Design and Implementation of Fertilizer Recommendation System for Farmers

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Design and Implementation of Fertilizer Recommendation System for Farmers

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Abstract

India is an agrarian nation. But creating a profitable yield for the farmer in each crop cycle is becoming a major challenge on various factors. Picking the reasonable fertilizer for the land and yield is an important and basic part of agriculture. Deciding the supplement levels in soil utilizing lab hardware can be restrictively costly, particularly in developing nations. The current frameworks on deciding soil nutrient substance and proposal for fertilizer isn't sufficiently proficient efficient enough. This paper introduces a compelling technique for estimation of nutrient dimension in soil and suggestion for appropriate fertilizer. The proposed methodologies comprise of four stages: soil analysis, data pre-processing, data analysis and Recommendation. The soil sample is analyzed using an IoT based device utilizing NPK sensor with two electrodes are set to calculate collect the NPK ratio of the soil nutrient and for pre-processing, the data gathered from sensors are figured into correct dataset and machine learning algorithm is utilized to recognize the reasonable fertilizer. This venture is extremely valuable to farmer to pick the right fertilizer toward the start of product cycle and amplify the yield

Index Terms; *soil analysis, Machine learning, precision agriculture, Random forest algorithm, NPK detection, Nutrient analysis.*

I. INTRODUCTION

India is a horticulture based country and agriculture is considered as the key for human progress since ancient times. Farming part has a vital job in Indian economy, Agriculture division an unquestionable requirement for GDP development in India and furthermore Agriculture gives the foremost methods for work for more than 60 percent of India's populace. But in the recent years due to multiple fertilizers present in market, farmers gets confused and apply the fertilizer famous around his locality without second thought. This leads to two major problem low yield or soil pollution. Due to insufficient nutrient after applying fertilizers the yield of crop is reduced. Due to over fertilization, the land and food produced from the land will be polluted resulting food poisoning. The over usage of fertilizer also leads to root burn, mineral degradation, soil acidification and ground water pollution. Fertilizer plays a major role in farming and contributes around 55% of the yield enhancement. There are three main nutrients in soil that play a major role in farming: Nitrogen (N), Phosphorous (P) and Potassium (K) collectively known as NPK. The best possible recognition of these nutrients at starting stage is essential for the successful development of the harvest. The proposed framework centers to effectively estimating these nutrients in soil and characterizing them to recommend the fertilizer for the corp. The proposed methodology can be classified into four phases: the first phase is the estimating nutrient level.

This estimation of nutrient is done using a NPK monitoring unit with Arduino UNO as the microcontroller to read the values from it. The electrodes in the NPK monitoring unit are immersed

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in the soil sample for few inches to calculate the NPK values from the soil. The second phase is preprocessing of data using java calculating the data from the sensors and formulating them in the dataset and saving the data in the cloud and encrypting them in SHA algorithm for security purposes. The third phase is the classification of the soil quality with the similar data present in the database. The classification is carried out using the machine learning technique clustering and classification. The final phase is identifying the appropriate fertilizer using crop requirement dataset and fertilizer dataset containing the fertilizers available with NPK ratio. After all these phases the suitable fertilizer information is sent to the farmer for the crop he specified.

II. RELATED WORKS

Each element has an absorption wavelength of light, In [1], the authors has proposed an methodology in which a light beam with absorption wavelength of the nutrient will be passed on the soil sample to detect the intensity of the light reflected and find range of voltage for classifying the nutrient content as high, medium and low. In [2], the authors suggest the approach of using UV spectrophoto sensor which calculates the a intensity of the passed UV light to the soil solution and the intensity of the light before passing the soil solution to calculate the absorbance using Beer’s law to estimate the content of the nutrient in the soil sample. In [3], author explains about using fiber optics, humidity, temperature and sunlight sensor estimate the NPK values of soil and other parameters and pass it to the microcontroller to remotely control the work in the agriculture field such as fertilization, pumping of water depending on the sensor readings. This paper gives the basic structure for smart agriculture.

In [4], authors highlights the methodology the determine the absorption wavelength of each nutrient in soil sample using different spectrometer with varying wavelength light emission feature like Deuterium-Halogen lamp (DH) with a wavelength range from 210 nm to 1200 nm, Ocean Optic spectrometer which has a range from 200 nm to 1100 nm. In [6], author gives the basic structure of smart farming using cloud computing and IoT. The IoT module acts both as sensor the collect the real time data of the field condition on various parameters and works which perform various activities on the field on instructions from the controlling unit. The IoT devices are connected by wireless networks to transmit data to the controlling unit and cloud computing is performed to give instructions to the workers IoT units to perform the necessary tasks. Constant notification on the field condition and actions performed will be reported to the farmer. In [7], authors’ uses data analytics to predict the rainfall on any region based on the historical data of 10 years of rain fall and temperatures. The model uses regression analysis to predict the rainfall of the following year 2013 using rainfall and temperature data of 2002-2012. The model is beneficial for both farmers to plant the crops accordingly and water management system of local government.

In [9], author presents farmbeat an IoT platform which uses Azure cloud to store and communicate with the farmer. An IoT base station is set up to connect with IoT sensors, a local computing module is used for decision making and basic controls of the sensors from drone flight control to precision mapping. In [10], authors uses various sensors to collect data from the field on daily basis and acquires knowledge from the data to recommend a betterment in the farming techniques. The farming information and data are feed to the system on farming techniques, geospatial data, and crop structure and market information and recommends a better option for the farmer at each step of crop cycle.

In [12], author proposes a way to optimize the crop price by using data mining and Recommendation analysis. In [13], authors’ uses multi-linear regression and density based clustering algorithm to

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analyze the crop yield for each year with the historical data.

Paper [16] illustrates the model of a wireless network farming using various sensors plucked into the soil at various places in the field to gain real time information about the field .The data collected will be automatically uploaded in the cloud and notified to the farmer about the condition of the field so that he/she can take necessary steps accordingly.

[17] is an smartphone irrigation sensor which uses an smartphone as a sensor which is confined in a chamber under controlled illumination and buried at the root level of the plants. A smartphone app is developed to activate the smartphone to take a picture and transmit it through Wi-Fi. The image is then converted from RGB to gray scale to identify the wet areas. This would then give the instruction to irrigation pump and makes the smartphone go to sleep mode. [18] Propose a similar model with using wireless sensors instead of smartphones to monitor the water content in soil.

Pesticides possess the similar disadvantages of fertilizer. Over application of pesticides harms the soil and food products. [19] Uses wireless sensors to monitor the chemical content in the soil and suggest the optimal pesticides dosage release according to current value. [25]An Indian survey has been conducted with collaboration of multiple agriculture centers for fertilizer recommendation system depending on the soil nutrient content. The report can be used to find the fertilizer amount required for each crop in different districts and soils. [26]Australian paper formulates the calculation of unit of soil fertilizer needed with the NPK ratio in the fertilizer and the needed nutrient content for the soil in kg/HA.

[33, 34, 35] theorizes on the effect of customized fertilizers on the various crop production and yield for a particular crop season.

[35] Web services provides the calculation of ppm from the NPK ratio of the soil. [36] Web services isused for the calculation of individual nutrient content from the ppm value. [37] is the Tamil Nadu Agricultural University portal which provides different fertilizers name with NPK ratio of each. [38] Project on developing an autonomous robot which takes the parameters such as pH, water level, temperature and humidity to spray the necessary amount of fertilizer into the soil. [39] Is a government article on estimating the amount of fertilizer needed to apply on the field based on the nutrient requirement and NPK ratio of the fertilizer.

III. OVERVIEW OF PROPOSED SYSTEM

The proposed system aims to estimate the nutrient content and recommend the suitable fertilizer to be used for higher productivity. Under application of fertilizer results in low yield due to insufficient nutrients present in the soil for the crop.Over usage of fertilizer results in soil pollution. The food products from the polluted soil will be food poisoning and health issues for the consumers. The system consists of four modules as follows:1)Soil analysis,2)Interfacing with java API,3)Data Anaytics,4)Recommendation.

The functional diagram of the proposed system is given in the figure1.

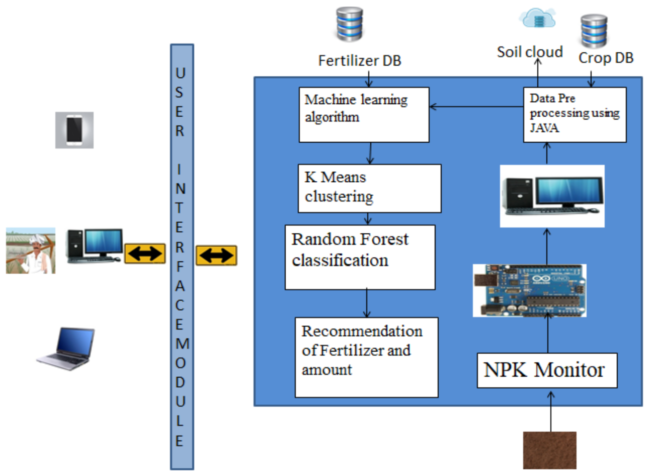

Figure1: Architectural diagram

Soil Analysis:

The nutrient detection comprises of NPK monitoring unit and Arduino UNO. Arduino UNO is a

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microcontroller used to work the NPK monitoring unit just as get the data from it. The NPK monitoring unit is actualized on the procedure of Conductivity Measurement in soil which utilizes two electrodes of same material submerged for few inches in the soil to ascertain the flow of ions in the soil. Alternating Current Voltage is passed in one electrode and the voltage gain in other electrode is determined in the Arduino to check the flow of ions in the soil. The flow of ions is straightforwardly proportionate to the NPK ratio of the soil. In this manner the NPK ratio is gathered from the NPK monitoring unit and sent for data preprocessing.

Interfacing with JAVA API:

Using java programming for data preprocessing we calculate other factors of the soil and upload them in the cloud for centralized maintenance of the data. We calculate the individual ppm value of the soil from the NPK ratio and total ppm value.

From the reference of [35], we can arrive at the following formulas which are used to find the ppm value for individual nutrient.

For Nitrogen:

PPM N= 13.1925 * % of N

For Phosphorus:

PPM P=5.8047* % of P

For Potassium:

PPM K=10.949 * % of K

The kg/HA is used as a universal unit for calculating the nutrient content in a soil and also in estimating the amount of fertilizer to use. Thus ppm to kg/ha conversion is used to estimate the nutrient content in the soil.

[36] Is used to convert the ppm value taken obtained from the previous calculation to kg/HA unit.

Nutrient (kg/HA) = 2.5* PPM of Nutrient

These data are saved in the form of .csv(comma separated values) for future analysis purpose. Multiple soil samples from different farming fields have been subjected to soil analysis to collect the data. This data is saved in the cloud and local database for further analysis and clustering purposes.

Label	N	P	K	N (ppm)	P (ppm)	K (ppm)	N (kg/HA)	P (kg/HA)	K (kg/HA)

The tabular format is the data frame for the soil sample after the data preprocessing phase.

The farmer inputs the crop he wants to aggregate for this crop cycle along with other details such as soil type, region and current season. From the dataset developed from the [25] report which contains the amount of fertilizer required for each crop depending on the nutrient level in the soil, soil type, region, variety and season. The dataset also contains the regression formula for the nutrient content required from the fertilizer for the optimum yield.

Sample regression equation is given below:

Crop: Rice

Season: Rabi

Soil: Alluvial

State: Andrapradesh

For Nitrogen content estimation:

FN = 4.63 T - 0.56 SN

For Phosphorus content estimation:

FP2O5 = 1.98 T - 3.18 SP

For Potassium content estimation:

FK2O = 2.57 T - 0.42 SK

Where FN,FP2O5,FK2O are fertilizer content required in kg/HA, T is the target yield and SN,SP,SN are the soil nutrient content in kg/HA.

For example, taking an soil sample of ratio 9:10:15,

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The ppm values will be

Ppm N= 13.1925 * 9 = 119

Ppm P= 5.8047 * 10 = 58

Ppm k= 10.949*11 = 112

The nutrient value in kg/HA

N(kg/HA) = ppm N * 2.5 = 297.5

P(kg/HA) = ppm P * 2.5 = 145

K(kg/HA) =ppm K * 2.5 = 280

The specification given about the crop, land and location are

Crop: rice

Season: rabi

Soil: Alluvial

State: Tamil nadu

Target yield= 60q/HA

FN = 2.3T – 0.32SN = 2.3 *60 – 0.32 * 297.5 =138 – 95.2 = 42.8

FP = 1.91T – 1.9SP = 1.91*60 – 1.9*145 = 114.6 – 275 = 0(since negative)

FK = 2.27T – 0.27SK = 2.27*60 – 0.27*280 = 136.2 – 75.6 = 60.6

Data Analysis:

Fertilizer Name	N	P	K	Weight

The above tabular form represents the data frame for the fertilizer survey

The fertilizer data is collected from various markets about the brand name and NPK ratio of the fertilizer is collected. This survey of fertilizer is used in Recommendation phase for recommending the fertilizer. The fertilizer dataset is passed into the data analysis phase which performs clustering and classification of the fertilizers Cluster analysis or clustering is the errand of grouping a set of objects so that objects in the same group (called a cluster) are more like each other than to those in different groups (clusters). It tends to be accomplished by different algorithms that vary fundamentally in their comprehension of what constitutes a cluster and how to efficiently discover them. Well known thoughts of clusters incorporate gatherings with small distances between cluster members, dense areas of the data space, intervals or particular statistical distributions. The proper clustering algorithm and parameter settings rely upon the individual data set and intended use of the results. Cluster analysis accordingly isn't an automatic task, but an iterative process of knowledge discovery or interactive multi-objective optimization that involves trial and failure. K means algorithm is one of the famous clustering algorithms which partition the data on basis of distance between the data and centroids of the clusters. K means algorithm randomly takes the centroids from the dataset for the clusters number specified. Distance between the current data and each centroid is calculated to find which centroid is nearest thereby belonging to which cluster. After each data the centroid is calculated by taking the mean of the parameters. After each iterations, it is checked whether any data has been transferred to any other cluster. When there exists no transfer of data from one cluster to another the K means algorithm is terminated. Characterization is the issue of distinguishing to which of a set of categories (sub-populations) a new observation has a place, based on a training set of data containing observations whose category membership is known. Characterization is viewed as an example of supervised learning, i.e., learning where a training set of correctly identified observations is accessible. Random forest classifier is a meta-estimator that fits various decision trees on various sub-samples of datasets and uses average to improve the predictive accuracy of the model and controls over-fitting. The sub-sample size is dependably equivalent to the original input sample size however the samples are drawn with substitution. The clustering and

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classification will be performed taking the N0PK ratio of the fertilizer as the parameters. The decision tree on the fertilizer dataset will be created and the recommendation phase is initiated with the fertilizer requirements and decision tree.

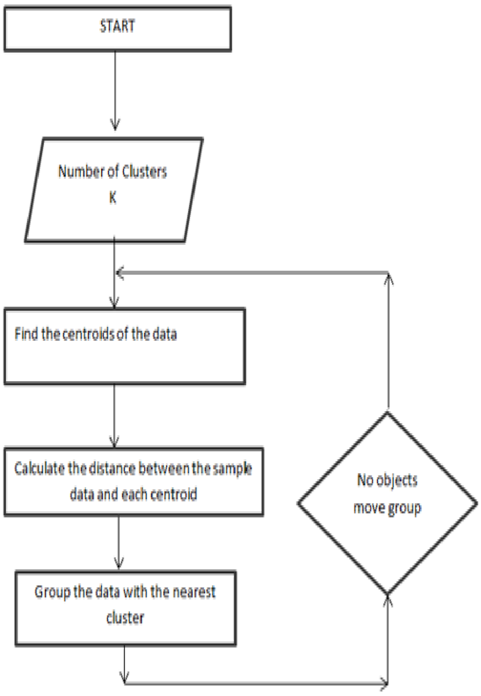

Fig: Flowchart for K means clustering

Recommendation:

After clustering and classification, Recommendation phase is initiated. Recommendation phase make use of the decision tree produced by the soil analysis and the fertilizer suitable for satisfying the requirements of the soil for the crop chosen selected. The fertilizer nutrient requirement is passed into decision tree to take the correct fertilizer. The amount of fertilizer needed to apply for the crop cycle for the crop chosen is recommended using [39] report calculation A. The fertilizer chosen for the soil is substituted in the calculation to find the exact amount of fertilizer that has to be used.

Amount of fertiliser kg/ha = kg/ha nutrient ÷ % nutrient in fertiliser x 100.

The fertilizer, details and the amount that has to be applied is intimidated to the farmer through a GUI for the farmer understanding.

IV. HARDWARE SETUP

Soil sample is collected in a small bowl for analysis. The NPK sensor used has two electro chemical diodes which should be immersed in the soil sample. The diodes will calculate the ions movement in the soil and produce the total nutrient content in the soil as a ppm. The individual npk ratio will be calculated later with the ppm value.

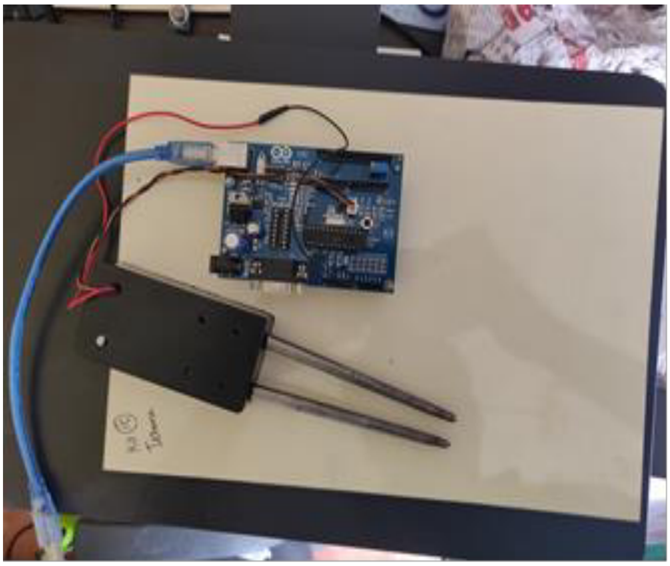

Fig :IoT module for calculating the NPK value

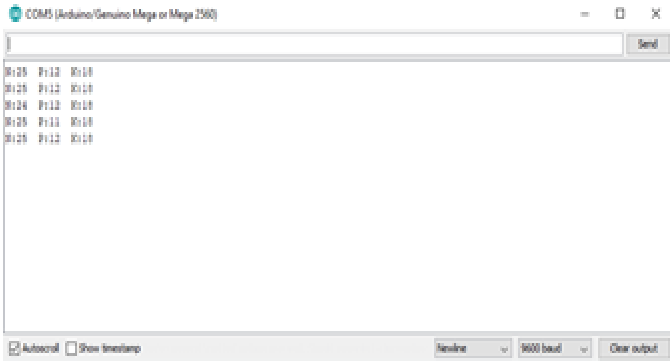

Fig: IoT output in Arduino IDE

The NPK ratio that is obtained from the soil analysis phase will be subjected to Data preprocessing phase in which individual ppm of NPK will be calculated. In one teaspoon of soil sample, a ratio of 1:1:1there will be 13ppm of nitrogen, 6 ppm of phosphorus and 11 ppm of potassium present in the soil sample. Thus multiplying the NPK ratio with 13:6:11 will result in the ppm value in the soil sample in one

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teaspoon. The kg/Ha is calculated from the ppm value calculated. One ppm in the soil content reflects a value of 2.5 kg/HA in the soil. Thus all the ppm values of the soil is multiplied by 2.5 to acquire kg/HA. These values are formulated into an dataset saved in .csv file for future analysis usage in R programming. The csv file is also saved in the cloud for centralized usage and access of data.

Crop	State	Season	Variety	District	Soil	N (kg/HA)	P(Kg/HA)	K(kg/HA)	Target yie	Coefficier	Coefficier	Coefficen	Coefficier	Coefficen	Coefficent of SK
Rice	Andra pra	kharif	mashuri	guntur	Black soil(vertisols)	330	105	372	55	3.79	0.5	3.19	3.17	1.6	0.19
Rice	Andra pra	kharif	pothana	Karim nag	Inceptisols(sandy loam)	364	90	370	60	3.78	0.44	1.96	2.13	2.96	0.36
Rice	Andra pra	kharif	MTU-2067	Maruteru	Alluvial	342	88	428	60	2.3	0.32	1.91	1.9	2.27	0.27
Rice	Andra pra	kharif	MTU-5182	Nandyal	Black soil	302	41	439	70	3.35	0.33 2.52		4.53	1.24	0.12
Rice	Andra pra	kharif	NLR-9672	Nellore	Alluvial	331	93	375	50	3.47	0.37	2.53	2.12	1.89	0.2
Rice	Andra pra	kharif	Tellahamsa	Rajendran	Light Black soil(Sandy clay	346	97	399	55	4.2	0.55	2.7	2.67	2.22	0.21
Rice	Andra pra	kharif	pothana	Warangal	Black soil(vertisols)	330	39	449	55	4.75	0.75	2.75	4.2	1.99	0.15
Rice	Andra pra	Rabi	Tellahamsa	Nandyal	Black soil	419	71	550	55	2.83	0.32	2.29	2.98	1.34	0.17

Fig: Crop dataset

The data analysis phase will be initiated once all the values required is calculated. The input from the farmer will be taken on the crop he is planning to aggregate for this particular crop season. The soil sample will be clustered with the historical data collected before. From the clustered data the crop dataset is used to calculate the amount of nutrient that is required for the current state of soil. The nutrient amount required is in the unit of kg/HA. The appropriate fertilizer that is suitable for the soil sample is taken from the fertilizer dataset.

Fertilizer r	N	P	K	Weight
Ammoniu	20.6	0	0	100kg
Ammoniu	25	0	0	100kg
Calcium A	13	0	0	100kg
Calcium N	15.5	0	0	100kg
Urea	46	0	0	100kg
SSP 14%	0	14	0	100kg
SSP 16%	0	16	0	100kg
Rock phos	0	18	0	100kg
Potassium	0	0	60	100kg

Fig: Fertilizer dataset

The amount of selected fertilizer required for the soils nourish to produce the maximum yield is calculated in the Recommendation phase.

Fig: Crop registry GUI

The above screenshot represents the crop details entry by the farmer specifying the crop to be aggregated, state and district the location of the land, variety of the crop; season developed and soil type of the land. The data is used to get the record from the crop database to calculate the fertilizer nutrient level required. The nutrient content requirement is passed to data analysis phase to give the appropriate fertilizer to be used.

Fig: Fertilizer recommends

The above figure is the output of the project stating the required fertilizer is potassium chloride and the suitable amount that has to be applied should be 100kg.

V. EXPERIMENTAL RESULTS:

The above figure is the output of the project stating

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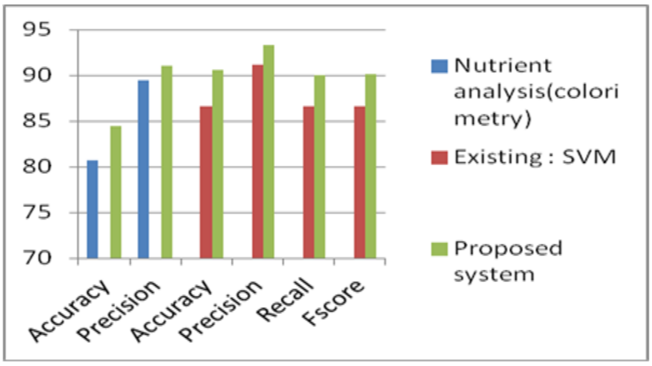
the required fertilizer is potassium chloride and the suitable amount that has to be applied should be 100kg.



Feature Modules	Accuracy (%)	Precision (%)
Nutrient analysis(colorimetry)	80.67	89.44
Proposed	84.46	91.04

Fig: Performance analysis for nutrient analysis

Modules	Precision (%)	Accuracy (%)	Recall (%)	Fscore (%)
Nutrient analysis(colorimetry)	86.66	91.10	86.66	86.66
Proposed	90.60	93.33	90.00	90.14

Fig: Performance analysis for recommendation system

VI. CONCLUSION

The proposed system calculates the NPK ratio of the soil sample from a farming land and recommend the suitable fertilizer needed to apply on the correct proportion to nourish the soil for the crop selected. The proposed system helps the farmers to maximize the yield for the given crop cycle without affecting the land and soil properties. This also ensures that healthy crops have been cultivated by reducing the chances of over fertilization. This fertilizer recommendation system opens up new opportunities in the field of robotics to create autonomous mobile robots to spray appropriate fertilizer taking the NPK value into account. Smart farming and precession farming can be advanced by calculating the NPK value for more accurate values. This recommendation system is also beneficial to Government in analyzing the soil condition of any region and the requirements of the farmer to maximize the soil production. The fertilizer companies can use the dataset produced in the process to create customizable fertilizer depending on the need for each region.

VII. ACKNOWLEDGEMENT

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