MULTIMEDIA COMMUNICATIONS TECHNICAL COMMITTEE
http://www.comsoc.org/~mmc

MMTC Communications - Frontiers

Vol. 18, No. 5, Sep 2023

CONTENTS

SPECIAL ISSUE ON Recent Advances in IoT Based Precision Agriculture and its Applications

Guest Editor: Parijata Majumdar[1], Diego Alberto Oliva Navarro[2] and Sanjoy Mitra[3]
[1]Techno College of Engineering Agartala, Tripura,India, er.parijata@gmail.com
[2]Depto. de Innovación Basada en la Información y el Conocimiento, Universidad de Guadalajara, CUCEI, Guadalajara, Mexico,
diego.oliva@academicos.udg.mx
[3]Tripura Institute of Technology Narsingarh,India, mail.smitra@gmail.com

The fourth agricultural revolution, known as Agriculture 4.0 makes use of digital technologies to transform the agricultural industry into one that is more environmentally conscious, intelligent, and productive. New agricultural technologies have been developed to improve sustainability and find more efficient farming practices. This includes all digitalization and automation processes in the workplace and in our daily lives, such as robots, the Internet of Things (IoT), artificial intelligence (AI), big data, virtual and augmented reality. The impact of these technological advancements on our lives is significant. It introduces us to precision agriculture from a technical perspective. With the help of this, farmers can effectively grow and maintain crops on cultivable land by utilizing a data-driven strategy that utilizes the most of their available resources. Massive amounts of data are generated by everyday operations. The majority of this data was untapped until recently, but big data technologies allow for the utilization of this data to enhance crop performance and yield. Digital harvesters, especially in Agriculture 4.0, can help manage large areas in a variety of situations, depending on the type of crop and its growth requirements. This special issue provides a brief overview of Agriculture 4.0 and its state. A thorough discussion of smart farming, a number of important technologies, and particular domains for exploring Agriculture 4.0 is followed by discussion of the major applications of Agriculture 4.0 technologies.
Technologies such as Machine learning, a model-independent approach, can create usable solutions to next-generation Agriculture 4.0 applications. These technologies simplify our daily tasks without us even realizing it, which makes them indispensable to our existence. Thus,this Special Issue seeks articles covering various subjects that fall under its purview.

The first paper proposed suggests a practical and easy-to-use yield prediction system for farmers. Farmers can connect to the proposed system via a mobile application. GPS facilitates user location identification. The user enters the area and type of soil. Selecting the most profitable crop list or forecasting crop yield for a crop that the user has chosen are made possible by machine learning algorithms. Furthermore, the system recommends when fertilizers should be applied in order to maximize yield.

In the second paper, the rice harvest is predicted, and the factors influencing rice production in different parts of Maharashtra, India, are examined. Using a random forest algorithm, the software seeks to provide a rice harvest while precisely forecasting the yield. Tripura will use an Indian government database to show how successful harvest forecasting is. The random forest model in Maharashtra uses boundaries like temperature, humidity, rainfall, and location to define the annual variation of the regional rice crop.

The third paper proposes an approach to resolve lack of awareness of the advantages of the agricultural programs in the agriculture sector using a Collaborative Recommendation System. Through a web application, our research system generates a profile of basic requirements and responds to farmers' agricultural queries, all while recommending government schemes designed to support farmers. The recommendation system also informs farmers on a regular basis about new government initiatives and programs, as well as current developments in the agricultural sector.
The fourth paper proposes a smart irrigation system based on open-source technology that senses ground parameters such as soil temperature, moisture content, and environmental factors in addition to weather forecast data sourced from the Internet. The proposed system's intelligence is derived from an intelligent algorithm that takes into account both sensed data and parameters from the near-term weather forecast, such as UV, humidity, precipitation, and air temperature.

Dr. Parijata Majumdar is currently working as Associate Professor at Techno College of Engineering Agartala. She obtained her PhD in Computer Science and Engineering majoring in IoT, Machine Learning, Precision Agriculture from NIT, Agartala, India. She has published numerous research papers and patents in reputed international conferences & international journals. Her areas of interestinclude Artificial Intelligence, Internet of Things, 5G, Blockchain, Precision Agriculture, Cloud computing and Optimization Techniques.

Dr. Sanjoy Mitra is an Associate Professor of Department of Computer Science and Engineering (CSE) at Tripura Institute of Technology, Narsingarh, India. He obtained his PhD degree from Assam University, India. He has published numerous research papers and patents in reputed international conferences & international journals. His areas of interest include Machine Learning, Green Internet of Things, Blockchain, Precision Agriculture, Real Time Applications and VLSI systems.

Diego Oliva obtained a Ph. D. in Informatics in 2015 from the Universidad Complutense de Madrid. Currently, he is an Associate Professor at the University of Guadalajara in Mexico. He has the distinction of National Researcher Rank 2 by the Mexican Council of Science and Technology. Since 2022 he has been a Senior Member of the IEEE. In 2022 he obtained the distinction of Highly Cited Researcher by Clarivate (WoS). Diego Oliva is co-author of more than 100 papers in international journals and different books. He is part of the editorial board of IEEE Access, Mathematical Problems in Engineering, IEEE Latin America Transactions, and Engineering Applications of Artificial Intelligence. His research interest includes Evolutionary and swarm algorithms, hybridization of evolutionary and swarm algorithms, and computational intelligence.

Crop Recommender System Using Machine Learning Approach

***Trishita Das*[1]*,Ryan Solgi*[2]**

[1] *Techno College of Engineering Agartala, Tripura, India, trishita.cse.tcea@gmail.com*

[2]*University of California, Santa Barbara, ssolgi@ucsb.edu*

Abstract

This paper suggests a practical and easy-to-use yield prediction system for farmers. Farmers can connect to the proposed system via a mobile application. GPS facilitates user location identification. The user enters the area and type of soil. Selecting the most profitable crop list or forecasting crop yield for a crop that the user has chosen are made possible by machine learning algorithms. Support vector machine (SVM), artificial neural network (ANN), random forest (RF), multivariate linear regression (MLR), and K-nearest neighbor (KNN) are a few of the machine learning algorithms used to predict crop yield. With 97% accuracy, the Random Forest yielded the best results out of all of them. Furthermore, the system recommends when fertilizers should be applied in order to maximize yield.

Keywords: Crop Yield Prediction, Machine Learning, Crop Recommender System, Fertilizer

1. Introduction

IoT is a network of devices and sensors that receive or transfer data through wireless gateways. India has a long history of agriculture. India is currently ranked second globally in terms of agricultural output. About 50% of the workforce was employed in forestry and fisheries, two sectors closely associated with agriculture, which accounted for 16.6% of the 2009 GDP. India's GDP's financial contribution from agriculture is declining [1]. The main element influencing agricultural revenue is crop yield. Numerous variables, including climatic, geographic, organic, and financial aspects, affect crop yield [2]. Farmers find it challenging to determine which crops to plant and when to do so due to volatile market prices [3]. The novel aspect of the suggested system is that it offers guidance to farmers on how to optimize crop yields while also recommending the most lucrative crop for the particular area. In order to maximize crop yield and thereby help meet the nation's growing demand for food supplies, the proposed model offers crop selection based on economic and environmental conditions [4]. The suggested model looks at a number of variables, including temperature, precipitation, area, season, and type of soil, to forecast crop yield. The optimal timing for applying fertilizers is also assisted by the system. The current crop yield recommendation system is either hardware-based and therefore expensive to maintain, or it is not readily available.

2. Related work

In order to evaluate the effect of meteorological parameters on crop production in the designated Madhya Pradesh districts, one of the early works created a specialized website [5]. The districts were chosen based on the crop's growing region. The first five districts with the highest crop area were selected based on these criteria. The dominant crops in the districts that were chosen served as the basis for the crops chosen for the study. The crops that were chosen were maize, soybean, wheat, and paddy, for which yield data was tallied over a continuous 20-year period of knowledge. For the selected crops, the established model's accuracy ranged from 76% to 90%, with an average of 82%. Using the Pandas profiling tool, the historical datasets are filtered to obtain the datasets for Maharashtra. The multilayer perceptron neural network was used in the design of the crop yield prediction model, and the Adam optimizer, bias, and weight were adjusted to increase accuracy. The suggested model predicts crop yield by using an artificial neural network (ANN) with a three-layer neural network [6].

3. Methodology

Historical information is gathered from a number of trustworthy websites, including Indian Water Portal.com, Kaggle.com, and data.gov.in. The regions of Tripura 4/21 ed by the data sets. Numerous details are included in the data, including the state, district, year, season, crop type, area under cultivation, production, etc. In other datasets with state and district specifications, the soil type is an attribute. After being extracted, this soil type column is combined with the primary data set. In a similar manner, average rainfall and temperature are added to the primary data sets for the particular region from a different dataset. The data sets undergo pre-processing and cleaning. The mean values are used in place of the null values. Labels are created from the categorical attributes prior to the algorithms being processed. The suggested model's system architecture is shown in Fig.1. The prediction module and the fertilizer module are the two sections of this smartphone app. A mobile application provides a range of services. The farmer must complete the registration process on the app.The farmer can use the mobile application services after completing the registration process. Utilizing particular attributes chosen from the data sets for that particular crop, the prediction module forecasts the crop yield. The farmer whose crops yield the highest is also recommended by the predict module. The fertilizer module helps the farmer apply fertilizer at the appropriate time.

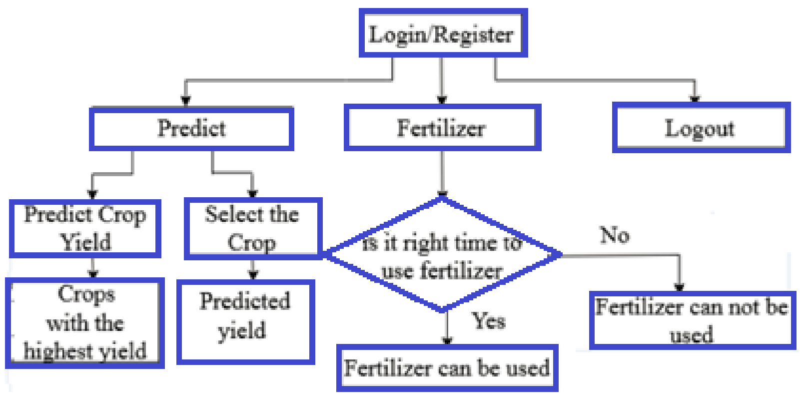

Fig.1 System Architecture

Registering is the first step towards using the app's services. The app uses GPS to find the farmer's location and determine their region at the time of registration. After logging in successfully, the user has access to two services. The first service is the yield prediction, which can be done with a crop recommender system or for the chosen crop. Determining the ideal time to apply fertilizer is the second service. The user must enter the area being farmed, the type of soil, and the anticipated crop into the prediction tool. The yield for the particular crop chosen is predicted by the system. The crop recommender system can be used by the farmer if he is unsure of the crop that should be planted this year. The farmer only needs to enter the area and soil type in the crop recommender system. The crops and their estimated yields are listed by the system. This makes choosing a crop to plant easier for farmers. It's critical to apply fertilizer at the right time. Rainfall that occurs too early will be a waste of the farmer's money and effort. The farmer will receive guidance on when to apply fertilizer from the proposed fertilizer usage service. With Open Weather API, the model forecasts the amount of rain that will fall at a given location over the course of the next 14 days. When there is more than 1.25 mm of rainfall, it is advised not to use the fertilizers. The method for predicting crop yields is machine learning. The machine learning approach is used to find the patterns and correlations. Using historical data sets, the model is trained by representing the outcome with prior experience. To predict yield, a number of common machine learning algorithms are employed. The Random Forest regression algorithm yielded the highest accuracy among the algorithms chosen. In order to produce the most reliable and accurate predictions, Random Forest constructs a large number of decision trees and then combines them.

4. RESULTS AND DISCUSSIONS

The crop yield prediction accuracy for each of the chosen algorithms is compared. With a 95% accuracy rate, the Random Forest algorithm was found to be the most effective for the provided data set. A number of machine learning algorithms, including ANN, SVM, Random Forest, Multivariate Linear Regression, and KNN, are used to predict crop yields. The total results of the accuracy comparison of different machine learning algorithms are displayed in Table 1.

Algorithm	Accuracy (%)
Artificial Neural Network (ANN)	88
Support Vector Machine (SVM)	77
Multivariate Linear Regression (MLR)	62
Random Forest (RF)	97
K Nearest Neighbor (KNN)	90

There are two options: Option 1: The user is aware of the crop that is scheduled for this season and is curious about the potential yield. The user will choose a crop and related factors like area and type of soil. The Random Forest Algorithm is internally used by the predictor block to forecast the crop yield for a crop that the user has selected.

Option 2: When the user is unsure of which crop to plan for this year, the farmer selects the recommender system. The recommendations for the different crops based on soil type and area. Users have a choice from the anticipated list of suggested items. Determining when a farmer should apply fertilizer is another feature. The system determines when to apply fertilizers by analyzing the weather for the next 14 days. Fig. 2 illustrates the flow chart of the proposed system.

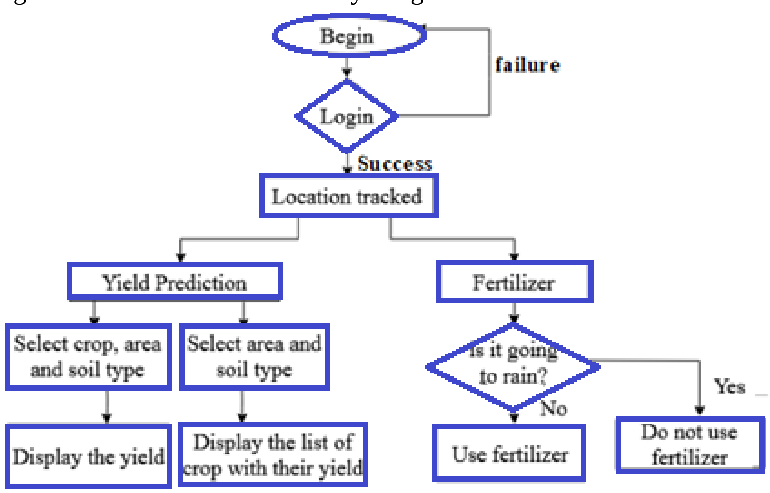

Fig. 2 Flow Chart

5. Conclusion and Future scope

The limitations of the systems in use today and their usefulness for yield prediction were emphasized in this paper. A suggested system connects farmers via a mobile application. Users can use a variety of features in the mobile application to help them choose a crop. Farmers can forecast the yield of a particular crop with the aid of the built-in predictor system. The integrated recommender system enables the user to investigate potential crops and their yield in order to make more informed choices. Using the provided datasets from Tripura, a variety of machine learning algorithms, including Random Forest, ANN, SVM, MLR, and KNN, were tested to determine their yield to accuracy. With a 97% accuracy rate, the results show that Random Forest Regression is the most effective algorithm when applied to the datasets. The suggested model also looked at when to apply fertilizer and suggests a suitable amount of time. In order to generate accurate predictions, future work will concentrate on periodically updating the datasets, and processes can be automated.

References

[1] Umamaheswari S, Sreeram S, Kritika N, Prasanth DJ, "BIoT: Blockchain-based IoT for Agriculture", 11th International Conference on Advanced Computing (ICoAC), 2019 Dec 18 (pp. 324-327), IEEE.

[2] Jones JW, Antle JM, Basso B, Boote KJ, Conant RT, Foster I, Godfray HC, Herrero M, Howitt RE, Janssen S, Keating BA, "Toward a new generation of agricultural system data, models, and knowledge products: State of agricultural systems science. Agricultural systems", 2017; 155: 269-88T.

[3] J. Swamy and T. N. Murthy, "eSmart: An IoT based Intelligent Health Monitoring and Management Systemfor Mankind", International Conference on Computer Communication and Informatics (ICCCI), pp. 1-5,2019.

[4] Kumar R, Singh MP, Kumar P, Singh JP, "Crop Selection Method to maximize crop yield rate using a machine learning technique", International conference on smart technologies and management for computing, communication, controls, energy, and materials (ICSTM), 2015 May 6 (pp. 138-145). IEEE.

[5] Veenadhari S, Misra B, Singh CD, "Machine learning approach for forecasting crop yield based on climatic parameters", IEEE International Conference on Computer Communication and Informatics, (pp. 1-5), 2014.

[6] Kale, Shivani S., and Preeti S. Patil. "A Machine Learning Approach to predict Crop Yield and Success Rate." In 2019 IEEE Pune Section International Conference (PuneCon), pp. 1-5. IEEE, 2019.

Authors Bio-data

Trishita Das received the B.E. degree in Computer Engineering from the Techno College of Engineering Agartala under the Universityof Tripura, India, in 2023, and started persuing M.Tech. degree in Computer Science. Her research areas include Data Science, Machine Learning , predictive modeling through Data Analytics, Natural Language Processing. She deployed ML model in EC2 to control ESP8266 to regulate house lighting using MQTTS.

Ryan Solgi is pursuing PhD from University of California, Santa Barbara. His research areas include Machine Learning, Precision Agriculture, Tensor Computation, Metaheuristics, Optimization, Hydrology, and Remote Sensing. He has published numerous research papers and patents in reputed international conferences & international journals.

Rice Yield Prediction Model Based on IoT and Deep Learning

Joyjit Dhar[1], Alberto Ochoa Ortiz-Zezzatti[2]

[1] *Techno College of Engineering Agartala, Tripura, India, joyjit @gmail.com*

[2] *Universidad Autónoma de Ciudad Juárez, alberto.ochoa@uacj.mx*

Abstract

In this work, the rice harvest is predicted, and the factors influencing rice production in different parts of Maharashtra, India, are examined. Using a random forest algorithm, the software seeks to provide a rice harvest while precisely forecasting the yield. Tripura will use an Indian government database to show how successful harvest forecasting is. The random forest model in Maharashtra uses boundaries like temperature, humidity, rainfall, and location to define the annual variation of the regional rice crop.

Keywords: Amazon Web Services(AWS), REST API, MySQL, Random Forest Regression.

1. Introduction

Crop yield prediction is essential to the production of food worldwide. To enhance domestic food establishments, policymakers base their import and export decisions on precise forecasts. Given that soil, climate, and management work together to determine yield, the goal of harvesting should change not only from one season to the next but also from one area to another [1]. Numerous models of crop yielding rely on simulation or mathematical models. This paper suggests a software system that makes use of machine learning ideas and techniques to effectively predict crop yields in a range of crop conditions [2]. Better accuracy will be achieved by integrating machine learning with additional technologies like the Internet of Things (IoT), utilizing sensors in all fields to monitor real-time results, and more.

2. Objectives

The objectives of the article are presented as follows:

1. Provide accurate forecasts for rice yields using Machine Learning.
2. Integrating real-time data obtained from various sensors.
3. Using data obtained from climate and soil sensors to predict conditions and timers for farmers.

3. Existing systems

When taking into account a single weather parameter, current systems predict paddy yields using ANN structures [3]. Several farms owned by the same company were the subject of some studies carried out in large corporations.

1. In this study, crop acreage and yield forecasts were mapped using SNAP software using both field-based surveys and satellite data.
2. The data sets used in the earlier study came from Government of India public records between 1998 and 2002.
3. Matching the retrospective model, which would assist us in forecasting crop yields as a function of monthly rainfall and temperature, was one suggested strategy. Because we must forecast the yield based on past yield data in comparison to the environmental parameters, the system is capable of using regression.
4. The MLR technique is employed in the system comparison model to examine the impact and causal relationships between the predictive variables and the objective (y ≡ Yield).
5. The system employed KNN (k-neighbor) to categorize new cases according to the similarity scale and store all cases that were available. Retrospective and separation problems have both been used by KNN [4].
6. The Deep Gaussian system was utilized in some systems to forecast the data output from remote sensor data.

The Spiking Neural Networks method for Crop Yield Estimation Based on Spatiotemporal Analysis of Image Time Series has been applied in certain systems.

4. A comparison of the current setup

4.1 Prediction of Rice Crop Yield

As was previously mentioned, several systems employed various machine learning algorithms to forecast the crop yield of rice crops. Crop yield limits were estimated in a variety of current systems by using climatic conditions. For instance, analyzing the soil requirements for a good yield and providing the necessary solutions to improve the crop yield of rice in the event that the yield is below average can be achieved by simultaneously applying the weather and land conditions. This will not only provide the crop condition for rice.

4.2.2 Permitting Farmers to Utilize the Website for Outcome

In light of the previous system, these were intended as a research project and did not give users or farmers complete program participation. The user can easily get the guessing results in the format of their choice. After receiving the results, the user can assess whether his yield is low and identify the necessary steps to improve the state of his farm as well as other elements that might be able to boost output and raise yield. Water is present in soil moisture. The most effective and reasonably priced sensor for determining soil moisture content is the capacitive sensor. The analog sensor output from Earth can be transformed into percentages and can be displayed at 0.96OLED.

This paper aims to provide more information on the required soil conditions in order to develop a system that can accurately predict the yield of a rice crop. You'll get better results and save time by doing this.

4.1 Specifics of the Implementation

4.1.1 Regression using Random Forest

During training and class removal—that is, a classroom (planning) or direct prediction (retrieval) of individual trees—many decision trees are created. Random forests, also known as random decision forests, are an integrated learning method for classification, retrieval, and other tasks. To finish their training set, random decision-making forests rectify deciduous trees' practices. We decided that 100 decision trees would be used in this study, and that 80% of the total data would be sampled. Every tree that is generated independently of pre-built trees is made using the Bagging meta-algorithm. Samples are pressed to accomplish this. We test our model using the remaining 20% of the database after it has been trained.

4.2 Analysis

The Random Forest Regression algorithms are employed. Tripura will use a government database to show how accurate harvest forecasting can be. The random deforestation model in Tripura is informed by boundaries, which include temperature, humidity, rainfall, and location. These parameters help define the annual variation of the regional rice crop. R squared values typically range from 0 to 1, with the possibility of a negative value if the model performs worse than the horizontal line. The return line is very similar to the data if the value is close to 1. In the process of analyzing the test data, we have also established a data set in the Reverse plan to highlight patterns found in the database. The application displays the JSON output of the rice crop yield prediction made using the Random Forest Algorithm and Internet of Things sensors after all the information has been entered, including the crop name and field size. It displays the yield forecast results for the next 10 and 20 days in addition to the current prediction.

4.3 Data Acquisition

Soil Moisture sensor provides the soil with the appropriate amount of moisture as it emerges by measuring the amount of water present in the soil. Unlike other sensors on the market, this soil moisture sensor uses capacitive sensing to determine the moisture content of the soil. It has a great service life because the materials used to make

it are resistant to corrosion. Apply it to the soil surrounding your plants, then keep an eye on the soil moisture data in real time. An onboard voltage controller with a v[illegible] ınge of 3.3 ~ 5.5V is included with this module. ideal for 3.3V and 5V power supplies for a low-voltage microcontroller. NodeMCU is an open-source development board with firmware based on Lua, designed primarily for IoT applications. Writing code and uploading it to the board is made simple by the open-source Arduino Software IDE. Any Arduino board can be utilized with this software. The IDE program works with a variety of operating systems, including Linux, Mac OS X, and Windows. The programming languages C and C++ are supported by it.

5. Results

All of the goals and implementations outlined in the suggested system are carried out. In the current section, the screenshots are visible. The images are from the MySQL workbench, an Android application, and a cloud server hosted by Amazon Web Services. Flask, Arduino, Java, and Amazon Web Services are used in the construction of the application which are loosely coupled because it's a microservice application. Among the many AWS services utilized are AWS IoT Core, AWS Amplify, Amazon Simple Storage Service, AWS Lambda, Amazon Elastic Compute Cloud, Amazon Rekognition, Amazon Relation Database Service, and Amazon DynamoDB. Prior to making a prediction, we must first take a picture of the crop, or we can select one from the gallery. Next, the Amazon Rekognition service is used to make a prediction about the image. It indicates that the crop has been found. The application uses Flask to serve the incoming request and makes a REST API call to the AWS Elastic Compute Cloud instance where the rice crop yield prediction code is executing. Using MQTT Protocol, the Arduino IDE is used to link the NodeMCU ESP8266 to the AWS IoT Core. Policies and certificates are needed in order to create an object in IoT Core. Instead of storing the certificates inline in the script, Sketch is used to upload them to the device's drive. Figure 1 shows Box plot for rice yield prediction.

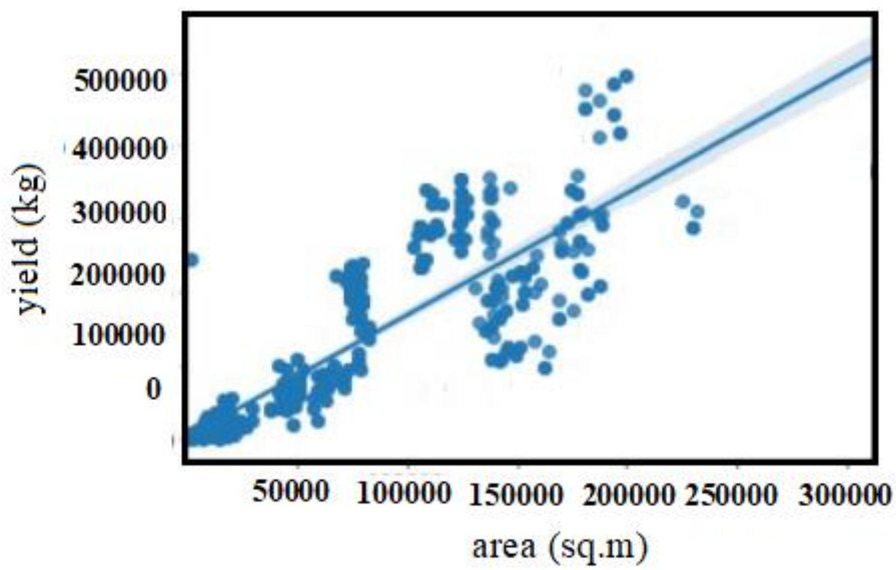

Figure 1. Box plot for rice yield prediction

6. Conclusion

Significant progress has been achieved in the difficult task of rice harvest prediction in the past few years. Improving decision-making regarding national food import/export and food security may benefit farmers and other stakeholders through the development of precise models for crop yield estimation utilizing various technologies. This study has shown how machine learning techniques can be used to predict the yield of rice crops. As a result, it draws the conclusion that classifiers that were employed on the dataset under study and that were previously reported ought to be suggested for additional rice prediction model development.

References

[1] Ayush Shah, Akash Dubey, Vishesh Hemnani, Divye Gala and D. R. Kalbande. 2018. Smart Farming System: Crop Yield Prediction Using Regression Techniques.
[2] Niketa Gandhi, Owaiz Petkar, Leisa J. Armstrong. 2016. Rice Crop Yield Prediction Using Artificial Neural Networks.
[3] Vinushi Amaratunga, Lasini Wickramasinghe, Anushka Perera, Jeevani Jayasinghe, and Upaka Rathnayake. 2020. Artificial Neural Network to Estimate the Paddy Yield Prediction Using Climatic Data.
[4] Girish L, Gangadhar S, Bharath T R, Balaji K S, Abhishek K T. 2018. Crop Yield and Rainfall Prediction in Tumakuru District using Machine Learning.

Authors Bio-data

Joyjit Dhar received the B.E. degree in Computer Engineering from the Techno College of Engineering Agartala under the Universityof Tripura, India, in 2023, and started persuing M.Tech. degree in Computer Science. His research areas include Data Mining, Machine Learning , Data Analytics, Artificial Intelligence. She deployed ML model in EC2 to control ESP8266 to regulate house lighting using MQTTS. Real Time Chat-Room App. Build a Django application for real-time chatting using Channels. Used vanilla JavaScript with Web Sockets for front-end and Tailwind CSS for styling. Implemented user authentication and login.

Alberto Ochoa Ortiz-Zezzatti (Bs'94–Eng.Master'00; PhD'04-Postdoctoral Researcher'06 & Industrial Postdoctoral Research'09). He has 11 books, 37 chapters in books related with AI and 487 papers related principally with Logistics and Social Modelling using different Artificial Intelligence techniques. He has supervised 37 PhD theses, 39 M.Sc. theses and 47 undergraduate theses. Implemented user authentication and login. His research interests include ubiquitous compute, evolutionary computation, natural processing language, social modeling, anthropometrics characterization and Social Data Mining. In his second Postdoctoral Research participated in an internship in ISTC-CNR in Rome (2009),

A Recommendation System For Precision Agriculture

Souvik Roy[1], Aditya Debnath[2]

[1] Techno College of Engineering Agartala, Tripura, India, souvik.cse.tcea@gmail.com

[2] Techno College of Engineering Agartala, Tripura, India, aditya.cse.tcea@gmail.com

Abstract

In India, agriculture is one of the most significant industries, and farmers are among the most vital members of society. The agricultural sector is the main driver of the nation's economy. Even so, Indian farmers' suffering never ends. Lack of awareness of the advantages of the agricultural programs and schemes that the Indian government has proposed is one of the main reasons for the ongoing suffering of Indian farmers.One approach to resolving this issue is the Agriculture Sector Collaborative Recommendation System. Many workshops are held to educate farmers about government programs and schemes, but the outcomes are still not what is anticipated. Even if they are aware that they are unsolved, numerous NGOs and institutions have devised a variety of solutions to address this issue. Through a web application, our research system generates a profile of basic requirements and responds to farmers' agricultural queries, all while recommending government schemes designed to support farmers.The recommendation system also informs farmers on a regular basis about new government initiatives and programs, as well as current developments in the agricultural sector.

Keywords: Precision Agriculture, web application, recommendation, KNN algorithm, cosine similarity.

1. Introduction

Approximately 25% of India's GDP is derived from agriculture, which employs over 60% of the labor force.
Notwithstanding advancements in the field of agriculture, issues have persisted, aggravating Indian farmers and citizens. It is estimated that inefficient methods of harvesting, farming, transportation, and storage of goods produced from government-subsidized crops result in the loss of one-fourth of India's produce. Issues that cause farmers to lag behind include uneven land distribution, the land tenure system, holdings that are divided and fragmented, cropping practices, volatility and swings, and labor conditions. Inadequate farming practices also pave the way for various issues that eventually impact the nation's economy as a whole. The deceleration of agricultural growth remains a critical issue for India's agricultural sector. One of the main causes of the decline in Indian agriculture's growth is the reduction in funding for agricultural research and development.As a result, certain technologies and approaches are required to collaborate and develop a system for farmers that addresses their problems. There are many programs that focus on a single area, such as the kind of soil required for farming, the kinds of crops that can be grown, or other utilities needed for agriculture. However, there aren't many of these programs that advise farmers on the right course of action to take in order to increase yield, increase profit, cut costs, and receive assistance from the government. We have developed a combined solution that makes use of numerous technologies in order to gain a deeper understanding of the details and offer the most profitable option. In order to address the various challenges that farmers and the nation as a whole confront, the Indian government has put forth and executed numerous farmer welfare programs. Farmers are supposed to use these schemes to advance in the agricultural sector. The programs offer assistance in the form of cash, marketing support, irrigation equipment, crop insurance, and subsidies to farmers and their families. However, for farmers to benefit from these schemes, they must reach every remote area of India. Despite the government of India's numerous solutions, farmers still face a variety of issues as a result of a lack of exposure to farmers and ignorance of various government initiatives. Numerous applications exist for crop recommendations and other related issues [1]. Farmers are ignorant of the various government programs and policies that can assist them with a range of agriculturally related issues. This project's primary goal is to illustrate the volume of questions farmers have about specific topics, like financial assistance and crop identification, and to recommend various government programs to them so that they can receive assistance and understand how to get it. This paper is organized as follows: The literature review of numerous published papers is introduced in Section 2, the proposed system is introduced in Section 3, the experimental results are explained in Section 4, and the agenda is concluded with suggestions for future work in Section 5.

2. Literature Survey

The research focuses on developing a recommendation system that can gather raw data for environmental factors like soil and weather parameters from seasoned farmers, agricultural researchers, and other stakeholders in Crop Selection Method to Maximize Crop Yield Rate using Machine Learning [2]. These parameters are used to study structures and recommend crops to farmers. Predictive modeling and statistical data analysis are used to predict an appropriate crop in accordance. Crop Selection Method (CSM) is a technique used to solve crop selection problems, maximize crop net yield rate throughout the growing season, and achieve maximum economic growth. Agricultural Recommendation System is proposed [3], where the system is used for domain knowledge and used to send recommendations to the farmers based on climate conditions and geographic data. The system shows experimental outcomes as a section of implementation of proposed architecture. The farmer types queries to the query engine, in order to get information for a specific crop. Query asked are matched to GIS data, crop knowledge domain or both, the query is transformed into a semantic web query and after performing reasoning and semantic processing, the result is sent to the mobile device of user. In the Recommendation Framework [4], the system suggests a recommendation system using collaborative filtering and SVM for the vast amount of data in the form of ratings, reviews, opinions, complaints, remarks, feedback, and comments about the items such as (product, event, individual, and services). GA is a method of optimization. In this case, the recommendation uses a hybrid filtering technique to hone in on various factors while taking into account reviews produced by various reviewers.

3. Proposed System

It is the goal of query analysis to identify the issues that farmers deal with all year long. For farmers, there is a registration and login page. Since farmers occasionally have the ability to understand local languages, we have included Hindi and Marathi into the user interface, with English serving as the primary language. It will ensure that the interface is easy to use. We require farmers to fill out a profile with basic information such as their name, age, phone number, location, pan card number, and whether or not they own the land they cultivate. This is because many government schemes have eligibility requirements. The crucial portion is this page. Table 1 shows glimpse of user dataset. The aforementioned dataset was obtained from data.gov.in, the Kisan call center. A service offered by government organizations for the benefit of farmers is the Kisan Call Center. Farmers can contact the Kisan call center and have their questions answered in their native tongues. The suggested system was developed using machine learning technologies and methodologies, which include collaborative filtering with a model-based approach using the KNN algorithm, Cosine Similarity, Support Vector Machine, and Brute algorithm implemented in Python. The data frame is rotated as schemeid and userid columns to provide the best possible data interpretation. The values that are null are all zeros.

Table 1 : User Dataset.

User ID	Scheme ID	Rating
2	22	4
2	9	5
2	21	1
3	22	3
3	14	4
3	15	5

Three things have been deduced from the number of schemes, users (farmers), and scheme ratings: Many of the user scheme matrix's values are zeros. Because the data we worked with was sparse, we used the scipy-sparse-matrix module to prevent memory leaks and overflow issues [5].

3. Modelling Recommender System

Ratings are pivoting into scheme features after the data is loaded into a Pandas Data Frame. Recommender systems employ a technique called collaborative filtering. Collaborative filtering is a technique for automatically predicting (filtering) a user's interests by gathering preferences or taste data from numerous users (collaborating). Although these forecasts are user-specific, they are based on data gathered from numerous users. Collaborative filtering use cases typically involve enormous amounts of data. Although there are many variations of collaborative filtering systems, many widely used systems only require two steps [6].

1. Consists of users who rate similarly to the active user.
2. Creates a prediction for the active user based on the ratings from users or groups similar to step 1.

This is included in the user-based collaborative filtering subheading. The Nearest Neighbor Algorithm, which is user-based, is the use case for this.
The collaborative item-based subtype is another The filtering process is item-centric.
1. Create an item-item matrix to ascertain the connections between item pairs.
2. By looking at the matrix and comparing that user's data, it includes the current user's preferences.

Similar methods are used by KNN to classify an object: it looks up its closest neighbors and selects the most well-liked category among them [7][8].

Algorithm:

1. Examine the data that was entered.
2. Choose X for the designated number of neighbors.
3. (a) Determine the difference between the query value and the current value for each value in the data set.
(b) Add up the value's index and distance from an ordered collection.
4. Sort the indexed and distances collection in ascending order according to the distances.
5. From the ordered collection, choose the first X entries.
6. Obtain the labels from collection of the selected X entries.
7. Provide the mode of the X-labels if the classification is correct.

Improvements to the KNN algorithm:

1. To obtain the best outcome, we have selected the best value for k.
2. Rather than utilizing techniques like Euclidean or Manhatten distance, we created our own model based on cosine similarity because we found that it performs better on our data due to higher variance, which leads to higher accuracy and faster classification.
3. The preprocessed, uncorrelated dataset is straightforward [9].

Support Vector Machine is an additional modeling algorithm that was considered for this project (SVM). The supervised machine learning algorithm is being applied to classification problems involving data sets. Classification issues are the primary application for this algorithm. Each data item in this SVM algorithm is plotted as a point in n-dimensional space, and each feature value corresponds to a specific coordinate.

4. Experimental Results

The KNN algorithm produces more accurate results than the Support Vector Machine algorithm, which was used to process the model. The comparison table is shown in Table 2:

Table 2. Comparison Table of Algorithms

Algorithm	Accuracy	Precision
KNN	0.81	0.89
SVM	0.75	0.81

With the "curse-of-dimentionality" plaguing Euclidean distance, we had instead used cosine similarity for nearest neighbor search. The system has been analyzed, and the results are shown graphically in Figure 1.

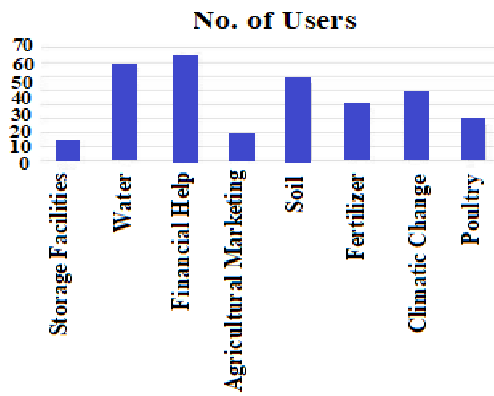

Figure 1. Graphical representation of analysis using cosine similarity

5. Conclusion and Future Work

In this work, the query analysis was completed through the use of support vector machines and the KNN algorithm for collaborative filtering with gradient ascent singular value decomposition. When comparing the outcomes of the implementation of KNN and SVM, it is found that KNN performs more intuitively. The achieved accuracy is almost 89 percent. The goal of future research is to use more sophisticated algorithms and bigger data sets. One-stop shopping for farmers can be facilitated by connecting the same application with other government assistance programs.

References

[1] Understanding Machine Learning: From Theory to Algorithms By: Shai Shalev-Shwartz and Shai BenDavid, 2014.

[2] Rakesh Kumar, M.P. Singh, Prabhat Kumar. Crop Selection Method to Maximize Crop Yield Rate using MachineLearning Technique.ieeexplore.ieee.org/document, 2015.

[3] Vikas Kumar, Vishal Dave, Rahul Bhadauriya, Sanjay Chaudhary : KrishiMantra: Agricultural Recommendation System , Proceedings of the 3rd ACM Symposium on Computing for Development, 2013.

[4] Sung Hwan Min and Ingoo Han : Recommender Systems Using Support Vector Machines, Proceedings of the 5th international conference on Web Engineering, 2005.

[5] Bailey, T. Jain, A.“ A note on distance-weighted kNearest Neighbors rules”, IEEE Trans. Systems, Man, Cybernetics, 8:311-313, 1978.

[6] Breese, J.S., Heckerman, D., and Kadie, C. : Empirical Analysis of Predictive Algorithms for Collaborative Filtering. In: Proceedings of the 14th Conference on Uncertainty in Artificial Intelligence, 1998.

[7] Sadegh Bafandeh Imandoust And Mohammad Bolandraftar :Application of K-Nearest Neighbor (KNN)

Approach for Predicting Economic Events: Theoretical Background ,S B Imandoust et al. Int. Journal of Engineering Research and Applications Vol. 3, Issue 5, pp.605-610, 2013.

[8] Gou, J., Du, L. Zhang, Y. amp; Xiong, T. quot;A New Distance-weighted k-nearest Neighbor Classifierquot;, Journal of Information amp; Computational Science, 9(6): 1429-1436, 2012.
[9] Hellman, M.E., quot; The nearest neighbor classification rule with a reject option quot;, IEEE Trans. Systems, Man, Cybernetics, 3: 179-185, 1970.

Authors Bio-data

Souvik Roy received the B.E. degree in Computer Engineering from the Techno College of Engineering Agartala under the Universityof Tripura, India, in 2023. He was an Intern where he is currently studying the efficiency of Personalized Medicine utilizing machine learning techniques. This research allows me to delve into the intersection of healthcare and advanced data analysis. He is a working as a graphic designer. He is also Familiar with FIGMA, Adobe Suite etc.

Aditya Debnath received the B.E. degree in Computer Engineering from the Techno College of Engineering Agartala under the Universityof Tripura, India, in 2023. He designed a Machine Learning IntegratedWeb App. Build a web app to predict software developer salary to help job seekers make batter decisions, based on location, education and experience using Stack Overflow Developer Survey Data-Set. He used Python Streamlit for app UI integration with ML model. Used Scikit-Learn library for model training.

Soil Moisture and Weather Prediction for An IoT based Smart Irrigation System

Bharat Bhusan[1], Snehasish Roy[2], Santoloke Paul[2]
[1]School of Engineering and Technology, Sharda University, Greater Noida, India
[2]Techno College of Engineering Agartala, Tripura, India, snehas.cse.tcea@gmail.com

Abstract

The cyber and physical worlds are becoming more interconnected thanks to Internet of Things (IoT) solutions that rely on the data acquisition and intelligent processing of application-specific sensors. Smart irrigation systems powered by the Internet of Things (IoT) can aid in optimizing the use of water resources in precision farming landscapes. This paper describes a smart irrigation system based on open-source technology that senses ground parameters such as soil temperature, moisture content, and environmental factors in addition to weather forecast data sourced from the Internet. The proposed system's intelligence is derived from an intelligent algorithm that takes into account both sensed data and parameters from the near-term weather forecast, such as UV, humidity, precipitation, and air temperature.

1. INTRODUCTION

One of the world's most pressing issues these days is water scarcity. In every field, water is essential. Water is also vital to our daily existence. One area where a significant amount of water is needed is agriculture. Water waste is the main issue facing agriculture [1]. Each time the fields are given an excessive amount of water. There are numerous methods for preventing or reducing water waste in agriculture. The system's goals are to detect the water level, manage the system both manually and automatically, and conserve energy and water resources. In comparison to population growth, agriculture has produced low yields due to climatic changes and a lack of precision. The development of intelligent irrigation systems based on dynamic prediction of the field's soil moisture pattern and future precipitation information is imperative for the efficient and optimal use of fresh water during irrigation. In this paper, an intelligent system that forecasts soil moisture using data gathered from field-deployed sensors and online weather forecast information is presented [2]. Using a sensor node that they designed themselves, the field data has been gathered. Information visualization, decision support, and node-side connectivity have all been integrated into the development of the server-side software. An innovative algorithm for predicting soil moisture has been created, and it is based on machine learning techniques that are applied to sensor node data and weather forecast data. The algorithm exhibits reduced error and increased accuracy. The suggested method might assist in choosing irrigation strategies that maximize water use.

2. Literature Review

The system controls the green house's roofing and watering using Arduino technology [3]. For making decisions, it compares statistical data from sensors (such as those measuring moisture, temperature, humidity, and light intensity) with the weather forecast. Sensor noise is reduced by applying the Kalman filter. Temperature, pH, and humidity sensors are used by the Agriculture System (AgriSys) [4] along with hybrid inference to input sensor data. The system keeps track of the sensor data on the PC and LCD. Muhammad [5] (2010) suggested a straightforward solution to the issue of "Automatic irrigation control problem using Artificial Neural Network Controller." When the suggested system is contrasted with an ON/OFF controller, it becomes evident that the ON/OFF controller-based system is severely limited and fails miserably. Conversely, the ANN-based method has made it feasible to apply improved and more effective control. There is no prerequisite for these controllers. understanding of the system and possess innate ANN based systems have a large resource saving potential (energy and water) and is capable of offering all forms of agriculture optimal outcomes. The "Smart Irrigation System Based on Soil Moisture Using Iot" was proposed by S. Nalini Durga (2018). The industry that contributes the most to India's GDP is still agriculture. However, when we look at the technology used in this industry, we discover that not much has changed. Modern technology has advanced greatly, and this has a big impact on a lot of different fields like healthcare and agriculture. In our nation, agriculture is the main industry. India depends mostly on agriculture for its income, so the sector's development is crucial. The majority of irrigation systems are still run manually today. Traditional methods that are currently in use include sprinkler irrigation and drip irrigation, among others. These methods must be coupled with IoT in order for us to utilize water efficiently.

2. PROPOSED SYSTEM

As seen in Fig.1, sensors, a microcontroller, a WiFi module, and an Android application can all be used to automate irrigation. The inexpensive soil moisture sensor keeps an eye on the field all the time. The Arduino board is connected to the sensors [6]. The user receives the sensor data via wireless transmission, enabling him to regulate irrigation [7]. The mobile application can be made to analyze the data it receives and compare it to the temperature, humidity, and moisture threshold values [8]. The choice can be made manually through the application with user interruption, or automatically by the application without user intervention. The motor is turned on when the soil moisture level is less than the threshold value and turned off when the soil moisture level is higher. The Arduino is linked to the sensors. This hardware uses a wifi module for communication, allowing the user to access the data via a mobile device running an Android application that retrieves sensor data from the Arduino via the wifi module. For real-time monitoring, the web service uses a trigger from the user-friendly web interface to control the node. The water pump can be operated remotely in both manual and automatic modes by using this web-based interface. The WiFi module or mobile data communication module can be used in the suggested architecture as a communication medium between the field device and the server. The data in this experiment was sent to the server via a WiFi module [9]. Sending data from the gateway node to the server can be accomplished with a WiFi module or a mobile data communication module.

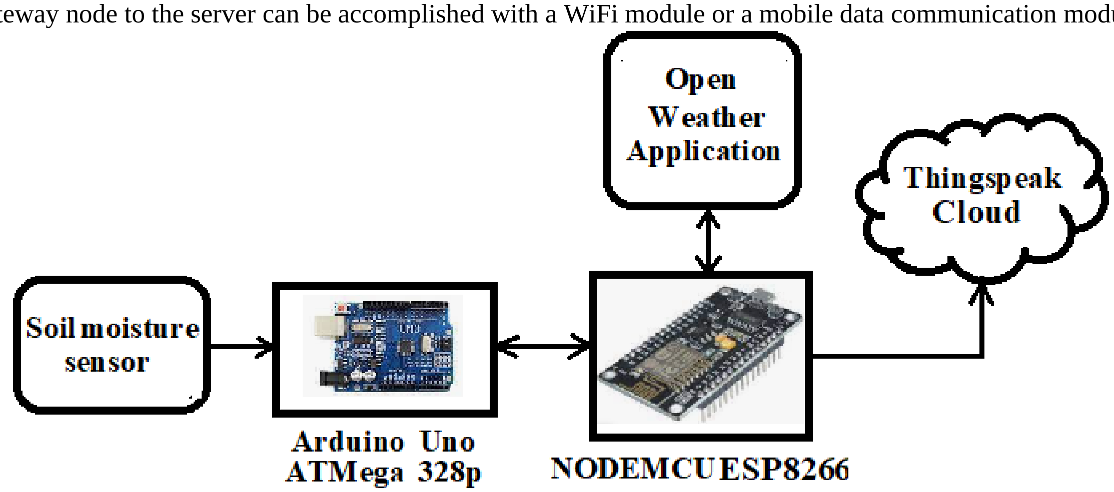

Fig.1 Block diagram of proposed system

3.1. SMART SYSTEM OF IRRIGATION

The primary objective of an automated irrigation system with a WSN and GPRS module is to maximize the amount of water used for agricultural crops [10]. The distributed wireless sensor network (WSN) in this system is made up of temperature and soil moisture sensors. Gateway units are used to manage sensor unit data, send commands to actuators for irrigation control, and transfer data from sensor units to base stations [11]. The primary mechanism of this system consists of connecting the Arduino microcontroller, which is connected to the other electrical components mentioned above as illustrated in Fig. 1, to the soil moisture sensor that was previously embedded in the plant. The sensor measures the moisture content of the soil by sending data and parameters to the microcontroller, which manages the pump. The microcontroller notifies the relay module to run a pump so that a certain volume of water can be given to the plant if the soil moisture content falls below a predetermined threshold [12]. When the water supply is sufficient, the pump shuts off. Using the Internet of Things, the application uses remote monitoring to keep an eye on the entire farm (IoT). The application uses two different kinds of nodes and a sensor network. Nodes employ energy-saving algorithms to conserve energy [13]. Data is collected from nodes to base stations using a tree-based protocol. Two nodes make up the system: one collects all soil and environmental parameter values, and the other is equipped with a camera to take pictures and keep an eye on the crops [14]. Sensor readings in this system are not taken into account when the environment changes. The system user cannot program an application. For application, there is no controlling system.

Table: 1 Test Case Analysis

Soil Condition	Moisture Content	Relay Status	Water Pump Status	Test Case Status
Dry	<1000 >600	ON	ON	TRUE
Moist	<600 >400	OFF	ON	TRUE
Wet	<400	OFF	OFF	TRUE

3. CONCLUSION AND FUTURE SCOPE

This study suggests a hybrid machine learning-based approach and an Internet of Things-based smart irrigation architecture to forecast soil moisture. The suggested algorithm predicts the soil moisture for the next few days using recent sensor data as well as weather forecast data. In terms of accuracy and error rate, the soil moisture prediction is more accurate. Furthermore, a prototype standalone system incorporates the prediction approach. Because the system prototype is built using open standard technologies, it is inexpensive. It is an intelligent system because of the auto mode, and it can be further tailored for situations unique to a given application. We intend to carry out a water-saving analysis in the future using the suggested algorithm with multiple nodes in addition to minimizing cost of the system. Because machine learning needs a large amount of data, our collected meteorological data greatly aids in improving the execution. The area- or region-specific forecast can be carried out to provide more precise farming recommendations of which crop can be grown through data analysis based on the weather and the soil. Camera feeds can be used to further industrialize this paper for examining the plants' or leaves' discoloration and send the findings to control the illness from any place. It is possible to shield the field area from the trespassers by using surveillance and AI.

REFERENCES

[1] G. M. Salim, H. Ismail, N. Debnath, and A. Nadya, "Optimal light power consumption using LDR sensor," in 2015 IEEE International Symposium on Robotics and Intelligent Sensors (IRIS), Oct 2015, pp. 144–148.

[2] N. Putjaika, S. Phusae, A. Chen-Im, P. Phunchongharn and K. Akkarajitsakul, "A control system in an intelligent farming by using arduino technology," 2016 Fifth ICT International Student Paper Conference (ICT-ISPC), Nakhon Pathom, 2016, pp. 53-56.

[3] A. Abdullah, S. A. Enazi and I. Damaj, "AgriSys: A smart and ubiquitous controlled-environment agriculture system," 2016 3rd MEC International Conference on Big Data and Smart City (ICBDSC), Muscat, 2016, pp. 1-6.

[4] A. Gheith, R. Rajamony, P. Bohrer, K. Agarwal, M. Kistler, B. L. W. Eagle, C. A. Hambridge, J. B. Carter, and T. Kaplinger, "Ibmbluemix mobile cloud services, "IBM Journal of Research and Development, vol. 60, no. 2-3, pp. 7:1–7:12, March 2016.

[5] A. Lage and J. C. Correa, "Weather station with cellular communication network," in 2015 XVI Workshop on Information Processing and Control (RPIC), Oct 2015, pp. 1–5

[6] Pandey, V.S., Sharma, D., Shukla, A.K., Tyagi, S., 2017. A low-cost zigbee based temperature and humidity acquisition system for research and industrial applications. In: Dutta, C.R.K.S.D.K. (Ed.), International Conference on Communication Computing and Networking, pp. 379–385.

[7] I. Corporation, "Ibm-blue-mix" [Online] Available: https:// www.ibm.com/cloud- computing/bluemix/

[8] H. Saini, A. Thakur, S. Ahuja, N. Sabharwal, and N.Kumar, "Arduino based automatic wireless weather station with remote graphical application and alerts", in 2016 3rd International Conference on Signal Processing and Integrated Networks (SPIN), Feb 2016, pp. 605–609.

[9]Y. Zhou, Q. Zhou, Q. Kong, and W. Cai, "Wireless temperature amp; humidity monitor and control system," in 2012 2nd International Conference on Consumer Electronics, Communications and Networks (CECNet), pp. 2246–2250.

[10] Jaguey, J.G., Villa-Medina, J.F., Lopez-Guzman, A., Porta-Gandara, M.A., 2015.Smartphone irrigation sensor. IEEE Sens. J. 15, 5122– 5127.https://doi.org/10.1109/JSEN. 2015.2435516.

[11] Mean Squared Error [WWW Document], 2018. Tutor vista (accessed 8.29.18). https://math.tutorvista.com/statistics/ meansquared-error.html.

[12] M.H. Asghar, A.Negi, and N. Mohammadzadeh, “Principle application and vision in internet of things (IoT),” in International Conference on Computing, Communication Automation, May 2015, pp. 427–431.
[13] Roopaei, M., Rad, P., Choo, K.R., Choo, R., 2017. Cloud of things in smart agriculture: intelligent irrigation monitoring by thermal imaging. IEEE Cloud Comput. 4, 10–15.
[14] Viani, F., Bertolli, M., Salucci, M., Polo, A., 2017. Low-cost wireless monitoring and decision support for water saving in agriculture. IEEE Sens. J. 17, 4299–4309.https://doi.org/ 10.1109/JSEN.2017.2705043.

Authors Bio-data

Snehasish Debnath received the B.E. degree in Computer Engineering from the Techno College of Engineering Agartala under the Universityof Tripura, India, in 2023. He developed a system that enabled remote control and automation of lights, fans, and appliances via the internet, enhancing convenience and energy efficiency. He harnessed AWS, specifically employing EC2 instances, to optimize processing and facilitate effective communication within the system. He implemented projects like Heart Disease Prediction using Machine Learning and Super Image Resolution using Convulation Network.

Santoloke Paul received the B.E. degree in Computer Engineering from the Techno College of Engineering Agartala under the Universityof Tripura, India, in 2023. He completed internship with Celebal Technology. Worked on Data Science.He completed internship with MIT Square. Worked on Data Technology (DataTech). He is proficient in MS Excel, Word, PowerPoint and Outlook. He is also proficient in LaTeX. He a project on “Web Development” under a group where we have created and deployed a website comsic.in.

Dr. Bharat Bhushan is an Assistant Professor of Department of Computer Science and Engineering (CSE) at School of Engineering and Technology, Sharda University, Greater Noida, India. He received his Undergraduate Degree (B-Tech in Computer Science and Engineering) with Distinction in 2012, received his Postgraduate Degree (M-Tech in Information Security) with Distinction in 2015 and Doctorate Degree (PhD Computer Science and Engineering) in 2021 from Birla Institute of Technology, Mesra, India. In the year 2021 and 2022, Stanford University (USA) listed Dr. Bharat Bhushan in the top 2% scientists list.