PLANT HEALTH MONITORING USING IoT: SMART OPTIONS FOR INDIAN FARMERS

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INTRODUCTION

Agriculture is an important sector in the Indian economy. It is the largest source of livelihood as 70 percent of the rural population in India are engaged in agriculture and its allied branches. Indian agriculture has registered impressive growth over the last few decades. It contributes about 17% to the total GDP. The exponential growth of population has however, marginalized the advances made in the agricultural sector.

Modernization in the agriculture sector has helped farmers increase production and prevent crop losses due to pests, diseases, climatic changes etc. Healthy plants which are free from disease are important for profitable crop production however, plant health needs to be monitored constantly. Traditional methods to monitor the plant health are tiresome, time-consuming and labour intensive. Indian farmers are adopting precision farming methods in agriculture to implement modern technology to the time tested traditional know-how. The Internet of things (IoT) has brought a huge impact on agriculture and has opened up a new era in the monitoring of plant health.

CONTEXT

Healthy plants are vital for agriculture. If crops remain healthy, it results in profitable production. Healthy plants ascertain sustainable growth in face of environmental stress, pests and various plant diseases. Agriculture is the mainstay of Indian economy. A series of successful agricultural revolutions has put India on the roadmap to self-sufficiency. However, the sheen of spectacular growth in agriculture has gradually diminished as the productivity levels of several crops remain unsatisfactory. Plant health remains a major concern; thus monitoring plant health becomes crucial.

Indian farmers traditionally practise intensive farming to get maximum yield from available land. They depend on the monsoon cycle for major crops and use various kinds of chemical fertilizers, pesticides and insecticides to increase production. Increased production is also accredited to improved pest and disease management strategies which include early detection,

monitoring the disease, better understanding of various pathogens and the use of different control measures.

Modernization, mechanization and increased investments in agricultural infrastructure are transforming the agriculture sector in India. Indian farmers have started adopting different modern techniques like the precision farming methods in agriculture. Information technology plays a key role in precision agriculture. It enables farmers to collect information and data for better decision making. Precision agriculture is a proactive approach that reduces some of the risks and liabilities common to agriculture. Precision agriculture is an umbrella concept for IoT-based approaches where decisions made by farmers are based on data determined by machines with superhuman accuracy. With IoT, there is no guesswork as precision farming involves sensors. Farmers monitor various conditions like humidity, soil pH, soil moisture, water level, light, relative humidity with the help of IoT.

The Internet of Things (IoT) was first developed in 1999 by the network radio frequency identification (RFID) system proposed by the Massachusetts Institute of Technology (MIT) Auto-ID Labs (Sarma *et al.*, 2019). The IoT roadmap is towards a smart future. It has a wide range of applications and has covered and reached almost every sphere of human life, be it health care, smart home, smart city, environmental monitoring, industry, agriculture and so on.

Agriculture is an ideal candidate for the deployment of IoT solutions because it occurs in wide areas that need to be continuously monitored and controlled (Islam *et al.*, 2015, Asghari *et al.*, 2019). IoT technology is playing an important role in various areas of protected agriculture as it is capable of helping farmers monitor soil condition, climate change and animal and plant health (Dlodlo and Kalezhi, 2015).

With the development of agricultural sensors, wireless communication, cloud computing, machine learning, artificial intelligence, drone based imaging and big data technologies, agriculture is seeing rapid changes in farming techniques. Proximity sensing is used for high-resolution data in soil testing. Proximity sensing requires sensors to be in contact with soil or in close proximity. Remote sensing is used where sensors are built into airborne systems and it helps in soil characterization. Cognitive IoT solutions can sense all this data and provide insights to farmers. The data can be accessed remotely by farmers.

In precision farming, computer vision technology, IoT and drone images generate data to ensure swift decisions taken by farmers. This has helped farmers in disease identification at

an early stage, pest identification, nutrient deficiency recognition and more. Detection of plant disease by naked eyes does not provide accurate results especially during the early stages. Mohammad *et al.*, worked on image processing techniques to detect leaf diseases accurately. It was done in five phases - image acquisition, preprocessing of the acquired image, feature extraction, classification of the diseases and displaying the result. A detailed survey about classification of the agricultural diseases by using the Support Vector Machine classifier has been provided (Mohammad *et al.*, 2016).

Optimal use of pesticides is possible if plant disease is detected at an early stage. This requires continuous monitoring which is expensive and time consuming. Rothe and Kshirsagar stated that image processing techniques are used as an effective way to recognize and classify the plant leaf diseases quickly (Rothe and Kshirsagar, 2014).

Plant diseases seriously affect the quantity and quality of agricultural products. Manual plant disease detection is tedious, as it requires vigilance and is work and labour intensive. Detection of plant diseases using IoT provides promising steps towards sustainable agriculture. An automated system detects the presence of disease in the plants using sensors like temperature, humidity and colour parameters. Islam *et al.*, integrated image processing and machine learning to allow diagnosis of diseases from leaf images. This automated method could classify potato plant diseases based on an open source plant image database called `Plant Village'. They demonstrated disease classification of over 300 images with an accuracy of 95%. Thus, IoT presents a path toward automated plant diseases diagnosis on a massive scale (Islam *et al.*, 2017). Cameras in the IoT system are able to capture crop diseases and insect pests in the greenhouse in real time, helping farmers find problems and take targeted preventive measures (Ma *et al.*, 2015).

Pavel *et al.*, proposed a Raspberry Pi based IoT device which sends images of plants to classify diseases and updates environmental parameters like air temperature, humidity, soil moisture and pH in a MySQL database in real-time. Multi-class support vector machine (SVM) is applied to categorize diseases using fourteen types of features of color, texture and shape obtained when implementing gray level co-occurrence matrix where the system was able to classify with an accuracy of 97.33% (Pavel *et al.*, 2019).

Image processing uses algorithms where images are imported as inputs and the output could be another image or features associated with the input image. It performs machine learning and artificial intelligence operations on an image, in order to extract some useful information

from it. IoT and image processing in combination assist to increase crop yield and reduce the chances of crop failure. In plant leaf classification, leaf is classified based on its different morphological features. Advanced machine learning algorithms like Neural Networks, Genetic Algorithm, Support Vector Machine, Principal Component Analysis & K-nearest neighbour classifiers have been used in plant health study. Plant diseases classification has a wide application in agriculture.

Akkas and Sokullu explained about the system based on IoT for measuring the humidity level in Real time (Akkas and Sokullu, 2017). Srinidhi Siddagangaiah reported that by sensing all the factors related to growth, farmers could get data related to the factors affecting plant health (Siddagangaiah, 2016). Phalke *et al.,* described the IoT components, use of IoT in agriculture and how it benefits farmers (Phalke *et al.,* 2017). Kuruva and Balumuri used Raspberry Pi and other sensors to monitor temperature and humidity (Kuruva and Balumuri, 2016). IoT enabled agriculture has helped bridge the gap between quality and quantity of crop yield. In IoT enabled agriculture, data inputs from multiple sensors in real-time and storage in a database has ensured swift action and less damage to crops. With seamless end to end intelligent operations, IoT-enabled agriculture allows farmers to monitor plant health in real-time.

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