Fertilizer Recommendation System based on Soil Macronutrients Analysis using IoT & Cloud Computing

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Abstract : Agriculture is the lifeline of Indian economy . India is a land of variety of soils. Soil health plays a crucial role in ensuring sustainable production with optimizing fertilizer utilization. New farmers are coming out without knowledge of soil characteristics because of insufficient soil testing labs in the states of the country. Also existing methods of soil testing are costly and time consuming .Today, a driving force behind increased agricultural production at a lower cost is the Internet of Things .Remote monitoring of soil parameters is an emerging trend which has the potential to transform agricultural practises and increase productivity .Soil sensors are used for sensing soil nutrient content and hence determine custom fertilizer profiles based on soil nutrient content.

***Index Terms* - IoT, Cloud Computing, Agriculture, Soil Macronutrients, Fertilizers.**

I. INTRODUCTION

Agriculture is the backbone of the Indian economy. The UN Food and agricultural organization predicts the global population will reach 8 billion people by 2025 and 9.6 billion people by 2050 (FAO 2009). This means that the world will need to produce 70% more food in 2050 than it did in 2006. India's arable land area of 159.7 million hectares is the second largest after US. Food security, nutritional security, profitability, sustainability are major principles of present and future agricultural development. With the steady rise in the population of humans and livestock there is a pressure mounting up on soil for increasing the food production. The soil macronutrients, nitrogen (N), phosphorus (P), and potassium (K), are essential elements for crop growth. The application of commercial N, P, and K fertilizers has contributed to a tremendous increase in yields of agricultural crops that feed the world's population (1)

IoT and cloud computing are expected to have a significant impact on farming while meeting the increasing consumption needs of a global population that is estimated to increase by 70% by 2050.Indian farmers are at preliminary level in realizing the potential of IoT and cloud computing for agricultural development as compared to other developed nations

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1.1 IoT

IoT is the extension of internet connectivity into physical devices and everyday objects embedded with electronics ,internet connectivity and other forms of h/w (such as sensors) .These devices can communicate and interact with others over the internet and they can remotely monitored and controlled. IoT is emerging as the third wave in the development of the internet . The 1990s' Internet wave connected1 billion users, while 2000s' mobile wave connected another 2 billion ,The IoT has the potential to connect 10X as many (28 billion) " things" to the Internet by 2020.

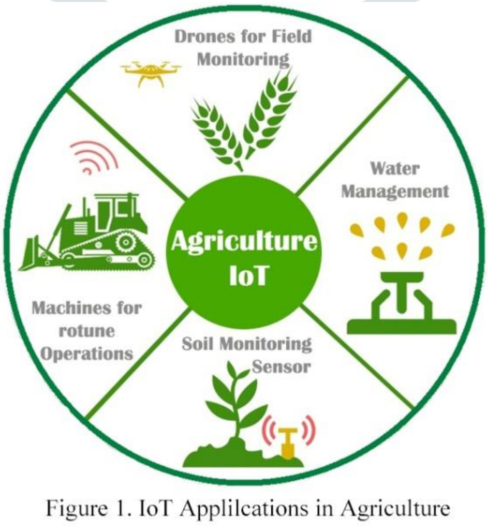

Figure 1. IoT Applilcations in Agriculture

IoT has key attributes that distinguish it from the "regular " Internet as captured by Goldman Sach's SENSE framework: Sensing , Effective, Networked, Specialized, Everywhere.

Cloud computing

Recently, cloud computing emerged as the leading technology for delivering reliable, secure, fault-tolerant, sustainable, and scalable computational services, which are presented as Software, Infrastructure, or Platform as services (SaaS, IaaS, PaaS). Moreover, these services

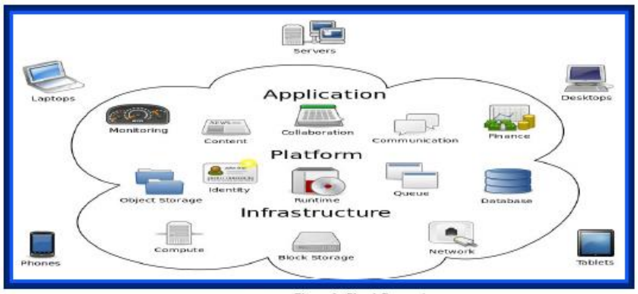

Figure 2. Cloud Computing

may be offered in private data centers (private clouds), may be commercially offered for clients (public clouds), or yet it is possible that both public and private clouds are combined in hybrid clouds. The cloud and cloud computing are amongst the most recent advances in the field of IT. IT infrastructure and applications are provided to end users as services using a standard pay per use model. Cloud computing is a powerful tool for accessing high performance computing(HPC) and storage infrastructure at reduced prices via the internet.

Some of the key characteristics of cloud computing are

- On demand access
- Elasticity
- Cost effectiveness
- Scalability
- Minimal infrastructure management
- Location independence

II. Role of IoT and Cloud Computing in Agriculture in Rural India

2.1 IoT for Agriculture

Datang Mobile proposes Wisdom Agriculture system solution of Internet of Things for Agriculture. The system has three layers, namely, sensor layer, transport layer, application layer. Their functions are as follows:

1)Sensor/Information Collection Layer: The main task of this layer is to achieve automatic and real-time transformation of the physical figures of real-world agricultural production into digital information or data that can be processed in virtual world through various means. The information categorise that Internet of Things for Agriculture collects are:

- Agricultural sensor information: temperature, humidity, pressure, gas concentrations and vital signs, etc.
- Agricultural products attribute information: name, model, feature and price, etc.
- Agricultural working status information: operating parameters of apparatus, equipment, etc.
- Agricultural location information: location of products, etc.

The main task of Information collection layer is to mark the various kinds of information, and collect the marked information and the physical information in the real world by sensing techniques, and then transform them to digital information for processing. Information collection layer involves these techniques: two-dimension code labels and readers, RFID tags and readers, cameras, GPS sensors, terminals, cable networks, sensor networks and wireless networks.

2) Transport/Network Layer: The main task of this layer is to collect and summarize the agricultural information acquired through Sensor Layer for processing. Transport Layer is the nerve centre and cerebra of Internet of Things for Agriculture, transmitting and processing data. The network layer includes the integration of the Internet network and telecommunication, network management centre, information centre and intelligent processing centres.

3) Application Layer: The main task of this layer is to analyze and process the information collected so as to cultivate digital awareness of the real word. It is a combination of IOT and Agricultural Market intelligence.

2.2 Benefits of IOT in Agriculture

The following are the benefits of IOT applications in agriculture:

1) Improvement in the use efficiency of inputs (Soil, Water, Fertilizers, Pesticides, etc.)
2) Reduced cost of production
3) Increased profitability

4) Sustainability
5) Food safety
6) Protection of the environment

2.3 Cloud Computing in Agriculture

In rural areas, it is not economically viable for farmers to deal with service providers on an individual basis. They need comprehensive and cost effective service providers with multiple services. MBR Consumer Services Pvt. Ltd. Founded in 2005 by Rama Krishna is one such venture to meet the rural market demand. It began as a super bazaar based out of Eluru, Andhra Pradesh. It was initially set up for only 10 villages and gradually expanded to 55 villages. It enables the consumers to have day-to-day transaction with the company. It is making pioneering micro franchising level efforts to create a far-reaching positive impact in bringing a qualitative change and implement revolutionizing super bazaar model in rural areas.

The real India lives in its villages and smaller towns and therein lies the future of India. Rural India has been ignored for more than 60 years and the cloud technology will bring the change that is required to bridge the divide rural India and Urban India, and will improve the Indian rural economy. The principal source of income of India is agriculture. So the development of the ICT is basically focused on the Indian agriculture sector. Cloud computing is a general term used to describe a new class of network based computing that take place over the internet. These platform hide the complexity and details of underlying infrastructure from users and applications by providing very simple graphical interface. Latest technological development has through a dramatic change in every field and agriculture is no exception to it. Cloud computing technology impacted positively on agriculture field and related services they provide for users.

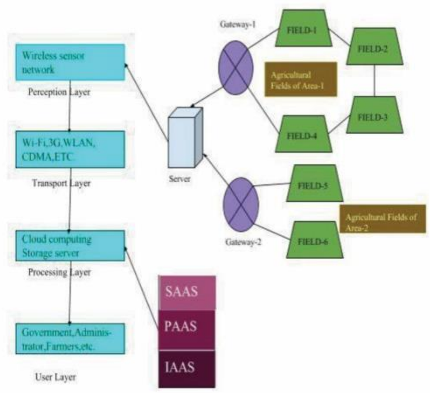

Figure 3. Cloud Computing and IoT based Agricultural Proposed Model

2.4 Benefits of Cloud Computing in Agriculture

- Data Readiness any time & any where
- Local and global communication
- Improve economic condition of the Nation
- Enhanced the GDP of the nation
- Ensure food security level
- Motivation of farmers and researchers
- Reduction of technical issue
- Rural-Urban movement
- Data availability at any time and at any location without delay
- Improve market price of Food, seeds, other product

2.5 Challenges of Cloud Computing in Agriculture

- Maintenance & Supervision by third party, So data security is less
- Indirect administrator accountability
- Farmer is unknown for cloud computing technology
- Less physical control
- Attraction to hackers
- Need on the network connectivity
- Requires a constant Internet connection
- Platform facility is not easily available for farmers
- Farmers training necessary for this technology
- Does not work well with low-speed connections
- it runs the risk of security

III. LITERATURE SURVEY

3.1 Fan Tong Ke et al, (2013) proposes how smart agricultural practises and agricultural modernization can be possible by combining the major features of cloud computing and key techniques of IoT. A combination of these technologies can promote rapid development of agricultural modernization and smart farming meeting the global population demands of food production.

3.2 Komal. Bodake et al, (2018) proposes a soil based fertilizer recommendation system using data mining techniques in regional language. The tool is developed in regional language so that farmers can understand easily and take proper decisions regarding crop prediction.

3.3 Abbas . I et al , (2018) proposes a system that focuses on monitoring the key parameters of soil like temperature ,humidity ,pH and predicting the crop to be planted in the soil. The proposed system consists of a series of array of sensors like temperature, humidity, pH sensors . The data is being sent to cloud for further processing like comparing it with stored data and make further crop prediction.

3.4 Rakesh Patel et al , (2013) proposes how cloud computing and its effective implementation can be used as an ICT tool in developing Indian agricultural sectors in rural India. The implementation of the cloud computing model in agriculture sector will have tremendous impact on the economic development of the nation.

IV. PROPOSED ARCHITECTURE

The proposed architecture comprises of the following steps

4.1 Creating a WSN (wireless sensor network)for sensing soil's macronutrients.(N,P,K).

NS2 SIMULATORS : A wireless sensor network (WSN) consists of a number of sensors which are spatially distributed and are capable of computing, communicating and sensing.NS2 is an event-driven simulation tool that is useful in studying the dynamic nature of computer networks.NS2 provides users with executable command ns which take on input argument, which is the name of a Tool Command Language (TCL)simulation scripting file. Network Animator (NAM) is a TCLbased animation tool for viewing network simulation traces and real world packet traces. Scripting languages such as AW K (Aho Weinberger Kernighan) script and PERL script can be used to calculate the performance metrics using these trace files.

4.2 Data collection and data aggregation in WSN.

Data aggregation is an energy efficient technique in WSNs. Due to high node density in sensor networks same data is sensed by many nodes, which results in redundancy. This redundancy can be eliminated by using data aggregation approach while routing packets from source nodes to base station

4.3 Transferring the packets from source to main server updating the soil sensor status to the network.

4.4 Cloud environment is created

4.4.1 Cloud simulators It is not possible in the real world for researchers to have actual cloud infrastructure to perform real time experiments and implement new algorithms and methodologies. The need for a cloud computing simulator arises in order to witness an implementation scenario in the real world. Cloud simulators play a crucial role in reducing the complexity of the infrastructure in executing new algorithm ,security threats and measuring the overall quality and performance of the infrastructure.

4.4.2 CloudSim CloudSim is probably the most famous & popular simulator for cloud environments & parameters. It was developed in the CLOUDS Laboratory, at the Computer Science and Software Engineering Department of the University of Melbourne. The CloudSim library is used for [17]:

- Large scale cloud computing at data centres
- Virtualized server hosts with customizable policies
- Support for modelling and simulation of large scale cloud computing data centers
- Support for modelling and simulation of virtualized server hosts, with customizable policies for provisioning host resources to VMs
- Support for modelling and simulation of energy-aware computational resources
- Support for modelling and simulation of data centre network topologies and message-passing applications
- Support for modelling and simulation of federated clouds
- Support for dynamic insertion of simulation elements, as well as stopping and resuming simulation
- Support for user-defined policies to allot hosts to VMs, and policies for allotting host resources to VMs

4.5 Using the data mining techniques soil sensor status and nutrient level data is being classified and appropriate class of fertilizers is being recommended

Naive Bayes: A Naive Bayes classifier is one of the classifiers in a family of simple probabilistic classification techniques in machine learning. It is based on the Bayes theorem with independence features. Each class labels are estimated through probability of given instance. It needs only small amount of training data to predict class label necessary for classification.

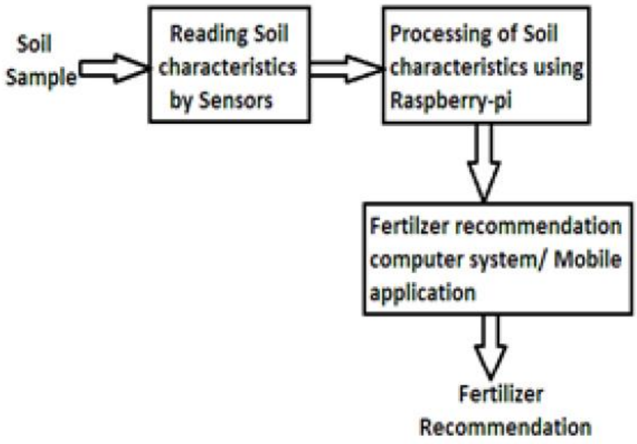

Figure 4. Soil Based Fertilizer Recommendation System using IoT.

V. Proposed Algorithm

5.1 Algorithm 1: Naive Bayes Algorithm

• D: Set of tuples

1) Each tuple is an 'n' dimensional attribute vector
2) X : (x1,x2,x3,……xn)
3) Where xi is the value of attribute Ai

• Let there are 'm' Classes : C1,C2,C3,……Cm

• Bayesian classifier predicts X belongs to Class to Class efficiency

Likelihood Class Prior Probability

$$P(c \mid x) = \frac{P(x \mid c)P(c)}{P(x)}$$

Posterior Probability Predictor Prior Probability

$$P(c \mid X) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c)$$

Above,

- *P(c|x)* is the posterior probability of class (c, target)
- given predictor (x, attributes).
- *P(c)* is the prior probability of class.
- *P(x|c)* is the likelihood which is the probability of predictor given class.
- *P(x)* is the prior probability of predictor.
- *P(Ci|X)>P(Cj|X)* for 1<=j<=m , j!= i
- Maximum Posteriori Hypothesis

5.2 Algorithm 2 : Fertilizer Recommendation

INPUT: Nutrients
OUTPUT: Fertilizer recommendation.

1) while 1 do
2) NPK ← Record nutrients from the sensor (NPK sensor) ⊲ NPK sensor is used to record the NPK values into the database.
3) Bayes ← Posteriori (NPK) ⊲ Find the probability of each nutrients from the database.
4) Predict← predict (Posteriori (recorded, Ground Truth)) ⊲ Based on posterior probability the matched group of fertilizers are suggested to the user.

VI. Conclusion

Agriculture is one of the sector that is expected to be highly influenced by advances in the domain of IoT and cloud computing. A model has been proposed for fertilizer recommendation based on soil classification using multiple techniques: IoT , Cloud Computing and Data mining. .This model will ensure better crop production by combining the major techniques of IoT and key features of cloud computing.

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