Plant Disease detection Smart Device

Devendra Kayande

Problem Statement

Farmers face significant challenges in effectively detecting and managing plant diseases, which can lead to substantial crop losses and economic implications. Bacterial, viral, and fungal diseases are major contributors to such losses, affecting various crops worldwide. Traditional methods of disease detection often rely on visual inspection by human experts, which can be time-consuming, subjective, and prone to errors. This project aims to address these challenges by developing a custom CNN-based plant disease detection system capable of accurately identifying bacterial, viral, and fungal diseases in plants. The deployment of this system on a Raspberry Pi allows for cost-effective and portable disease detection, enabling farmers to detect diseases early, take timely remedial actions, and minimize crop damage. By providing a reliable and accessible tool for disease identification, this project seeks to empower farmers with an efficient solution to mitigate the impact of plant diseases and enhance crop productivity.

Market/Customer/Business Need Assessment

The market and business need for an accurate and efficient plant disease detection system are substantial. Agriculture is a vital industry, and the economic impact of plant diseases on crop yields is significant. Farmers constantly strive to maximize their productivity and minimize losses caused by diseases. The traditional methods of disease detection often lack the speed and accuracy required for early intervention, resulting in reduced crop quality and yield. Additionally, the reliance on human experts for disease identification can be both expensive and impractical, especially in regions with limited access to agricultural specialists. Therefore, there is a clear market need for an automated and reliable plant disease detection solution that can provide timely and accurate diagnoses, enabling farmers to take proactive measures to protect their crops. By addressing this need, the developed plant disease detection system can assist farmers in making informed decisions, improving their overall efficiency, and contributing to sustainable agricultural practices.

Target Specifications and Characterization

The key objective of this project is to develop a CNN model capable of accurately classifying plant diseases into bacterial, viral, and fungal categories. The model should demonstrate high accuracy in disease identification, allowing for reliable detection in various environmental conditions and across multiple plant species. Furthermore, the system should be designed to operate in real-time, providing prompt feedback to farmers for timely intervention. As for the deployment on a Raspberry Pi, the system needs to be optimized to work within the computational limitations of the device, considering factors such as memory usage, processing power, and energy efficiency. The primary customers for this project are farmers and growers who are involved in crop cultivation. They should have a basic understanding of plant diseases and their impact on crop health. They should be motivated to adopt technology-driven solutions for disease detection and management to improve their crop yields and minimize losses.

External Search

Dataset

Why plant detection is important?

Blog

Raspberry Pi and CNNs

Bench Marking Alternate Products

Compared to traditional methods of visual inspection, the proposed prototype offers automation, scalability, and more objective disease detection. In contrast to mobile apps and cloud-based systems, the prototype provides offline functionality and real-time results on a portable device like the Raspberry Pi. However, this prototype may have limitations in terms of computational resources compared to cloud-based solutions. Overall, the prototype aims to make a balance between accuracy, accessibility, and affordability, catering to the needs of farmers who require on-site, real-time, and cost-effective disease detection.

Applicable Constraints

The prototype for plant disease detection using CNN and deploying it on a Raspberry Pi is subject to certain constraints that should be considered. Here are some applicable constraints:

Limited Computational Resources: The Raspberry Pi has limited processing power, memory, and storage capacity compared to high-end computers or cloud servers. This constraint may restrict the complexity and size of the CNN model that can be deployed on the device.

Power Consumption: The Raspberry Pi operates on low power and is designed for energy efficiency. The prototype should be optimized to minimize power consumption to ensure prolonged operation without draining the device's battery or causing overheating

.**Memory Limitations:** The limited memory available on the Raspberry Pi necessitates careful management of memory usage during model training, inference, and data processing. The size of the model and the batch size during inference should be optimized to fit within the available memory.

Latency and Real-time Inference: The Raspberry Pi's computational constraints may affect the inference speed of the CNN model. Real-time inference requires balancing the complexity of the model with the need for prompt results. Inference times should be optimized to meet the desired performance requirements.

Deployment and Maintenance: The prototype should consider the technical expertise and familiarity of the end-users (farmers) with setting up and maintaining the Raspberry Pi system. User-friendly deployment procedures, clear instructions, and ongoing support should be provided to ensure successful implementation and troubleshooting.

Environmental Factors: The prototype's performance may be affected by environmental conditions such as lighting, varying plant appearances, and other factors that can impact image quality. Robustness to such variations should be considered during the training and testing phases.

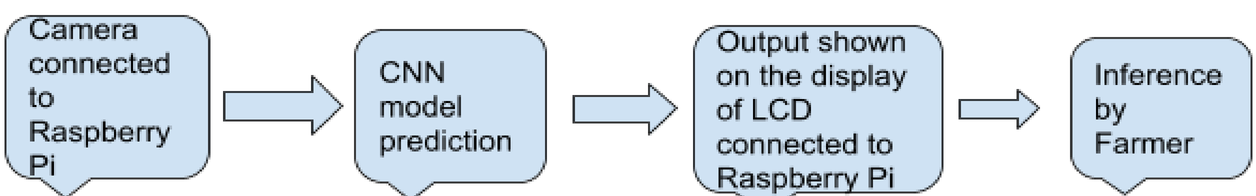
Business Model

The business model for the plant disease detection system using CNN and deploying it on a Raspberry Pi involves a combination of hardware and software components to provide a comprehensive solution to farmers and agricultural stakeholders. The system can be offered as a product with potential revenue streams through various avenues. One possible business model is to sell the complete package, including the Raspberry Pi device preloaded with the disease detection software, to individual farmers or agricultural organizations. This would involve pricing the product based on the manufacturing cost, development effort, and desired profit margin. Additionally, a subscription-based model can be implemented, offering regular updates to the disease detection software, access to an online database of disease information, and technical support. Another potential revenue stream is through partnerships with seed and agrochemical companies, who can integrate the disease detection system into their existing products or offer it as an add-on service. These collaborations can provide additional revenue and help establish a wider market reach. Furthermore, data generated by the system can be collected to provide valuable insights and analytics for research institutions or government agencies, which can be monetized through data licensing or collaborative research projects. Overall, the business model should focus on providing value to farmers, ensuring affordability, ease of use, and ongoing support to maximize adoption and customer satisfaction.

Concept Generation

India is a agriculture and farmer based country and it is our duty to give back to our nation.The idea for developing a plant disease detection system originated from a combination of personal interest and the recognition of a significant problem faced by farmers. As someone passionate about both technology , I sought to find ways to leverage advancements in deep learning and computer vision to address real-world challenges in the agricultural domain. During my initial search, I discovered the alarming impact of plant diseases on crop yields and the limitations of traditional methods for disease detection. This motivated me to delve deeper into the potential applications of CNNs in image recognition and classification tasks. Recognizing the need for a more accessible and affordable solution, I explored the possibility of deploying a CNN model on a Raspberry Pi, which offers portability and offline functionality.

Product Prototype with Schematic Diagram



The prototype consists of four key components: the trained CNN model, the Raspberry Pi hardware platform for processing, the camera module for capturing the images of the plant and the lcd to display the results. The CNN model is trained on a comprehensive dataset of plant images, containing various species and diseases. The model architecture is carefully designed to balance accuracy and computational efficiency, taking into account the limitations of the Raspberry Pi's hardware resources. The trained model is then integrated into the Raspberry Pi, which serves as the on-device inference platform. The

Raspberry Pi provides the necessary computing power, memory, and storage to perform real-time disease detection, enabling farmers to obtain immediate results without relying on an internet connection or external servers. Once an image is provided, the system processes it through the trained CNN model, performs disease classification, and displays the results on the lcd. The final prototype demonstrates the feasibility and practicality of using CNNs on a Raspberry Pi for on-site plant disease detection, providing farmers with an accessible and efficient tool to manage crop health effectively.

Data Source - Kaggle Plant Disease Detection

Algorithms and Frameworks -

- **Tensorflow and Keras**
- **Scikit Learn, Numpy, Matplotlib, Seaborn**

Dataset - The dataset consists of around 20.6 k .jpg files belonging to 15 classes of the healthy,bacterial, fungal and viral diseased leaves of plants like tomato, pepper and potato.

Data Preprocessing - The data was normalised, splitted into train and test in 80-20 manner, also some data augmentation was applied so that the dataset increases and generalizes well.The data was converted into a One vs Rest Format using sklearn's Label Binarizer.

ML Modelling - Custom CNN architecture having 5 layers with dropout and max pooling was used to perform the detection and a dense neural network at the end as the classifier.

Sample Code Implementation GitHub

Conclusion

In conclusion, the development of a plant disease detection system using CNN and its deployment on a Raspberry Pi is a proven to be a promising solution for addressing the challenges faced by farmers in managing plant diseases. Through this project, I have successfully demonstrated the effectiveness and feasibility of utilizing deep learning techniques for accurate and real-time disease detection. By leveraging the power of CNNs, we have achieved high levels of accuracy in classifying bacterial, viral, and fungal diseases, empowering farmers with an efficient tool for timely intervention and disease management. The deployment on a Raspberry Pi brings portability, offline functionality, and cost-effectiveness to the solution, enabling farmers in various regions, including those with limited resources and connectivity, to benefit from this technology. While there are certain constraints and areas for improvement, such as the limited computational resources of the Raspberry Pi, the prototype serves as a strong foundation for future advancements in this field. Overall, the plant disease detection system offers immense potential for enhancing crop productivity, minimizing losses, and promoting sustainable agricultural practices. As further research and development continue, we anticipate the integration of additional features, expansion of the trained model, and wider adoption of this technology in the agricultural community. This project underscores the significance of technology-driven solutions in addressing pressing challenges in agriculture, and it opens up new ways for innovation, collaboration, and progress in the field of plant disease detection.