AI-Driven Leaf Disease Detection Using Computer Vision for Enhancing Computational Thinking Skills

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Abstract—**Today, Artificial Intelligence (AI) technologies receive widespread adoption yet students in their beginning educational years encounter limited opportunities to work with these systems. The research demonstrates a basic leaf disease detection system which uses computer vision technology to enhance users' computational thinking abilities. The system performs plant leaf image analysis through initial processes which include resizing and removing unwanted elements.**
The researchers employ a Convolutional Neural Network (CNN) to determine whether the leaf exists in a healthy state or a diseased condition. The project demonstrates to students how real-world problems receive solutions through the application of AI techniques. The program enables users to develop skills in logical reasoning and pattern identification and both methods of solving problems and sequential thinking. The system demonstrates its ability to accurately identify plant diseases while serving as an effective tool for conducting basic plant health assessments. The research links academic knowledge to real-world usage while providing students with an accessible method to grasp artificial intelligence principles.

Index Terms—**Artificial Intelligence, Computer Vision, Leaf Disease Detection, CNN, Computational Thinking.**

I. INTRODUCTION

The last few years have seen Artificial Intelligence (AI) emerge as an essential component of multiple technologies which people utilize throughout their daily activities. The widespread adoption of AI technology creates challenges for students because they learn about its concepts during advanced academic studies which makes initial comprehension difficult. Research shows that agriculture remains vital for the economy while plant diseases create major agricultural losses because they need to be detected before they destroy crops.

Farmers used to examine plant leaves by hand to discover disease indicators, but this approach required too much time and produced unpredictable results. Machines now use computer vision technology to analyze images and detect patterns with higher accuracy than before. Scientists developed an automated system which uses image analysis methods to identify leaf disease outbreaks.
This project develops a system which uses deep learning techniques to identify plant leaf diseases through image analysis. The system follows simple steps such as image collection, preprocessing, and classification to give results about the health of the leaf.

The project achieves two objectives because it addresses a real-world challenge while it promotes better computational thinking abilities. The students who work on this system will acquire skills which enable them to divide complex problems into smaller parts while using logical thinking to create detailed solutions. Students use these abilities to comprehend how artificial intelligence functions in actual business environments.

The project goal requires students to learn through practical activities which enable them to practice AI skills while solving an important real-world problem.

II. RELATED WORK

Many researchers have worked on detecting plant leaf diseases using image processing and artificial intelligence techniques. In earlier studies, researchers used traditional machine learning methods which included Support Vector Machines (SVM) and Random Forest for classification purposes. The methods needed operators to extract features manually because they required extraction of color and texture and shape elements which resulted in slow operation and reduced accuracy levels.

Deep learning development through Convolutional Neural Network (CNN) technology has produced substantial enhancements for leaf disease detection systems. CNN models can automatically learn features from images because they eliminate the requirement of human labor. Several studies have shown that CNN-based approaches provide better accuracy compared to traditional methods.

Some research works have applied different CNN architectures such as AlexNet, ResNet, and EfficientNet to classify plant diseases. These models have achieved high accuracy levels, in some cases above 95%, which demonstrates their ability to perform real-world tasks.

Other studies have also focused on improving model performance by using techniques like data augmentation, preprocessing, and transfer learning. The methods enable researchers to manage small data collections while they enhance system performance across multiple scenarios. The research community uses publicly available datasets like PlantVillage to train their models and assess their performance during testing. The latest research studies deep learning techniques which combine with mobile technology to enable farmers to detect diseases through real-time systems which provide practical benefits.

III. METHODOLOGY

The system uses a systematic approach to identify plant leaf diseases through the application of image processing and deep learning methods. The first step involves gathering a collection of leaf images which contains both healthy leaf samples and diseased leaf samples. The images may be obtained from both public data sources and original data creation. The dataset quality and dataset diversity determine how well the model performs in its tasks.

The next step involves preparing the collected images through preprocessing methods which enhance their suitability for analysis. The process involves three primary actions which include resizing images to a standard size and eliminating all unwanted elements and establishing uniformity in pixel brightness across the images. Preprocessing improves image quality while providing uniformity during model training processes. The images go to a Convolutional Neural Network (CNN) model after the preprocessing stage. The CNN system automatically identifies essential characteristics which include color distribution and surface details and object forms within the leaf images.

The system uses these characteristics to divide the images into two groups which represent healthy plants and diseased plants. The model undergoes training with labeled data which contains images linked to their respective classes. The model develops skills to recognize different disease patterns during its training process. The model undergoes evaluation after its development through testing with new images to assess its operational capabilities and precise results. The system generates output through its two functions which include diagnosing leaf image diseases and determining whether the leaf exists in a healthy state. The results can be displayed through a simple interface, making it easy for users to understand.

This methodology helps students learn disease detection while developing their computational thinking abilities through its requirement of students to follow logical procedures and break down problems and analyze problems in a structured manner.

1: Data Collection

Researchers collect leaf images from dependable sources which include PlantVillage and other dataset repositories. The dataset includes both healthy and diseased plant leaves to ensure proper learning.

2: Data Preprocessing

The collected images undergo analysis preparation through execution of these procedures.

- All images will be resized to a standard dimension.
- Noise elements will be eliminated to improve the visual clarity of the image.
- The pixel values will be adjusted to a standard range.

This process establishes uniformity which leads to better results in model functioning.

3: Dataset Splitting
The dataset is divided into two parts:
• Training Set – used to train the model
• Testing Set – used to evaluate model performance

4: Model Selection
The research team selected a Convolutional Neural Network (CNN) model because it provides strong performance for image classification research.

5: Feature Extraction
The CNN system extracts essential image features which include:
• Color patterns
• Texture details
• Shape characteristics

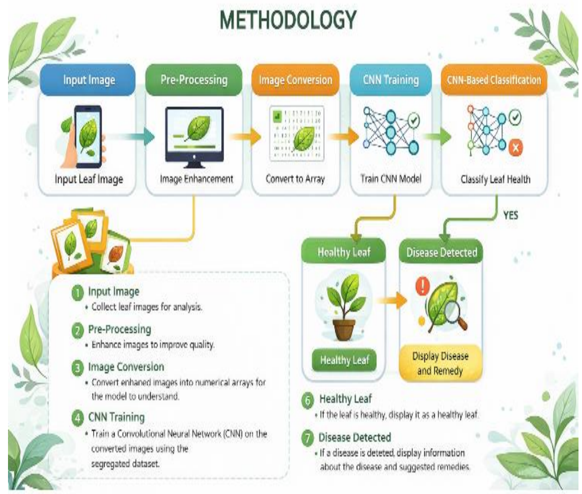
6: Model Training
The model uses the training dataset for its training process. The CNN system learns to identify different leaf disease patterns during this stage of training.

7: Model Testing
The trained model undergoes testing with new images from the testing dataset to determine its accuracy and performance capabilities.

8: Prediction
The model processes a new leaf image which serves as input. The system predicts whether the leaf is:
• Healthy
• Diseased (and identifies the specific disease type)

9: Result Display
The prediction result is displayed through a user-friendly interface such as a GUI or web application which enables users to easily comprehend the results.

10: Skill Development Aspect
The project enables students to develop computational thinking skills because it teaches them:
• Logical reasoning
• Problem-solving ability
•Step-by-step analytical thinking



COURSE CONTEXT
People working in various industries today use Artificial Intelligence (AI) as a crucial element of their work in the current digital environment. Academic programs present AI concepts to students at advanced levels which leads to students suffering from inadequate operational abilities because they lack practical experience of actual work. People require educational programs which deliver basic artificial intelligence knowledge through practical teaching methods to learn about AI throughout their initial educational period.

The agricultural industry serves as a fundamental sector which benefits from technological advancements that bring substantial benefits. The agricultural sector encounters a widespread problem because farmers rely on manual processes to identify plant diseases at their initial stages which frequently results in identification mistakes. Students acquire practical knowledge through AI applications when they study real-world cases such as leaf disease detection.

This course provides students with an opportunity to learn computer vision and deep learning through a practical project which combines both fields. Students obtain practical experience because they will apply real-world data to develop predictive models which demonstrate the prediction process. The course provides students with practical experience through active learning since it emphasizes learning through implementation instead of theoretical study.

The project-based approach helps students develop computational thinking skills through three essential activities which include problem decomposition and pattern recognition and systematic solution development. Students obtain essential skills which establish their base knowledge before they proceed to examine advanced AI subjects.

The course demonstrates that teaching artificial intelligence together with actual work applications helps students learn better because they find the material more enjoyable and their understanding of the subject matter improves.

COURSE DESCRIPTION

The course teaches students basic Artificial Intelligence principles together with computer vision fundamentals through practical exercises and real-world applications. The project develops an AI-powered system which uses image processing and deep learning methods to identify plant leaf diseases. The course teaches students how to apply theoretical knowledge for solving actual problems.

Students will learn the basic concepts of image preprocessing, feature extraction, and classification using models such as Convolutional Neural Networks (CNNs).

The course teaches students how to use Python and OpenCV together with deep learning frameworks for system development and evaluation. The course teaches students programming skills while they develop their ability to think computationally. Students will practice breaking down complex problems, identifying patterns, and designing logical step-by-step solutions. The course uses hands-on activities together with project-based learning to provide students with real-world experience in artificial intelligence applications. The students will learn to create a basic image-based disease detection system while they study how AI applications function in agricultural settings.

The course provides beginner students with AI learning resources which they can use to develop practical knowledge.

LEARNING OUTCOMES

The audience must learn about artificial intelligence technology.

The fundamental principles of artificial intelligence and computer vision and deep learning must be explained.

The process of image preprocessing requires image resizing and noise elimination and image normalization for leaf images.

The team will build a convolutional neural network model to perform image classification through training.

The team will use visual elements of color and texture and shape to identify and categorize different plant leaf diseases.

The system will undergo testing through new data which will determine how accurately it performs its tasks.

The user will operate various programming environments which include Python and OpenCV and deep learning software.

The user must demonstrate problem-solving abilities through task decomposition and pattern identification and development of complete solutions.

The team will build a functional system which enables users to identify basic plant diseases.

The user needs to interpret model results by expressing them in understandable terms.

The hands-on experience from AI projects will help learners build their confidence to use what they learned.

COMPUTATIONAL THINKING

Your project demonstrates computational thinking through your systematic approach to organizing the leaf disease detection process which you use to analyze the problem and implement AI solutions.

1.Problem Decomposition Breaking the problem

You divide the main task into smaller steps which include:

• Collect leaf images
• Preprocess images
• Train the model
• Predict disease

2.Pattern Recognition

You identify patterns in leaf images which include:

• Spots or discoloration

• Texture changes
• Shape variations The model uses these patterns to differentiate between healthy leaves and diseased leaves.

3.Abstraction
Focusing on important details You select essential leaf features which include color and texture and edges while ignoring all other details of the complete background.

4.Algorithm Design Step-by-step solution
You design a process that starts with inputting an image and then proceeds through preprocessing and CNN model execution until reaching prediction and output generation. This solution functions as an algorithm which solves the problem.

5.Logical Thinking Evaluation
You evaluate the model by conducting tests and measuring accuracy which you use to create performance enhancements based on obtained testing results.

CRITICAL THINKING
1. Evaluating Data Quality
The dataset selection process requires you to evaluate two factors which include:
• Are the images clear?
•Are all disease types properly represented?
• The dataset shows equal distribution of samples among different categories.
This process enables you to develop a trustworthy model through proper evaluation.

2. Choosing the Right Approach
You prove that Convolutional Neural Networks (CNNs) provide superior performance when compared to traditional techniques.
You evaluate multiple techniques which leads you to choose the best method for image classification.

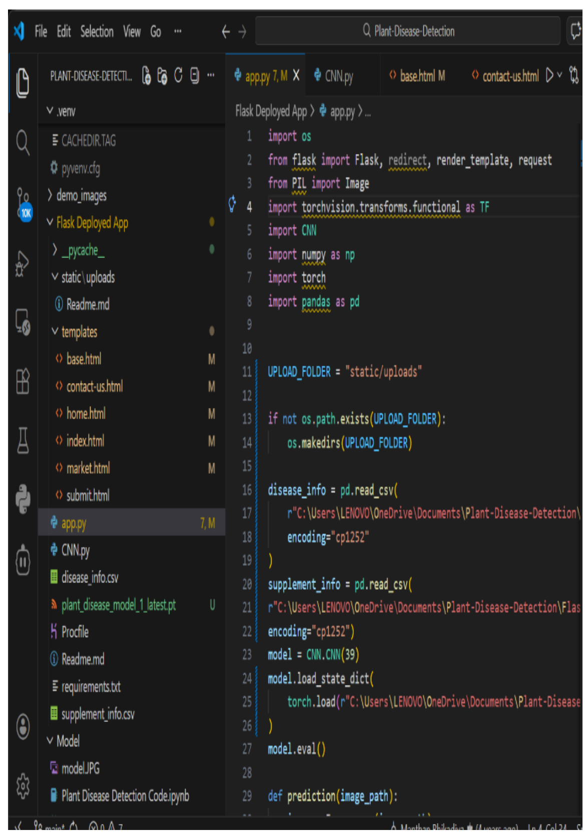
3. Analyzing Model Performance
The evaluation process begins after training when you assess three aspects:
• Is the accuracy good enough?
• Are there false predictions?
• Where is the model making mistakes?
The process helps you learn about the positive aspects and negative aspects of your work.

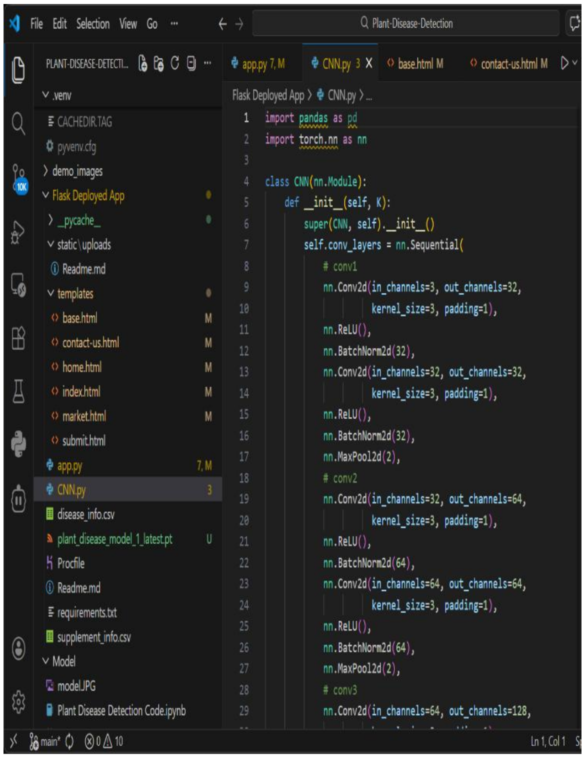
4. Identifying Limitations
You consider real-world challenges which include:
• Poor image quality
• Different lighting conditions
• Similar-looking diseases
The ability to identify these problems demonstrates critical thinking skills.

5. Improving the System
You attempt to achieve better outcomes through your analysis by:
• Using better preprocessing
• Increasing dataset size
• Tuning model parameters

6. Making Logical Decisions
You use logical reasoning to make all decisions at every step of the process which includes training data selection and model parameter decisions and output interpretation.

IV. CODE





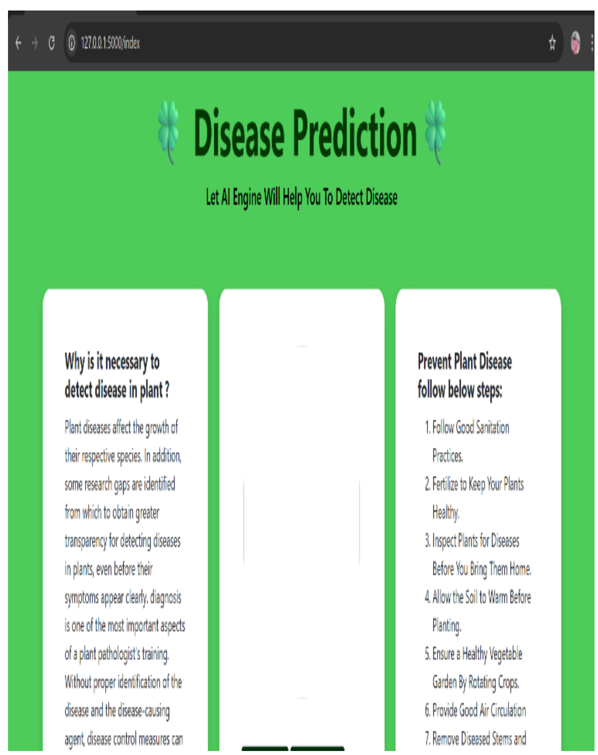
V. RESULTS

The developed system was tested using a dataset of plant leaf images that included both healthy and diseased samples. The system achieved accurate leaf image classification performance after training the Convolutional Neural Network (CNN) model. The model demonstrated successful leaf disease identification through its analysis of color changes and texture patterns and visible patterns on leaves.

The model achieved better accuracy results after the implementation of preprocessing methods which included image resizing and noise elimination. The system performed well on most test images, correctly predicting whether the leaf was healthy or diseased. The model produced incorrect predictions because the images exhibited poor lighting and low quality and multiple diseases displayed similar symptoms.

The system maintained dependable performance which functioned properly for typical applications. The output of the system is displayed in a simple format, which requires users to submit a leaf image while the system provides predicted results. The simple design of the system enables users to operate it without difficulty.

The results demonstrate that the project successfully addresses a real-world problem while providing students with practical AI implementation experience. The process shows how developers can use machine learning and computational thinking methods to create functional software solutions.



VI. DISCUSSION

The proposed system for leaf disease detection using computer vision shows that deep learning can be effectively applied to real-world agricultural problems. The use of a Convolutional Neural Network (CNN) helped in automatically identifying important features from leaf images, which improved the overall classification performance.

The system can process images to deliver instant results without requiring any human intervention. The preprocessing steps, which included resizing and noise removal, produced better input data quality that directly affected model accuracy.

The system achieved good performance results when it was evaluated with clear images that had correct labels. Testing revealed several limitations in the system. The model performance dropped when it encountered images with inadequate lighting conditions and complicated background elements and low-resolution details. The system failed to differentiate between certain diseases because they shared identical visual characteristics. The problems demonstrate that researchers must collect diverse and high-quality datasets for their work. Another important point is that the system works well in a controlled environment but may need further improvement for real-time field conditions.

The prediction results face disruptions because of weather changes and shadow movements and variations in camera positioning. The project helped students develop their computational skills while enhancing their critical thinking abilities.

The project developed problem-solving skills through systematic analysis which led to system improvements. The project demonstrates that AI-based methods can detect plant diseases, but there remain opportunities to enhance both accuracy and system performance and its ability to function in actual environments.

VII. CONCLUSION

This project developed an AI-based system which detects plant leaf diseases through its use of computer vision methods.

The created model successfully analyzed leaf images to categorize them into healthy and diseased states with high precision. The system used preprocessing steps together with a Convolutional Neural Network (CNN) to extract vital visual characteristics that included color patterns and texture data which enabled successful predictions.

The project shows that AI can be used as a useful tool in agriculture to support early disease detection and reduce manual effort. The system achieves good performance results in most situations but it encounters difficulties when handling both low-quality images and diseases that present similar visual characteristics. The project achieved two objectives through its practical implementation which developed students computational thinking abilities while they solved real-world problems.

The system showed actual results through structured methods which demonstrated the application of theoretical concepts to actual situations.

The research shows how AI and computer vision technology can create straightforward solutions which help students learn effectively. The team plans to develop three key areas which include improving prediction accuracy and developing solutions for real-time activities and extending their dataset for better results.

The project developed an AI-based system which detects plant leaf diseases through its application of computer vision technology. The developed model was able to analyze leaf images and classify them as healthy or diseased with good accuracy.
The system used preprocessing steps together with a Convolutional Neural Network (CNN) to extract vital visual characteristics which included color patterns and texture data that enabled successful predictions.
The project demonstrates how artificial intelligence functions as a beneficial agricultural tool which enables farmers to identify plant diseases at an early stage.

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