A Review of Fertilizer recommendation systems on Smart Agriculture using IOT

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Abstract

Smart Agriculture Systems give emphasis to the necessity of modern technology includes the Internet of Things (IoT), Cloud and Artificial Intelligence (AI), Machine Learning (ML), Decision Support System (DSS) in the agricultural process. Modern technology and digital tool are used to renovate these agricultural domains towards intelligent and dynamic, leads to higher production using less human supervision. A new paradigm precision and introduction of smart agriculture has emerged for great productivity in agriculture with the reduced utilization of resources. Administering soil nature like fertility is the major of agriculture handling in a sustainable way. Soil fertility accounts to the level of nutrients actively present in the soil which are essential for growth of plant and helps in production of food quantity for the highly increasing population. The root of precision agriculture in terms of sustainable and profitable way is supplying necessary exact amount of fertilizer accordingly to the real-time context. Fertilizer Recommendation application targeting towards optimization of nutrient utilization through determining the exact volume of fertilizer to apply depends on those plant's health. These application system helps in chemical and fertilizer cost reduction, possible improvement in production and environment preservation. For better crop yield, productivity, and sustainable soil quality accurate fertilizer need to be efficiently used. In real time systems without considering soil level of fertility, type of crop, and type of soil many fertilizers recommendation systems have been proposed. For sustainable developments in agriculture efficient fertilizer application model is a prerequisite.

Keywords - Precision Agriculture (PA); Internet of Things (IoT); Machine Learning (ML); Artificial Intelligence (AI) ; Cloud ; Decision Support System (DSS); Fertilizer recommendation Systems;

I. Introduction

In agriculture for efficient productivity towards this optimal use of resources brings a new paradigm called Precision and Smart agriculture which have emerged. Soil fertility is the measure of level of nutrients present in the soil that are essential for plant growth. Thus growth of plants is directly proportional with the soil fertility level. Controlling soil fertility helps in sustainable agriculture which in turns helps in production of food for the keep on-increasing population. Depletion in the level of soil nutrients leads to soil fertility level low that has been resulted by extensive crop production. Injudicious usage of fertilizers leads to soil fertility problems which directly affects productivity and yield in agriculture.

The correct fertilizer is selected based on numerous factors. These efficient application with fertilizers preserves resources along with prevents soil deterioration. For crop with good yield, productivity enhancement and making sustainable quality of soil accurate fertilizer supply forms the basic requirement. For solving issues on conventional methods on soil fertility mappings, a diversified IoT-based soil fertility mappings ,architectures are suggested and executed.

Among various agricultural issues, helping farmers by suggesting them the accurate amount of fertilizer to preserve their money and corresponding workforce. In the traditional method, each fertilizer's level was decided randomly or their financial position will decide the quantity that leads to soil erosion and wastage of resources. Many IoT-assisted works have been defined so far for soil fertility and fertilizer recommendation.

Generally Urea (N), Single Super Phosphate (SSP) and Unit of Potash (MOP) are the three essential fertilizers in practice. NPK values will decide the right amount of fertilizer for every land. Smart agricultural systems based on current IoT communication technology - AI, ML, DL, DSS and Wireless Networks, using IoT agricultural sensors valuable data are gathered and evaluated for farmers. Soil nutrient value that is extracted by the sensors is stored in a cloud environment and used as recommendations by farmers. In real-time depends on fertility, soil type, and crop type of the land, an appropriate amount of fertilizer is advised using soil NPK level. The proposed solution is evaluated in terms of accuracies. This paper systematically summarizes some of the recently proposed fertilizer applications. The various key technologies of proposed fertilizer recommendations are discussed and analysed in detail.

II. Comparison of Related Work

A. **Deep Learning based Fertilizer Recommendation Model**

Bhuvaneswari Swaminathan et al. [1] proposed a Fertilizer Recommendation Model using IoT driven Artificial Intelligence technique helps deploying the smart farming as system provided energy limited consumption. Based over sensors and AI technology a complete mechanisation model is designed as an advanced intelligent agricultural recommendation. Similar sensor and smart fertilizers forecasting system have been incorporated in this model. Thus, appropriate volume and mixture of fertilizers required for land has been identified using this smart farming system. The Deep Learning algorithm is deployed on sensor extracted nutrients information and derived the solution. This solution been developed in easy interactive module on mobile application. Apache Mahout framework shows this hidden type of modules from those extracted data using for data mining process which applies the DL algorithm. An Intelligent agricultural platform that applies Machine Learning techniques for selecting all suitable crops for land, predicting fertilizers quantity, extras. Data categorization algorithms helps in redundancy removal and new machine learning models speed up the data process. This Fertilizer application determines volume of using fertilizer depends on these plant's health which optimize nutrient utilization. This results in fertilizers and chemicals cost reduction, increase in production, and preservation of environment. Suggesting those required volume of fertilizers help those farmers in saving hard money avoiding corresponding more fertilizer and extra workforce. NPK values ensures the correct volume of fertilizers required on land. The sensors extracted recommended soil nutrients value from the land and are stored in the cloud environment. For each unknown land ML and DL algorithms are applied in this work for predicting fertilizer amount. Accurate prediction of fertilizer amount is achieved by a Bi-LSTM deep learning network.

Based on the predicted value from Bi-LSTM network recommendation of fertilizers is given to the unknown land. The models are designed with Python and dataset of soil nutrients were tested against this model. Available nutrients, crop cultivation, and recommended fertilizers are input as data in this platform. On each prediction model this data is fed and executed with standard parameter. The average value of the parameters are determined with ten executions. An effective better outcome is resulted from Bi-LSTM prediction model. These modules recommend correct amount of fertilizer based on needed nutrients values and suggesting crops. These system helps farmers in taking decisions on fertilizers. This working system using a deep learning approach offers a smart agricultural technology in fertilizers recommendation with the high-profile matching experts' opinion.

B. **Machine Learning based Context aware Fertilizer Recommendation Model**

Arfat Ahmad Khan et al. [2] designed a machine learning-based context-aware fertilizer recommendation, a soil fertility mapping architecture which is IoT-assisted. This fertilizer recommendations system is based on real-time fertility levels of soil, crop types, and soil types for accurate fertility in soil management. Thus, accuracy of proposed IoT-assisted fertility mapping is assessed. Accuracy of this system is differentiated against the standard soil chemical analysis method. Precise fertilizers recommendation system based over the real-time sensation on soil fertility levels, soil types, and crop types using machines learning model is also proposed. Machine learning algorithm such as Logistic Regression (LR), SVM, KNN, and GNB models are applied on this recommendation system. Major objective of this machines learning model is to endorse those exact amount of fertilizer. This depends on the levels of soil fertility which in terms of macro-element (NPK), crop types, and soil types. The existing level of soil fertility is recorded to directly define the level of NPK in soil. The real-time soil NPK level gives input to this machine-learning model to recommend an appropriate amount of fertilizer. It uses Logistic Regression (LR), Gaussian Naïve Bayes (GNB), Support Vector Machine (SVM), and k-Nearest Neighbor (KNN) based machine learning models to predict the fertilizer according to the context. Logistic Regression is a supervised machine learning algorithm used for classification and predictive analysis. This is based on the probability of occurrence of an event from a set of input conditions which are independent variables in a linear relationship. Gaussian Naïve Bayes (GNB) is a classification model for an independent input feature set based on conditional probability. Support Vector Machine (SVM) is a supervised machine learning algorithm applied on multidimensional dataset used for binary and multiple classifications. K-Nearest Neighbor (KNN) is a supervised machine learning that groups similar data nearby. The deep learning approaches are not suitable for the small dataset size since the available dataset is small. For training and testing the dataset is partitioned into 80:20 ratios. The machine learning model used Sickert learns python library for the implementation. For missing and inappropriate values in the dataset pre-processing is done. The objective of the machine learning model is to recommend appropriate fertilizer (y) from the set of input conditions ‘X’, $F(X) \rightarrow y$. For each set of input tuples (X), the appropriate fertilizer (y) is recommended according to the input features. Thus, accuracy of the proposed solution is evaluated in terms of soil fertility mapping. The machine learning models are evaluated based on accuracy, precision, and recall. The accuracy of the model is the number of correct predictions out of the total prediction made by the machine learning model. By applying GNB algorithm on the proposed model an accuracy level of 97%, 96% is attained respectively on training and testing dataset. Precision in the ratio of True positive (Tp), to the sum of the ‘Tp’ and false positive (Fp). Recall is the ratio of the ‘Tp’, to the sum of ‘Tp’ and False Negative (Fn). The evaluation of the proposed model reveals that GNB on fertilizer recommendation system reached with accuracy of 94% and 96% on trainings and tested dataset. Due to availability of limited dataset, thus the deeper network in neutral was not applicable. Therefore, deep learning application can suits well for larger dataset.

C. **Solar Fertigation – Smart IoT based Fertilization System**

Ahmad, U et al. [3] suggested fertigation with support system built using photovoltaic solar power energies with an IoT system for precision irrigation solving purpose which is integrated with a crop database. The crop database has the features such as soil content including moisture, quality of water, and plant watering update with real-time sensor. Farmers need to be supported intelligently by controlling, monitoring, and automatic scheduling irrigation and using fertilization strategy. Solar fertigation is a stand-alone system having photovoltaic panels installed in rural or remote locations. These panels support in smart irrigation and assisting farmers by decision-making process. It is the smart IoT based prototype helps in water, nutrient, and energy saving sustainable system. This is an agronomic model that the intelligent system with integration that schedules these irrigation and fertilization via automatic watering. An agronomic DSS platform is an innovative irrigation control approach is a hybrid predictive model. Crop growth is monitored directly in the field and making decision phases were linked to the growth process of the cultivated crop which is done by sustaining farmers. The wireless sensor network application towards irrigation facility management depends on Radio Frequency Identification (RFID) and Quick Response (QR) code is applied. This automatic fertigation explains crop water requirements based on collecting real-time data in addition to history. Considering the plant and soil needs automatic Fert-irrigation system achieving ideal utilization of fertilizers and water. ETc (Crop Evapotranspiration) feature includes type of crop, stage of growth, weather conditions, humidity ratio, temperatures, and plant-sensor help in decision making intelligent way in terms of watering crops. The designed fertigation system is constructed on a cloud computing infrastructure which has a greater number of physical module that are powered electrically by photovoltaic supply of power operated in an automated way. This model helps optimally in estimating water quantity and nutrient required for plants. This agronomic model based on sensor data and helps in calibrating the irrigation scheduling and fertilization phases. The agronomic parameters for various weather conditions are collected from precision irrigation strategies and analysed with different irrigation schedules. A hybrid system that is based on weather that has been integrated with data of crops (crops database and data of user) and soil data (data of user and soil sensor) is used for real-time irrigation schedule purpose. Using these Weather data collected by weather sensors this model estimates the ETc (Crop Evapotranspiration). The crop information obtained from databases contains data of seedling and crop growth stages. The volume of efficient rainfall consumed through ETo concerning this utilized rainfall (RU) is estimated in this empirical method. In addition, soil textures, crop depletion factor (p), yield factor (ky), and root depth (Zr) are used for the soil parameter estimation. The control unit defines the type and optimal quantities of fertilizer, the timing, and the fertigation methods for each crop. It is recommended on the agronomic database and WSN data connected to soil and environment. Real-time monitoring data is utilized for irrigation and nutrient suggestion and correction strategy.

IV. CONCLUSION

The paper gives a detailed survey about various IoT based Fertilizer recommendation systems. Every system has its own advantage since we analysed different domains used in fertilizer prediction systems. Thus using these technologies integrated an effective fertilizer system may be proposed efficiently.

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