MVP Journal of Engineering Sciences, *Vol 1(1), DOI: 10.18311/mvpjes/2018/v1i1/18273, June 2018* *ISSN (Online) : To be applied*

Soil based Fertilizer Recommendation System using Internet of Things

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Abstract

In India economy is mainly based on agriculture still we are not able to make it profitable and make sustainable use of our land resources[7]. Main reason is lack of knowledge regarding soil. There are many types of soil present and each type of soil has different characteristics. So it is necessary to test soil characteristics. There are different tools present for soil analysis, but these tools do not give accurate and desired result every time and also farmer needs to take pain of visiting laboratory for soil analysis. But it is very difficult to test all soil types in time from laboratory. Also tools which are present for soil analysis are not in regional language. Hence there is a need of tool to do soil analysis which can be made available to the farmer. The main objective of our work is to develop a soil based fertilizer recommendations system which can be used for regional soil analysis which in turn helps the farmers to cultivate and produce the proper crop. This tool will be in regional language so farmer can understand it easily.

Keywords: Electrochemical Sensor, Fertilizer Recommendation, Raspberry pi, Soil Analysis, Soil Moisture Sensor

1. Introduction

India is a land of versatile soils. In India economy is mainly based on agriculture and agricultural productivity is depends upon soil type. But the major problem pertaining to the Indian farmers is lack of sufficient knowledge about their soil. Each soil type has different characteristics i.e. there are various nutrients present in the soil. Deficiency of the nutrients to decrease in productivity. So, there is need of soil analysis. The alarming situation of farmer's suicide and the silent on the same; to lead the idea to put the efforts in the design and development of a sophisticated soil testing and fertilizer recommendation system. Our system will be used for soil analysis in order to increase crop yield. Soil analysis is done through the sensors. Based on soil analysis report fertilizer will be recommended to the user.

Fertilizer will be recommended using nutrient status table stored in the database. By comparing values of nutrients with table classification will be done. And accordingly fertilizer will be recommended to the user. Our system will help farmers for better crop yield which in turn maximizes profit. This increase the

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financial status of farmers. Our system also trying to fulfill the vision of our honorable prime minister that every farmer should have soil health report.

1.1 Motivation of Project

The alarming situation of farmer's suicide and the silent on the same; lead the idea to put the efforts in the design and development of a sophisticated soil testing and fertilizer recommendation system. As the agricultural productivity is mainly depends upon the soil condition which is mainly depends upon nutrients present in the soil. So, there is need of soil testing system. Based on soil analysis fertilizer should be recommended to the farmers in order to increase crop productivity and in turn increase the financial status of the farmers.

1.2 Internet of Things (IoT)

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to connect and exchange data.[1,2] IoT has many applications, and it can use in many fields. One of the field is agriculture, for smart farming. The IoT contributes significantly towards innovating farming methods. IoT technology can be used to automated farming techniques. Smart farming is a concept quickly catching on in the agricultural business. Offering high-precision crop control, useful data collection, and automated farming techniques, there are many advantages a networked farm has to offer. Many agriculture industries adopt IoT technology for smart farming to enhance efficiency, and to increase profit and productivity and minimized human intervention. Ultimately it saved time and cost. Farming challenges caused by population growth and climate change have made it one of the first industries to utilize the IoT. The integration of wireless sensors with agricultural mobile apps and cloud platforms helps in collecting vital information pertaining to the environmental conditions– temperature, rainfall, humidity, wind speed, pest infestation, soil humus content or nutrients, besides others – linked with a farmland, can be used to improve and automate farming techniques, take informed decisions to improve quality and quantity, and minimize risks and wastes. The app-based field or crop monitoring also lowers the hassles of managing crops at multiple locations.[1,2]

2. Related Work

As soil is measure source of nutrients needed by crop and deficiency of the nutrients will leads to decrease in crop productivity. That's why there are many researchers had contributed and come up with a different solution in order to provide better crop productivity.

Mansi Shinde *et al.* proposes recommendation system for predicting suitable crops based on NPK values of soil[4]. The system provides the notification using SMS service which include the recommended crop. Naive bayes algorithm is used to predict most suitable crop. However efficiency of naive bayes is less compared to KNN algorithm. The system forces the farmers to provide input to system manually in contrast to proposed system which collects data automatically and provides the result on single login. The system also provides only single crop which is less compared to proposed system which provides with a list of N different suitable crops.

Nikita and Tanmay Baranwal proposes three recommendation system based on past data.[5] Since efficiency of random forest algorithm is higher than naive bayes and ID3, it uses random forest algorithm to predict appropriate crop based on current NPK value of soil. However random forest algorithm doesn't deal

with large number of categories in categorical variable. Another crop rotation recommendation system is described in this paper which uses FP tree. Paper also provides recommendation for appropriate fertilizers using sufficiency method. However this method would put additional pressure on soil to match its fertility with required conditions thus degrading the soil condition.

Daryl H. Hepting *et al.* proposes a system which is a recommendation engine that not only makes recommendations based on type and quantity of nutrients present in the soil, weather conditions and irrigation facilities present in the farm but also suggests the type and quantity of fertilizer to be used.[6] The data is collected though the sensors present in the farm and the

Author	Paper Title	Year	Methodology	Limitations
Kiran Shinde, Jerrin Andrei, AmeyOke[3]	Web Based Recommendation System for Farmers	2014	FP tree algorithm to predict appropriate crop based on current NPK Value of soil. Fertilizer recommendation using sufficiency method.	This method would put additional Pressure on soil to match its fertility with required conditions thus degrading the soil condition.
Mansi Shinde, Kimaya Ekbote, Sonali Ghorpade, Sanket Pawar, Shubhada Mone[4]	Crop Recommendation and Fertilizer Purchase System	2016	Naive bayes algorithm is used to predict most suitable crop	The system forces the farmers to provide input to system manually.
Lokesh.K, Shakti.J, Sneha Wilson , Tharini.M.S[7]	Automated crop prediction based on efficient soil nutrient estimation using sensor network	2016	Random Forest algorithm and apriori gen algorithm for crop prediction and fertilizer recommendation	The previous crops cultivated are also taken into consideration.
K. Spandana, Sai Supriya KPL	Soil Quality testing using Sensors in Smart Agriculture for Crop Production and Maintenance using IOT	2017	Decision tree algorithm	Only Soil Moisture is tested using this system.
D S Suresh, Jyoti Prakash K V & Rajendra C J[8]	Automated Soil Testing Device	2013	Microcontroller based system for Automated Soil Testing Device for agriculture	High cost

data on weather is obtained from the weather institute with the wireless sensor network. The system uses statistical predictive modeling for prediction and recommendation of crops. The advantage of this system is that it is easily available and uses gsm network for communication which is cheap and available to farmers nationwide.

Lokesh *et al.* proposes the development of a mobile application which recommends crops to be cultivated in a year in such a way that the fertility of soil will be maintained.[7] For this the previous crops cultivated are also taken into consideration so that the next crop suggested will be different following the crop rotation principle. The system is highly efficient as it uses random forest algorithm which has an efficiency of 80% compared to that of "Naive Bayes" which is 40% and that of "id3" is 60%. Apart from just recommending the crops the system provides recommendation for fertilizers and an online purchase system using Apriori algorithm for frequent item sets so that the soil quality maintenance will be simplified by the use of appropriate fertilizers.

3. Proposed Architecture

Figure 1 represents the architecture of Soil Based Fertilizer Recommendation System. In this system user will first login to the system it is a existing user. Otherwise, user have to register to the system providing name, Contact details, land information, crop details etc. Then user will upload the soil test report to the system for soil analysis. If report is not provided by the user then analysis of soil is done through sensors. Sensors will measure the nutrients present the soil. This sensed data will be stored in the database. Fertilizer will be recommended using nutrient status table stored in the database. By comparing values of nutrients with the table classification will be done. Classification will be done using Naive Bayes algorithm. Fertilizer will be

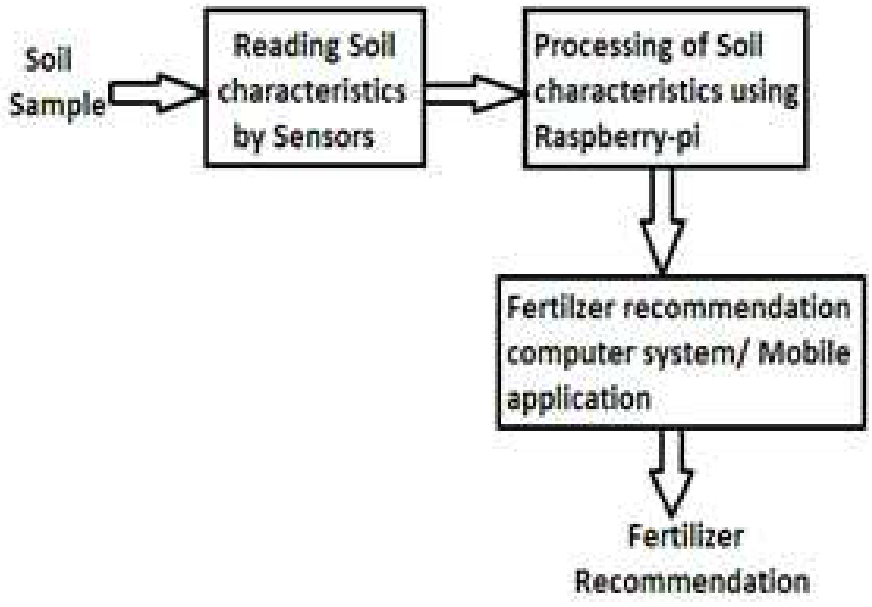


Figure 1. Soil Based Fertilizer Recommendation System using IoT.

recommended to the user through the mobile application or website. Our system uses Data centric i.e. Client Server architecture. Clients and server is connected through the cloud. Continuous network connectivity is required for our system.

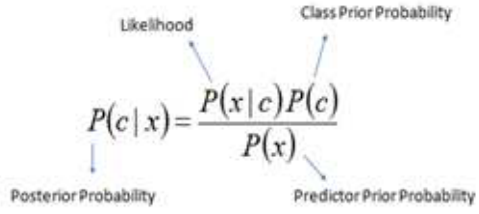
4. Proposed Algorithm

Naive classifiers are a family of simple probabilistic classifiers based on applying Bayes theorem with strong (naive) independence assumptions between the features.

Naive Bayes is a simple technique for constructing classifiers: models that assign class labels to problem instances, represented as vectors of feature values, where the class labels are drawn from some finite set. It is not a single algorithm for training such classifiers, but a family of algorithms based on a common principle: all naive Bayes classifiers assume that the value of a particular feature is independent of the value of any other feature, given the class variable. For example, a fruit may be considered to be an apple if it is red, round, and about 10 cm in diameter. A naive Bayes classifier considers each of these features to contribute

Probabilistic model:

- 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



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

P(Ci|X)>P(Cj|X) for 1<=j<=m , j!= i

- Maximum Posteriori Hypothesis

independently to the probability that this fruit is an apple, regardless of any possible correlations between the color, roundness and diameter features.

Naive bays implementation Steps:

1. Calculate prior Probabilities of class to be predicted.
2. Calculate conditional probabilities.
3. Calculate posterior probability.
4. Highest probability among above is predicted class for query tuple.

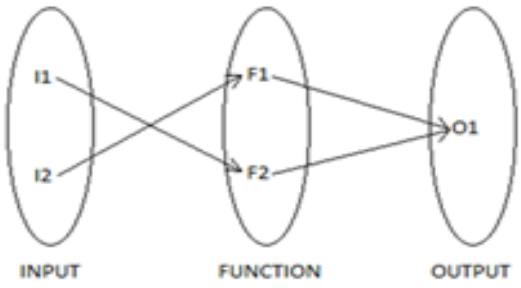


Figure 2. Mathematical Model.

Let S be a system such that, S={I, F,O}

I= Set Of Input

I= {I1, I2}

I1= Soil Report

I2= Soil Sample

F= Set Of Function

F= {F1, F2}

F1= Analysis of Soil using Sensors

F2= Soil Test Report Analysis

O= Set of Output

O= {O1}

O1= Fertilizer Recommendation

5. Outcomes

Distinguish between the various aspects when conducting a soil analysis. Interpret the current status of the soil in terms of optimal pH. Make appropriate fertilization recommendation of the soil in the most economical way. Put these soil properties as reported in the analytical report in terms of plant production and soil quality and fertilization. Calculate the NPK (Nitrogen, Potassium and Phosphorus) requirements to optimize plant production.

6. Advantages

Our proposed system will be in the regional language so that farmer can use it easily. Farmer need not take pain of visiting laboratory for soil testing as our system will also use for soil testing. Proposed system will give fast and accurate results.

7. Conclusion

In this digital world each and every sector is undergoing a dramatic change due to IT field. But, in agriculture field, till date not much work has been done. We have proposed a model for advanced farming using multiple techniques: IOT, Cloud-Computing, and Data Mining. Through this model farmer will be able to get details regarding required fertilizers from his soil sample. This is used to improved crop production with reduction in cost of fertilizer and thus improves the agriculture sector in India. The data is collected in the database regarding crop details and soil conditions which provides total fertilizer requirements.

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