JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Development of a simplified, sensor based quick soil testing method to test nutrients in soil

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***Abstract* — Farming and agriculture contribute significantly to the country's economic growth. Farming is regarded as the best financial support area in the country, and it is among the most important factors in increasing GDP In farming, the farmer's primary goal is to test the soil in order to increase crop output while avoiding negative consequences. In the traditional technique of agriculture, physical exertion is necessary to travel the location and acquire soil samples from the field, which are then sent to a facility for assessment of all micronutrients. This procedure is time demanding and requires a significant amount of time to complete. The information recorded by using the IoT framework and monitoring devices may be used to monitor the soil. For this purpose a number of approaches on the topic of soil nutrient analysis have been analyzed effectively and elaborated in this paper with utmost detail. These approaches have served as building blocks for understanding the current and the pre-existing methodologies which have laid the foundation for an effective framework for soil nutrition analysis. This is done by using the Deep belief neural network and K-nearest neighbor classification algorithms on the collected data through the NPK sensor**

Keywords: *Soil Nutrition, Internet of Things, Deep Belief Networks, K Nearest Neighbor, Fuzzy Classification.*

I INTRODUCTION

Soil is the outermost layer of the earth's crust that covers the planet's surface and is utilized for agriculture. The major goal of soil analysis and testing of soil samples from a specific location is to furnish an in-depth insight of soil characteristics, yield, and pharmacological activities, as well as considerations for improving the soil's general quality. In addition to properly implement the evidence received from the outcomes and consultations of soil evaluation measures, it is critical that the relationship amongst soil nutrient and its influence on the progress of diverse plant varieties be well understood, maintaining other characteristics in the area in consideration.

Soil diagnostics also goes to facilitate long-term soil nourishment and general soil quality by encouraging sustainable agriculture and other preservation of natural resources for maintaining the soil fruitful while avoiding the negative impacts of synthetic ingredients. Soil is a complex substance made up of both physicochemical and biological elements. The elemental configuration are indeed the consequence of weather-induced disintegration of the bedrock involving thermal and physical mechanisms, meanwhile the organic sections are made up of dead and live fauna and flora. The farming industry contributes significantly to India's GDP. Economic circumstances, extreme weather events, human resource management, and labor costs are all potential factors that limit the farming sector's development. However, due to increasing population expansion, agriculture yields must be increased.

Agricultural production must be improved in order to increase yield. As a result, before establishing a harvest, farmers must do a soil study. The amount of fertilizer used in a certain farm area is influenced by the pH of the soil. Soil micronutrients and pH are physiologically, chemically, and biologically relevant conditions for agricultural production efficiency. By supplying the insufficient ingredient, crop-specific needs such as soil phosphorus, potassium, and nitrogen can be met. The soil composition inside a field may vary depending on the season, prior harvest, and various other factors stated. As a result, a soil quality examination is beneficial for growing plants in excellent condition.

Farming is essential for any country's growth. It makes a substantial influence to the country's economic development. The adoption of appropriate soil is a significant criterion for improving agricultural production. Soil testing is a crucial element to improve the farming performance in this case. Currently, soil testing is done by hand, therefore takes a long time and exposes the possibility of human mistake. As a result, soil testing in the present day is unavoidable. Soil testing is carried out in this study utilizing a new approach that is easier to build, takes much less time, and is less expensive.

The soil variety forecast has a considerable impact on agriculture's ability to increase yields.

Several varieties of sensors are being used to determine numerous soil characteristics, such as moisture in the soil, ambient temperature, and nutrient availability like Nitrogen, Phosphorous, and Potassium, to minimize manual monitoring of soil characteristics. The kind of soil is anticipated based on the measurements of the soil characteristics. Producers can utilize the recommended approach to eliminate using the present soil testing regime and instead employ the needed fertilizers for their cultivation. Producers are in desperate demand of innovative agricultural practices and technologies that will enable them increase overall produce.

Because the majority of producers are illiterate, they may have difficulties interpreting the text generated by soil analysis. Preparation of Soil with Perfect amount of the fertilizer makes significant impact on the yield. Farm owners are correcting insufficient soil properties by applying the right proportion of fertilizers in the right places. In a word, soil preparation entails uniform distribution, high-quality fertilizers combined with the appropriate quantity of moisture prior to the sowing procedure. This soil preparatory method has a substantial influence on production. As a result, soil testing and evaluation are required prior to soil preparation to identify deficiencies in soil nutrients and characteristics.

If the water concentration in the soil is optimal for greater crop output, they may extract water from the soil and decompose minerals to form the dissolved salts, which is critical as an occasional source of nourishment for maturing vegetation. The Instructions Soil testing has a number of drawbacks, including an inability to understand the features of soils when analyzing, as well as being inconsistent, time demanding, and requiring initiative to acquire. Nutrient levels might fluctuate during the planned procedure.

This paper segregates the section 2 for the evaluation of the past work in the configuration of a literature survey. Section 2 discusses the proposed methodology and finally, section 4 provides the conclusion and the future work.

II RELATED WORKS

Yang Tan [1] According to the researchers, the goal of this study is to see how effective the Continuous Wavelet Transform approach is in removing the effects of Sliding mode control on VIS-NIR spectrum and Soil Organic Content quantification algorithms. Parameters such as the best wavelet filter, the best disintegration ratio, and the particular areas of Soil Organic Matter are discovered during the trials. The authors proposed using the PCA-RF approach to construct Soil Organic Matter projections relying on the multi scales correlations and examined if it is useful in enhancing the accuracies of estimation techniques. Utilizing the spectra dataset from wet specimens, soil organic materials are extracted by using ideal configuration of Continuous Wavelet Transform scale and number of PCs. Ultimately, the Continuous Wavelet Transform was identified as a possible spectrum adjusted approach. The connection corresponding to the principal constituent may be strengthened on the decomposing parameters, and characteristics that are distorted by noise or inconspicuous to spectra can be recognised.

The multipath stage of the NavIC L5 signal as well as proportional soil water content of farmland are described by Sushant Shekhar [2]. The study demonstrates that the NavIC signal is quite sensitive to changes in soil water content. The results show that NavIC signals can be a useful instrument for determining the amount of moisture of agricultural land areas. The estimates are predicated on data gathered over a lengthy period of time. With the devised approach, the amplitude fluctuation of a multipath transmission was noticed. The mirrored output from the capacitive surface of the ground affects the C/N0, creating multipath frequency fluctuation. With the assistance of a soil moisture sensor, in presence quantitative soil moisture information was gathered, which would have been necessary to create an alignment with the input signal. The NavIC multipath stage and in situ observed macroscopic soil water content had a strong connection in this investigation. The results of the study may be used to construct a soil moisture extraction method using NavIC multipath information for use in drought surveillance, climate change research, groundwater recharge, farming, and other fields.

Varsha Kiran Patil [3] indicates that researchers have used the methodology proposed in this research to effectively conduct soil assessment of specimens at several regions around Pune, Maharashtra, India. The color detectors' measurement results are stored in the cloud as R, G, and B quantities. These quantities are represented using the contractor's color scheme. Any user with necessary qualifications may view all real-time cloud metrics linked to heat, moisture, relative humidity, R, G, and B position. Producers may use this feature to observe soil characteristics from their cellphones using authorized API privileges. As a result, real-time cloud-based soil nutritional and soil component monitoring nearby Pune (India) has been effectively deployed. Farmers may utilize this suggested platform to acquire real-time soil characteristics at their disposal instead of relying on soil analysis lab reports.

Haibin Wang [4] several crop varieties have autotoxicity as being one of the reasons of soil health or replanting disorder. It is a unique intraspecific allopathy phenomena in which an agricultural plant's chemicals hinder the development of other agricultural crops of the very same genus. Plant dysplasia, a dangerous illness characterized by a considerable reduction in production and efficiency, is produced by the long-term cultivation of the very same vegetation types on the very same soil. The constant harvesting issue was also present throughout the tea forest restoration procedure. Persistent harvesting, pruning, reduced fertility, and an instability in the soil ecological integrity, according to the experts, contributed to a decline in productivity and the establishment of relatively low tea gardens. Many researchers have attempted to alter low-yield tea gardens using various approaches, but with little success.

Carsten Montzka [5] SMAP, SMOS, and ASCAT worldwide magnitude soil humidity production arrays were used to modify the approach for forecasting sub-grid variations in soil moisture. Utilizing probabilistic assessment of 1D unsaturated gravity flow predicated on the Mualem-van Genuchten (MvG) paradigm, the technique employs a closed-form formulation to characterize how moisture in the soil fluctuation relies on average moisture content. It is feasible to forecast the standard deviation over average moisture in the

soil correlation for every large degree grid cell using high definition soil characteristics data given by SoilGrids. While supplying the coarse grid moisture levels, a look-up tabular mapping is provided that displays the sub-grid groundwater standard deviation of an ASCAT, SMOS, or SMAP image. The maximal entirely acceptable sub-grid variations was determined by combining the highest and lowest soil moisture readings from a lengthy time period. This data is being used to calculate the quantity of terminals per pixel that are required for proper certification.

Supachai Puengsungwan [6] the basic notion of the Internet of Things ecosystem is to address problems using real information. Traditionally, data monitoring and analytics might fall under this category. The Internet of Things ecosystem might essentially be organized into four components: linked items, cloud computing, user interaction, and business intelligence. Both linked sensing devices and interconnected control equipment can be interconnected. The linked sensors might constitute the intake element of the IoT environment, as opposed to the standard process component. Temperature, airborne particles, respiratory rate, and other variables could be used as input information. Bidirectional connection exists seen between linked devices. The internet serves as a real information distribution system. Every element of the Internet of Things would be able to connect to the cloud in order to publish or retrieve real statistics.

Mayssa Hachem [7] According to the definition, forensic soil science is the study of soil that involves using soil science to solve legal concerns about any crime scene. As per the notion of soil transmission, soil is recognized a potent contact residue. The diversity of samples collected makes it difficult for investigators to discriminate amongst them, making forensic soil investigation a difficult task. It is a burgeoning area, and that there is a general lack of knowledge between soil researchers owing to its innovativeness. Soil testing expertise has progressed dramatically in subsequent times, substantially specializing the area, which has additionally discouraged major investigation departments and academics from employing soil data. As a result, it is critical to understand the various procedures used to examine soil samples for forensic purposes.

Sudha Bhatia [8] illustrates how soil analysis processes are used to better comprehend soil composition, which is an important aspect in assessing the overall health and capacity of the soil. It is commonly known that nitrogen, phosphorus, and potassium are perhaps the most essential micronutrients for plant development and production in the bulk of crop varieties. The third specimen, enhanced with silver nanoparticles, revealed substantially greater concentrations of all the nutrients – calcium, phosphorous, and magnesium, according to the investigation in the specimens stated above. This result was found in the specimen attributable to the fact that silver nanoparticles collected in the topsoil, functioning as an environmentally benign fertilizer that might also improve plant development.

Suman Mohapatra [9] elaborate on how the suggested approach, with the aid of the Arduino, was able to collect the characteristics contained in the soil utilizing several sensors. The knowledge obtained is then utilized to determine soil composition. Regression Analysis, SVM Classifiers, and Naïve Bayes Classifier were used as standard supervised intelligence techniques in order to achieve this. Finally, based just on Random Forest Classifier's lowest RMSE result, this approach was chosen to get the algorithm closer to the final stage. A serverless application was created to put a smile on the farmer's face by effectively converting a text into speech in 15 different languages. This application is hosted on the internet with almost no hosted server and at no cost. The program was created with a serverless method and a microservices-based framework that required less work and expense to construct. Producers can now devote their time and manual labor more efficiently as this technique approaches automation. This will serve as a straightforward alternative for producers by providing them with the knowledge they need to attain a high output and hence maximize their productivity.

Jiaqing Chen [10] Contamination by heavy metals in soil, such as arsenic, lead, mercury, nickel, cadmium, and others, is an essential aspect of environmental poisoning, according to the author. There are two types of emission sources: natural and industrial. Wastewater irrigation, incorrect solid waste management, and dry and wet precipitation of heavy metal vapor created by fossil fuel usage are all examples of manmade inflow. The identification of soil heavy metal pollution's content and composition has now emerged a controversial problem in the environmental scientific community due to its significant camouflage, lengthy tenancy duration, decreased mobility, permanence, and inability to be destroyed by microbes. This research employs Laser-Induced Breakdown Spectroscopy to perform quick and reliable formative and summative assessments of heavy metal components in soil.

Hema Pallevada [11] Producers increasingly use lab testing services to check the soil quality of their farms. The growers, on the other hand, will have to wait several weeks for such findings. Sometimes farmers are getting the findings, which are occasionally erroneous. The cause for this might be due to the screening team's incompetence or defective specimens sent for examination. Several farmers use technology to evaluate their crops, although this is restricted to those who have vast fields. As a result, the researchers have designed a system that identifies soil properties and offers information on the quantity and kind of fertilizer to be applied. The goal of developing such a mechanism at a low cost for moderate to medium range producers has been achieved. Farmers may now evaluate their soil themselves for a very small price and then determine on the quantity and type of fertilizer to use, resulting in an improvement in crop production. A function to test red soil might be added to the suggested program to enhance it.

Tingli Wang [12] The fluctuation in underlying soil layer moisture is comparable to the eventual outcome of soil root layer moisture contents, according to the study, and the sample surface moisture content is much more impacted by external pressures and fluctuations. When compared to the alternative two scenarios, the Noah-MP model reveals substantial changes in fall, with the moisture content of the soil of the bottom zone in the central plateau increasing considerably, and the non-significant rise tendency extending throughout the entire region. The prevailing research findings could only describe significant disparities in soil moisture

content between the three approaches, but they have been constrained by time and do not take into account other factors such as droughts, global warming, or human involvement, which could attempt to clarify the ramifications of the discrepancies.

Temurbek Kuchkorov [13] The use of GNSS monitoring data in conjunction with sensing devices to evaluate if the soil properties in Uzbekistan will increase the dependability of the findings is examined in this article. In the case of soil surveillance, real-time satellite measurements such as SAR, sensor readings, and photographs generate a requirement for big data management. It allows professionals to identify regions based on distinct soil properties and aids in the development of decision-making mechanisms.

Madhumathi R [14] offered a legitimate monitoring and reporting platform for moisture in the soil, nitrogen, potassium, phosphorus, acidity, and climate. As a result, an application system is developed that shows measured soil model parameters and recommends fertilizer for cultivating a specific crop. In combination to soil macronutrients such as nitrogen, potassium, and phosphorus, various micronutrients such as zinc, molybdenum, manganese, iron, and copper are necessary for a crop's continuous development, which has an influence on yield. With the right incorporation of such newest features and standards, the solution may be upgraded to evaluate such aspects.

Siddalinga Nuchhi [15] this technique is extended by measuring crop nutrient indicators in connection to successful agricultural production. Devices collect the required characteristics including such moisture content, heat, nitrogen, potassium, phosphorus, and saturation, and the information is delivered to producers via a cloud platform from which they can readily view data collected on their smart phones or computers. The three elements Nitrogen, Potassium, and Phosphorus support plant development in a very efficient manner, and their lack leads the crop to reduce its production. The conclusion gained from the data would be that the measures of application performance are fairly precise and dependable.

III RELATED WORKS

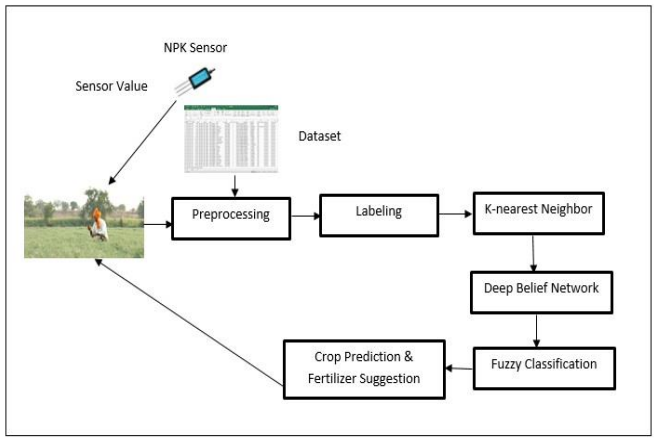

Figure 1: System Overview

The system overview diagram above depicts the system and its various modules. The step by step elaboration is depicted in the section given below.

Step 1: NPK and Moisture sensor value collection – The moisture sensor and NPK sensor are utilized in the field to collect the readings. The NPK sensor consists of a probe that is embedded into the soil. This probe has 3 prongs that are utilized to measure the Nitrogen, Potassium and Phosphorus contents in the soil. These values are recorded through the help of a microcontroller called Arduino Uno. The Arduino Uno provides the necessary power and a channel to collect the incoming readings from the sensor. These readings are then uploaded by the farmer on the designed webpage which will then be subjected to the preprocessing in the next step.

Step 2: Preprocessing – The collected sensor values are then effectively segregated and provided to the java code for the purpose of preprocessing. The Dataset as well is provided for the preprocessing to remove the redundant and incomplete data. The preprocessing procedure is essential to reduce the number of errors and also improves the execution time of the proposed system. The preprocessed data is then provided to the next step for the purpose of labeling.

Step 3: Labeling – The preprocessed data is then effectively labeled in this step of the process. The system selects the relevant attributes for the evaluation of the crop prediction. The selected attributes are labeled through the conversion of the values into a relevant integer value. Labeling procedure improves the execution of the subsequent steps in the system increasing the overall efficiency of the entire procedure. The preprocessed and labeled values are then provided to the next step for the purpose of achieving the clusters.

Step 4: K Nearest Neighbor – The values achieved in the previous step that are preprocessed and labeled are utilized as an input in this step of the procedure. The nearest neighbors are extracted and then utilized for the purpose of achieving the clusters. These clusters are then provided to the Deep Belief Network in the next step.

Step 5: Deep Belief Network – The Deep Belief Network or DBN is being used for the purpose of evaluating the soil values and providing a relevant prediction and fertilizer suggestion. For this purpose the output layer and hidden layer values are calculated to achieve the probability scores for the crop type. The probability scores are then provided to the next step for the fuzzy classification approach for the classification.

Step 6: Fuzzy Classification – The probability scores obtained from the previous step are provided as the input in this step of the procedure. The fuzzy classification approach utilizes the fuzzy crisp values for the purpose of complete classification of the probability scores. The fuzzy crisp values consists of 5 ranges such as Very Low, Low, Medium, High and Very High. The segregation according to these values is performed and the probability of the crop prediction is provided to the user as the result along with the fertilizer suggestion depending on the nutrient deficiency.

IV CONCLUSION AND FUTURE SCOPE

The farming industry contributes significantly to India's GDP. Economic circumstances, extreme weather events, manpower capacity, and labor costs are all potential variables that limit the farming sector's development. However, given the population expansion, agriculture yields must be increased. Soil quality must be improved in order to increase production. As a result, before establishing a produce, producers must do a soil study. The amount of fertilizer used in a certain field area is influenced by the pH of the soil. Soil conditions and pH are technically, physiologically, and biologically relevant conditions for agricultural production efficiency. By supplying the lacking constituent, crop-specific needs also including soil pH, potassium, and nitrogen can indeed be met. The soil conditions may vary throughout a field depending on the environment and prior crop, as well as various other factors outlined before. As a result, a soil characteristics examination is beneficial for plant growth in better health. A number of methodologies to soil nutrient analysis have been efficiently studied and expanded in this series of surveys with utmost detail for this goal. These methods have functioned as a basis for comprehending current and previous procedures, laying the groundwork for an efficient mechanism for soil nutritional assessment, which will be covered in additional articles.

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