DESIGN AND DEVELOP A FRAMEWORK OF PRECISION FARMING FOR MAIZE USING IoT AND EDGE INTELLIGENCE

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ABSTRACT

Precision Farming is the new age technology, one should adopt to boost the process of farming and receive better output. Here, A Framework is proposed for obtaining the desired standard quality of the crop maize providing all the required conditions to achieve this. Some Parameters like soil parameters, environmental parameters are considered to observe the crops for their well being and check the original status of the crop. Usually after receiving data from IoT device, with in-built sensors to detect temperature, humidity, soil moisture, and soil nutrients such as nitrogen, potassium, and phosphorus, it goes to Cloud Server for further processing by running algorithms. Here, Edge Analytics and Edge Intelligence play the role between Edge Device and Cloud Server for preprocessing of the data to reduce the burden on Cloud Server. Further this change can be proved to be beneficial in every aspect as we have already entered in the era of Big Data.

Key words: Precision Farming, IoT device, sensors, Cloud Server, Edge Analytics, Edge Intelligence, Big Data.

INTRODUCTION

For understanding the framework for precision agriculture that we intend to create, we need a thorough understanding of what is agriculture. What was the need for bringing Precision Agriculture? What are the digital technologies that can be used with Precision Agriculture to make it fruitful for farmers?

1. FARMING

Farming is growing crops and keeping animals for food and raw materials. Farming is a part of agriculture.

Agriculture [28] is the art and science of cultivating the soil, growing crops and raising livestock. It includes the preparation of plant and animal products for people to use and their distribution to markets. Traditionally, farmers have used a variety of methods to protect their crops from pests and diseases. They have put herb-based poisons on crops, handpicked insects off plants, bred strong varieties of crops, and rotated crops to control insects.

Farming methods often vary widely around the world, depending on climate, terrain, traditions, and available technology. Low-technology farming involves permanent crops: food grown on land that is not replanted after each harvest. Higher-technology farming involves crop rotation, which requires knowledge of farmable land. Scholars and engineers not only use crop rotation and irrigation, but plant crops according to the season, type of soil, and amount of water needed.

There are lot of challenges in the way of farming. Biggest challenge is overpopulation. Agricultural practices in developed and developing countries have led to a severe loss of valuable topsoil, water, and other resources. Many countries need better programs for replanting forests.

 There is a need for upgradation of traditional farming methods so as to make proper use of the limited resources, fulfilling the increasing demands of food and that too with sustainable environment. It is where Precision farming comes into picture

1. PRECISION FARMING

 Precision Farming is a farm management concept that revolves around the process of observing, measuring, and responding to various inter-and intra-field variability inputs for modern agriculture[39].

‘Precision agriculture is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production.’ The International Society of Precision Agriculture adopted the above definition of precision agriculture in 2019.

Emerging technologies, such as geospatial technologies, Internet of Things (IoT), Big Data analysis, and artificial intelligence (AI), could be utilized to make informed management decisions aimed to increase crop production. Precision agriculture (PA) entails the application of a suite of such technologies to optimize agricultural inputs to increase agricultural production and reduce input losses.[13]

Precision agriculture is described in the literature by various terms such as Precision farming (PF), Site-Specific input Application (SSA), Site-Specific Agricultural Technology and Variable-Rate Treatment (VRT). In the following, these terms will be used synonymously. A broader term is Smart Agriculture that also appears to cover later technical developments such as auto steering systems, controlled traffic farming and autonomous systems like agricultural robots.

Precision farming incorporates information and communication technologies into machinery, equipment and sensors used in agricultural production systems. Technologies such as the IoT and cloud computing are advancing this development even further by introducing more robots and artificial intelligence into farming[40].

For example, farmers can use smartphones and tablets to access real-time data about the condition of almost anything involved in their day-to-day operations like soil, plants, terrain, weather, location of assets, conditions of assets, livestock, resource usage.

1. INTERNET OF THINGS

Internet of things (IoT) is considered to revolutionize the way internet works and bring together the concepts such as machine to machine (M2M) communication, big data, artificial intelligence, etc. to work under a same umbrella such that cyber space and human (physical systems) are more intertwined and thus ubiquitous giving rise to cyber physical systems. This will involve billions of connections and smart products communicating with each other mostly without human intervention to achieve smart objectives. The idea of IoT has enticed significant research attentions since the massive connectivity bring varieties of challenges and obstacles including heterogeneity, scalability, security, big data, energy requirements, etc

 IoT works [29] with various enabling and emerging technologies such as wireless sensor networks (WSNs), sensor technologies, machine learning and artificial intelligence (AI), big data and analytics, etc. At the heart of IoT is WSNs, consisting of sensors deployed in a sensing area to monitor specific phenomenon (such as environmental monitoring) and collect data. Furthermore, even more pervasive network configuration are being developed where all possible devices (mostly of heterogeneous nature) connect with each other to sense, gather and analyze data of different nature to act upon the intelligence gained from deep insights of the data. These actions are mostly without human interaction.

The results from IoT Total Addressable Market (TAM) reveal that the number of IoT-connected devices in the overall world will grow from 7.6 billion to 24.1 billion and will lead to the revenue tripling from USD 465 billion to over USD 1.5 trillion[1].

IEEE explains IoT as a network that connects uniquely identifiable Things to the Internet. The Things have sensing/actuation and potential programmability capabilities’’ [1]. IoT essentially uses connected devices to perform a group of tasks like process monitoring, environmental sensing, and health monitoring. Wireless Sensor Network (WSN) are the most crucial underlying technology for IoT. A WSN is a network formed by deploying sensors to collect and forward the data to the enterprise or cloud for further processing. This precise data from the sensors, aerial devices, and IoT solutions are used for increasing farm productivity with environmental sustainability, predicting climate change, , monitoring, and having a proactive reaction to crop performance. It also helps in choosing a suitable crop by observing and measuring the demand or dependent factors.

1. EDGE ANALYTICS

Edge analytics[42] is a method of data collection and analysis that uses an automated analytical data computation that is performed at a sensor or other device. This is performed before the data is sent to a centralized store.

This process involves collecting, analyzing, and making decisions based on data that was generated within the same physical environment. The cloud isn’t involved in the process of data analysis, and all of the work is done on embedded devices.

For many businesses, streaming data from disparate IoT sources creates a huge store of data which is difficult to manage. By filtering the data through an analytics algorithm as it’s created at the edge of the network, parameters can be set to decide what data is worth migrating to the cloud or data store.

Edge analytics is real-time data analytics or analytics at the platform where data collection is taking place. Edge analytics may be descriptive, analytical, or predictive.

1. EDGE INTELLIGENCE

More recently, with the proliferation of mobile computing and Internet of Things (IoT), billions of mobile and IoT devices are connected to the Internet, generating zillions of bytes of data at the network edge. Going hand in hand with this trend, there is an urgent need to push the AI frontiers to the network edge so as to fully unleash the potential of the edge big data. To meet this demand, edge computing, an emerging paradigm that pushes computing tasks and services from the network core to the network edge, has been widely recognized as a promising solution. The resulted new interdiscipline, edge AI or edge intelligence (EI), is beginning to receive a tremendous amount of interest [36]. There are 4 types components of Edge Intelligence [41]: (a)Data Collection on Edge -In edge intelligence, a distributed data system, known by edge caching, collects and stores the data generated by edge devices. (b) Edge Training-During training, the optimal values for all the weights and biases, or the hidden patterns, are learned based on the training set cached at the edge. Edge training usually occurs on edge servers or edge devices. (c) Inference On Edge- Algorithms are used to infer the testing instance by a forward pass to compute the output on edge devices and servers. (d) Offloading-Training and inference are complemented with offloading strategies that take care of all the computing power distribution across tasks.

II LITERATURE REVIEW

In [1], a design of a multidisciplinary agriculture solution model for Precision Agriculture AgriFusion combining emerging technologies like Machine Learning (ML) and Artificial Intelligence (AI), edge computing and other emerging technologies is proposed. With the use of Blockchain and IoT, a trusted food traceability system is presented [4]. Blockchain is used for security reasons for proposed Blockchain based Producer- Consumer Model (BPCM)[5]. Blockchain and IoT together analyse agricultural data. The survey shows that the duo helps in Precision agriculture smart apps[6]. Four-tier green IoT-based agriculture architecture with smart agriculture is being described. Usage of technologies is also highlighted[7]. A generalized Blockchain security architecture is proposed[8]. [9] presents supply chain architecture using IoT and Blockchain detailed with concerns and security threats of the existing system. [10], [11],[17] details about UAV applications in crop monitoring process and data acquisition and technologies are discussed.

In [12], a low-cost farmland digital twin framework named as AgriLoRa for smart agriculture is proposed for low budget farmers with wireless sensor network cloud servers to run the algorithms. [13] gives a survey on vegetation indices and their latest use in Precision agriculture, covering studies between 2015 to 2020. [14] summarizes agriculture related UAS applications. Also discussed the AFarCloud project from Europe. AI and Big Data applications made familiar in Precision Agriculture [15]. [16] Analyses how to accurately place the sensors in the field and the height of the drone to catch the data.

Applications of Machine Learning in the field of agriculture are reviewed with respect to prediction of soil parameters, prediction of crop yield, disease, and detection of weed in crops and species [19]. A deep learning framework AgriSegNet for automatic detection of farmland anomalies is proposed to boost Precision Agriculture Potency. In [24], IoT-based sensible Agriculture observation model is planned for properties like Temperature, Rain Wind, Acoustic, pH levels of the cornfields, Humidity, Location and Chemical for sensible agriculture applications.

III PROPOSED METHODOLOGY

There are five stages for the development of the framework

1. Phase-1 Data Collection: The input data will be collected from IoT device. Data would be like environmental data, soil data, crop or plant data, etc.
2. Phase-2 Data Processing: The data collected by IoT device is processed with Edge Analytics.
3. Phase-3 Decision Making: This unit takes help of Edge Intelligence to take decisions intelligently.
4. Phase- 4 Cloud Server: The data is sent to the cloud server for storage.
5. Phase- 5 Services: Providing various services to farmers related to environmental conditions, soil conditions, etc.



Figure: Showing research methodology Phases



Figure Showing Process of Research Methodology

IV FUTURE SCOPE

The technique used in this framework can be used in every aspect wherever the cloud servers are involved. Since this is era of big data and to handle this kind of massive data on cloud server will overburden it and will consume more time than expected. Today in this fast life nobody wants to wait for anything. So, Edge Intelligence can be better given a thought to apply. In Precision farming, this proposed model is an initiative but it can be fruitful in other areas too.

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