

AI-Based Plant Disease Diagnosis using Smartphone

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Agriculture is becoming increasingly digitized, and AI is being recognized as one of the key ways of improving crop health. Plant disease detection on a smartphone allows for quick and inexpensive plant disease diagnosis. Laboratory tests or the services of a plant pathologist are no longer necessary in some cases since it is sufficient to take a picture of the affected plant. Crop diseases due to fungi, bacteria, viruses, nematodes and nutrient deficiencies still decrease production, deteriorate product quality and have adverse effects on farmers' lives. It is estimated that pests and diseases destroy up to 40% of all food crops worldwide (FAO, 2021). Crop losses in the yield of wheat, rice, maize, potatoes and soybean are in the range from 17% to 30% (Savary et al., 2019). Early diagnosis and detection of infections are crucial in order to prevent their spread and protect the crops. The following article discusses how AI based plant disease detection works, which technologies are used for this purpose, advantages and disadvantages, and the importance of this technology for farmers and agricultural extension.

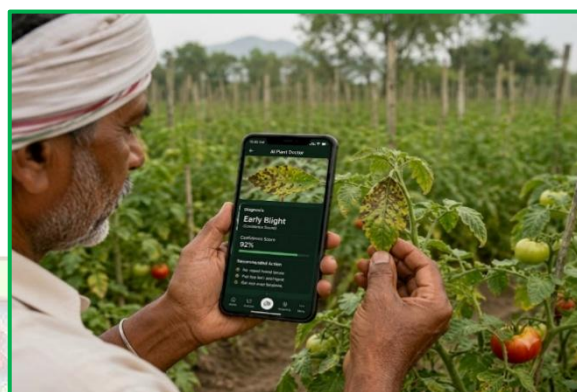


Figure 1. AI-powered plant disease diagnosis using a smartphone

Importance of Rapid Diagnosis

When the weather conditions become favorable, diseases tend to spread rapidly. Warm and humid weather conditions with persistent rains provide the perfect environment for infections, and once an infection takes root, the disease spreads rapidly within the field. Late diagnosis results in low yield, poor quality and increased cost of using chemicals to protect crops. It is important to note that late diagnosis will mean that the cause of the disease is not clear, thus leading to indiscriminate use of pesticides that increase cost and promote resistance. Traditionally, farmers relied on plant pathologists, extension agents or laboratory tests. Although this method is accurate, it is time consuming, costly and difficult to access especially in remote areas. This has resulted in farmers using visual methods and the guidance from input dealers to diagnose the cause of infection but their diagnoses are often wrong, leading to ineffective management of the disease. AI-powered applications in mobile phones enable farmers to take pictures of the infected plant and receive a diagnosis within seconds and even management tips right there in the field.

How AI-Based Diagnosis Works

The process generally involves five steps:

- **Image capture:** The farmer photographs the affected leaf, fruit, stem or whole plant. Clear images improve accuracy.
- **Image processing:** The app adjusts brightness and contrast, reduces background noise and isolates the infected region.

- **Feature extraction:** A deep learning model trained on thousands of healthy and diseased plant images picks out features such as leaf spots, yellowing, lesions, wilting, mould growth and necrosis.
- **Disease classification:** The features are compared with learned patterns to predict the most likely disease, usually with a confidence score. Some systems also estimate severity.
- **Advisory:** Many apps describe the disease and suggest chemical, biological and cultural control measures, preventive strategies and nutrient management. Some also connect farmers with experts.

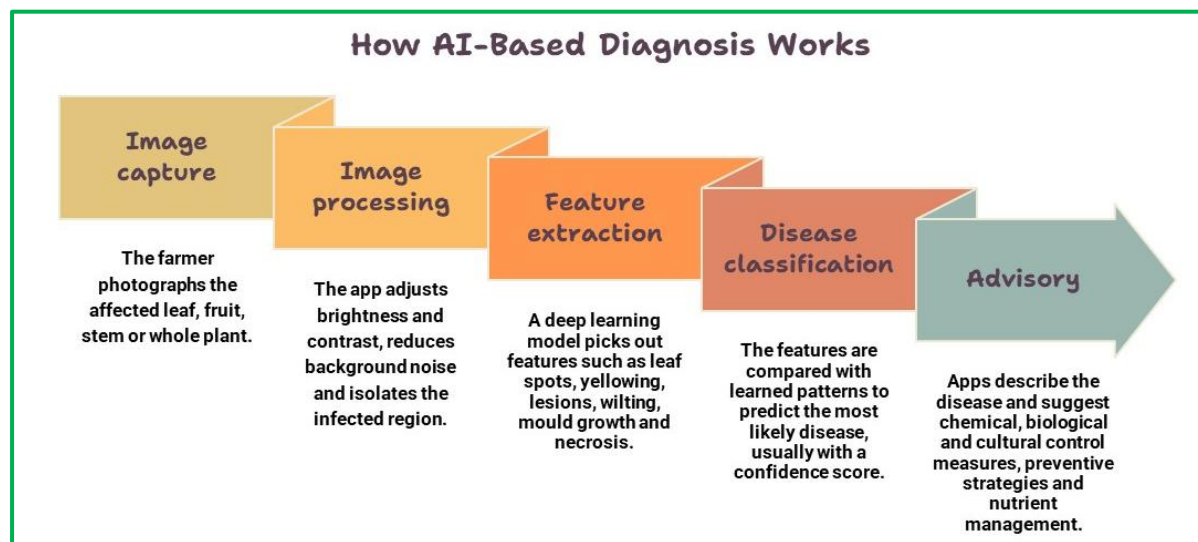


Figure 2. Steps in smartphone-based plant disease diagnosis

Deep Learning and Public Datasets

Through deep learning, computers can learn automatically using large datasets of labeled images rather than relaying on hard-coded algorithms. Learning takes place based on variations in color, texture, form, and pattern of lesions which are not visible during inspection of the field. VGG16, ResNet, DenseNet, EfficientNet, MobileNet, and Vision Transformer have been used successfully for detection of plant diseases. The family of MobileNets has the special ability to work well with the use of minimal computing power. Therefore, apps can be created which run even on inexpensive mobile phones (Howard, 2017). Segmentation of the image, transfer learning, and Explainable AI are also used by researchers. The system utilizes publicly available image data for training such as PlantVillage database (Hughes & Salathé, 2015), PlantDoc database (Singh et al., 2020) and the New Plant Diseases dataset. The symptoms are dependent on the variety of the crop, the climate, the soil, and the cultivation process. Hence, the researchers are now developing the datasets by collecting data according to the regional requirements. With increasing availability of high-quality plant images through research and agricultural organizations, the system would continue to improve to suit the needs of Indian agriculture.



Figure 3. How a deep learning model learns disease patterns from plant images

How effective are such technologies?

Research shows that deep learning algorithms can identify various diseases of plants with an accuracy of over 90%, and it was found that for various crops in a laboratory setting, accuracy rose to over 99% for some plants most likely due to their ability to pick up on subtle signs of a disease that would be easily overlooked when visually inspecting them (Ferentinos, 2018; Mohanty et al., 2016). The situation in the field is much more challenging. Lighting issues, shadowing, dust, cluttered backgrounds, overlapping leaves, insect damage, and different stages of a disease reduce accuracy of imaging (Barbedo, 2018). Different diseases and nutrient deficiencies often have shared features. Thus, AI based diagnosis should be used as a support system only.

Popular Smartphone Applications

National Pest Surveillance System (NPSS), launched by the Ministry of Agriculture and Farmers' Welfare on 15 August 2024, is an AI and ML-based digital platform that includes a mobile app and web portal. It identifies pests in the uploaded images of crops and provides solutions based on their location. NPSS encourages the scientific and need-based use of pesticides and reduces the reliance on pesticide retailers. It helps in pest surveillance, forecast, and early warning. This system is beneficial for farmers, KVKs, agricultural universities, and extension officers. Plantix is used for detecting plant diseases, pests, nutritional disorders and provides information about these conditions and offers a platform for farmers to receive advice. Agrio is an application that uses AI technology for diagnosing diseases in addition to managing farms with help from weather data and observation of the farm in question. The PlantVillage Nuru mobile application which is used for field diagnosis of cassava disease (Ramcharan et al., 2019) and the Leaf Doctor application which is used for quantifying plant diseases (Pethybridge & Nelson, 2015) have also been instrumental in the development of crop health management through digital means. The latest mobile applications are being developed taking into account local languages and offline diagnostic capabilities since rural settings may not have proper internet facilities.



Figure 4. AI-based disease diagnosis in the farmer's field

Benefits for Farmers and Extension Services

Early detection helps farmers take preventive actions before the spread of infection, thus saving their yield and quality. Proper identification removes guesswork, resulting in a reduction in usage of unnecessary pesticides and hence, costs associated with production, while also ensuring high quality and marketability of their products. Farmers no longer have to travel to laboratories or await any special assistance since there are many of smartphones in villages today. Quick and accurate information about symptoms, causes, and ways of dealing with diseases will help make informed decisions. AI tools also enhance extension services by allowing user to draw up disease maps in real time using field data. This allows one to detect any emerging hot spots and set up early warning and forecasting systems. Extension officers can diagnose and advise farmers during farm visits without waiting for lab results, which is valuable in distant regions. These applications are very useful in the teaching process during meetings with farmers, demonstrations, and training sessions by Krishi Vigyan Kendras (KVKs) and universities.



Figure 5. Benefits of AI-based plant disease diagnosis

Challenges and Limitations

Challenges such as varying field conditions, similar symptoms that with different, a lack of region-specific training data, poor connectivity and older phones with low-resolution cameras still limit the performance of agricultural apps. Many existing apps were trained on images from controlled conditions or limited regions. Offline models and lightweight apps are gradually overcoming these connectivity and device challenges. AI diagnosis should be a decision-support tool and not a replacement for agricultural experts. Continued research, improved datasets, better mobile technologies and close collaboration among researchers, extension agencies and farmers will further increase their accuracy and usefulness.

Future Directions

It is expected that future applications will offer voice-based guidance in regional languages and facilitate interaction through 'large language models.' With the help of 'Edge AI,' it will be possible to diagnose problems directly on a smartphone, even without an internet connection. By integrating data from drones, satellites, weather stations, GPS, and 'Internet of Things' (IoT) sensors along with information on local weather, crop stages, and the severity of diseases, AI applications can provide with precise, location-specific recommendations. This will assist them in the more effective use of pesticides. Over time, these applications could evolve into smart 'digital farming assistants' that help farmers make informed decisions, boost productivity, and strengthen their climate resilience.



Figure 6. The future of AI in agriculture

Role of Agricultural Institutions

Agricultural institutions, in particular agricultural universities and research institutes, have to make use of high-quality images obtained from various agro-climatic zones, to develop and assess artificial intelligence models. Agricultural extension agents can use these tools for demonstrating agricultural practices and training farmers, making it easier for farmers to

understand the advice. In this regard, ICAR and state agricultural universities may integrate these tools with their advisory services, and private agritech companies should ensure that these tools are developed in user-friendly applications available in local languages..

Practical Tips for Farmers

- Photograph the affected part in natural daylight, with the camera steady and the diseased area in focus.
- Take several images from different angles, including close-up and whole-plant views, and avoid cluttered backgrounds.
- Keep the camera steady and capture only the affected plant part, as blurred or poorly focused photographs may give incorrect predictions.
- Use the latest version of the app to benefit from updated disease databases.
- Follow recommended control measures only after considering local crop conditions and the label instructions of plant protection products.
- Consult agricultural experts or extension personnel if symptoms are severe or unusual, or if the prediction appears uncertain.

Conclusion

AI-based diagnosis is making crop health assessment faster, more accessible and more practical. Powered by deep learning and computer vision, smartphone apps give timely diagnosis and management advice, supporting early action, judicious pesticide use and lower costs, while strengthening extension through surveillance and early warning. Challenges remain, but locally relevant datasets and collaboration among universities, ICAR institutes, KVKs, developers and policymakers will help realise the full potential of this technology. Rather than replacing experts, these tools complement their expertise by delivering science-based guidance to farmers' fields, contributing to sustainable agriculture and food security. With continued research, innovation and strong extension support, smartphone-based AI can become a practical companion for everyday crop management.

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