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SOIL PARAMETER MONITORING AND DECISION SUPPORT SYSTEM IN PRECISION AGRICULTURE BASED ON MACHINE LEARNING

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Abstract: Precision Agriculture is an approach to farm management that uses information technology (IT) to ensure that the crops and soil receive exactly what they need for optimum health and productivity. It is an approach where inputs are utilized in precise amounts to get increased average yields, compared to traditional cultivation techniques. Precision agriculture seeks to use new technologies to increase crop yields and profitability while lowering the levels of traditional inputs needed to grow crops (land, water, fertilizer, herbicides and insecticides). The mechanism that aids precision agriculture is Decision Support System (DSS) based on machine learning which gives a machine the ability to learn without being explicitly programmed. DSS is a software-based system used to help decision-makers compile useful information from a combination of raw data, documents, and personal knowledge; to identify and solve problems; and to make an optimized decision. One of the important applications of DSS in agriculture is water and soil nutrient (i.e. fertilizer) management. The water resources are becoming increasingly insufficient to meet the demand in developing countries and their quality is declining due to inappropriate fertilizer management. In this project, various attributes related to soil health are collected and a decision support system is developed using regression based supervised machine learning technique to provide information about which soil nutrients are required to further improve soil health as well as present soil fertility. The proposed system parameters are simulated and analyzed in MATLAB software

***Index Terms* - Decision Support System (DSS), Precision Agriculture (PA), Regression, Machine Learning (ML)**

1. INTRODUCTION

In conventional agricultural practices, present soil fertility isn't considered throughout the crop cycle and the quantity of fertilizers to be applied is mostly guessed. This leads to either excess or deficiency of nutrition to plants which leads to poor plant growth as well as lower crop yields. Also fertilizers applied in inappropriate quantities can destroy or increase some natural weeds or micro-organisms thus disturbing the agro-ecosystem and it could also pollute underground water by nitrogen and phosphorous it contains. Water pollution through runoff, causing excessive richness of nutrients in a lake or other body of water (i.e. eutrophication) and pollution of atmosphere as gas emissions (e.g. N2O), , adverse effects on soil structure, imbalance of nutrients in soil, negative effects on soil PH, are some of the adverse effects of inappropriate use of fertilizers (i.e. Nutrients) in agriculture. This inaccurate usage of fertilizers causes economical damage to farmers and also negatively impacts the environment as soil fertility is degraded. This causes major unsustainability issues as plants with poor growth and crops with inadequate quality of yield are discarded leading to wastage of resources such as nutrients, fertilizers. pesticides, fresh water for irrigation, etc. spent on growing those plants and crops. Thus, there is a need of a system which could indicate current soil fertility and quantity of nutrition to be applied.

2. RELATED WORK

Most of researchers have performed their work in the field of agriculture related to monitoring parameters, its decision support system and intelligence by using machine learning algorithm, is discussed below.

Xiaoping Chena et.al. [3] evaluated, over a three–year period, the effect of a new irrigation scheduling method on seed cotton yield, water productivity, and economic profitability under an arid desert climate. The benefit of the DSS was that, compared to SMS, seed cotton yield, water productivity, and economic profitability were simultaneously enhanced. In addition, the DSS showed higher net water productivity compared to the SMS. Maximum crop yield, plant height, and aboveground biomass of cotton were obtained for the DSS–FI treatment, which may be attributable to better soil water status under the timely and more frequent irrigation events. Alberto Garinei et.al. [4] presented an approach for modeling soil moisture using machine earning techniques. Thus, the variation of SWI in a four days' period has been modeled through two different network-based models: a single hidden layer feedforward Artificial Neural Network (ANN) and a neuro-fuzzy network (ANFIS). Meteorological data, comprising rainfall, temperature, relative humidity and wind speed records, have been used as inputs in both models along with the last known SWI value.

Mohan Sridharan et.al. [5] described and experimentally compare the accuracy of OLS and statistical machine learning models for estimating crop water use (or evapotranspiration). We show that models based on machine learning algorithms provide significant improvement in accuracy in comparison with a state of the art energy balance model based on OLS. Ms. Priyanka S Jawale et.al. [6] presented a structure of a decision support system for more efficient and effective management of water supplies, and more timely delivery of irrigation water to agricultural users. The DSS may be linked with the SCADA (Supervisory Control and Data Acquisition) system for real-time monitoring of flow details and water level information and operation of canal gates to manage water deliveries.

Yonghui Wang et.al. [7] focused on a United State Department of Agriculture sponsored project for smart irrigation. Field sensors collect temperature, humidity information, and transmit them through wireless sensor network. Mobile devices, such as iPhone and iPad applications are developed for farmers to help them make decisions. Furthermore, a data cloud expands the system by providing data storage space. The system can observe data, such as temperature and humidity, from a computer and from mobile devices. The system can assist farmers to make irrigation decision and it is able to email or text the user. Ali Fares et.al. [8] presented a distributed IoT system which can better inform and engage farmers with the automated irrigation process in agriculture fields. They developed three different types of applications as part of the IoT system executing on sensing IoT devices, Azure cloud platform, as well as on users' mobile devices. These applications give the ability to users to set various irrigation parameters such as the thresholds for the moisture, temperature and humidity sensors, which makes the system widely useable for a different type of crops and soils considering they have their suitable soil moisture threshold values.

Akhilesh Patel et.al. [9] developed DSS for on-farm irrigation water management to make the irrigation scheduling for border, sprinkler and drip irrigation systems for wheat, maize, potato and chilli crops. Overall, this research will be very helpful to the farmer to take the decision on when to irrigate and how much to irrigate for sustainable on-farm irrigation water management. Jérôme Treboux et.al. [10] presented the impact of machine learning in precision agriculture. State-of-the-art image recognition is applied to a dataset composed of high precision aerial pictures of vineyards. The baseline uses color analysis and can discriminate interesting objects with an accuracy of (89:6%). The machine learning, an innovative approach for this type of use case, demonstrates that the results can be improved to obtain 94:27% of accuracy.

Haimid Vimit et.al. [11] aimed at the actuality that soil salinization deteriorates in oasis and irrigation scheme management is unreasonable from the point of view that develop irrigation decision support system (DSS) about irrigation area management, and studies the optimal distributing of irrigation water in the irrigation area which take the Alan Bauer et.al. [12] reported AirSurf, an automated and open-source analytic platform that combines modern computer vision, up-to-date machine learning, and modular software engineering in order to measure yield-related phenotypes from ultra-large aerial imagery. The tailored platform, AirSurf-Lettuce, is capable of scoring and categorizing iceberg lettuces with high accuracy (>98%).

Alexander Kocian et.al. [13] has goal is to maximize yield by minimizing water consumption, usage of fertilizers, and amount of arable land in an automatic fashion. Rachana P. Koli et.al. [14] presented android application which will be useful for farmers & agricultural institutes for cultivation of various kind of crops in various type of atmosphere. This smart phone app is easy to use and in affordable cost which will suggest most probable matching crops to people according to basic inputs like water availability in mm, average temperature, average soil Ph of farm, locality of farm, soil Type, Crop Duration etc so by certain calculation at backend this app will show most probable crops List for that farm. Benya Suntaranont et.al. [15] proposed a decision support system for weir sluice gate level adjusting. The proposed system, named AWARD (Appropriate Weir Adjustment with Water Requirement Deliberation), is composed of three modules, which are (1) water level prediction, (2) sluice gates setting period estimation, and (3) sluice gates level adjusting calculation. The standard error of prediction (SEP) is 2.58 cm and the mean absolute percentage error (MAPE) is 7.38%. The sluice gate setting period is practically adjusted. The sluice gate level is adjusted according to the water requirement.

Most of researchers developed precision agriculture for various scenarios in decision support system. Techniques are still under development and so it is important to take specialist advice before making expensive decisions. Initial capital costs while implementing DSS may be high and so it should be seen as a long-term investment. It may discourage farmers to not adopt this method of farming. Also, it may take several years before you have sufficient data to fully implement the system. Precision agriculture techniques are still under development and requires expert advice before actual implementation. It may take several years before the actual collection of sufficient data to fully implement the system. It is an extremely difficult task particularly the collection and analysis of data.

3. PROPOSED WORK

The proposed system for DSS in precision agriculture using regression based supervised machine learning to predict the parameters values as shown in fig.

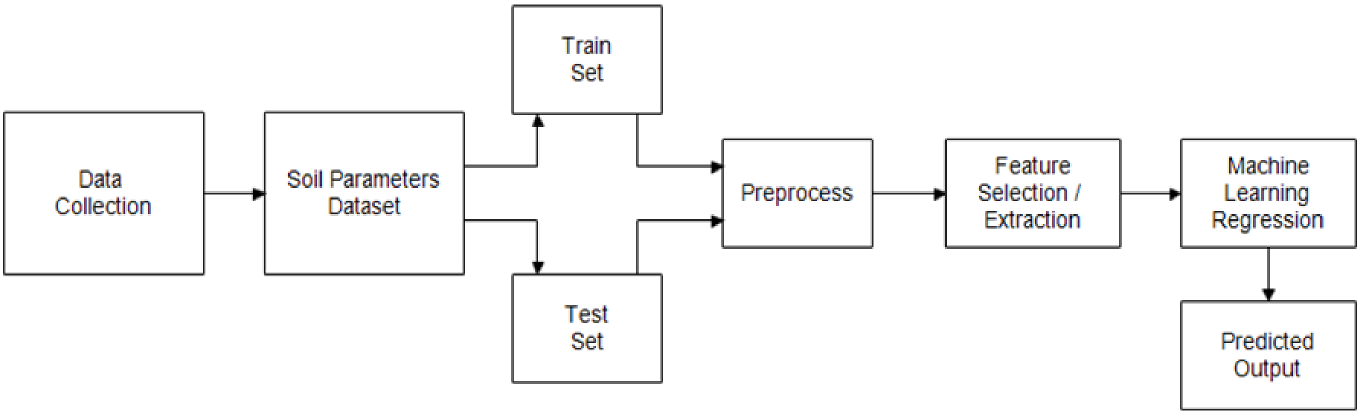

Fig. 1: Proposed Block Diagram

1. Data Collection

Soil parameters such as PH, soil electrical conductivity (EC), Organic Carbon percentage (%OC), available Nitrogen (N), available Phosphorous (P), available Potassium (K), Magnesium (Mg), Manganese (Mn), Iron (Fe), Copper (Cu), Sulphur (S) are needed to be extracted from soil samples. Extracting these parameters from soil samples require expensive and delicate instruments as well as certain chemicals. Thus, making the process of testing soil samples and extracting soil health parameters difficult and expensive. Therefore, soil samples are tested in a agricultural laboratory by paying a nominal fees. The agricultural laboratory then provided soil health parameters of soil samples.

2. Soil parameters dataset

The results provided by agricultural laboratory were printed on paper. Then all that data was converted in digital form so that it can be used in the program by entering all data in an excel file. Considering the nature and format of data, the soil parameter database was stored in an excel file for convenience. Storing database in an excel file also provides more productivity in program as each row and column can be addressed individually at any given time in program.

3. Training

From total of 85 samples data, data of 50 samples are used for training machine learning model, therefore, soil parameter data for 50 samples is stored in a single excel file titled as training_dataset.csv. While training machine learning model, this file will be used as a database in that program. These 50 samples are randomly chosen.

4. Testing

Since out of total 85 samples data, 50 samples data is reserved for training machine learning model, remaining 35 samples data is provided for testing machine learning model. The soil parameter data for these random 35 soil samples is stored in an excel file titled testing_dataset.csv. When testing of machine learning model will be performed, this file will be used as a database in that program.

5. Preprocess

For effective utilization of data in machine learning algorithm, normalization technique is used. In preprocessing, data normalization is performed. Normalization technique is performed on data set to prepare it to be used in machine learning model more effectively. In normalization process, values of numeric columns in the dataset are changed to use a common scale without losing information or distorting differences in the range of values. Normalization process creates new values that maintains general distribution and ratios in the dataset while keeping values within a scale applied across all numeric columns used in model. Thus, it eliminates problems that arise during combining the values as features during modeling when there is a great difference in the scale of numbers in the dataset.

6. Feature selection

In this section, feature selection is performed. Soil parameters that should be used as inputs are selected and imported to a feature vector in the program and soil parameters which should be used as output are selected and imported to a target vector in the program.

7. Machine Learning Algorithm

In this project, Random Forest Machine Learning Algorithm is used. In this project, random forest algorithm is used for regression. Random forest is a supervised learning algorithm in which a model is presented with example inputs and their desired outputs and the goal is to learn a general rule that maps inputs to outputs. The idea behind random forest regression algorithm is that, in order to find the output, it uses multiple decision trees. A decision tree is a result of breaking down a dataset into smaller and smaller subsets by splitting which then results in a tree with decision nodes and leaf nodes. Steps involved in random forest regression algorithm is as follow, First ‘N’ number of data points are chosen from the training dataset file created earlier. Then, a decision tree is built associated with these data points. Then, number of trees to be built are specified and previous steps are repeated. Then, for a new data point, we have to make each of the trees predict values of the dependent variable for the input given. At last, we have to assign the average value of the predicted values to the actual final output.

8. Predicted Output

In this project, the predicted output of soil fertility index is displayed along with nutrition to be added index. Soil fertility index is a value between 1 to 10 where 1 being very poor fertility and 10 being very rich soil fertility. Soil fertility index indicates how fertile the soil sample is to the end user. Nutrition to be added index is a value of quantity of nutrition which is to be applied to the soil to improve its fertility. Soil fertility index and nutrition to be added index are provided to end user.

4. RESULT AND DISCUSSION

The proposed work is implemented on Intel CORE processor i5, 8GB RAM Laptop configuration and operating system is Windows 10. MATLAB R2018b software was used to write the programming code. In this project, we used statistics and machine learning toolbox and dataset is collected from Local Agriculture laboratory. Proposed system is implemented in three phases, first is training phase in which input and output data given to learn the regression model using random forest supervised machine learning algorithm and its learning error rate is shown in fig 2. Then second is testing phase in which system predict the result based trained model as shown in fig 3 and its respective evaluation time required for testing in fig 4 for both output parameters. Then in third and final phase, user need to test the sample or need to predict data as input parameters and then parameters need to enter in system UI as shown in fig 5 and their respective result shown in fig 7.

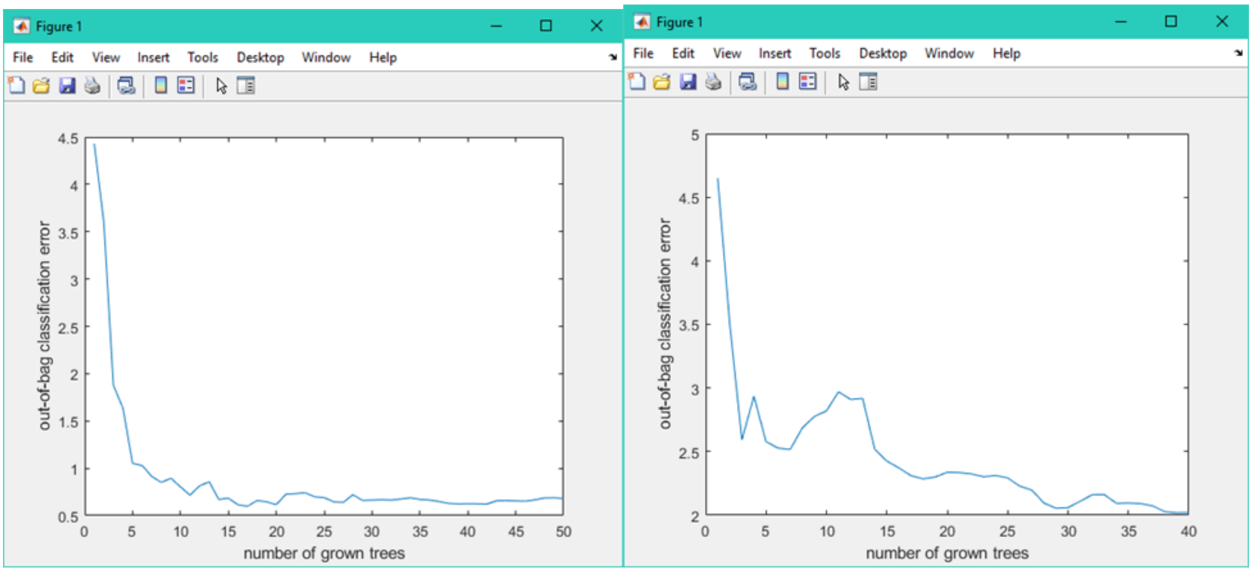

Fig 2: Learning Error using Random Forest Regression Modelling for a) soil fertility b) nutrient flow

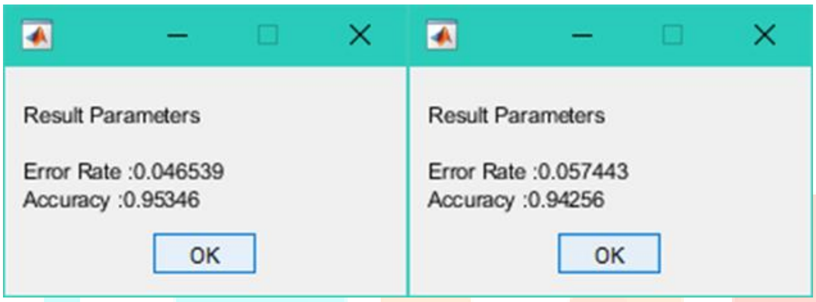

Fig 3: Predicted Result Parameters for a) soil fertility and b) nutrient flow

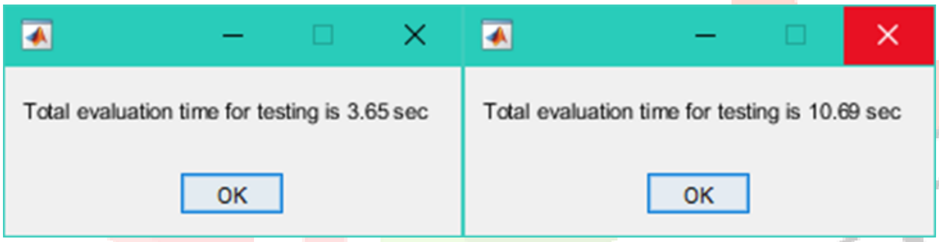

Fig 4: Testing Evaluation Time for a) soil fertility and b) nutrient flow

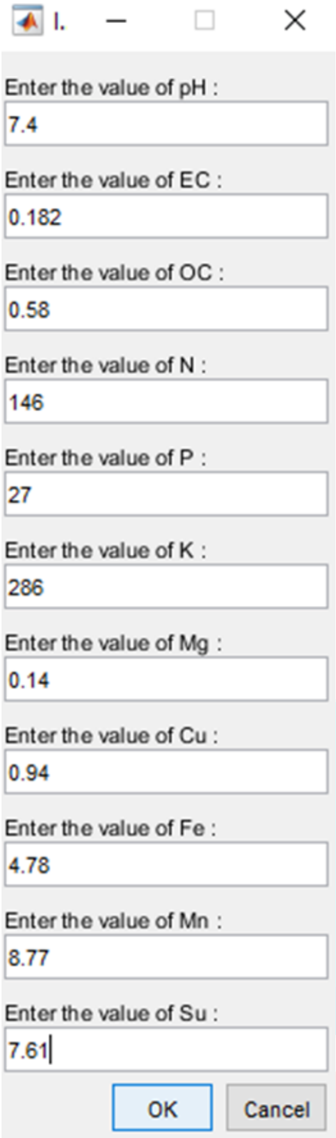

Fig 5: Test input for prediction application

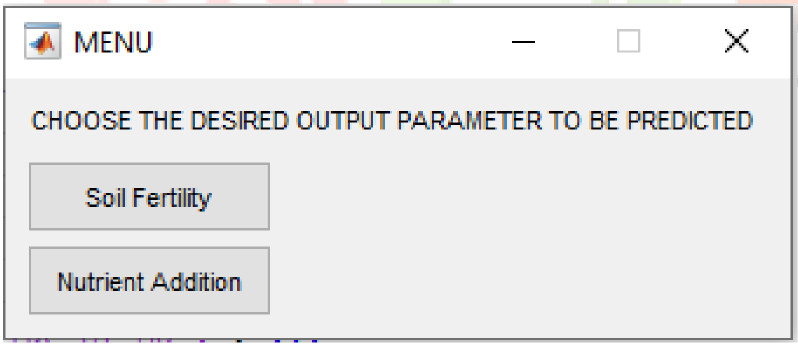

Fig 6: User selection choice for output parameters

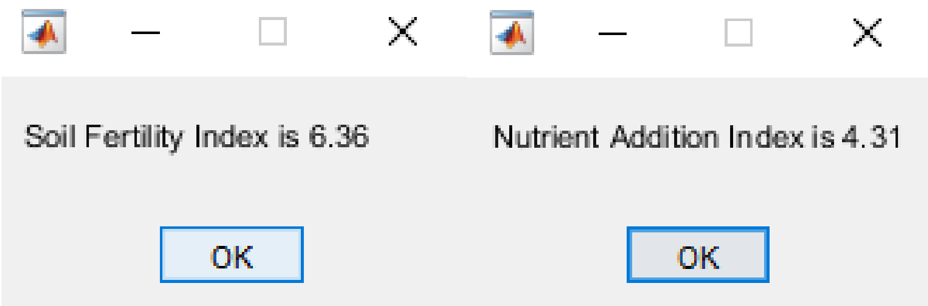

Fig 7: Predicted Output w.r.t. test input for a) soil fertility b) nutrient addition

5. CONCLUSION AND FUTURE SCOPE

A Decision Support System has been designed to improve resource management decisions in agriculture in order to help farmers. Growth of plants as well as yield of crops depends upon the amount of nutrition provided to them. The Decision Support System emphasizes on providing soil fertility results as well as predicted quantity of nutrients needed to be applied. Proposed Decision Support System is an effective tool for predicting nutrition requirements in precision agriculture over time as more data is provided to the model. The machine learning model utilized in the Decision Support system is Random Forest regression with 95.34% and 94.25% accuracy for both output parameters. The model calculates quantifiably key Parameters which is nutrition to be applied and soil fertility for decision processes. These parameters can aid decision makers in making effective decisions. Based on the predictions provided by proposed model, a farmer can make decisions about nutrition to be provided to the plants to improve their health as well as their yield.

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