Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 03, Issue: 04 (JULY-AUGUST, 2023)
Available online at http://www.agriarticles.com

The Role of Artificial Intelligence in Plant Pathology: Transforming Diagnosis and Treatment

(*Deepu Kumar, Aditya Kumar Gautam and Dinesh Choudhary)
CPGS-AS (Central Agricultural University, Imphal), Meghalaya, India, 793103
*Corresponding Author's email: deepukumardl9752@gmail.com

India ranks second worldwide in farm outputs. As of 2018, agriculture employed more than 50% of the Indian workforce and contributed **17-18%** to the country's GDP. India ranks first in the world with the highest net cropped area followed by US and China. Plant pests and diseases are the major contributors to biotic stresses that limit the realization of the yield potential of crop plants. The increase in the human population will require an additional 70% of the food by 2050. Losses caused by pathogens, pests and weeds, are altogether responsible for losses ranging between **20 and 40%** of global agricultural productivity. Crop losses brought on by pests and pathogens have both direct and indirect effects that result in qualitative and quantitative losses; they have a variety of facets, some with short-term and others with long-term consequences.

What is the need for plant disease detection?

Early and accurate detection and diagnosis of plant diseases are critical factors for the reduction of losses and spreading of diseases.

- To assess the effectiveness of the application of cultural, physical, chemical, or biological methods of containing pathogens.
- To determine the presence of pathogens in plant materials used in breeding operations.
- To swiftly identify and detect novel infections to stop their spread.
- To address the issues associated with complex diseases caused by two or more pathogens.

Common techniques for identifying and diagnosing plant diseases include

- Human raters' estimate of visual plant illness,
- Pathogen identification through microscopic analysis of morphological characteristics,
- Molecular diagnostic techniques
- Serological assays
- Microbiological diagnostic techniques

Based on typical plant disease symptoms (such as lesions, blight, galls, tumors, cankers, wilts, rots, or damping-off) or outward manifestations of a pathogen (such as urediniospores of Pucciniales, mycelium, or conidia of Erysiphales), traditional visual estimations can identify a disease.

A visual estimate is a skill that is only practiced by specialists and has been thoroughly studied. Due to the availability of comprehensive rules and standards utilized for assessment training, visual estimation has improved in accuracy and dependability.

Conventional methods of plant disease detection

Conventional methods of plant disease detection include molecular and serological methods that could be used for high-throughput analysis when large numbers of samples need to be analyzed. These techniques accurately identify the disease/pathogen by directly detecting the pathogens that cause it, such as bacteria, fungi, and viruses. All of these techniques take a lot of time and call for highly developed labs and highly qualified personnel. These approaches are not only ineffective on a wide scale but also expensive.

Different methods of serodiagnosis

- Enzyme-linked immunosorbent assay (ELISA)
- Western blots
- Immunostrip assays
- Dot-blot immune-binding assays and
- Serologically specific electron microscopy (SSEM).

Due to its excellent throughput potential, ELISA—first used in the 1970s—is by far the most used immunodiagnostic method. With this technique, antibodies attached to an enzyme are used to precisely bind the target epitopes (antigens) from viruses, bacteria, and fungi.

Based on colour changes brought on by the interaction of the substrate and the immobilized enzyme, the detection may be seen. Specific monoclonal and recombinant antibodies, which are commercially available, can be used to significantly enhance ELISA performance.

Nucleic acid-based methods

Some pathogen detection methods are DNA based:

- Fluorescence in situ hybridization (FISH)
- PCR variants: nested PCR (nPCR)
- Multiplex PCR (M-PCR)
- Real-time PCR (RT-PCR) and
- DNA fingerprinting

Others are RNA based:

- Reverse transcriptase- PCR and
- Nucleic acid sequence-based amplification (NASBA)

Artificial Intelligence in Plant Disease Detection

What is Al? Emulating human intelligence in machines created to behave and think like people is known as artificial intelligence (AI). Artificial intelligence (AI) is becoming more prevalent in home and office electronics, social networking, video streaming services, electronic commerce, and internet search engines.

The steps involved in the identification of plant stress by artificial intelligence Identification**, Classification, are Quantification and Prediction.**

Machine learning (ML): Computer systems may now be programmed to learn from inputted data without having to be constantly reprogrammed thanks to machine learning. In other words, without further assistance from a human, they continuously increase their performance on a task, like playing a game. Machine learning can be facilitated in a variety of ways. A basic decision tree is an example of a simple one. More complex ones use numerous layers of artificial neural networks.

Deep learning (DL): Deep learning is the next frontier of machine learning. Just as machine learning is considered a type of Al, deep learning is often considered to be a type of machine learning-some call a subset. Deep learning makes use of artificial neural networks that are made to resemble how humans think and learn, as opposed to machine learning, which uses ideas like predictive models that are simpler. As with machine learning, deep learning computer systems still receive input, but it is frequently given to them in the form of enormous data sets because deep learning systems require a lot of data to comprehend it and produce reliable results.

Generally used algorithms of a machine and deep learning for agriculture in the following

- Linear Regression
- Logistic Regression
- Decision Trees
- Support Vector Machine (SVM)
- Naïve Bayes
- KNN (K-Nearest Neighbors)
- K-Means
- Random Forests
- Gradient Boosting and Ada Boost
- Convolutional Neural Networks
- Recurrent Neural Networks

Scope of AI in agriculture: Artificial Intelligence (AI) and Machine Learning (ML) are being quickly incorporated into agriculture, both in terms of agricultural goods and field farming methods. - Given its capacity to comprehend, learn, and react to various situations (based on learning) to improve efficiency, cognitive computing in particular is poised to become the most disruptive technology in the agriculture services sector.

1. **Growth Driven by IOT (Internet of Things):** Every day, enormous amounts of data are produced in both structured and unstructured formats. They concern information on past weather patterns, soil reports, fresh research, rainfall, pest infestation, pictures taken by drones and other devices, and so forth. Two technologies that are primarily employed for intelligent data fusion are proximity sensing and remote sensing. Soil testing is one application for this high-resolution data.
2. **Image-based insight generation:** Drone-based imagery can assist with detailed field analysis, crop monitoring, field scanning, and other tasks. To ensure that farmers act quickly, computer vision technologies, IOT, and drone data can be merged.
3. **Identification of optimal mix of agronomic products:** Cognitive solutions advise farmers on the optimal selection of crops and hybrid seeds based on a variety of factors including soil quality, weather predictions, the sort of seeds they are using, pest infestation in a particular area and more. The recommendation can be further personalized based on the farm's requirements, local conditions, and data about successful farming in the past. External factors like marketplace trends, prices, or consumer needs may also be factored in to enable farmers to take a well-informed decision.
4. **Health monitoring of crops:** Remote sensing techniques along with hyperspectral imaging and 3d laser scanning are essential to build crop metrics across thousands of acres. It has the potential to bring in a revolutionary change in terms of how farmlands are monitored by farmers both from a time and effort perspective. Crops will also be monitored using this technology during their whole existence, with reports being generated in the event of irregularities.
5. **Automation techniques in irrigation:** In terms of human-intensive processes in farming, irrigation is one such process. Machines trained on historical weather patterns, soil quality and the kind of crops to be grown, can automate irrigation and increase overall yield. With close to 70% of the world's freshwater being used in irrigation, automation can help farmers better manage their water problems.

Machine learning-based Multi-Spectral Imaging for Plant Disease Detection: A discipline of research called spectroscopy focuses on determining which wavelengths of light will be absorbed or reflected by various materials when they are subjected to light rays. The leaves, stems, fruits and other components of plants all absorb and reflect light. Therefore, disease identification is achievable based on the optical characteristics of plant components. Light transmission through a leaf, Light absorbed by leaf compounds (such as pigments, water, sugars, lignin, and amino acids), and Light reflected from internal leaf structures or straight from the leaf surface are the characteristics of a leaf's optical properties.

Reflection pattern in healthy vegetation: Based on the remote sensing methods used, vegetation reflectance can be divided into three distinct spectral domains. The primary light-absorbing pigments in the visible spectrum (VIS: 0.4–0.7 m) include chlorophylls a and b, carotenoids, xanthophylls, and polyphenols. Chlorophyll a displays maximum absorption in the 0.41-0.43 and 0.60-0.69 um regions, whereas Chlorophyll b shows maximum absorption in the 0.45-0.47 um range. In the near-infrared domain (NIR: 0.7-1.3 µm), absorption is very low, and reflectance and transmittance reach their maximum values. This is caused by internal scattering at the air-cell-water interfaces within the leaves. Shortwave is another name for the mid-IR region, which spans the 1.3 to 2.5 m range.

Reflection pattern in sick and dead leaves: When a plant is under stress, chlorophyll production may decrease resulting in less absorption in blue and red bands in palisade cells. So along with the green band, red and blue bands are also reflected. Hence, stressed vegetation develops a yellow or brown color. NIR bands in stressed or sick plants are absorbed by stressed or dead cells rather than being reflected by the mesophyll cells. As a result, the picture has gloomy tones. Perthotrophic pathogens, like those that cause leaf spots, frequently cause tissue degradation because of pathogen-specific factors, in contrast to biotrophic fungi, such as powdery mildews or rusts, **Image Processing based Detection of Plant Diseases.**

Plant pathology uses digital photographs as crucial instruments for determining the health of plants. Red, green, and blue (RGB) digital images from digital cameras can be easily obtained and used for the detection, characterization, and quantification of diseases.

Deep Learning for Plant Disease Detection: A hierarchical representation of the data is provided by "deeper" neural networks used in deep learning (DL), employing a variety of convolutions. This enables greater learning capacities, which leads to improved performance and accuracy. The feature learning component of DL, i.e. automated feature extraction from raw data, where features at lower levels of the hierarchy are combined to produce features at higher levels. DL can solve more complex problems particularly well and fast, because of the more complex models used, which allow massive parallelization. Large datasets of photos with thousands of images are needed as the sources of data for training the DL model.

While some datasets come from well-known and widely accessible databases like PlantVillage, LifeCLEF, Malaya Kew, UC Merced, and Flavia, others are collections of actual pictures that the authors have personally gathered for their research.

Conclusion

Artificial intelligence is being used in plant pathology, which is altering the profession. Thanks to its ability to detect diseases early, diagnose with pinpoint accuracy, forecast epidemics, and optimize resource usage, AI is enabling farmers to adopt sustainable practices and maintain a supply of food for a growing population. With the adoption of AI in plant pathology, we embark on a path to a more prosperous, resilient, and amicable agricultural future. By utilizing the potential of AI, we can usher in a new era of agricultural excellence and pave the road for a society where plentiful harvests and healthy crops coexist.