ARTIFICIAL INTELLIGENCE IN AGRICULTURE

Abstract

India is an agricultural country. Agriculture is the primary occupation of more than half of the population in the country. From the time agriculture was started as a means for survival of human being, it has transformed in various ways over the time and the pace has rapidly increased in the last one decade due to globalization and technological advancement. The population of the world is increasing and there is long way to go to make this planet hunger free. Population growth, climatic changes and the reducing resources have put agriculture under tremendous pressure. Artificial intelligence has found its implementation in various sectors like healthcare, finance, manufacturing, marketing and others to overcome the traditional challenges and boost productivity. To ensure food security to the growing population, more efficient farming practices should be adopted using the recent technological advancements in the field of artificial intelligence. Artificial intelligence has the potential to drive an agricultural revolution to produce more food using fewer resources. This paper deals with how artificial intelligence has been adopted in agriculture to solve the challenges faced by farmers. Computer vision has found its applications in almost all fields and agriculture is one of them. The use of the advanced technologies in the ago industries is essential. In this paper the challenges faced in traditional method of farming and how smart farming can be helpful for the growth and sustainability of agriculture has been discussed.

Keywords: agriculture, artificial intelligence, drones, image processing, deep learning

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I. INTRODUCTION

India is the world's second-largest producer of rice, wheat, sugarcane, cotton, groundnuts along with fruits and vegetables. 25% of the world's pulses are also produced by India until 2019. Agriculture contributes almost 16% of the GDP in India. Artificial intelligence (AI) has made an impact on the lives of the people and has a lot of influence in almost all the domain of the industries and agriculture is one of them. AI is based on the concept of applying human intelligence in a way the machine can mimic it and execute the tasks from simple to most complex ones. AI is used to automate the jobs by using intelligent machines and to make things more accurate and efficient.

The art of cultivation of food crop and their management is called agriculture. One of the basic requirements of human is food. As the population of the world is increasing day by day, the demand and supply of food is also increasing, with the land and resources becoming insufficient to meet these requirements. This makes it necessary for the people to adopt a smarter and intelligent way in agriculture to become more efficient and be most productive and thereby make the world a better place to live in. The agriculture sector serves as the backbone to many other industries such as the food processing, textile, furniture, drug and cosmetic industries. This sector also provides market for other industries such as fertilizer and other agriculture equipment manufacturing industries. Thus agriculture is a vital contributor to the economy.

There are five stages in agriculture – soil preparation, sowing, manuring, irrigation, weed protection, harvesting and storage. Soil preparation is the initial stage where the soil is prepared for sowing the seeds by ploughing, leveling and manuring. The soil is loosened for proper aeration by ploughing and then distributed evenly and levelled. It is then manured. Sowing is the selection of good quality seeds. The depth of the soil, distance between the seeds and the climatic conditions such as rainfall, temperature and humidity plays in important factor in this stage. To produce a good and healthy crop, proper plant nutrients such as nitrogen, phosphorus and potassium are necessary. Supply of nutrients to the plants at regular intervals is necessary. Manuring is providing nutritional supplements and these supplements maybe natural (manure) or chemical compounds (fertilizers). Not only does manuring provide nutrients to the crops but also it replenishes the soil fertility as well. The supply of water to the crops is irrigation. This helps in keeping the soil moist and to maintain the humidity. Weeds are the plants that grow where it is not needed. Weed protection is important as they lead to low productivity, increases production cost and also lowers the crop quality. Harvesting is the cutting and gathering of the crop when it is matured. It is a labour-intensive activity. Storage is the post harvest stage where the products are stored to ensure food security.

Technological advancements in the agricultural sector are crucial not only to speed up the process but also to increase the efficiency. The emerging technologies enable the machines to see and understand the visual world as humans. In this paper, section II puts forward the challenges faced by farmers in traditional farming. Section III discusses about smart agricultural farming. Section IV discusses the challenges of AI adoption in agriculture.

II. CHALLENGES FACED BY FARMERS IN TRADITIONAL METHOD OF FARMING

With rapid growth of population, it has become more important to increase the crop productivity to feed the millions of hungry mouths by improving the farm outcomes. At the same time it is also important to conserve the precious natural resources. The crops need to be protected from the diseases and pests, weeds and fungi. There are a number of challenges that are faced by the farmers in the agricultural sector. Some of the main problems faced by the farmers are crop disease and pest infestations, pesticide control, weed management and lack of proper irrigation and drainage facilities.

Lack of knowledge about the pests and plants disease identification and classification is one of the reasons for the lower yield in production. They can have a devastating effect on the quality and quantity of the farm goods produced and thereby leading to both production and economic loss for the agricultural industry. Diseases can destroy the entire crops leading to severe loss for the farmers. Monitoring the health and the disease occurrence of the plants is very important for sustainable agriculture. The traditional approach to detect and identify the plant diseases is through visual observation by comparing the diseased plant with the healthy plant. This requires lots of human resources. In a developing country like India, people have to go long distances to consult the experts which is time consuming and expensive. As such computerized identification and diagnosis of the plant diseases and pests is widely needed in agriculture. Early detection of the diseases would help to take appropriate preventive measures and thereby ensure crop losses. Most of the plant diseases are caused by fungi, followed by virus and then by bacteria.

Owing to urbanization, the land availability for farming is decreasing day by day. Efficient methods of farming need to be devised so as to ensure food security of the population. The gap between water demand and the available water supply is increasing in different parts of the world. It is estimated that by 2025, over 3 million people would experience water stress [1]. Water harvesting procedures should be accepted as a proper irrigation system is very crucial for a good yield. Agriculture uses around 70% of the fresh water. Optimal use of water is linked to successful farming. There are several factors associated with the amount of water to be supplied to the fields. Plant types, climate, rainfall and other factors determine the plant irrigation needs. Overwatering or underwatering can damage the crops and thus the frequency and interval between successive irrigation needs to be controlled.

Weeds are the unwanted plants that compete with the crops for water, minerals and other essential nutrients present in the soil. They are persistent problems in crop production. They can diminish the commercial worth of the agricultural regions by lowering the crop quality. Herbicides are used to control the weed growth but they have negative consequences on human health and the environment [2]. To get rid of the weeds, herbicides are sprayed uniformly throughout the fields two or three times during the growth season, which mean that those areas without weeds are also sprayed. Recently weed control and management is an important area of study [3]. As such in precision agriculture expert systems are suggested for automatic weed control.

Pesticides are the chemicals that are extensively used to protect the plants from pests, disease carriers and also weeds. To apply a pesticide, it is important to identify the pests and disease correctly. Injudicious use of pesticides hampers the growth of the plants and can possess serious consequences as they easily get contaminated with the environment, food and water bodies. At times, the crop may be infected with more than one disease or pests and to fight such a condition different types of pesticides may have to be used. Therefore, it is essential to have a proper knowledge of these.

III. SMART AGRICULTURE

With the advent of advanced technologies in all domains, it is crucial to implement automation in agriculture. The population of the world is expected to reach over 9 billion by 2050 which means that there would be a need to increase the food production to feed the people. In India, three-fourth of the population depends on agriculture. This is a serious challenge for the agricultural industry to fulfill the food requirements [4]. The traditional farming system that is followed in the country is not enough to meet the growing demands of the growing population. There is a requirement of smart and efficient agriculture method that can produce crops on a large scale while reducing its impact on the environment. Precision agriculture is an efficient way to improve the crop yield and it is aided by advanced technologies such as data science, artificial intelligence, IoT (Internet of Things) and data mining. These technologies have made the agricultural applications incredibly efficient and simple. The manual techniques are time consuming and expensive.

The artificial intelligent technologies like artificial neural networks, machine learning and deep learning are used in agriculture industry for sustainable agriculture as it is the need of the hour. Without adopting the recent technologies for sustainable agriculture, India would not be able to meet its food security objectives without significant damage to its territory.

Deep learning is a sub-domain of machine learning which has shown excellent results in image identification [5]. Deep learning models achieved a breakthrough in image processing and can automatically extract the features of the image data and perform classification. The image processing techniques in deep learning models basically works in three steps: image acquisition through a camera, processing the image and then understanding the image. Machine learning and deep learning techniques have been used for the prediction of crop quality, weed detection, crop yield prediction, automatic counting of fruits and vegetables, and disease detection.

Drones, sensors and smart farming apps are used today for agricultural security, monitoring and pests control. Drones are used for spraying seeds and nutrients into the soil. The Agras MG-1 drone can carry 10 litres of liquid at one time and can cover over 6,000 square meters of farm area in just 10 minutes. Drones are also used for weed management over large agricultural areas. Sensors are used to determine the soil health such as its salinity, acidity levels and its moisture contents to aid in farming practices. The sensors are also used for weather forecasting and safeguarding livestock. Remote sensing and hyper spectral imaging has the potential to introduce a revolutionary change in how the farmlands are monitored. The paper [6] discusses about the applications of artificial neural networks, computer vision technologies and IoT in agriculture and others which helps in precision farming. Convolutional neural networks (CNN) are the best deep learning networks for the

image feature extraction [7]. A number of CNN architectures exist for image classification. Some of them are AlexNet [8], DenseNet [9], EfficientNet [10] and many others as developed by the researchers. Over the recent years, researches in agricultural based industries such as food processing and fruit classifications have gained a more focused research direction. The fruits and vegetables detection and classification has demonstrated to be a complex and a challenging task. In the food processing industries, detection and classification of the fresh and the rotten fruits is crucial. Many researchers have developed datasets for plants and crops and made it public for future researches to be carried out in due course of time. The automatic counting of fruits and vegetables using technologies helps in the marketing of these.

Crop monitoring and crop health assessment are crucial to the development of agriculture. The symptoms of plant diseases are mostly visible in the leaves initially. Accurate and timely detection of crop diseases and pests can help minimize crop losses and increase crop yield. Automatic plant disease detection using plant leaf and fruit images is tackled by traditional machine learning and image processing techniques. Many researchers have conducted researches using machine learning technologies [11]. Deep learning has produced higher prediction accuracies than machine learning. There have been many approaches with deep learning technologies to detect, identify and diagnose the plant diseases. Different deep learning models such as Vgg16, Vgg19, ResNet50, ResNet50V2, and ResNet101V2 have been used on both artificial data as well as on images collected from the fields and has decent accuracies in detections and predictions.

Irrigation is a much labour-intensive process in farming. For improvement in farming, spraying of pesticides, irrigation and harvesting should be automated. Innovative methods of farming are required for an effective outcome. Most of the fresh water resource is used for irrigation. Automation of the irrigation system can help to reduce the water wastage and to conserve the water thereby solving the water problem in farming. With the help of IoT sensors, the soil moisture contents can be checked to determine the right amount of water to get optimal yield and quality and the necessary actions can be taken. AI can help identify the areas which are being overwatered or underwatered with the help of sensors and hyperspectral imaging. Researchers have created intelligent pesticide spraying robots to minimize the usage of pesticides in the areas where it is not required [12]. However, there are still many challenges to overcome such systems in the field.

Technology can help us build a better tomorrow. It reduces the production costs, increase crop quality and ensure sustainability. IoT in agriculture is helping the farmers to boost productivity and reduce the wastes produced. IoT is a network of sensors and gadgets that can communicate with one another and share data. The need of IoT in forestry, weather forecasting, crop farming, livestock farming, wildlife management, rural financing and market identification has been mentioned in the paper “The Internet of Things in Agriculture for Sustainable Rural Development” [13]. AI can help in remote monitoring of the crops, automated irrigation system, etc. Better distribution and judicious usage of water in the fields by the automated systems ensures a good harvest to the farmers.

IV. CHALLENGES OF AI ADOPTION IN AGRICULTURE

There is a lack of infrastructure in the agriculture sector. The AI enabled applications are yet to be more robust and affordable to reach the farmers community for its optimum utilization. If the AI-powered solutions are made to be open source, then the applications would be more affordable and can thus result in faster penetration in the sector. Knowledge of IoT and technologies are necessary. The adoption of drones, sensors and other tools are relatively new in agriculture and the cost of acquiring such tools is high. This is the biggest challenge that the vast majority of farmers cannot afford such technologies. Establishing the support infrastructure for smart farming techniques is not an easy task. There also is the matter of reliability and trust of the farmers on the new methods of farming.

Lack of large general labeled public datasets availability of the field images is one of the main constraints in the agriculture research. There is a need for adequate number of training samples in training the deep learning models to be more robust [14]. The field of agriculture therefore provides a fertile ground for the upcoming researchers. Artificial intelligent models require a lot of data to precisely make the predictions or forecasting. Getting the data over the large agricultural areas under different conditions is a challenge. Crops are grown in different seasons and the crop data could be collected only during those seasons.

V. CONCLUSION

Future of farming is largely reliant on adapting to better solutions. The amalgamation of artificial intelligence and IoT in agriculture makes it easier for producers to make informed decisions. The advanced techniques are used to identify the best crop for a particular location and to identify the factors that may destroy the crops such as diseases, pests and weeds. They provide the insights about the crop growth and help the farmers to take the right decision. For the upliftment of the economy, research in agriculture and its related industry is very important. Although a number of researches are going on in this sector and many applications are already available, the industry is still not having sufficient services and remains to be underserved. It requires more robust applications exploiting the tremendous scope of artificial intelligence. Finally, with the population to hit the 9 billion mark in the coming years, adoption of smart farming to maximize the production is the smart way.

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