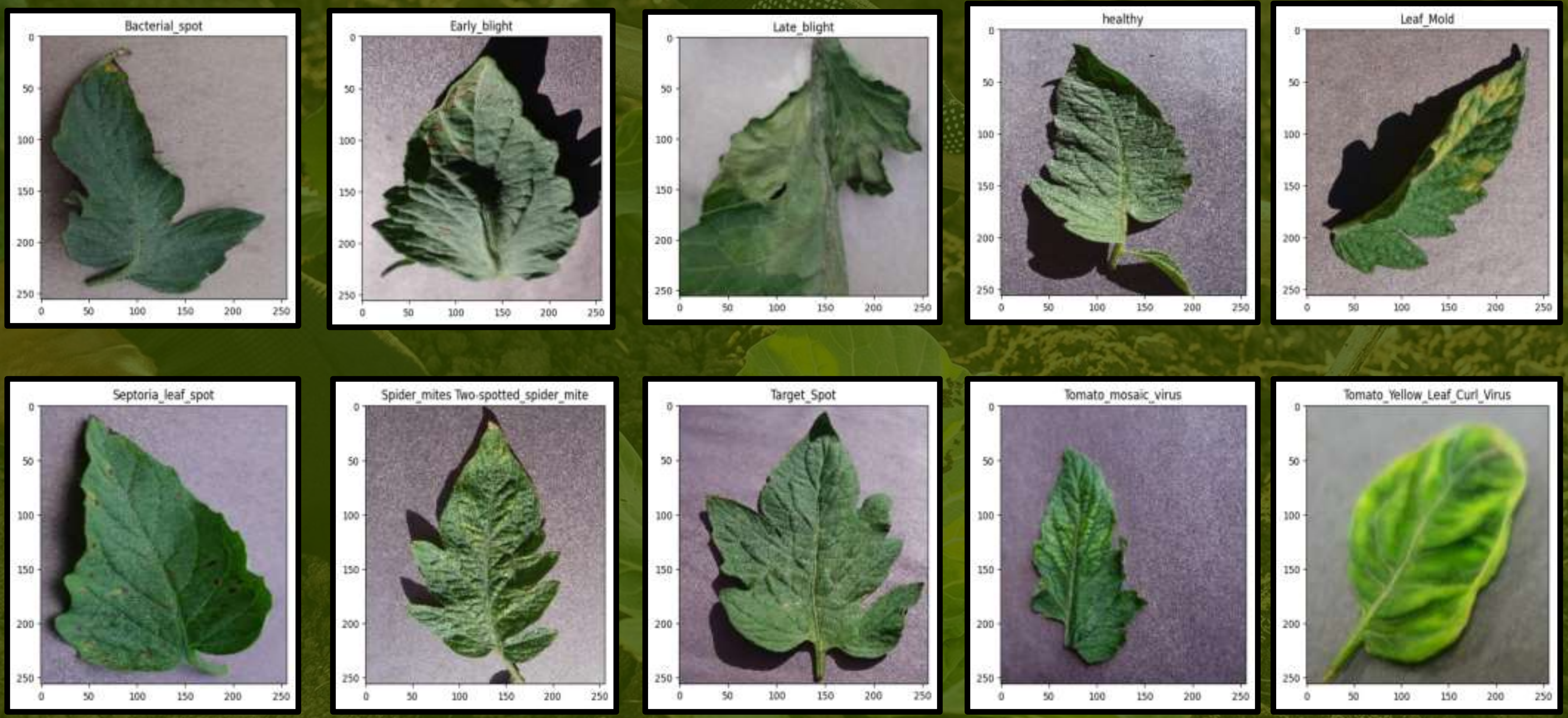
Tools &Technology

- ✓ Computer Vision
- ✓ Convolutional Neural Network
- ✓ Image Processing
- ✓ Internet of Things
- ✓ Web Development Framework
- ✓ Database Management System
- ✓ Image Processing Libraries
- ✓ Security Tools

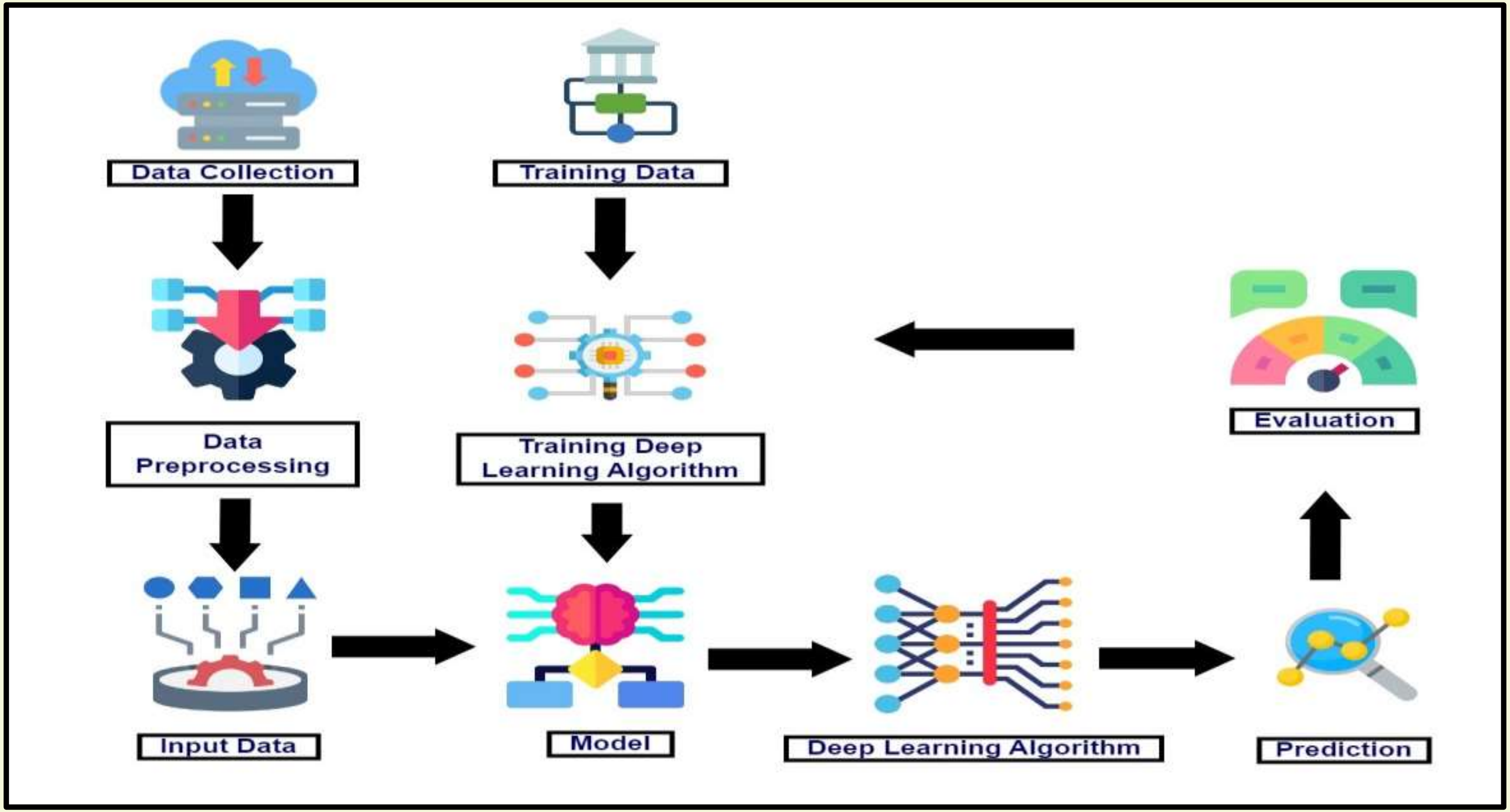
Dataset

- Dataset of this project have been obtained from Kaggle.
- It has 10,000 images of various tomato leaf.
- It has been augmented and the increased to 60,000 images.
- There are 10 categories in the dataset.
- Which include images of Acterial spot, Early blight, Late blight, Leaf Mold, Septoria leaf spot, Spider mites Two-spotted spider mite, Target spot, Healthy, Tomato mosaic virus and, Tomato Yellow Leaf Curl Virus.
- The dataset have been splitted into 80% training and 20% validation.

Dataset

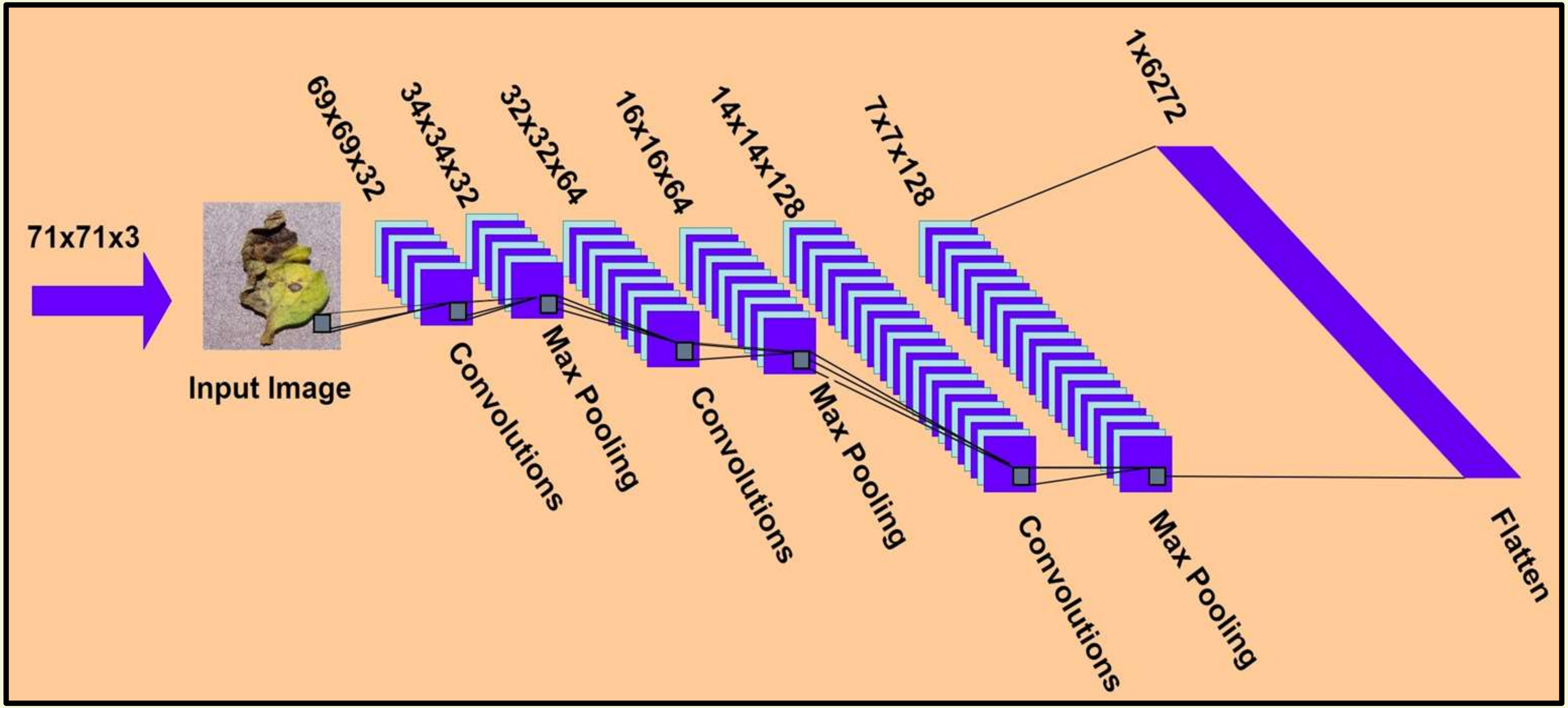

Bacterial_spot
Early_blight
Late_blight
healthy
Leaf_Mold
Septoria_leaf_spot
Spider_mites Two-spotted_spider_mite
Target_Spot
Tomato_mosaic_virus
Tomato_Yellow_Leaf_Curl_Virus

PLANNED METHODOLOGY



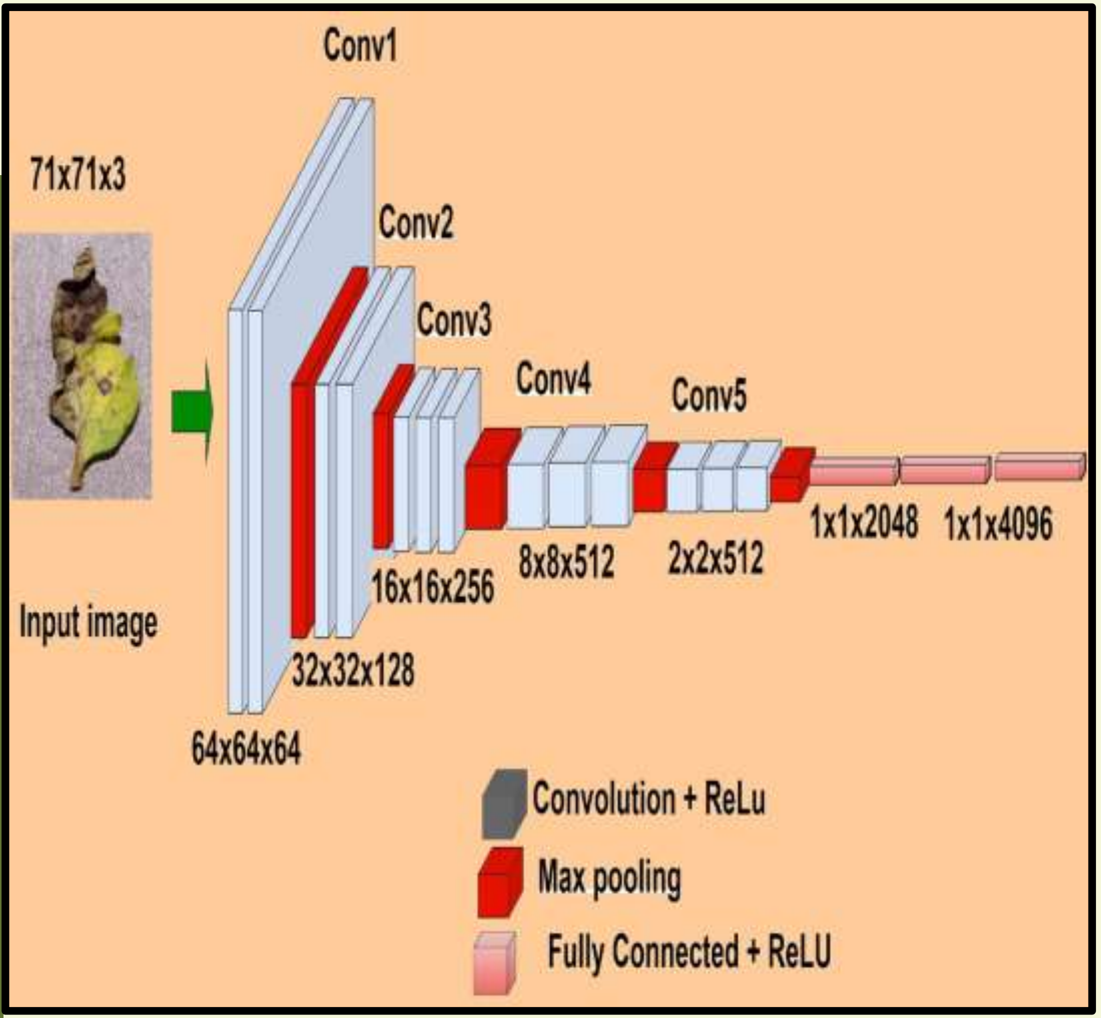
DESIGNS

Custom CNN

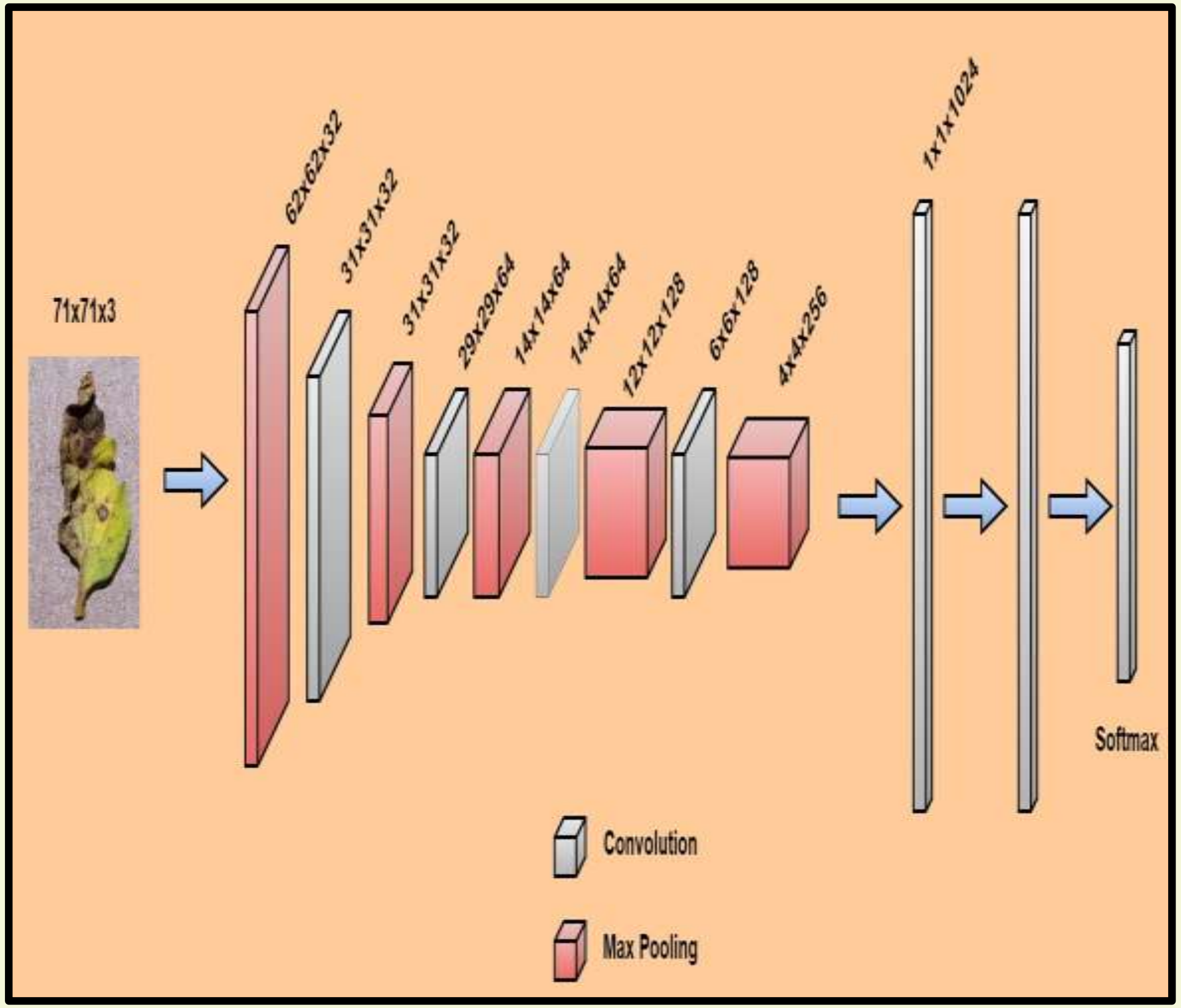


DESIGNS

VGG-16

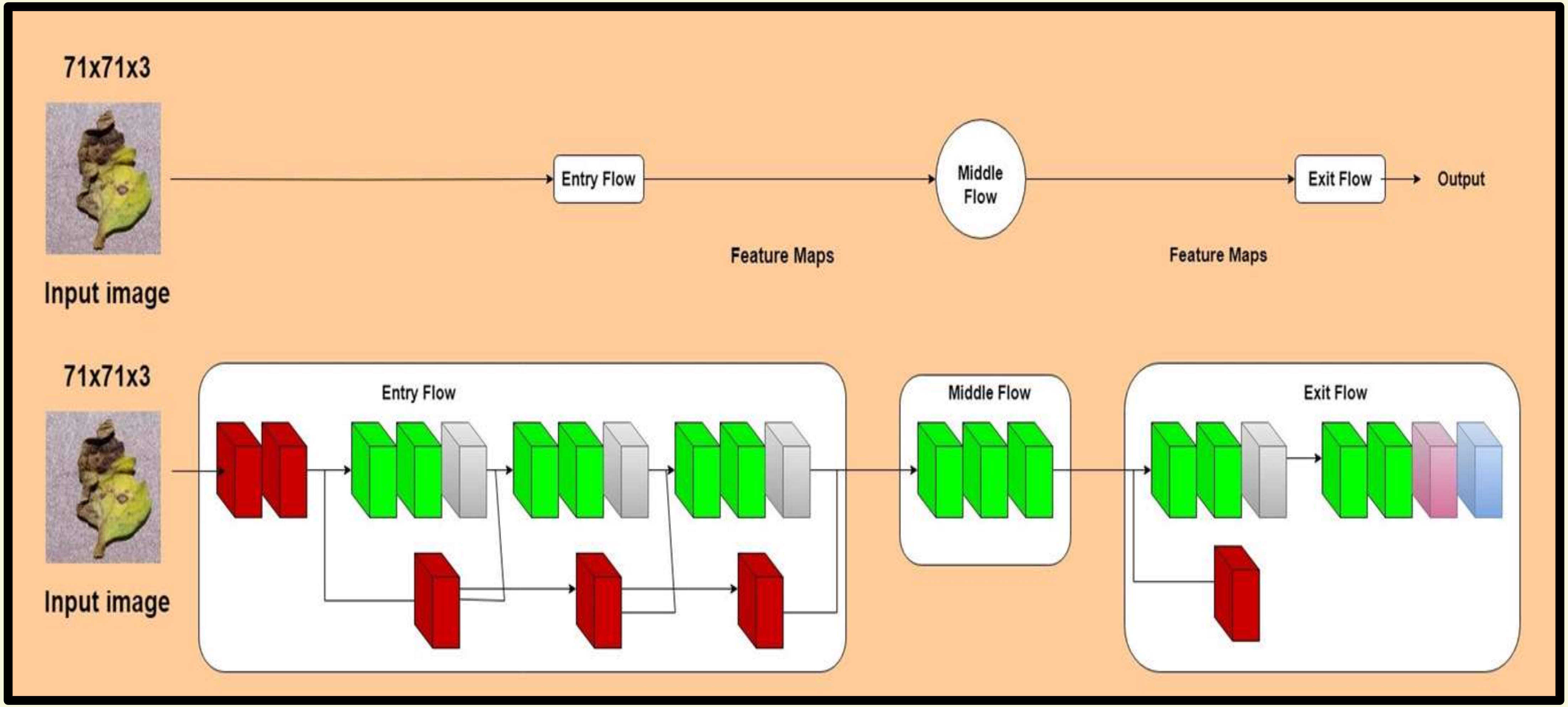


VGG-19



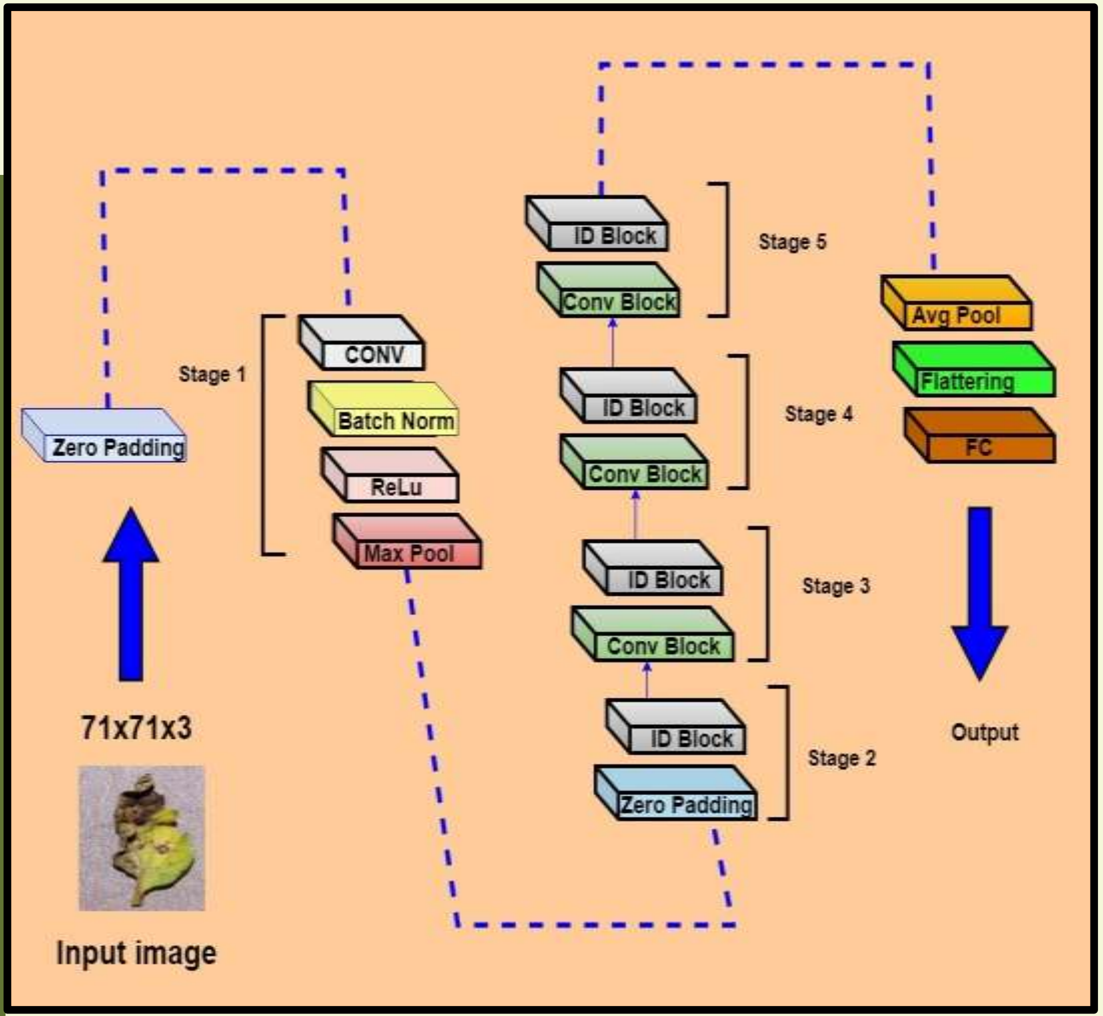
DESIGNS

Xception

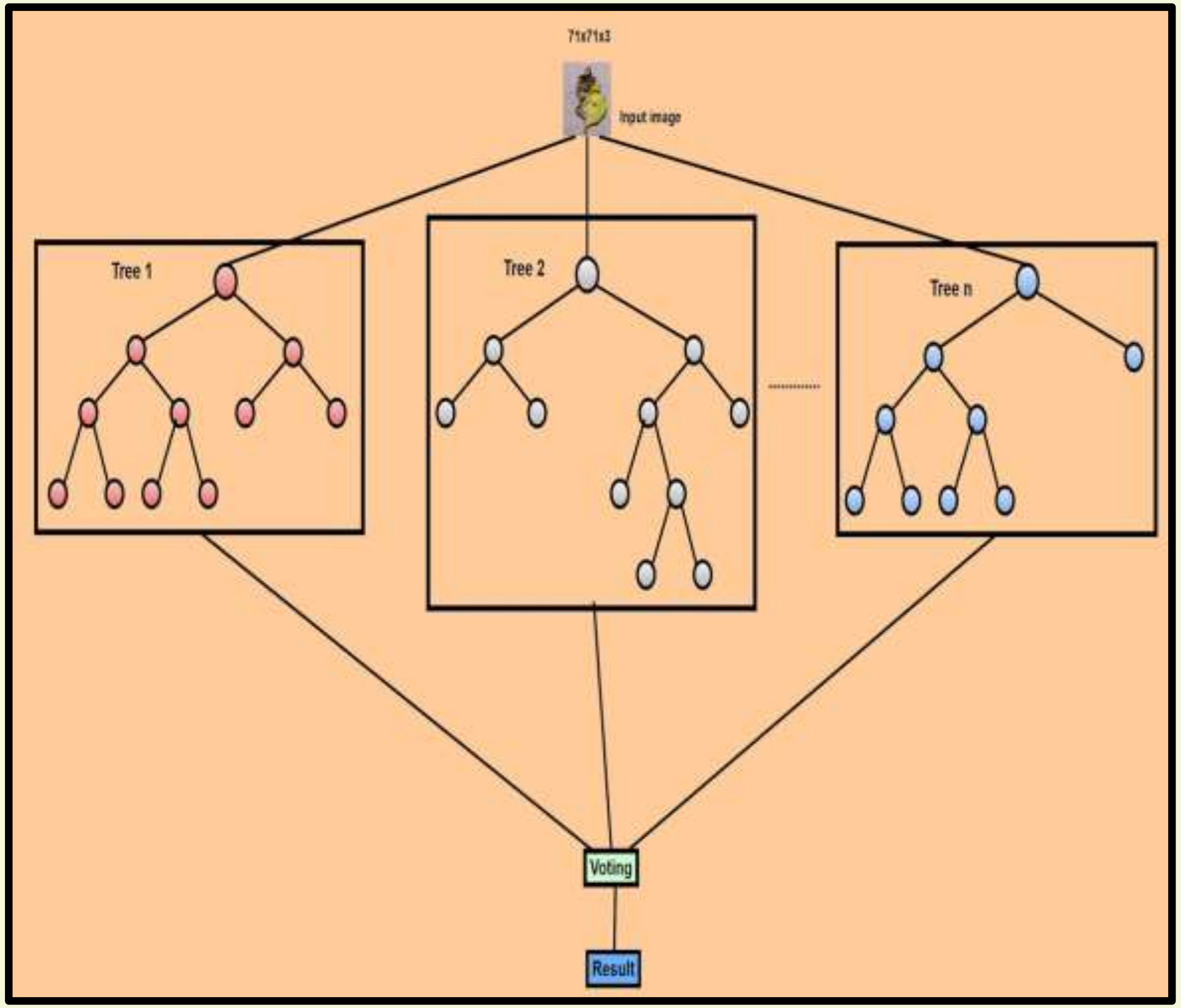


DESIGNS

ResNet-50

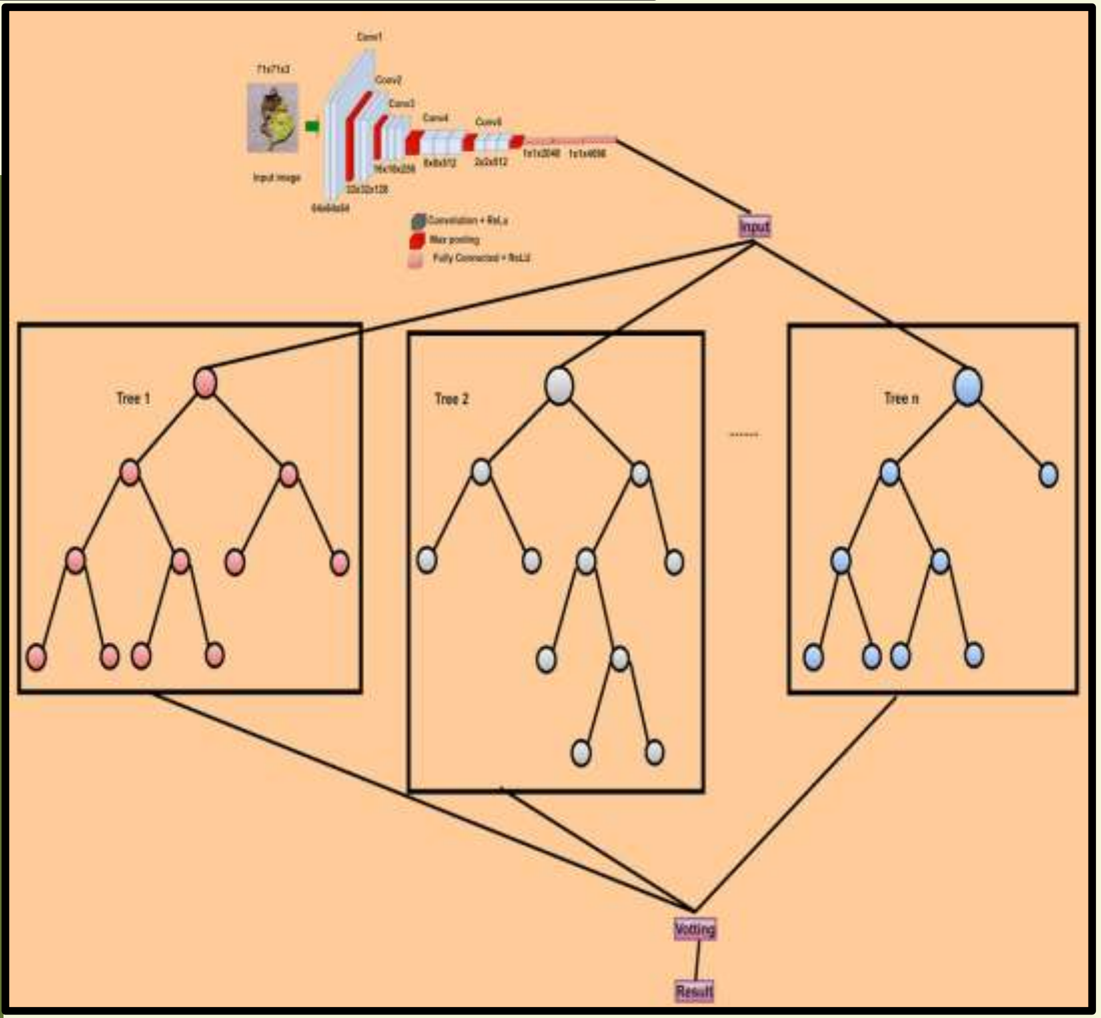


Random Forest

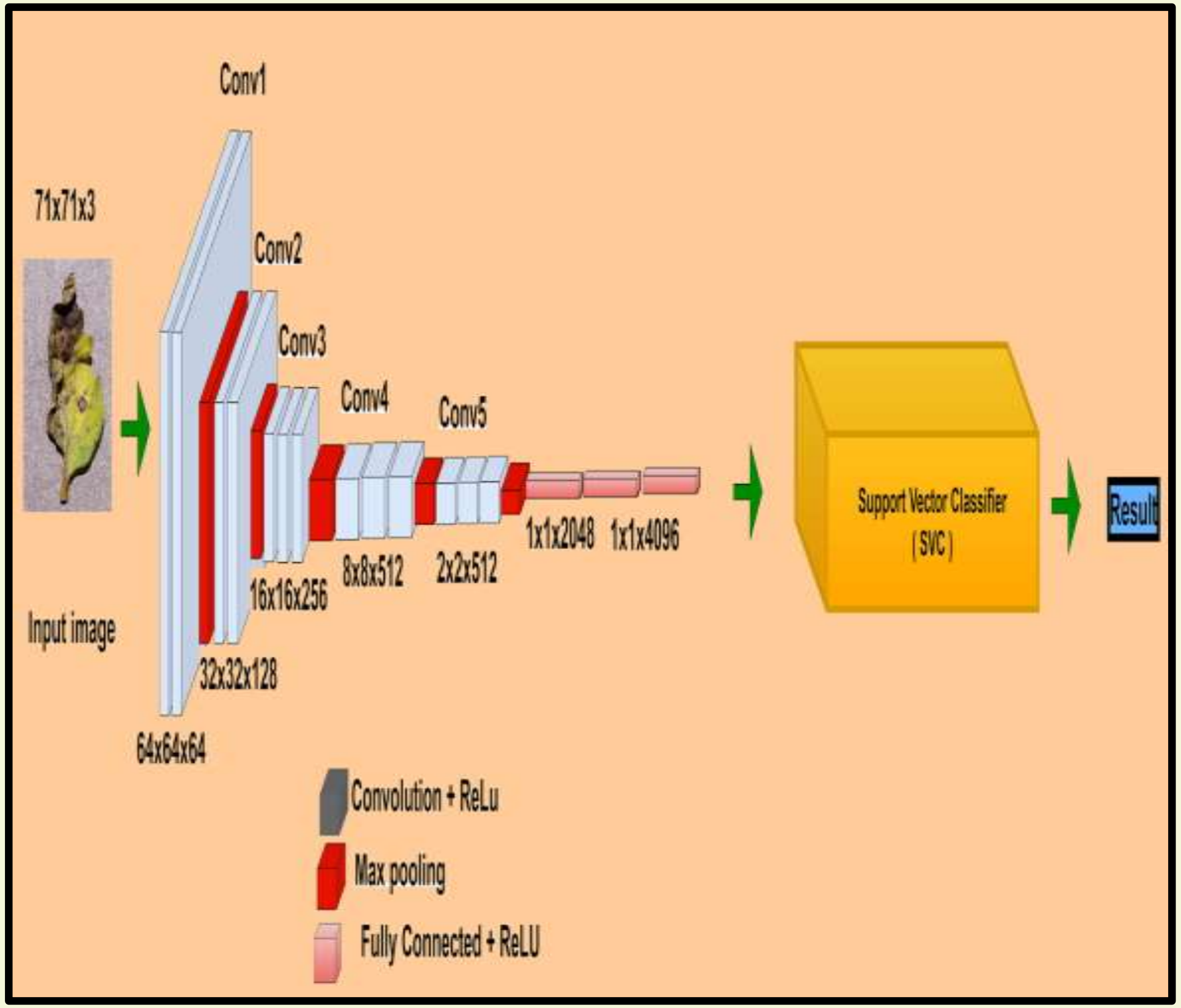


DESIGNS

VGG-16 and RF

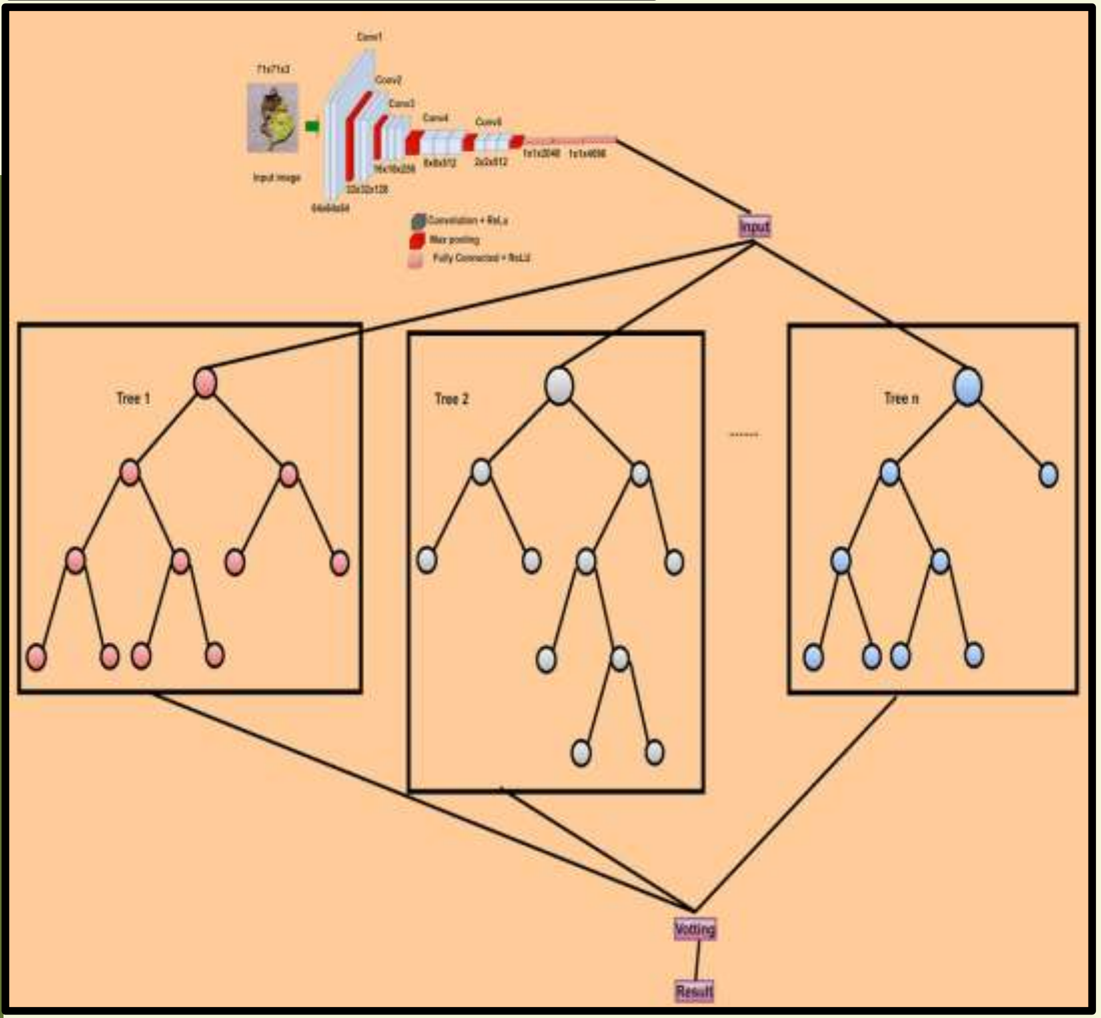


VGG-16 and SVC

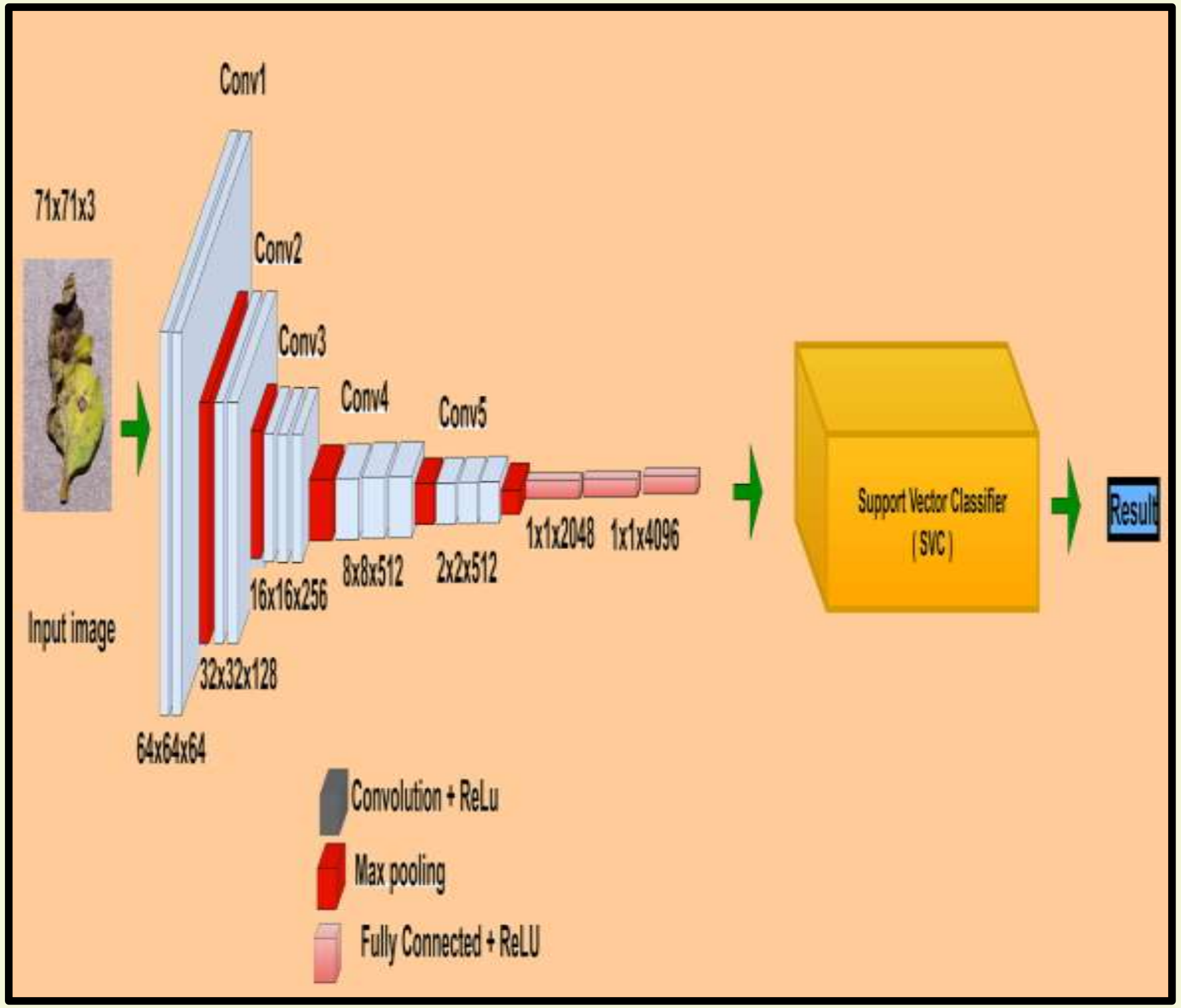


DESIGNS

VGG-16 and RF

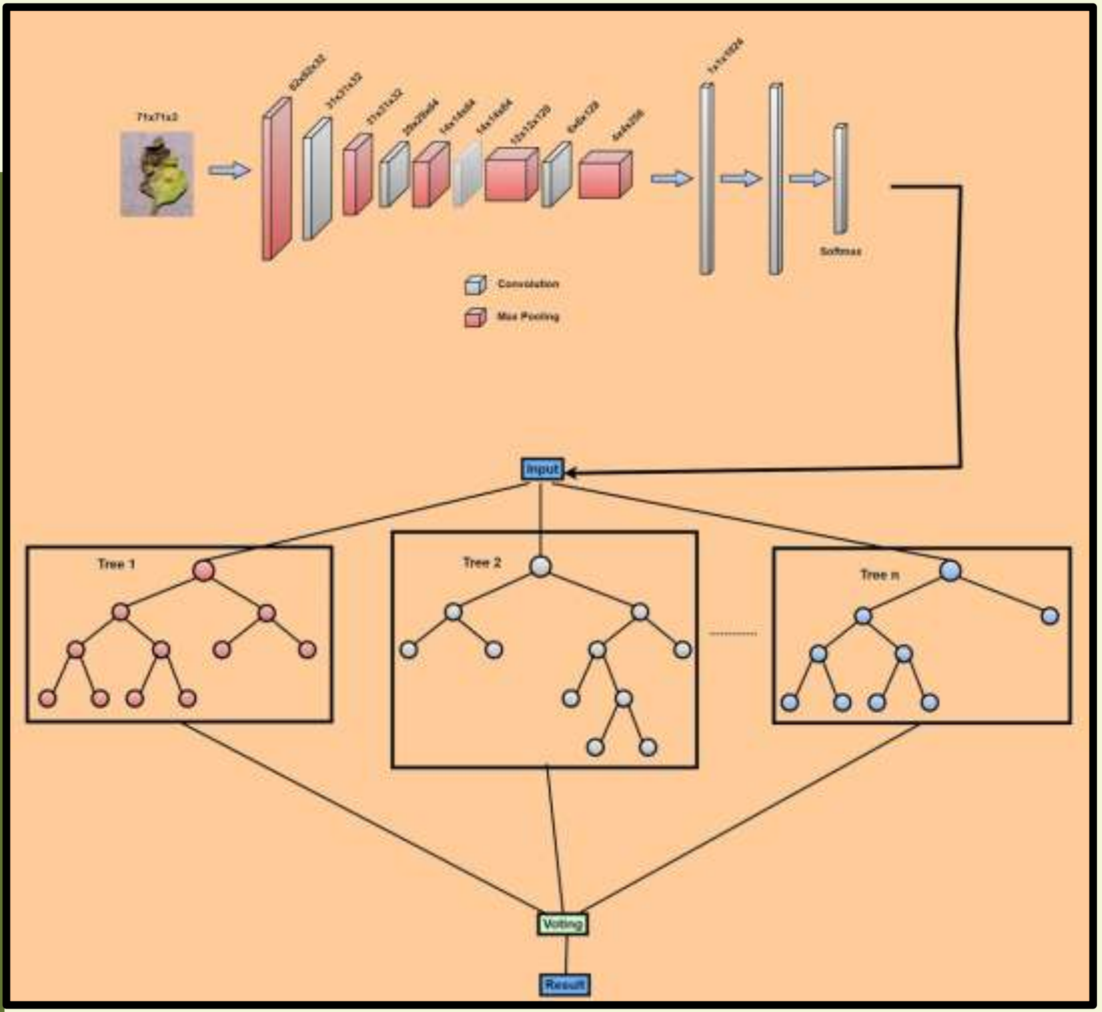


VGG-16 and SVC

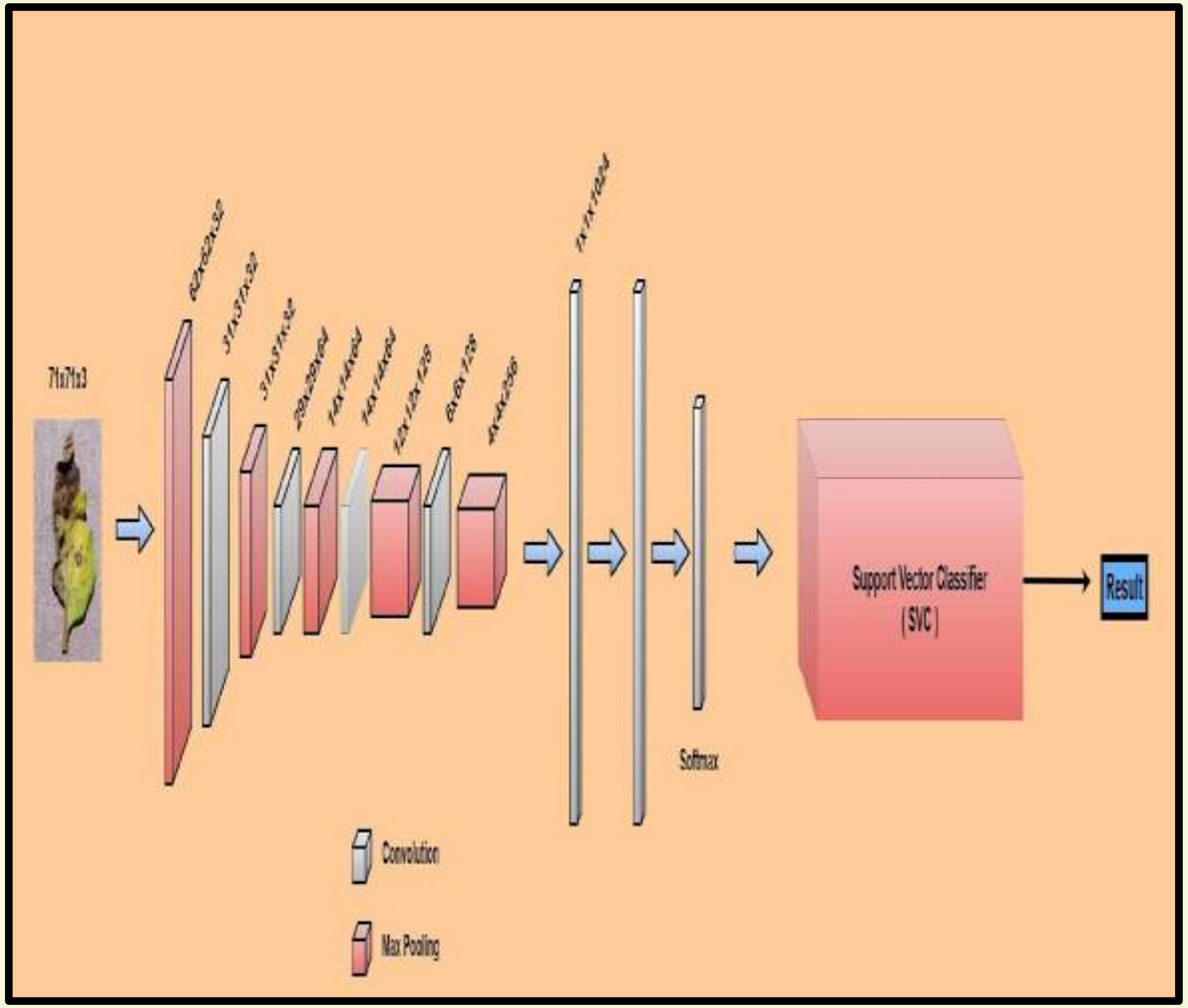


DESIGNS

VGG-19 and RF

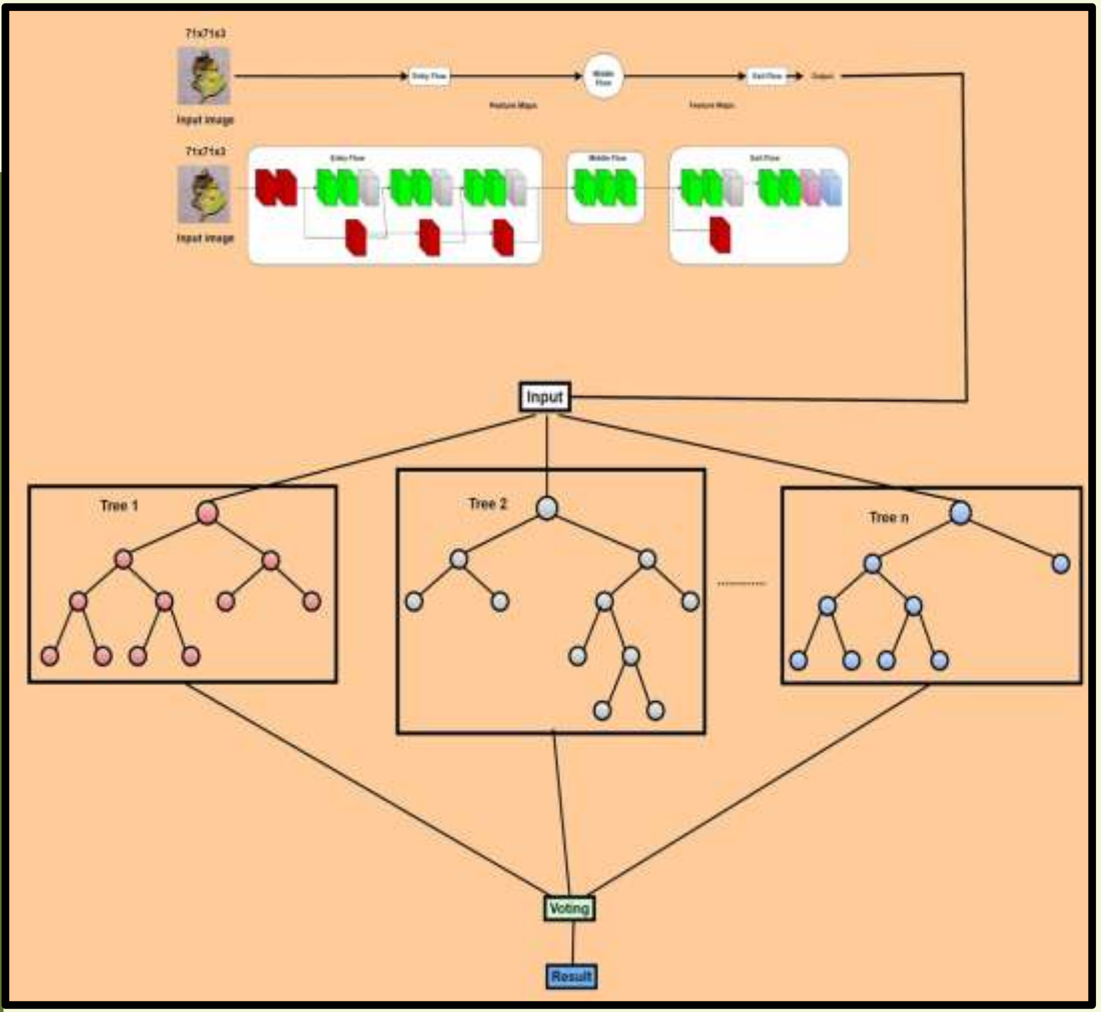


VGG-19 and SVC

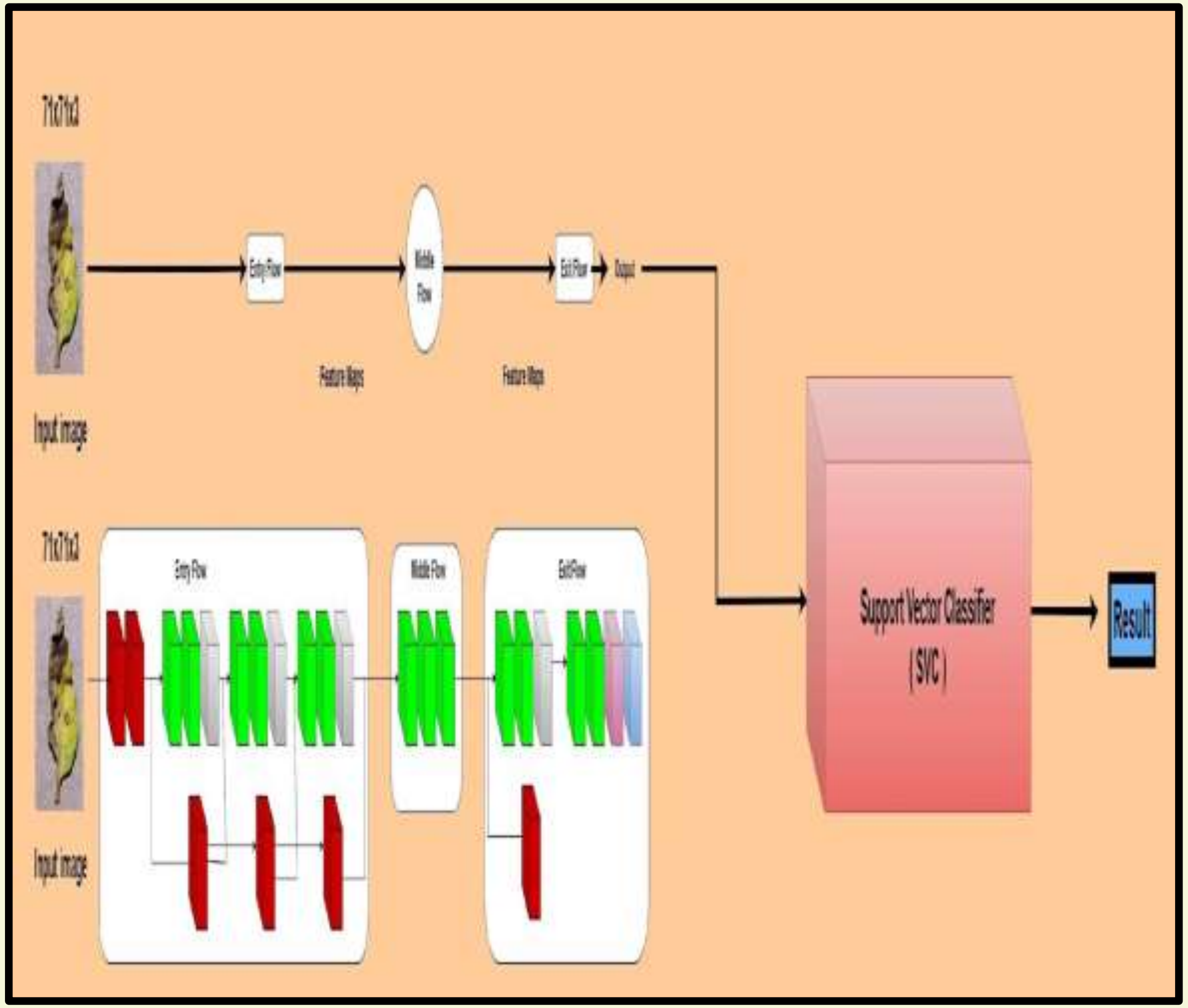


DESIGNS

Xception and RF



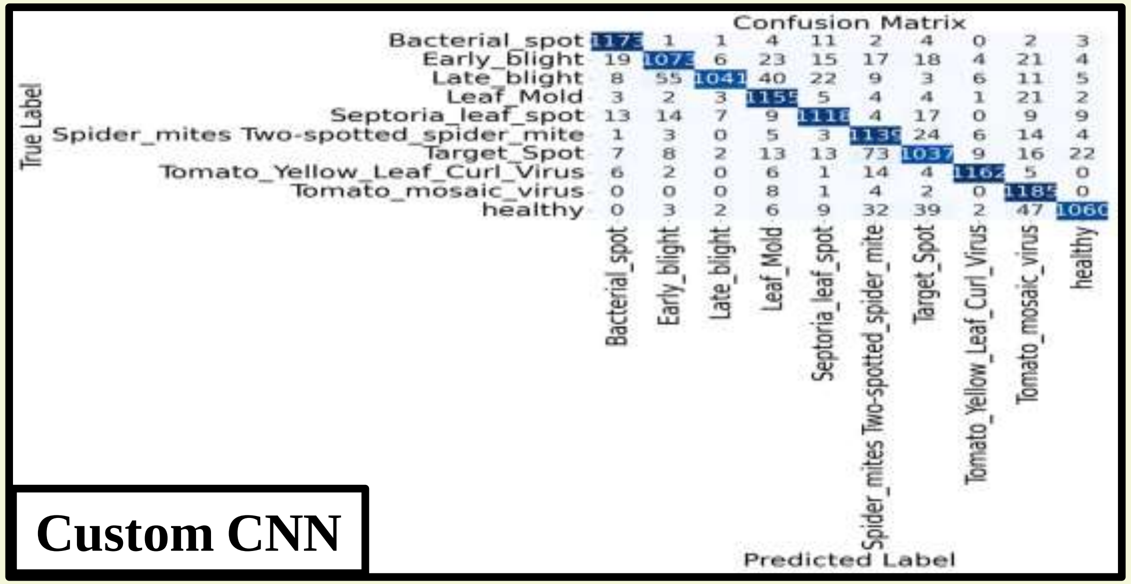
Xception and SVC



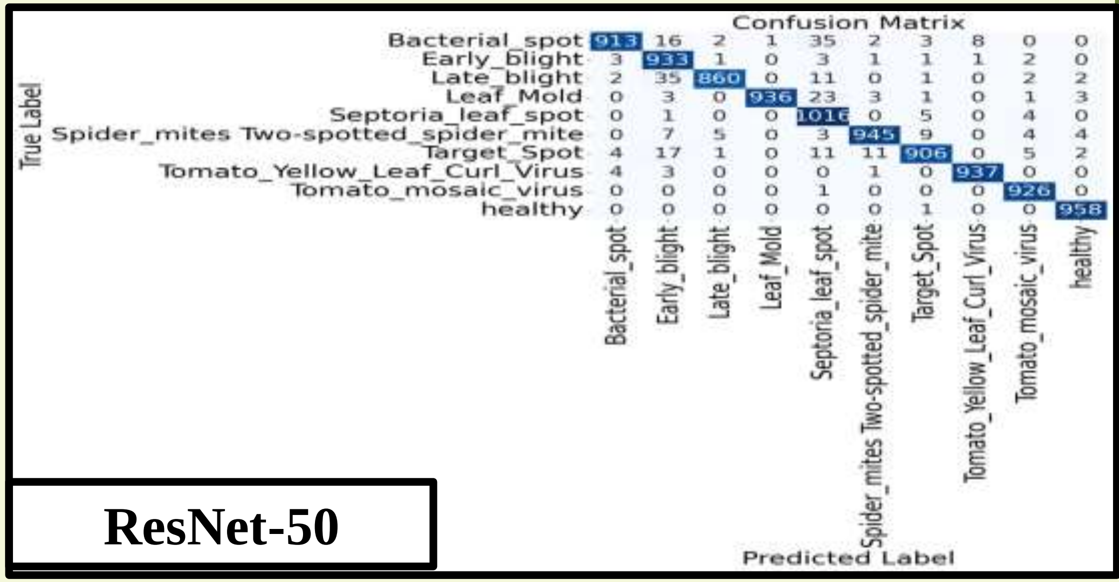
Obtained Results

Model Name	Avg. P (%)	Avg. R (%)	Avg. F1-Score (%)	Test Loss	Test Accuracy
Custom CNN	93	93	93	0.3096	93%
Xception	99	99	99	0.0045	99%
ResNet-50	97	97	97	0.0102	97%
Random Forest	61	61	61	0.3838	61%
Xception and Random Forest	58	58	58	0.4288	58%
VGG 16 and Random Forest	74	74	74	0.2245	74%
VGG 19 and Random Forest	74	74	74	0.2631	74%
VGG 16 and SVC	82	82	82	0.1799	82%
VGG 19 and SVC	82	82	82	0.1801	82%
Xception and	65	65	65	0.3304	65%

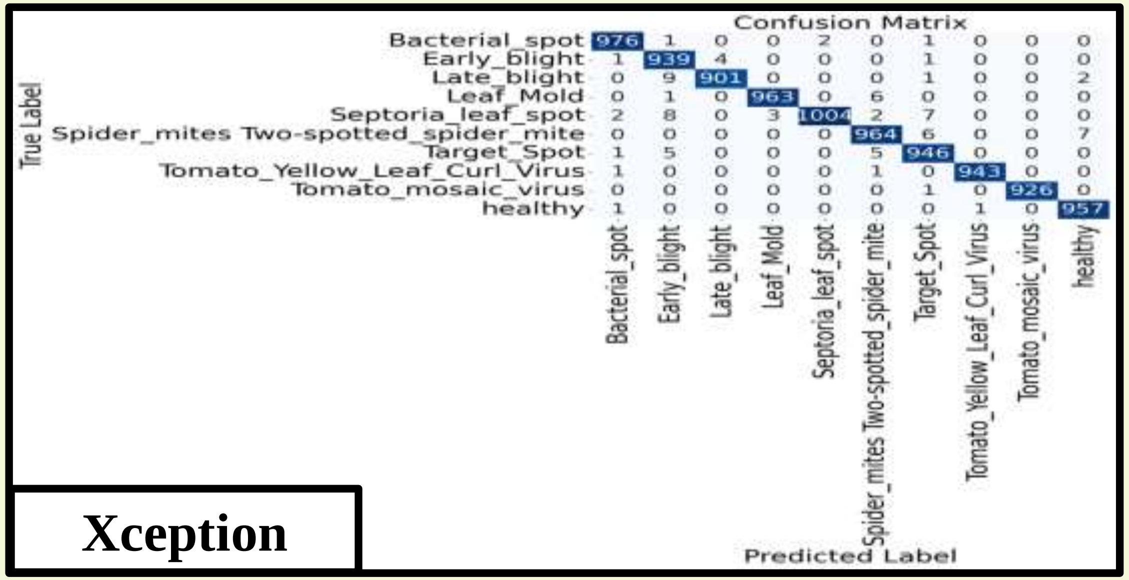
Result Analysis (Confusion Matrix)



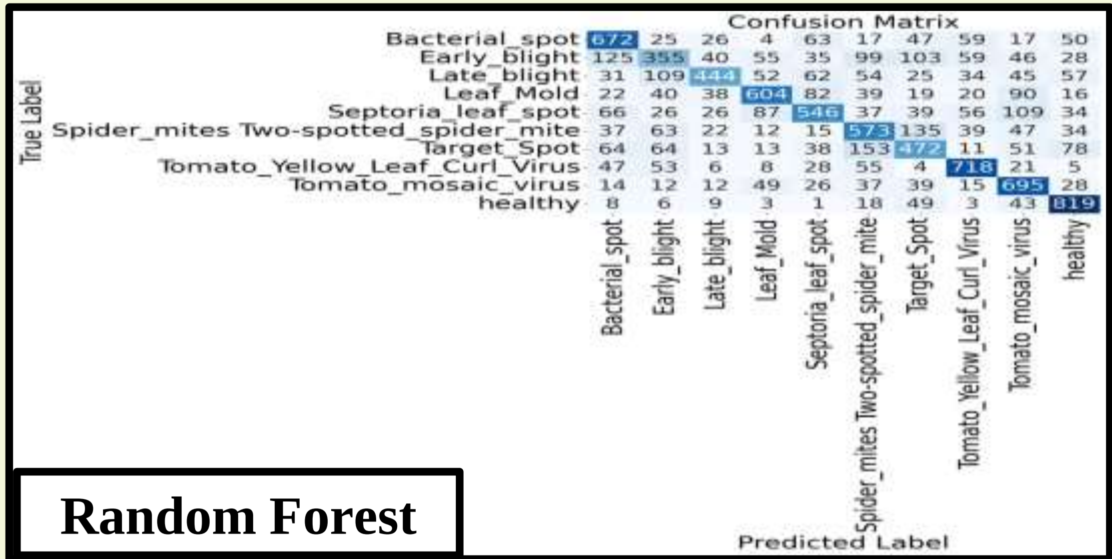
Custom CNN



ResNet-50

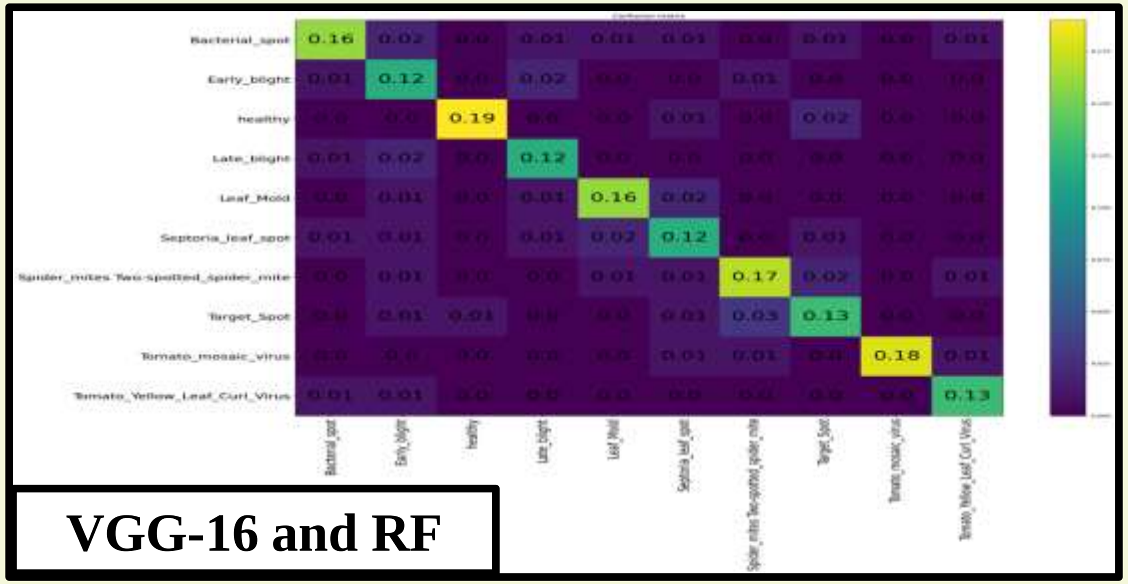


Xception

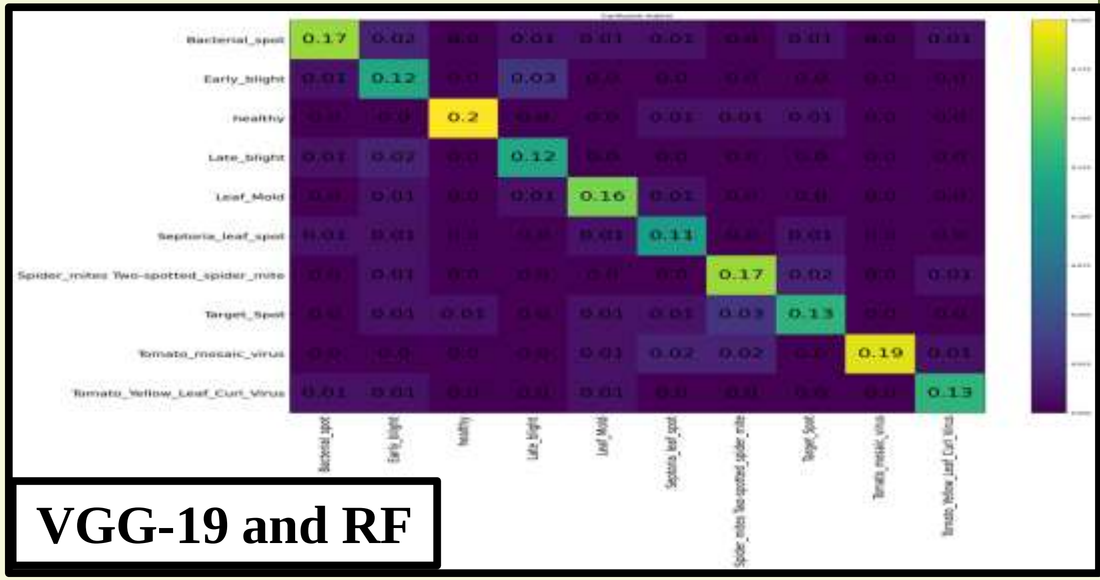


Random Forest

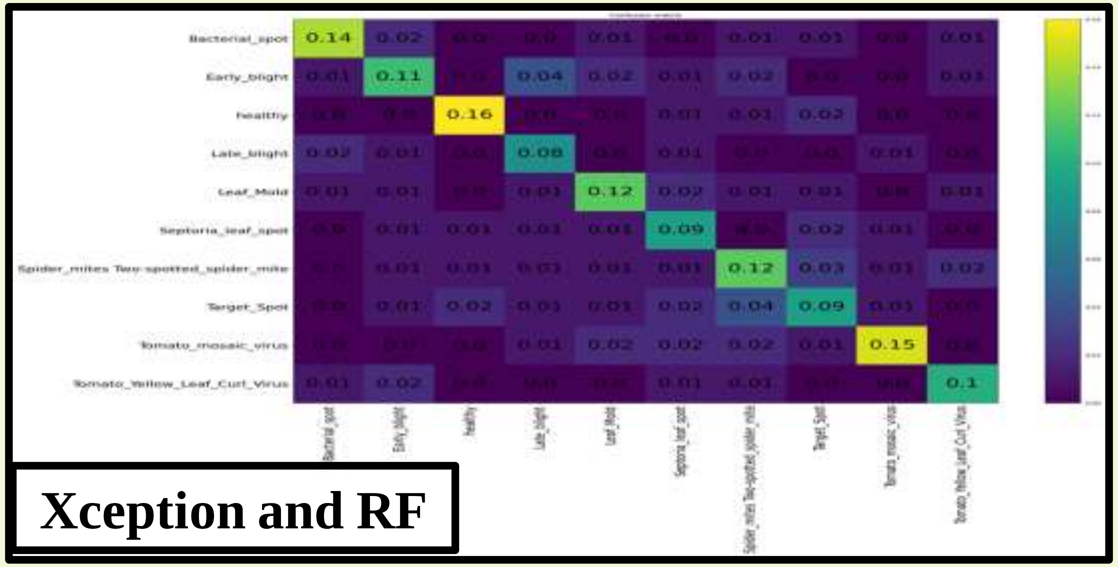
Result Analysis (Confusion Matrix)



VGG-16 and RF

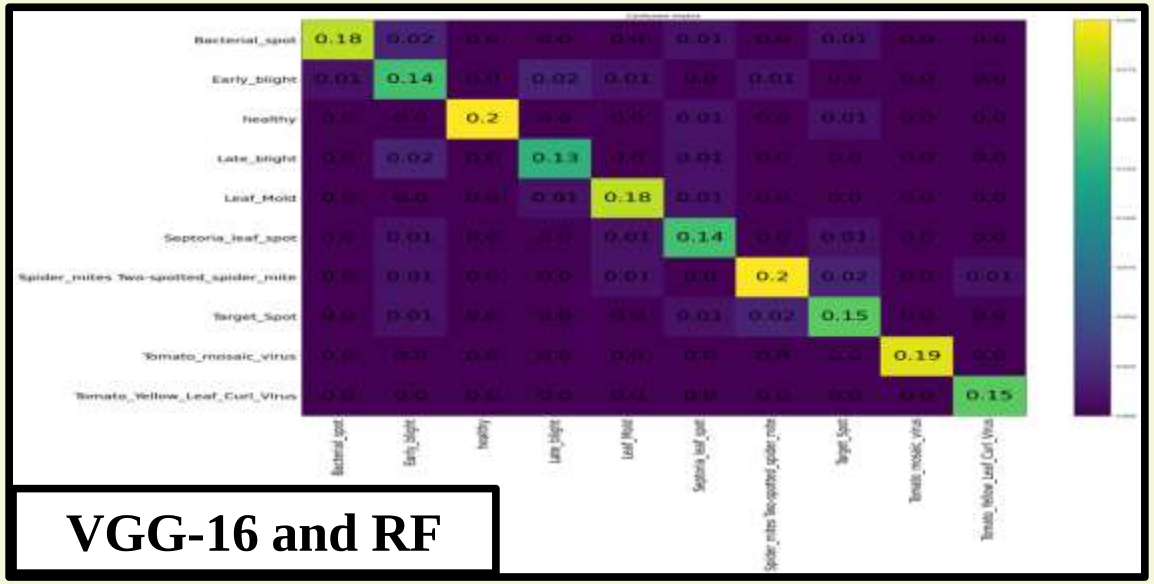


VGG-19 and RF

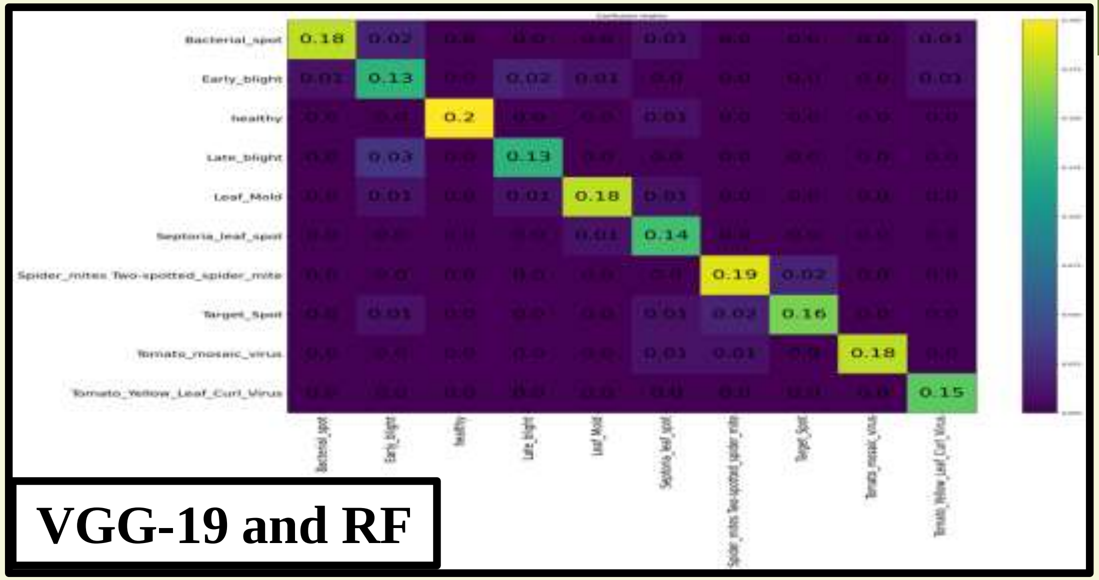


Xception and RF

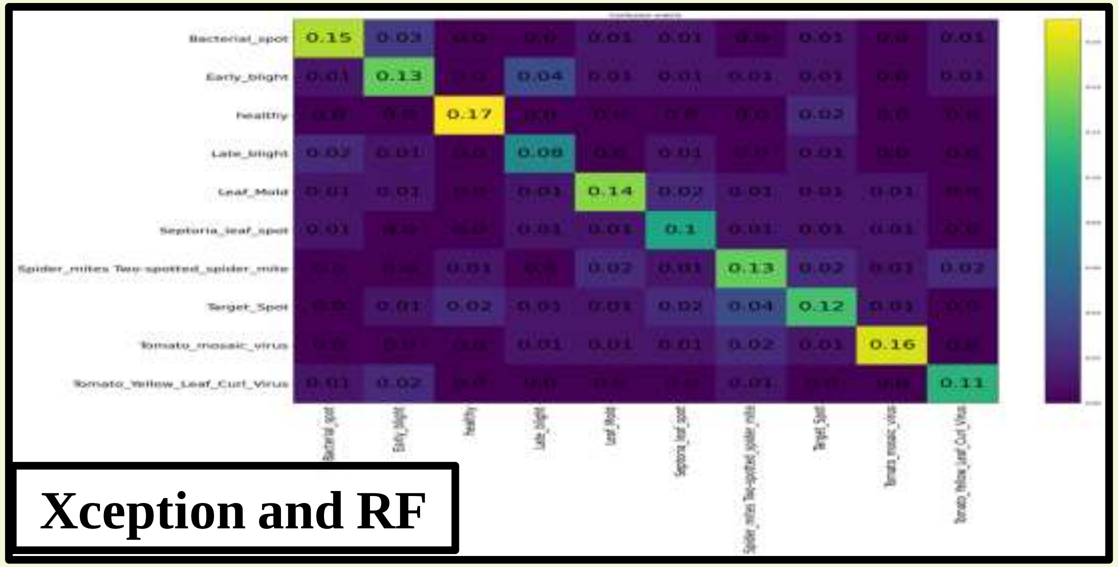
Result Analysis (Confusion Matrix)



VGG-16 and RF



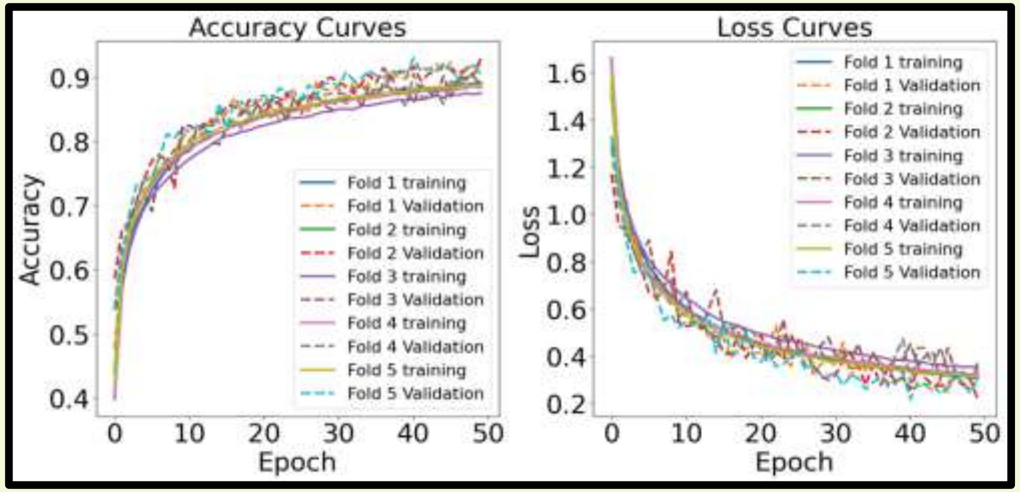
VGG-19 and RF



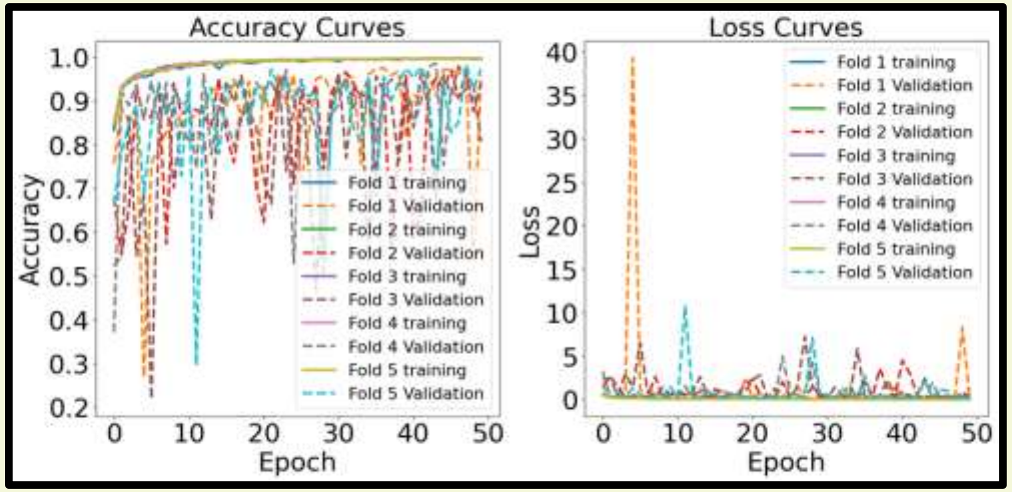
Xception and RF

Result Analysis (Accuracy and Loss)

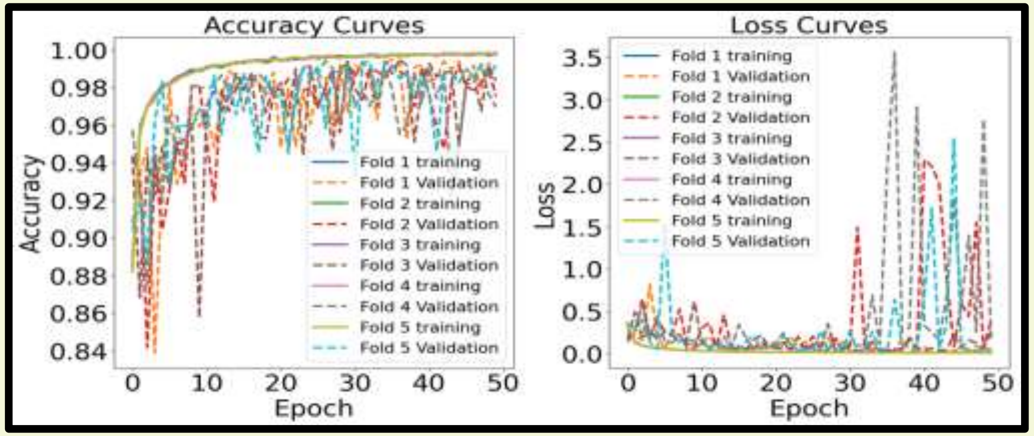
Custom CNN



ResNet-50



Xception



Cost Analysis

Here is a cost analysis calculation for automating tomato leaf disease classification using COCOMO:

Project size: 10,000 ESLOC

Project complexity: 3

Cost = K * E * (ESLOC)^F

where:

- K is a constant that depends on the development team experience
- E is a constant that depends on the project complexity
- ESLOC is the estimated source lines of code
- F is a constant that depends on the project complexity
- Sample calculation:

Using the following values:

- K = 2.8
- E = 3
- ESLOC = 10,000
- F = 1.12

The cost of the project can be calculated as follows:

Cost = 2.8 * 3 * (10,000) ^1.12 = $300,000

References

1. Agarwal, M., Singh, A., Arjaria, S., Sinha, A., & Gupta, S. (2020). ToLeD: Tomato leaf disease detection using convolution neural network. *Procedia Computer Science*, *167*, 293-301.
2. Ashok, S., Kishore, G., Rajesh, V., Suchitra, S., Sophia, S. G., & Pavithra, B. (2020, June). Tomato leaf disease detection using deep learning techniques. In *2020 5th International Conference on Communication and Electronics Systems (ICCES)* (pp. 979-983). IEEE.
3. Ahmad, I., Hamid, M., Yousaf, S., Shah, S. T., & Ahmad, M. O. (2020). Optimizing pretrained convolutional neural networks for tomato leaf disease detection. *Complexity*, *2020*, 1-6.
4. Kibriya, H., Rafique, R., Ahmad, W., & Adnan, S. M. (2021, January). Tomato leaf disease detection using convolution neural network. In *2021 International Bhurban Conference on Applied Sciences and Technologies (IBCAST)* (pp. 346-351). IEEE.
5. Tarek, H., Aly, H., Eisa, S., & Abul-Soud, M. (2022). Optimized deep learning algorithms for tomato leaf disease detection with hardware deployment. *Electronics*, *11*(1), 140.
6. Kaushik, M., Prakash, P., Ajay, R., & Veni, S. (2020, June). Tomato leaf disease detection using convolutional neural network with data augmentation. In *2020 5th International Conference on Communication and Electronics Systems (ICCES)* (pp. 1125-1132). IEEE.
7. Huang, X., Chen, A., Zhou, G., Zhang, X., Wang, J., Peng, N., ... & Jiang, C. (2023). Tomato leaf disease detection system based on FC-SNDPN. *Multimedia Tools and Applications*, *82*(2), 2121-2144.
8. Anandhakrishnan, T., & Jaisakthi, S. M. (2022). Deep Convolutional Neural Networks for image-based tomato leaf disease detection. *Sustainable Chemistry and Pharmacy*, *30*, 100793.

Appendix

CO	**Knowledge Profiles ,K**	**PO**	**Complex Engineering Problem , EP**
CO1 Integrate new and previously acquired knowledge for identifying a real-life complex engineering problem as the capstone project	K1: knowledge of plant diseases , images , light , rgb colors, pixels which falls in different natural sciences . K2: Mathematic and statistic for deep learning Concepts K3: System design and requirement engineering K4: IDE , Frameworks , Programming	PO1 Domain Knowledge	EP1: Through K3 and K4 EP2: for conflicting issues like training time vs dataset size EP3: Difficult and work in progress EP4: System requirements for understanding plant diseases and necessary pesticides , business idea are about of familiar domain . EP5: No standardized method is available for the plant disease recognition.

Appendix

CO	Knowledge Profiles ,K	PO	Complex Engineering Problem , EP
CO2 Examine various problem domains(literature review), define the problems, and formulate the objectives for the capstone project .	K8: Study of related paper for in depth problem Understanding and Solution mechanism	PO4 Investigation	EP1: Theory based knowledge of plant pathology and engineering EP6: Different User, farmer, agro-companies EP7: Project involves a number of interdependent components like plant disease recognition , pesticides recommendation.

Appendix

CO	Details	Knowledge Profiles, K	Engineering Problem, EP
CO3	Analyze various aspects of the objectives for designing a solution for the capstone project.	i) **Problem Analysis [K1, K2, K3, K4]** **K1:** Studying tomato leaf disease, identifying processes, policies, problems, and solutions. **K2:** Tomato leaf disease prediction requires different deep learning techniques and mathematics for processing tomato leaf data. **K3:** Project utilizes deep learning with different types of models for prediction of tomato leaf diseases. **K4:** Deep learning enhances security practice by utilizing various models for optimal output.	**(i) Problem Analysis [EP1, EP2, EP3, EP6, EP7]** **EP1:** Studying Bangladeshi tomato leaf diseases and gathering knowledge **EP2:** Some literature utilized structured and built-in functions. **EP3:** Analyze subject, topic, and solution for tomato plant disease prediction project using abstract reasoning and research. **EP6:** Interviewed plant scientists and disease researchers to study their systems, identifying requirements not found in reviewed papers, setting project objectives. **EP7:** Data processing challenges in predicting tomato leaf disease.

Appendix

CO	Details	Knowledge Profiles, K	Engineering Problem, EP
CO4	Design and develop solutions for the capstone project that meets public health and safety, cultural, societal, and environmental considerations .	**(i) Design and Implementation [K5]** **K5:** We acquired knowledge for predicting disease, data preprocessing, and deep learning models through analysis of YouTube videos and academic courses. We explored various approaches, including CNN and deep learning models, and designed a project for tomato leaf. Our project involved detecting diseases, data pre-processing, data augmentation, statistical analysis, and deep learning model prediction.	**(i) Design and Implementation [EP1, EP2, EP4, EP5, EP7]** **EP1:** Utilizing engineering knowledge at K3 through K8 levels, a fundamental-based analytical method is applied to predict tomato leaf disease index. **EP2:** Disease detection project utilized deep learning models and pre-processing, which were conflicting with engineering design. **EP4:** We made an effort to include issues that aren't commonly encountered in disease prediction. **EP5:** Our project aims to be understandable and maintain professional engineering standards for easy tomato leaf disease prediction. **EP7:** Preprocess and integrate data on tomato leaf disease over past three-4 years..

Appendix

CO	Details	Knowledge Profiles, K	Engineering Problem, EP
CO5	Identify and apply modern engineering and IT tools for the design and development of the capstone project	**(i) Materials and Devices [K6]** **K6:** Deep learning algorithms are needed for disease prediction in tomato leaf disease detection and risk assessment. Researchers have proposed algorithms and reviewed them, using Convolutional Neural Networks (CNN) and utilizing the latest tools. Teamwork and distributed workload are crucial.	**(i) Materials and Devices [EP1, EP2, EP4, EP5]** **EP1:** Utilizing engineering knowledge at K3 through K8, we develop a fundamental-based analytical method for disease prediction using our extensive skills. **EP2:** Tomato leaf disease prediction project utilized deep learning models and pre-processing, which were conflicting with engineering design. **EP4:** We made an effort to include issues that aren't commonly encountered in tomato leaf disease prediction. **EP5:** Our system aims to be user-friendly and maintain professional engineering standards, covering outside issues for easy disease prediction.

Appendix

CO	Details	Knowledge Profiles, K	Engineering Problem, EP
CO6	Assess and resolve social, health, safety, legal, and cultural issues associated to the capstone project's execution, taking into account applicable professional and engineering practices and solutions.	**(i) Social and Environmental Impact of Engineering [K7]** K7: Our project used sustainable technology without prohibited terms or software, ensuring social and environmental engineering benefits. We used accurate, trustworthy information with supporting documentation, ensuring a secure system for identifying tomato leaf illness. The system is safe for laboratory, testing, and experimental operations.	**(i) Social and Environmental Impact of Engineering [EP2, EP5, EP6]** **EP2:** Disease detection project utilized deep learning models and pre-processing, which were conflicting with engineering design. **EP5:** Our system aims to be user-friendly and maintain professional engineering standards, covering outside issues for easy disease prediction. **EP6:** Contacted plant experts to identify criteria not found in publications, focusing on specific specifications for the project's goal.

Appendix

CO	Details	Knowledge Profiles, K	Engineering Problem, EP
CO7	Environmental protection should be the top priority when starting any project, and our capstone project is in line with this principle. Since our program is computer-based, there is no risk of harmful substance release or negative environmental impact. All the tools and equipment required, including the camera, PC, and software, are not hazardous to the environment.	Our project is aimed at addressing a disease of tomato leaves. By providing a simple and efficient way to detect diseases, our system can help to save time and resources for healthy tomato leaves, simplify the process of identifying diseases for tomato leaf, and provide a reliable method for recovering the diseases.	**EP2: Range of conflicting requirements**: Farmers may not operate the website due to lack of familiarity with technology. **EP5: Extent of applicable codes:** We have taken steps to ensure data safety and integrity for the users. **EP6: Extent of stakeholder involvement and conflicting requirements:** The project has been developed in accordance with the requirements of the stakeholders.

Appendix

CO	Details	Knowledge Profiles,K	Engineering Problem,EP
CO8	Since our project required many tomato leaf photographs to train our model, we used two separate datasets. One dataset, consisting of 630 images of different tomato leaves in various lighting conditions, was manually collected by tomato leaf nursery and collected virtually from some reviewed papers and authentic websites. We made sure that the datasets contained both clear and fuzzy images of tomato leaves, and we took care to consider the ethical implications of our data collection.	Throughout the entire project, we have placed a strong emphasis on ethics and public safety. Our data collection process was carried out with the appropriate consent, and we have taken measures to ensure that our project has no negative impact on society.	EP2: Range of conflicting requirements: While implementing, we faced uncommon issues in obtaining the proper result. EP5: Extent of applicable codes: Modern tools have been used to develop this project. EP6: Extent of stakeholder involvement and conflicting requirements: Therefore, in this capstone project program, we aim to create a system that covers all types of users and allows them to save time and receive significant results.


Thank You!