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Use of artificial intelligence in plant pathology

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Abstract
Rapid development of new technologies like artificial intelligence (AI) provides a unique opportunity for developing automated systems for detection and diagnosis of plant diseases. Artificial intelligence (AI) was introduced in 1956, since then technology is developing but now emerging rapidly throughout the globe. In last few years, disease diagnosis is shifted from symptoms based diagnosis procedures to protein based or molecular based techniques. Different AI technologies like convolution neural network, artificial neural network and deep neural network have been successfully used for disease detection in rice, wheat, maize, cotton, tomato, peas, grapes, potato, cucumber, cassava, peach, mango, banana, apple, tea etc. Plant disease and pathogen detection by imaging sensors and image analysis is increasing rapidly. A recognition method based on visible spectrum image processing to detect symptoms of citrus greening disease on leaves was developed. A vision based novel transfer and deep learning technique for detecting symptoms of leaf scorch on leaves of Olive (*Olea europaea*) caused by *Xylella fastidiosa* with a true positive rate of 95.8±8% was also developed. Methods for disease diagnostics are still in the developmental stage. Computer vision based diagnostics and severity assessment of plant diseases has gained momentum in horticultural and field crops. Smartphone based field diagnostics are gaining popularity among the peoples engaged in farming systems. AI tools are so advanced that they can process huge data within seconds. Image based disease detection, sensor data fusion, precision agriculture and targeted treatments, disease prediction models, mobile applications, data bases and knowledge repositories will help for the development of AI driven solutions for farmers in the context of plant disease management.

Keywords: Machine learning, disease management, artificial intelligence (AI), applications (apps)

Introduction
The term AI has a bit of history in which takes back to 1956, where Alan Turing initiated the work of this particular field. He called it "Machine Learning" in a workshop held at Dartmouth College, USA [1]. Agriculture being one of the most important and ancient sector in the world, provides basic things that is a necessity for humans. As the population is rising rapidly the demand for food is also increasing day by day [2]. Avoiding barriers in the path of production is the best approach for fulfilling the rising demand. The barriers could be biotic or abiotic. Among the biotic ones, the major constraint is the infection of the diseases within the field. In order to combat this barrier Artificial Intelligence (AI) could be a great measure in this field in order to fulfill the demand of the world. These include various types of systems *viz*., deep neural networks (DNNs), convolution neural networks (CNNs) and artificial neural networks (ANNs). Machine learning is also widely used among the systems available [3]. Now the technology is spreading very fast, however it took more than 60 years for this. Artificial Intelligence could be stated as "A field of study which targets to replicate the capability of humans into robots, which also includes problem solving and learning" [2]. These can be readily used for the diagnosis in the crops such as, apple, banana, blueberry, cabbage, cassava, cantaloupe, celery cherry, corn, cucumber, eggplant, grapes, onion, orange, pepper, soybean, tomato, peach, etc. thereafter best performance of the system was recorded to be 99.53 (%) [4]. Apart from identifying symptoms visibly, more reliable way to capture photographs and asking the apps to help out is one of the major and an alternative way to complete the identification of the disease/disorder through using AI based applications, which on the spot gives the result and the its management strategies and can easily be installed on smart phones from google play store [5].

Top 5 countries in AI research field
There is an amazing factor if we look our country India in this research field i.e., AI field. Below are given top 5 countries which provide outstanding researches in AI;

Table 1: Country wise research in AI in year 2022 [6].

S. No.	Country	No. of Documents related to AI
1.	China	42631
2.	India	23089
3.	United States	13765
4.	United Kingdom	5132
5.	Germany	4241

In that too there are major 7 institutes which are doing major researches in AI field. Those institutes are listed below;

Table 2: Famous centers in India which do research and develop AI software [7].

S. No.	Institute
1.	Centre for Artificial Intelligence IIT Kharagpur.
2.	Centre for Artificial Intelligence & Robotics (CAIR), DRDO, Banglore.
3.	Robert Bosch Centre for Data Science and Artificial Intelligence, IITM, Madras.
4.	Artificial Intelligence Group, IISc, Banglore.
5.	Department of AI, IITH, Hyderabad.
6.	Academia Industry Collaboration on Artificial Intelligence.
7.	Laboratory of Statistical Artificial Intelligence and Machine Learning, IITR, Roorkee.

Working of AI (Machine Learning)

Basically this a prediction model, for this a numerical data is needed to be incorporated into the system about the severity of the disease or its incidence level. The DNNs can interpret the values in input layer of the system and then to output layer, produces the accurate nodal values in continuous chains. To produce accurate photographs/images proper datasets are needed that has to standardize [8]. This can be done under following headings;

1. **Data collection:** this includes capturing of photographs of plant parts via live cameras or mobile phones [9].
2. **Data preprocessing:** it is the second and important stage. These data should be collected from large number of sources like physical devices, software, tools, etc. It basically improves the effectiveness of the machine learning, normally done by cleaning and normalizing pictures dimension [9].
3. **Data segmentation:** plays a vital role in the recognition and characterization of various diseased samples/crops. It detects the content of a picture and also enables us to do image analysis [9].
4. **Feature extraction:** in a hierarchal manner the photographs are taken into the observations and it also identifies the parts of an object. In disease identification, color, texture and shape play an important role [9].
5. **Classification:** the software named as 'softmax' is basically used to classify the plant diseases separately [9].

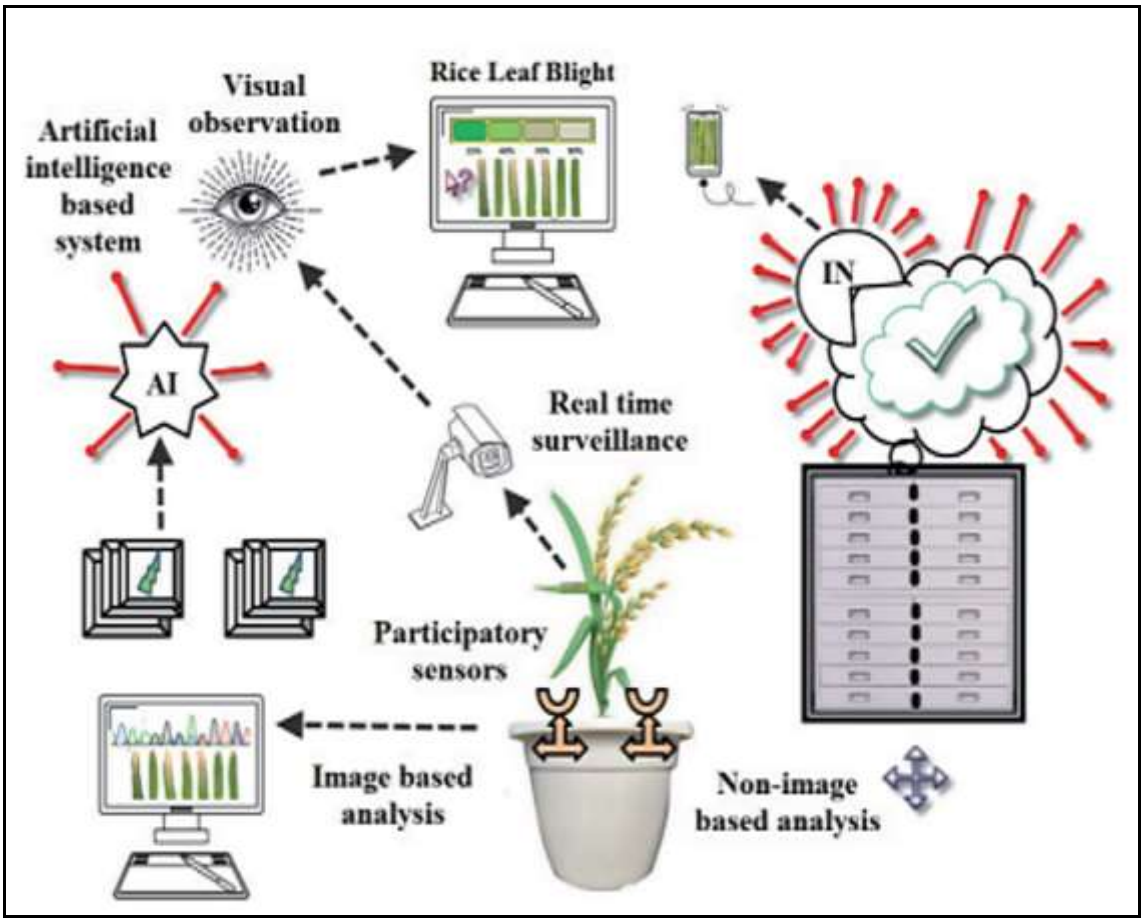

Fig 1: Schematic representation of machine learning [8].

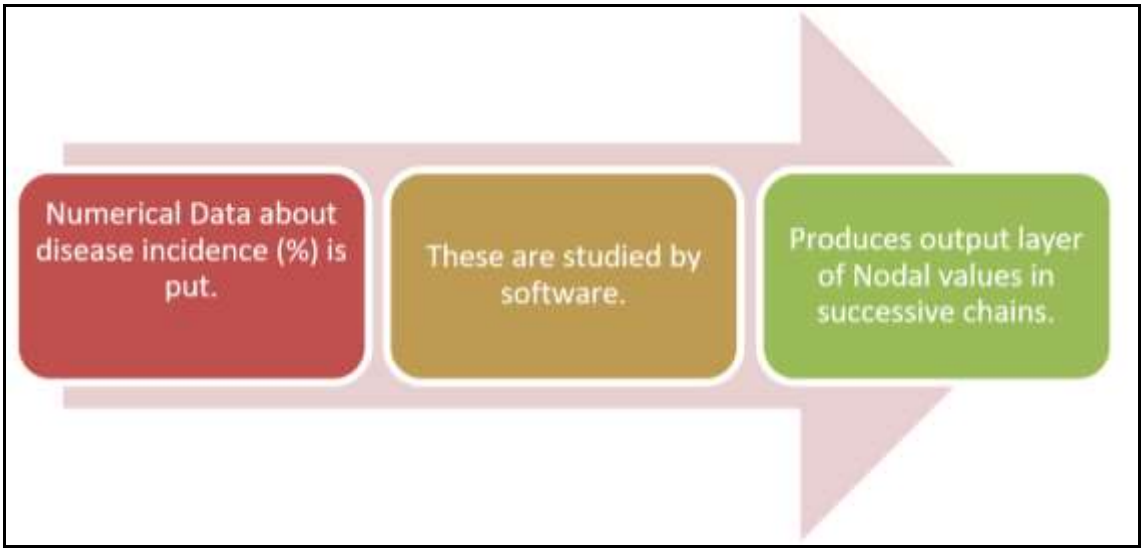

Fig 2: Process of working of DNNs and accuracy was found to be 99.35(%) [8].

Basic uses of AI in Plant Pathology

Diseases in the crops are a matter of great grave concerns, as this could cause a lot of yield and economical losses. Systems aided with the computers and internet are gaining extreme importance as detection and diagnosis is becoming easy day by day, saving the yield and wealth of the farmers [10]. Below are given some of the important uses where AI are used extensively;

Disease detection and diagnosis: AI integrated with the DNNs helps to identify the diseased plants. Promising results are being produced by the computerized imaging system but also needs an expertise for understanding the data [11].

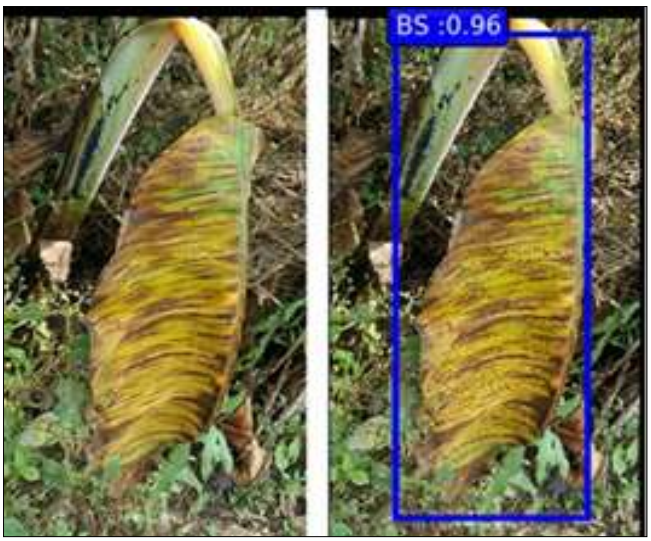

Fig 3: Image taken by AI in Banana infected by Black Sigatoka caused by *Mycosphaerella fijiensis* [11].

Hyper spectral imaging: it helps in locating and to determine the severity of the disease. It also helps in predicting the disease progress. This basically works on the principle of sensitive reflectance of the light. For e.g. 900-2400 nm intensity through NIR technique was found effective for soybean infected by charcoal rot [12]. A framework to separate asymptomatic and indicative red and white grape plantation cultivars by *Flavescence doree*, an important disease caused by phytoplasma, utilizing UAVs, multispectral, and up to 20 information highlights, gathering differentiating results between the cultivars and highest precision was recorded to be 88% [13].

Fig 4: Hyper spectral image of infected plant [14].

Sensor based monitoring system: spectral data is collected using these sensors which are fitted by the hyper spectral cameras. It minimizes the external disturbances hence giving clear and accurate image/data. These sensors are fitted into the field and give the data 24x7 [13].

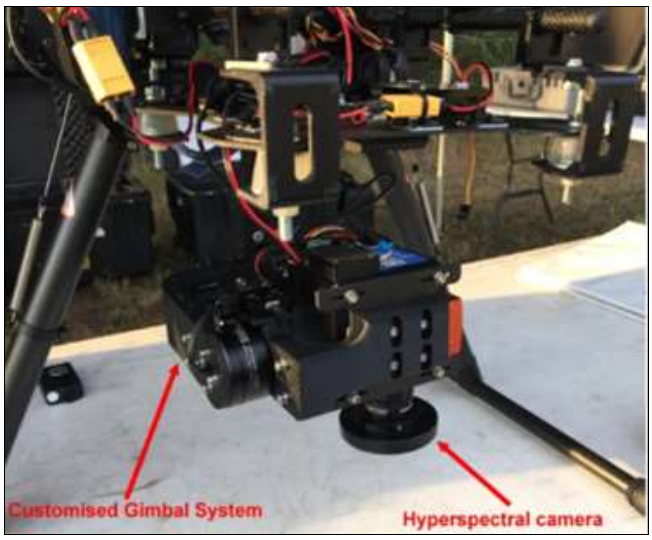

Fig 5: Sensor [13].

Target spraying through drones: also known as UAVs (Unmanned Aerial View) are fitted with the GPS (Global

Positioning System), real time image transmission systems, multiple sensors, wireless communications, automatic flight control and other accessories. Drones can capture high resolution images from aerial view making it easier to collect spatial data from any place. They can also conduct routine rounds/patrol for any abnormality entering into the field. Among all, German company which manufactures drones has become very famous for the pesticide spray [15].

Fig 6: Target oriented spraying in field through drones [16].

Classic applications/software used to identify plant diseases

In this advanced era of technology and in collaboration with the artificial intelligence, many mobile applications are readily available for androids, Microsoft store and iOS. The traditional approach of visual symptomology by humans is getting lower and the approach of computational system is seeking publicity. The apps which are available have lot of features *viz*., identifying diseases, identification of plant species, solutions to the problems the person is facing, marketplace for your goods, etc. [17].

Fig 7: Classic examples of apps used for disease identification [18, 19, 20].

Fig 8: Working of AI based apps in mobile phones [18].

These apps allow one to identify any disease properly giving services in wide range of languages. Some common steps one can follow to use the app;

i) Download the app from the store.
ii) Agree to the permissions.
iii) Select your preferred language.
iv) While using the app, one has to enable the GPS location if asked for it.
v) On the basis of the location, it gives you the spatial data (topography, soil texture, soil structure, etc.) and temporal data (mostly about the weather data like temperature, relative humidity, rainfall, etc.)
vi) Now you just have to click the photograph of the plant you want to.
vii) Select the relevant or matching pictures.
viii) Once selected, it will give you the exact data as needed including its management strategies.
ix) Even a person can make queries about the problem, and the persons receiving data in the company may reply to the queries.

Advantages of AI in Plant Pathology

- It will help farmers to increase the yield by assisting them to manage the diseases by giving proper guidelines [2].
- Identification of diseases and its management within friction of seconds is possible [2].
- It also suggests the pesticide or botanicals to be used in managing that particular disease [2].
- It may reduce human error.

Disadvantages of AI in Plant Pathology

- AI models are dependent on the quality and quantity of datasets.
- It will be very much expensive, especially in the regions/countries which are still developing and in countries where this technology is newly introduced.
- Data can be misused by anyone, when it is communicating using internet phishing can be a major issue.
- New models may not be competent with new emerging threats.

Key challenges in the adoption of AI technology

- Lack of understanding of AI technology. If the technology is introduced newly then for sure there will be some problem in the adoption process [21].
- Large expense for the installation initially. Any technology with excellent working efficiency and accuracy will be expensive [21].
- Hesitation of people in that particular place to adopt new technologies [21].
- The process may take longer time to be installed or when used initially. In short, a lengthy adoption process has to be followed with proper protocols [21].
- Technological limitations may also occur, as the technology is still developing round the globe [21].
- Privacy and security issues may be faced by the people in the process of adoption [21].

Future prospects of using AI

- Each and every information regarding disease from second to second and minute to minute will be done by AI [2].
- Notification from the field (current status) to the farmers will be sent through messages [2].
- It will help to produce sufficient food by eliminating disease through early detection, as population is rising

day by day it will be of great help [2].

- It may help n production of crops besides their natural seasons in greenhouse. The robots will be equipped very well for this [2].
- AI related companies are working hard for this day and night throughout, this will also help to save labor cost [2].

Conclusions

Global population is estimated to reach more than 9 billion by the year 2050, this will require more than 70% of the agricultural production overall to feed the world [22]. With the advancement of technology, the world is growing, so is our sector agriculture. AI is indeed the most wanted these days as it lessens the burden which is on the shoulders of the farmers. AI may help the farmers, scientist and other people globally to analyze the disease and other aspects as it hampers approximately 40% of the crop. It will help to achieve the data very precisely and also to reduce the human error. Application based on AI technology is very easy and very efficient which can be used by anyone. India is also coming in the list as our country is also using the drones and other advanced technology for the crop production. It may be expensive at present or initial level but in the coming years it will be most wanted technology.

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