TRIBHUVAN UNIVERSITY

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PASHCHIMANCHAL CAMPUS

A Major Project Proposal

On

“Maize-Medic: A Maize Disease Detection and Classification System using Convolutional Neural Network”

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ABSTRACT

Maize, or corn, is the second most cultivated crop both in Nepal and worldwide. It is a vital source of income and a way of life for many Nepali farmers, with production steadily increasing over the past decade. However, maximizing maize production and minimizing disease impact remains a challenge. Maize is susceptible to various diseases and fungi, which can significantly reduce productivity. Traditional methods for detecting and identifying maize leaf diseases early are often inefficient and suboptimal. Our project, Maize-Medic, aims to address this issue by developing a system to detect and categorize maize diseases and provide appropriate treatment and prevention recommendations. Utilizing a Deep Learning algorithm known as a Convolutional Neural Network(CNN), our solution allows farmers to use a simple smartphone equipped with a camera to take pictures of infected maize leaves. The system then analyzes the images to identify potential diseases and offers treatment suggestions like pesticides and recommendations to prevent disease spread and potentially recover affected crops. By providing immediate guidance, our project aims to provide a fast and accurate method for disease detection, as well as improve maize production and support the livelihoods of Nepali farmers.

Keywords: Maize, Disease, Deep Learning, Disease, CNN, Maize-Medic, Pesticides

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
ML	Machine Learning
DL	Deep Learning
GPU	Graphical Processing Unit
CNN	Convolutional Neural Network
SVM	Support Vector Machine
MAP	Mean Average Precision

CHAPTER 1: INTRODUCTION

1.1 Background

The ability of a machine to automatically learn from a set of data to identify, classify, predict, and analyze the data is known as Machine Learning(ML). Deep Learning(DL) is a subset of ML that teaches computers to process data in a way that is inspired by the human brain. ML and DL have their uses in many different fields, including agriculture. However, in the context of Nepal, such methods are seldom used on any large-scale projects involving agriculture. The use of machine/deep learning in crops for disease detection, identification, and classification can result in a huge impact on our country's food production. Maize is second to rice in terms of both area and production in Nepal. The detection and classification of maize diseases requires a lot of knowledge and often a late detection can cause major food wastage and loss. The knowledge for detection and prediction of diseases may not be present and accessible to every farmer. Machine learning and deep learning can help a lot to identify and diagnose maize diseases simply from the images of maize plants. Our goal for this project is to use deep learning models and image recognition algorithms to detect and categorize diseases with photos of infected leaves of the maize plant and then provide suggestions on how to contain and treat it with either traditional methods or modern chemical alternatives, as well as suggest prevention methods for the future. We can also use this information to generate a map with heat zones representing real-time outbreaks and alerting users in that region.

1.2 Problem Statement

Crop and plant diseases are among the leading causes of food scarcity and pose significant challenges in developing countries like Nepal. Maize is a staple crop in Nepal, and a disease outbreak can lead to substantial production losses and threaten farmers' livelihoods. Implementing an effective and accessible way of early disease identification, detection, and classification can greatly enhance food production and positively impact the economy. Although numerous studies have yielded valuable findings on crop diseases, farmers in developing countries like Nepal often have very limited access to this crucial information. Expanding access to these resources is essential for improving agricultural outcomes and supporting farmers.

1.3 Goals of Project

- To develop a web and mobile application for the detection and classification of maize leaf disease along with pesticide and insecticide suggestions

1.4 Application

The main applications of our projects are:

- Helps farmers detect maize diseases early, improving its production yield
- Provides a convenient tool for disease detection and early prevention by suggesting appropriate pesticides and insecticides
- Help farmers detect and classify various maize leaf diseases

1.5 Feasibility Study

A feasibility study for a project is an analysis of all the critical aspects of the project to determine its technical, operational, and economic viability. This study helps to analyze whether the proposed project is practically possible or not.

1.5.1 Technical Feasibility

We will be utilizing easily available and open-source tools for project development. Knowledge of Python, Machine Learning and Deep Learning is needed for the project, which can be learned through different learning platforms. ReactJS and React Native, two open-source Javascript Framework will be used for web and mobile app development respectively.

1.5.2 Operational Feasibility

As previously mentioned, maize is the second most consumed crop in Nepal and worldwide. This project aims to detect disease in maize leaves at an early stage, allowing for quicker action, which ultimately results in better crop yield. Consequently, higher production of maize reduces food shortage and directly addresses food scarcity.

1.5.3 Economic Feasibility

The investment for the development of the project is very low since we are using most of the tools that are open sources and freely available. We will use a publicly available dataset to train the model. Processing can be done using a CPU or GPU, either on our laptop or via Google Colab's free tier. We can also deploy the model on a server using a free cloud service.

CHAPTER 2: LITERATURE REVIEW

In recent years, plenty of have been conducted about the use of image processing using Machine Learning and Deep Learning models for the identification and detection of various plant diseases, including maize leaf diseases. Many studies have investigated the application of ML and DL methods for maize disease classification, along with their effectiveness.

Zhang et al. [1] classified various maize leaf diseases using Support Vector Machine (SVM) classifiers trained on a specialized dataset. The study found that the Radial Basis Function (RBF) kernel achieved the highest accuracy in classification tasks, with an average recognition rate of 89.6% for five selected disease categories. The Sigmoid kernel ranked second, with an average accuracy of 83.2%.

Bachhal et al. [2] proposed an automated maize leaf disease recognition system using a PRF-SVM model to address the challenges of detecting diseases in maize leaves under varying environmental conditions and lighting. The PRF-SVM model combines PSPNet, ResNet50, and Fuzzy Support Vector Machine (Fuzzy SVM). The model was evaluated on five different maize crop diseases along with healthy leaves, using the Plant Village dataset. The proposed method achieved an average accuracy of 96.67% and a mean Average Precision (mAP) value of 0.81, demonstrating its effectiveness in detecting and classifying various maize leaf diseases.

Masood et al. [3] proposed a Deep Learning model called MaizeNet for the localization and classification of various maize plant leaf diseases using deep learning techniques. The model is based on ResNet50 and uses the public dataset Corn Disease and Severity (CD&S) for training. It achieved an average accuracy of 97.89% and a mean Average Precision (mAP) value of 0.94. These results highlight the model's capability to accurately localize and categorize maize leaf diseases under challenging conditions, making it a promising tool for enhancing disease management and crop production.

Ahila Priyadharshini et al. [4] introduced a deep convolutional neural network (CNN)-based architecture for maize leaf disease classification, utilizing a modified LeNet model. This approach trained the CNNs on the PlantVillage dataset to identify four different classes: three disease classes and one healthy class. The model achieved an accuracy of 97.89%, underscoring the potential of deep learning methods in accurately classifying maize leaf diseases. The results from this study highlight the significant promise of CNN-based approaches in improving disease detection and management in agriculture, offering a robust solution for identifying plant diseases with high precision.

Wu [5] developed a two-channel Convolutional Neural Network (CNN) architecture based on VGG and ResNet for identifying maize leaf diseases. After constructing, preprocessing and testing on a custom maize leaf disease dataset, the study optimized the CNN's parameters, achieving an accuracy of 98.33% on the validation set. This performance surpassed the VGG model's 93.33% accuracy and outperformed the single AlexNet model.

Haque et al. [6], proposed a deep learning-based approach for identifying maize crop diseases. The study implemented three different architectures based on the Inception-v3 framework, trained on image data collected from fields from India. The noise was minimized by applying brightness enhancement techniques. Their Inception-v3 model achieved an accuracy of 95.99%. However, the computational time was increased due to the increased number of training parameters.

CHAPTER 3: METHODOLOGY

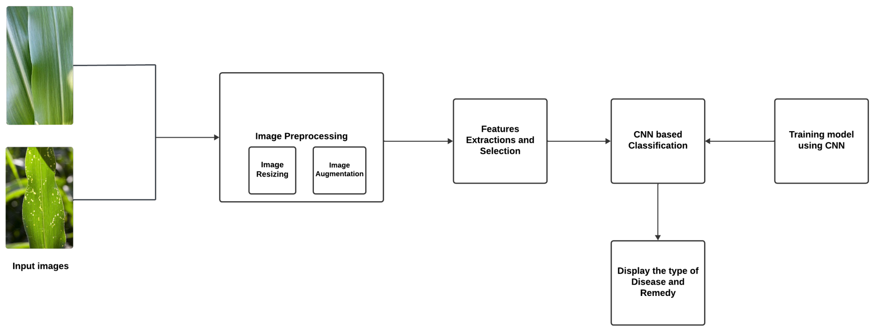

Figure 3.1: Methodology

3.1 Tools Used

This project will use the following libraries, frameworks, and tools.

- Jupyter Notebook
- Tensorflow or Pytorch
- Keras
- Scikit-Learn
- Numpy
- Pandas
- Matplotlib
- Seaborn
- Django
- ReactJS
- React Native
- Google Colab
- Python Imaging Library(PIL)

3.2 Data Collection

We will be using a publicly available dataset form Kaggle called Corn or Maize Leaf Disease Dataset [7] as the primary dataset for maize leaf disease classification. There are a total of 4 classes - Common Rust, Gray Leaf Spot, Northern Leaf Blight, and a healthy/normal plant class.

3.3 Data Preprocessing

Data preprocessing is a part of data analysis where data is prepared and processed into a format suitable for analysis or feeding it into predictive algorithms. It helps to transform raw data into a clean and consistent format understandable by ML and DL algorithms. Data preprocessing will impact the performance and reliability of our CNN model. The processes involved in data preprocessing for our image dataset are:

3.3.1 Image Resizing

In the dataset we are using, the images are of varying dimensions. The varying size and dimensions of the input will be un-inputtable in the CNN model. So, it is necessary to resize the input images to a consistent size before feeding them to the model, so that they can be processed uniformly.

3.3.2 Image Augmentation

Image data augmentation is the process of generating new transformed versions of images from the given image, to artificially increase the size and diversity of the dataset. We will apply transformations like rotations, horizontal flips, vertical flips, scaling, brightness adjustments, zooming, etc to generate more training samples and make the model more robust. This process helps to improve the ability of our model to generalize and thus perform more effectively on unseen images as well as different conditions.

3.4 Model Generation

We will be building our model based on CNN architecture because of its high accuracy and easy feature extraction from complex image patterns.

A Convolutional Neural Network (CNN) is a deep learning algorithm used for extracting key features and patterns from complex images. It is used for image classification and object detection. CNNs are highly accurate, relatively quick, and effective in detecting and extracting complex patterns and details. A CNN model takes an image as an input and assigns various parameters (weights and biases) to capture patterns in them.

The fundamental components of CNN are as follows:

3.4.1 Convolutional Layers

This is the layer that performs convolutional operations on the input images. In this layer, a set of learnable filters known as kernels are applied, resulting in a feature map. The filters/kernels are smaller matrices usually 2×2, 3×3, or 5×5 shape. Each filter is used to recognize different features or patterns in the image. This process extracts spatially local patterns or features, such as edges, textures, and shapes.

3.4.2 Activation Functions

Non-linear activation functions such as Rectified Linear Unit (ReLu), etc are applied after each convolution operation. This helps add non-linearity to the network which is required to learn complex and non-linear relationships between the features in the image data. It makes the network more robustfor identification.

3.4.3 Pooling Layers

Pooling layers help to reduce the spatial dimensions and size of the volume of the feature maps generated by the convolutional layers. They apply aggregate functions to reduce the spatial resolution while preserving the important features. These layers speed up the training process by preserving the most important features, reducing memory, and preventing overfitting. Following are the types of pooling layers:

- Max pooling
- Average pooling
- Sum pooling

3.4.4 Fully Connected Layers

These layers take the features extracted in the previous layers as input and integrate them together for mapping purposes. They are responsible for performing classification or regression tasks using the features extracted previously and mapping them to specific classes. They connect every neuron in one layer to every neuron in another layer, enabling the CNN to consider all features for classification.

3.5 Model Evaluation

We will evaluate our model using the validation datasets and evaluation metrics such as accuracy, precision, recall, and F1-score. Accuracy is the measure of the degree of correctness in classification, used to tell the percentage of correct predictions made by a model. We calculate it by dividing the number of correct predictions by the total number of predictions. Precision is the measure of the accuracy of the correct prediction made by a model. It is the ratio of correctly predicted positive observations to the total predicted positives. Recall measures the ability of the model to identify all relevant instances. It is the ratio of correctly predicted positive observations to all observations in the actual class. F1 is the harmonic mean of precision and recall. F1 takes both precision and recall into account.

3.6 Experimentation Tracking

MLFlow will be utilized to track all parameters, metrics, and models throughout the experimentation process. The logs of the various experiments and their corresponding results can provide us with a deeper understanding of how changes to the model, hyperparameters, and data influence its performance.

3.7 Model Deployment

The trained model will be integrated into a web and mobile application for real-time maize disease detection and classification.

CHAPTER 4: DEVELOPMENT AND SOFTWARE REQUIREMENTS

4.1 Development Environment

- VSCode
- Google Collab
- Jupyter Notebook

4.2 Programming Language

- **Python:** For analyzing, processing data, and synthesizing model
- **JavaScript:** For building a user interface for uploading and classifying images.
- **Django:** For the backend

4.3 Hardware and Software Configuration

We will utilize Google Colab for heavy computational work like training our CNN model efficiently. Python with Jupyter Notebook with essential libraries will be used locally, integrated with Google Colab.

4.4 Description of the Proposed System

Our proposed system aims to provide an efficient tool for detecting and classifying maize diseases. The system utilizes a Convolutional Neural Network (CNN) to detect and classify maize leaf images as diseased or healthy. It should be able to collect and preprocess a diverse dataset of maize leaf images and train a CNN model for image classification. Users can easily upload photos and receive disease diagnoses and remedies through our user-friendly mobile application.

CHAPTER 5: EPILOGUE

5.1 Gantt Chart

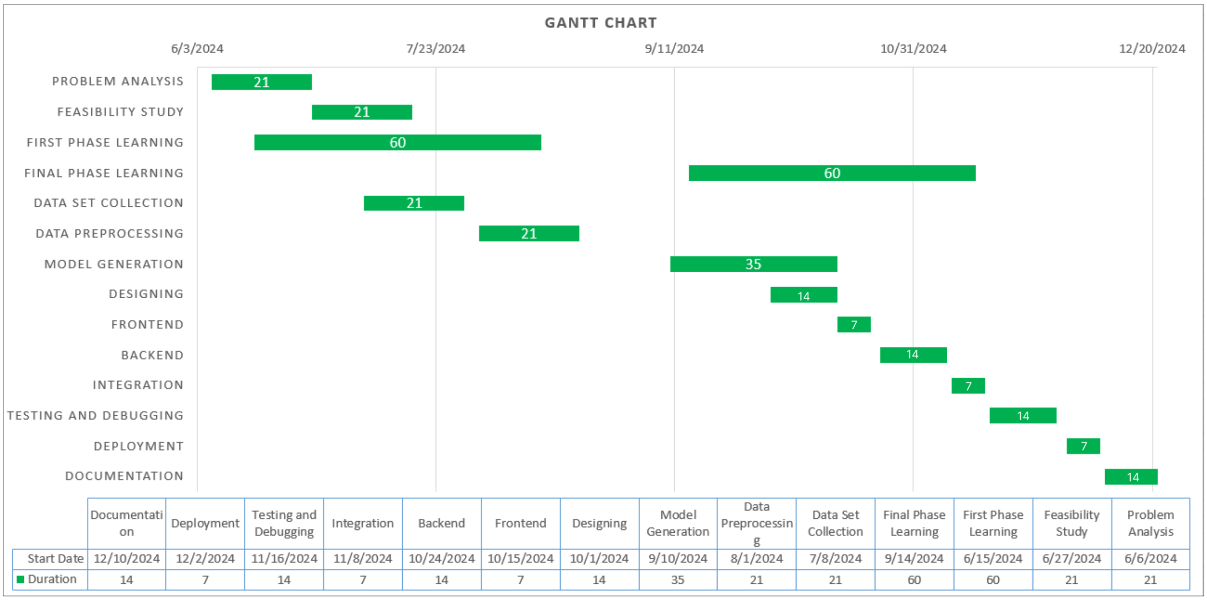

Figure 5.1: Gantt Chart

5.2 Estimated Cost

The estimated cost for the preparation of this project may include the following:

- GPU: NRs. 100000
- Dataset collection and Validation: NRs. 40000
- Deployment: NRs. 50000

CHAPTER 6: EXPECTED OUTPUT

In the end, we expect to build a mobile application that will identify and correctly categorize maize diseases based on a photo. The application will also suggest the appropriate remedies and treatment methods (pesticides, fungicides, etc.) as well as preventive measures to contain and prevent spread and outbreak.

CHAPTER 7: CONCLUSION

Maize is one of the most important crops that contributes significantly to the country's economy in several ways. However, various diseases can severely impact maize crop production. This project, through its systematic approach and utilization of Convolution Neural Networks(CNNs), demonstrates a clear pathway for the detection of disease in maize crops. To train our model, we used a variety of available datasets, ensuring a comprehensive foundation for our detection system. Our proposed approach is capable of the detection and classification of maize crop diseases. The implementation of the solution in a web app environment makes it accessible for end-users including farmers and soon. We conducted certain tests to assess the performance of our CNN model confirming its reliability and effectiveness that aid in the early detection and management of diseases.

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