Design of Smart Systems
BCT4004

Fastrack Semester
Slot: B1+B2

Under the guidance of
Mr. Manoov R

Farming Assistance using Machine Learning & Internet of Things

Link: Video Description

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Abstract

Agriculture, which is the foundation of many nations, is the economic backbone of the developing globe. For the best result, choosing to plant the right crop in a particular location is crucial. It is a problem that most farmers and other agricultural activists suggest crops using subpar, proven scientific methodologies. Our suggested effort will help farmers select the best crop based on factors like cost of cultivation, cost of production, and yield in order to increase productivity and profit from the suggested technique. In this project, we have tried to provide an IoT based crop recommendation system. To recommend the best crop, the user has to input parameters to get the details. A dataset comprising 6 different parameters such as Nitrogen, Phosphorus, Potassium content, temperature and humid conditions required to grow certain crops. It included the details of 21 different crops with suitable conditions. Since, the dataset comprises both input parameters along with their output (the type of crop), it turned into a classification problem that used a supervised machine learning algorithm. The algorithm chosen to compute the distance was KNN. The outcome of our project is a website that recommends the perfect crop when someone inputs the details of their soil using a machine learning model.

1. Introduction Section

1.1 Background of the problem

The developing world's economies are based on agriculture, which is the backbone of many nations. Making the choice to plant an appropriate crop in a certain place is essential for producing the highest output. The fact that farmers and other agricultural activists generally use inferior, scientifically validated methods for crop recommendation is an issue. Thus, to boost productivity and profit from the suggested technique, our proposed effort will assist farmers in choosing the appropriate crop based on parameters like cost of cultivation, cost of production, and yield.

1.2 Motivation of the proposed work

Agriculture is an important factor of the economy in India. In recent years due to industrialization; excessive use of pesticides the strength of soil is getting affected. Many of the methods followed by agriculture are not sufficient to increase productivity. The common difficulty present among the Indian farmers is they don’t have any information regarding the right crop based on their soil requirements so it affects the productivity.

Indian farmers face a lot of challenges in making decisions about which farming technique to opt for and which crop should be selected for which climate. The common problem exists among Indian farmers that they don’t choose proper crops so as to obtain max yield which are based on topographic features and financial aspects. In the agriculture sector, achieving max crop yield at min cost is the goal of production. In order to boost productivity and profit from the suggested technique, our suggested effort will assist farmers in choosing the ideal crop based on elements like cost of cultivation, cost of production, and yield.

1.3 Focus of the proposed work

India practices routine methods of farming. We can employ IoT devices and wireless sensor networks to automate and monitor farm operations. The IoT system's mobile app allows farmers to get updated agricultural conditions via a smartphone. The major goal of this activity will be to choose a crop that is appropriate for the given field.

1.4 Proposed work contribution

The proposed approach improves upon the current system by adding fresh methods to the work schedule that was already in place. Node MCU, a soil moisture sensor, temperature and humidity sensors, a pH sensor, a current amplifier, and Mail make up the hardware. For data collection, the sensors are inserted into various locations in the field. They examine many factors such soil alkalinity, temperature, humidity, and moisture content. The sensor data is kept in a database, then uploaded to a web app where the crop is forecasted using the KNN algorithm. The predicted crop, or the outcome, is then mailed to the farmer.

2. Literature Survey / Related work

1. **Title:** IoT based Classification Techniques for Soil Content Analysis and Crop Yield Prediction

Authors: R. Reshma; V. Sathiyavathi; T. Sindhu; K. Selvakumar; L. SaiRamesh

Citation: Proceedings of the Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC) IEEE Xplore Part Number:CFP20OSV-ART; ISBN: 978-1-7281-5464-0

Methodology: Soil type, groundwater level, local population, daily and seasonal needs of the locals, farmer labour available, range of the same plantation, and range of farming land in the area are all factors considered in the proposed system. Data mining techniques are used to predict crop yield by classifying soil into low, medium, and high categories using available datasets.An analysis was performed based on these parameters to determine which crops can be grown in the given soil type.

Limitations of the existing work: This endeavor can be strengthened by employing fuzzy or intelligent techniques, which are not used in the current study, to forecast the soil for cultivation of future crops.

Result and Inference: The goal of the research was to use classification techniques to anticipate the kind of soil and the best crop for the soil. The accuracy number is used to determine the most appropriate classification strategy among the Support Vector Machine and Decision Tree methods.

2. **Title:** Impact of Machine Learning Techniques in Precision Agriculture **Authors:** Rahul Katarya, Ashutosh Raturi, Abhinav Mehndiratta, Abhinav Thapper

Citation: 3rd International Conference on Emerging Technologies in Computer Engineering: Machine Learning and Internet of Things (ICETCE- 2020), 07-08 February 2020, (IEEE Conference Record # 48199)

Methodology: The frameworks discussed in the paper are focused on crop recommendation systems, a subset of precision agriculture that uses various machine learning algorithms to recommend crops based on certain rules and data. The type and quantity of data fed determine the accuracy of the recommendation. Because of the statistical nature of these algorithms, yield can be significantly increased. A high accuracy measure is desired because the consequences of not having one are enormous, including the waste of seeds, time, and a significant loss in productivity, among other things. Temperature, soil properties, humidity, and other factors can all be considered when making recommendations.

Limitations of the existing work : Because soil properties and nutrients are the most important factors in crop recommendation, they deserve special attention. To make this technology more accessible to farmers and, as a result, lead to more profitable yields, a web/mobile application with an easy-to-use interface is desired.

Result and Inference: This paper discusses KNN, Similarity-based Models, Ensemble-based Models, Neural Networks, and other procedures. These algorithms take a variety of external factors into account, such as meteorological data, temperature, and others like soil profile and texture, to provide the best recommendations that not only result in higher yields but also in the most efficient use of resources and capital.

3. **Title:** Fuzzy Decision Support System for Recommendation of Crop Cultivation based on Soil Type

Authors: A.M.Rajeswari, A.Selva Anushiya, K.Seyad Ali Fathima, S.Shanmuga Priya, N. Mathumithaa5

Citation: Proceedings of the Fourth International Conference on Trends in Electronics and Informatics (ICOEI 2020) IEEE Xplore Part Number: CFP20J32-ART; ISBN: 978-1-7281-5518-0

Methodology: The fuzzy-based rough set approach proposed here is used to help farmers make crop selection decisions on their agricultural land. The method proposed has been tested on 24 different crops. The PH, soil type, and location are the most important factors in determining the crop for the region. The proposed method employs Fuzzy Logic to handle border conditions while partitioning numerical attributes. Rough set-based rule induction is used to develop the fuzzy rules. For the MF with three and five linguistic terms, the proposed method is used.

Limitations of the existing work : There was no implementation of an Android application to assist young and inexperienced farmers in raising awareness about their soil type, soil health, and crop suitable for their land.

Result and Inference: In terms of prediction accuracy, the experimental results show that the LEM2 algorithm's fuzzy rules outperform other algorithms for both discretized and fuzzified datasets.

4. **Title:** Feature-Based Analytical Crop Recommendation System

Authors: Manas Oswal; Karan Mahajan; Shubham Pagare; Vishal Kasa; Jyoti Malhotra;

Sambhaji Sarode

Citation: 2021 IEEE Pune Section International Conference (PuneCon) MIT ADT University, Pune, India. Dec 16-19, 2021

Methodology: They proposed a system for storing the optimal values of selected features for a variety of plants in this paper. For the purposes of this manuscript, they chose five features: temperature (min and max), rainfall (min and max), soil types, soil pH (min and max), and previous crop. When a user invokes the system, it traverses the entire dataset, calculates the score for each plant, and then recommends the plant with the highest score. Each feature contributes to the overall score of a plant.

Limitations of the existing work : To incorporate weather forecasts, the system must be integrated with third-party weather APIs. When compared to ML models, the accuracy of the suggestion was not implemented.

ResultandInference:
Amathematicalapproachbasedonfuzzylogicmembershipfunctionsis used by the system. In contrast to a machine learning-based approach. A mathematical approach based on fuzzy logic membership functions is used by the system.

5. **Title–** Crop Selection using IoT and Machine Learning

Authors– Sujaya S Nair , Christy Lueis , Vysakh Balachandran, Krishnaveni

Introduction : The system in this paper consisting of hardware and software components will help the farmers to select the best crop which is suitable for their land and soil type. Machine learning and IoT can contribute a lot in the agricultural sector. Use of sensors like DHT11, soil ph sensor will retrieve the temperature, humidity and ph values from the land. using a wi-fi module we can send out fetched data to a machine learning model. Using the values, the machine learning model will retrieve some crops which are suitable to the agricultural land and provided to the farmers using a web application.

Methodology : We established IoT sensors in farms to monitor the farm environment; the sensor equipment can help detect temperature, humidity, pH value of the soil. The data of our IoT sensors are transmitted to the server. Data from all sensors can be exported from the database to undergo data analysis. Our system does analyze the environmental factors of the farm and selects the suitable crops. Before analyzing any data,our system performs feature extraction like suitable months, soil types to ensure that both the analyzed data and the analysis result of predetermined targets are accurate. Our proposed approach and goals can effectively increase crop production and help analyze cultivation techniques of farmers.

Result and Inference : Since the plant that was recommended grew incredibly and the other one that was not recommended was not grown successfully, we could formulate to the conclusion that our system was successful in suggesting the right crop for the right climatic conditions. Therefore, our system could be used for a larger farm which could yield very good crops and the farmers could earn more profit from his/her farmland. Agriculture is gradually being replaced and enhanced by more sophisticated and accurate digital and electronic devices.

6. **Title:**Smart Agriculture System using IoT Technology

Authors:

Adithya Vadapalli1, Swapna Peravali2& Venkata Rao Dadi

Citation:

Adithya Vadapalli1, Swapna Peravali2& Venkata Rao Dadi. "Smart Agriculture System using IoT Technology" *International Journal of Advance Research in Science and Engineering*.

Introduction and Methodology: As conventional cultivating is more work intensive, risky and coming about to self-destructive due low yield or act of god. Little ranchers uninformed about the savvy agribusiness framework hotshots and corporate local area are partaking in the benefits of shrewd agriculture technology. Because of Pandemic Covid-19 which returned the migrants back to their individual towns and having no type of revenue are joyfully willing to come back to their unique horticulture cultivating as their occupation. As of now when the Smart Irrigation System is an IoT based gadget which is fit for mechanizing the water system process by breaking down the dampness of soil and the environment condition (like pouring) can be consolidated by little players in cultivating and appreciate high return benefit procuring. IOT headway assists in agrarian cultural data on conditions with enjoying environment, temperature, and efficiency of soil, reap web watching draws in area of weed, level of water, bug affirmation, creature obstruction into the field, change improvement, development. The ranchers can know get subtleties of ranch conditions with the assistance of far-off sensor outline work and WSN (Wireless Sensor Networking) frameworks sitting at home or some other spot.

Limitations of the existing work: Complex proceedings for a small-time farmer with the new era of technology.Unavailability of a solid network basis for the foundation of such high-level inter-connectivity.No particular or standard user-friendly interfaces have been discussed.

Result and Inference: The accessibility of sensors for the horticultural boundaries and microcontrollers can be effectively connected with one another and with the assistance of Internet of Things, remote sensor networks correspondence the difficulties experienced by the ranchers can likewise be diminished and a superior correspondence way for the exchange of valuable information can be accomplished between different hubs. In this way, ranchers can handle different gear's connected with rural and screen their yield on Smartphone or on PCs.

7. Title: Smart Farming using IoT, a solution for optimally monitoring farming conditions
Authors: Jash Doshi, Tirthkumar Patel, Santosh kumar Bharti

Citation: Jash Doshi, Tirthkumar Patel, Santosh kumar Bharti. " Smart Farming using IoT, a solution for optimally monitoring farming conditions" Elsevier Publications.

Introduction and Methodology: This gadget screens the ranch or nursery and in view of the readings of various sort of sensors like temperature, stickiness, soil dampness, UV, IR, soil supplements and gives various kinds of messages to the rancher about the current circumstances so the rancher can make a fast move. The fast moves made by the ranchers will assist them with expanding the efficiency in their cultivating and appropriate utilization of normal assets will be finished, which will make our item climate amicable moreover. Our item will expand the amount and nature of the harvests by appropriately checking the different current circumstances. It is an IoT gadget with the idea of "Fitting and Sense". Live information for various boundaries should be visible on Laptop and Smart Phones.

Limitations of the existing work: A lot of complexity is present in the architecture of this system and there is no working model that is suggested to monitor the health of the crop at intervals. Also, the cost of building even building the prototype of such a model is very expensive and time taking at large scale.

Result and Inference: Individuals are as yet chipping away at various Smart Farming innovation utilizing IoT, so the expected advantages of this innovation are, Remote checking for ranchers, water and other regular asset preservation, great administration additionally permits further developed domesticated animals cultivating, the things which are not apparent to necked eye should be visible coming about is precise farmland and harvest assessment, great quality as well as further developed amount, the office to get the ongoing information for valuable bits of knowledge.

8. **Title -** Intelligent Crop Recommendation System using Machine Learning

Authors– P. A, S. Chakraborty, A. Kumar and O. R. Pooniwala

Introduction : The aim of this paper was to assist the farmers in crop selection by considering all the factors like sowing season, soil, and geographical location using machine learning and neural networks.

Methodology : Several datasets were taken from kaggle and government websites and fed into the model. The dataset comprised of several parameters such as cost of cultivation of crops, yield, types of crops grown and rainfall and temperature dataset. These datasets were sent for preprocessing and then trained through machine learning algorithms such as linear regression and also fed into a neural network.

Result and Inference : The model recommended which crop was the best match using K-Nearest Neighbor classifier and also predicted the sustainability with up to 89% accuracy using neural networks. However, no real hardware implementation was present or even simulation for automated irrigation for a completely revolutionized agriculture system.

9. Title: Impact of Internet of Things (IoT) in Smart Agriculture **Authors:** O. Vishali Priya, Dr.R. Sudha

Citation: O. Vishali Priya ,1, Dr.R. Sudha. " Impact of Internet of Things (IoT) in Smart Agriculture " *IOS Press.*

Introduction and Methodology: This hypothesis of this paper originates from progressions including the Internet of Things, Big Data, and Distributed computing, among others, which have brought about the idea of astuteness. Cultivating IoT is an organization of screens, cameras,

and PCs that can all capability together to assist a rancher with playing out his work all the more successfully. This PC would be independent so they will actually want to associate with each other without the requirement for human intercession. To put it another way, the contraptions are pre-modified with the information on the second and the thought processes in speaking with different instruments in the plan.

Smart farming is an expansive term that alludes to horticultural and food creation rehearses that utilize IoT, enormous information, and progressed examination. The Internet of Things alludes to the incorporation of detecting, computerization, and investigation innovation into present farming cycles. The most well-known IoT applications in smart horticulture are as follows: Sensor-based frameworks , shrewd farming vehicles incorporate robots, independent robots, and actuators, associated farming settings incorporate shrewd nurseries and aquaculture and information examination, representation, and the executives' frameworks.

Limitations of the existing work: This paper only discuss about the overview/ architecture of the smart crop system that can be developed by smart farming activities. There is no mention of a dedicated device or method to overcome problems faced by farmers/cultivators using IoT.

Result and Inference : Brilliant farming techniques are required for the betterment of the agriculture sector. The Internet of Things would aid the advancement of savvy farming. IoT is utilized in different farming areas to further develop time productivity, water preservation, crop checking, soil the board, bug splash and pesticide wellbeing, etc. It additionally kills human work, dismantles rural strategies, and makes a distinction in brilliant cultivating execution. Farming is a calling that has depended on conventional practices and encounters up to presently. Nonetheless, the progression of time has impacted provincial customs, and they have begun to adjust to the progression of progress. The use of the Internet of Things (IoT) in farming would build yields and assist control with all developing activities. Farming unquestionable requirement go through huge upgrades since a significant part of the populace depends on it for endurance.

10. Title: Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides.

Authors: Tanha Talaviya, Dhara Shah, Nivedita Patel, Hiteshri Yagnik, Manan Shah

Citation: Tanha Talaviya, Dhara Shah, Nivedita Patel, Hiteshri Yagnik, Manan Shah. " Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides." *Keai Publications.*

Introduction and Methodology: The paper talks about using AI in the field of Agriculture sector, and the upcoming technologies that can help to bring revolution to the respective field. Various new technical ideas including Image recognition and perception, chatbots for farmers, and electrically affiliated irrigation methods including dielectric and neutron moderation are mentioned in the paper. Also, there has been mention of chemical-based methods to tackle

weeding. Use of UAV vehicles like drones can also be an effective solution in this aspect. Advance based crop monitoring and data analytics can also act as cherry on the top of the smart agriculture system.

Limitations of the existing work: This paper lacks practical demonstration of any of the ideas discussed above. There is mention of many technologies although there has not been any hardware or on groundwork done in the development phase of any of these ideas.

Result and Inference: The farming business faces various difficulties, for example, absence of powerful water system frameworks, weeds, issues with plant checking because of yield level and outrageous atmospheric conditions. In any case, the exhibition can be expanded with the guide of innovation and consequently these issues can be addressed. It tends to be improved with various AI driven methods like re-bit sensors for soil dampness content identification and computerized irrigation with the assistance of GPS. The issue looked by ranchers was that accuracy weeding strategies beat the enormous measure of harvests being lost during the weeding system. Not in the least do these independent robots further develop productivity, they additionally diminish the requirement for pointless pesticides and herbicides.

11. Title: Artificial Intelligence in Agriculture: An Emerging Era of Research **Authors:** Paras M. Khandelwal and Himanshu Chavhan

Citation: Paras M. Khandelwal and Himanshu Chavhan. Artificial Intelligence in Agriculture: An Emerging Era of Research" *ResearchGate Publications.*

Introduction and Methodology: In horticulture there is a speedy transformation to AI in its different cultivating procedures. The idea of mental registering is the one which mirrors human point of view as a model in PC. This outcome as fierce innovation in AI fuelled farming, delivering its administration in deciphering, gaining, and responding to various circumstances (in view of the learning procured) to improve effectiveness. Furthermore, some of the interesting ideas that are discussed in the paper includes, Image-related insight generation, Disease detection in crops, Field management, identification of optimal mix for agronomic products, Automation techniques that are used in irrigation, use of drones and other UAV vehicles. Also, one important and unique concept discussed in the paper included Precision farming that was related to working on high resolution images and using ML and AI to predict proxy information. Yield Management is also discussed in this paper where satellites are used for crop arrangement and organization.

Limitations of the existing work: The idea discussed here are great although they are very expensive to implement and require huge capital investments. The ideas discussed here are also not connected to the ground or the root level, thus the ideas discussed in this paper are not suitable for small farmers.

Result and Inference : All in all, the fate of cultivating in the times to come is to a great extent dependent on adjusting mental and physical arrangements. However, an immense exploration is still on, and numerous applications are now accessible, the cultivating business is as yet not having adequate help, stays to be underserved. While it descends in managing practical difficulties and requests looked by the ranchers, involving AI dynamic frameworks and prescient arrangements in tackling them, cultivating with AI is just in an early stage. To take advantage of the huge extent of AI in horticulture, applications ought to be more vigorous. The ideas discussed here are full of potential and with time and furthermore advancement in this new technology these ideas can bring revolution in the agricultural sector.

12. **Title:** Knowledge Discovery Through the Machine Learning of Farming Parameters and Yield Performance

Author: Y. T. Chong , P. K. Loo , Z.Q. Ding

Citation: Y. T. Chong, P. K. Loo and Z. Q. Ding, "Knowledge Discovery Through the Machine Learning of Farming Parameters and Yield Performance," 2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), 2019, pp. 1550-1552, doi: 10.1109/IEEM44572.2019.8978814.

Methodology: The arrangement of the farming operations, such as a fish holding tank or a rack for growing crops. The characteristics that are known to be crucial to the yield of the farming activity are being measured and tracked by sensors. Computer vision is used, for instance with a camera mounted over the subjects, to monitor and track the produce of the farming activity. The inputs for knowledge discovery using machine learning may also include additional data that may be connected to the yield depending on prior knowledge. A food production corporation may set up the knowledge discovery system suggested in the paper in the case when it wishes to learn or discover a set of ideal environmental factors for a specific fish or vegetable type that it may use to boost the yield rate. He will specifically continue to grow the specific fish or veggie while gathering sensor and vision data for a long. The farming company may alter the parameter values during the data gathering period in an effort to increase yield. After the designated time has passed, the collected data may be delivered in batches for knowledge discovery. However, employing the proper learning algorithms, such as an artificial immune learning system, online or dynamic learning is feasible.

Limitations of the existing work: Singapore wants to boost its food security by increasing food production. Over the next ten years, it is now intended to triple its capacity for food production. The city-state aims to meet 30 percent of its nutritional demands by 2030, often known as the "30-by-30 vision." 10% is created at the moment. This project aimed to increase the local food production's yield in this situation.

Result and Inference: Farmers might subsequently be able to set up a similar system to computationally understand the growing characteristics of specific crops in relation to different environmental parameters based on the results. This will be especially helpful for farming businesses that are just starting out or for established businesses working with novel crops.

13. Title : ADAPTING WEATHER CONDITIONS BASED IOT ENABLED SMART IRRIGATION TECHNIQUES IN PRECISION AGRICULTURE MECHANISMS

Authors: Keswani, Bright, Ambarish G. Mohapatra, Amarjeet Mohanty, Ashish Khanna, Joel JPC Rodrigues, Deepak Gupta, and Victor Hugo C. de Albuquerque

Citation: Keswani, Bright, Ambarish G. Mohapatra, Amarjeet Mohanty, Ashish Khanna, Joel JPC Rodrigues, Deepak Gupta, and Victor Hugo C. de Albuquerque. "Adapting weather conditions based IoT enabled smart irrigation techniques in precision agriculture mechanisms." *Neural Computing and Applications* 31, no. 1 (2019): 277-292.

Introduction: In this paper, they proposed a holistic smart agriculture application that consists of various agricultural sensors, drones, and IoT hardware and software utilities. Several sensors can gather specific cornfield data and send it to the coordinator node which is capable of communicating with a drone. The drone flies over the large-scale cornfields at certain times of the day and collects the data from coordinator nodes. It delivers the cornfield data to the gateway as a relay node. The farmers monitor the data on graphical monitoring interfaces with the help of IoT software

Methodology: The system uses heterogeneous sensor nodes which are capable of sensing acoustic, rain, wind, light, temperature, and pH levels of the cornfields for smart agriculture applications. The specific properties of the cornfields are gathered with special-purpose sensors at coordinator nodes, and then the coordinator node sends the data to the Drone as a relay node. It is sufficient for the sensor nodes to detect conditions at specific times of the day because the data in the cornfields do not change rapidly. The Drone provides data to the base stations for monitoring on farmers' visual devices. Therefore, the necessity for long-distance communication between sensors on a region of large-scale cornfield is eliminated.

Limitations of the existing work: This paper only discusses corn fields. It fails to work for other crops.

Result and Inference : In this Drone assisted data gathering process is also developed for large-scale cornfields. CSMA/CA-based wireless network is proposed for each acre of a cornfield

14. **Title:** Smart Irrigation system using Internet of Things.

Authors: Leh, Nor Adni Mat, Muhammad Syazwan Ariffuddin Mohd Kamaldin, Zuraida

Muhammad, and Nur Atharah Kamarzaman.

Citation: Leh, Nor Adni Mat, Muhammad Syazwan Ariffuddin Mohd Kamaldin, Zuraida Muhammad, and Nur Atharah Kamarzaman. "Smart irrigation system using internet of things." In *2019 IEEE 9th International Conference on System Engineering and Technology (ICSET)*, pp. 96-101. IEEE, 2019.

Introduction: This paper mainly focuses on the irrigation part where the field is monitored from time to time and based on the environmental conditions like humidity, Temperature, Soil moisture, etc the device is programmed for watering the fields.

Methodology: The data is first collected from the different sensors here Sensors like Moisture level of soil, Temperature of the area, air moisture, and Water Level are used. They are attached to a breadboard which is internally connected to the Arduino Board. The data from the board is sent to the Arduino IDE. The programming language that is used runs instructions that extract the data and reflect it. If the data is not valid then the process ends

Limitations of the existing work: Data was not stored permanently for further use. Should consider the cost-effective prediction of soil moisture using the recorded data. The system should be further customized for application categorical scenarios. The system should minimize the cost by conducting a water-saving analysis based on the proposed algorithm with multiple nodes.

Result and Inference : Notification for users for necessary actions. Shrewd water system with brilliant control around the right choice depends on continuous field information. Ease to use the system, even common people can know how to use these techniques to improve productivity with adequate resources.

15. **Title:** An IoT-Based Smart Irrigation System **Authors:** Rawal, Srishti.

Citation: Rawal, Srishti. "IoT-based smart irrigation system." *International Journal of Computer Applications* 159, no. 8 (2017): 7-11.

Introduction & Methodology: This paper mainly revolts around the automation aspect of the project as much as it can be controlled manually. In this paper, three different types of sensors have been implemented for measuring three different parameters simultaneously. The data is then sent to the system hub which consists of Arduino and Node MCU. A display is also installed for viewing the output figures on the spot. Node MCU transports the data to the digital platform of the server for processing the data. The n those data are sent to the mobile application of the user. The user then can perform manual tasks or can choose not to as Arduino will be executing the

required commands if the parameter levels fall below the threshold values. Another motor of the system is used for pesticides After a certain amount of time or at a specific time interval this motor is switched on to provide the legitimate volume of substance then switches off by itself.

Limitations of the existing work: The pricing that came within the compass was a bit overpriced.It can’t find out the health of crops which can be done using image processing. It takes some time trial-time time data to the mobile application.

Result and Inference: Through this project, we can easily find out the readings like pH level of the soil, moisture of the soil, and temperature. It automatically turns the motor on and turns off when the field meets the necessary water requirement. We can see real-time data through the cloud and assess the condition of our farm.

3. Proposed Methodology (Framework)

3.1 Novelty

Our idea is based on gathering the values through a DHT sensor, and then utilizing these values, to get finer results. Note that our project is unique in 3 ways, they are:

1. Instead of using an external microprocessor like Arduino, we have directly used ESP8266 - a wifi chip to perform the aggregation of data, thus reducing the cost of hardware.
2. Note that not only have we collected the data and put it up on the cloud, but also we have performed data visualization on the cloud.
3. In the phase-2 of the project, we have performed data analytics to describe the best crop that a farmer can grow based on the environmental conditions of the farm.

3.2 Method and approaches

The project focuses on the following methods and approaches:

1. Data for a set of crops is collected using sensors.
2. The DHT11 sensor is placed in the soil and left to detect the values of temperature and humidity.
3. The sensor is connected to the Node MCU to give the output values of the sensor to it.
4. Then we interface NodeMCU and send the values to it.
5. Then using the API keys of the chosen cloud platform, we send the temperature and humidity values to the cloud for NodeMCU.
6. The data is then analyzed using Machine Learning algorithms.
7. The best crop is suggested for the type of soil input into the model.
8. A website is then built around this crop recommendation system so as to make it easy for farmers to use it.

3.3 Metrics and measurements

The crop would be suggested based on the following characteristics of the soil:

1. Nitrogen content

2. Phosphorus content

3. Potassium content

4. Temperature 5. Humid

5. pH

6. Rainfall

3.4 Data Analysis methods

The highest accuracy producing Machine Learning algorithm will be trained on the data set generated from the sensors which will be then used to generate crop recommendations for the type of soil the farmer inputs into the model.

DESIGN OF THE PROPOSED IDEA:

Tasks:

1. Pranav DS (19BCT0135) - Research related to hardware, suitable microcontroller and sensors required.
   Designing the connections required for hardware's functionality.
   Resources used are various blogs and research papers.

2. Parth Maheshwari (19BCT0221) - Research related to cloud, visualization of data, connecting the hardware to cloud.
   Use of arduino to code the functionality of the components.
   Resources used are various Arduino blogs for coding and Thingspeak forums.

3. Muzzammil Hussain (19BCT0162) - Research related to prediction model to be used, creating GUI interface. Use of python programs to create a GUI interface and use of KNN algorithms to predict.

Resources used are various youtube for processing data and blogs to create simple GUI.

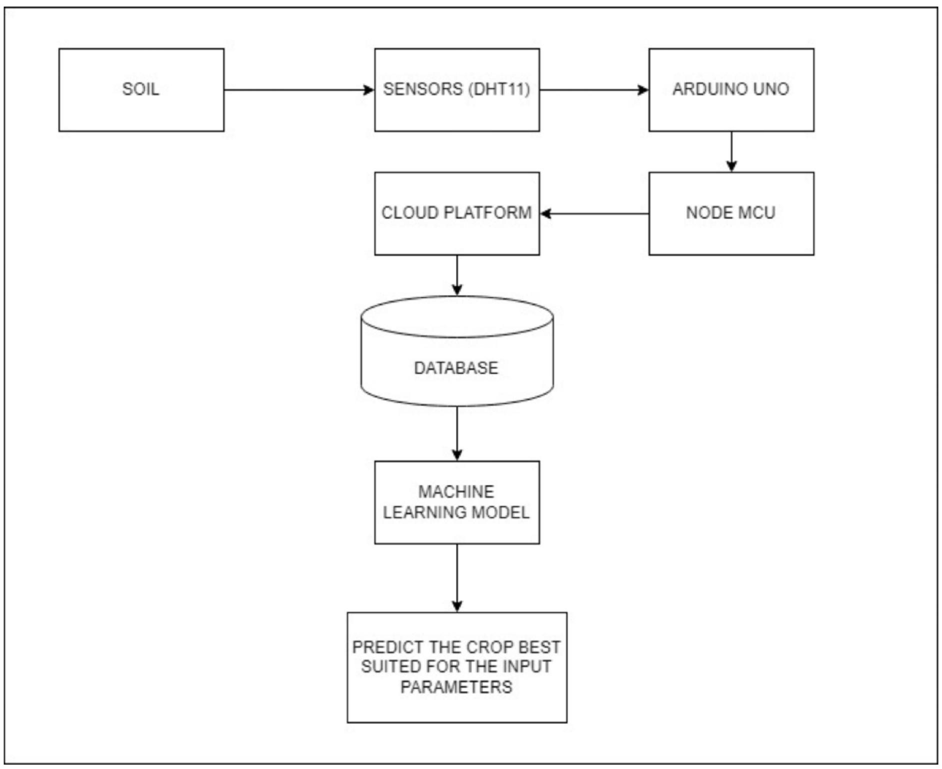
Hardware Components required:

1. DHT 11

2. Node MCU

3. Connecting wires

4.1 Architecture Diagram



4.2 Algorithms of the proposed work

Crop Recommendation using Machine Learning

To recommend the best crop, the user had to input parameters to get the details.

A dataset comprising 6 different parameters such as Nitrogen, Phosphorus, Potassium content, temperature and humid conditions required to grow certain crops. It included the details of 21 different crops with suitable conditions

Since, the dataset comprises both input parameters along with their output (the type of crop), it turned into a classification problem that used a supervised machine learning algorithm. The algorithm chosen to compute the distance was KNN.

KNN stands for K-Nearest Neighbor. In this supervised learning algorithm, which is used for classification, we classify based on how it's neighbors are classified. It stores all it’s previous cases and classifies new ones based on how similar it is to the previous cases. Here, K signifies the amount of neighbors we take for comparing the distance. The distance used here is Euclidean Distance.

4.3 Description of the proposed work

The given steps were performed to get the recommendation system model

1. Data mining and finding the right dataset

2. Importing the necessary libraries

3. Performing some preprocessing techniques like label encoding, replacing missing numbers etc.

4. Splitting into X and Y data

5. Splitting the data into 70% training set and 30% testing set.

6. Performing KNN algorithm by choosing the right values of K. The value of K chosen here was 3.

7. Finding the performance metric of the model to calculate the accuracy and see how well the model performed.

Once the model was built, the user had to give the 7 input parameters.

The model calculated the three closest neighbors for the given parameters and recommended the best crop suited.

Hardware Implementation:

To monitor our crops, hardware was implemented.

Procedure:

- The DHT11 sensor is place in the soil and left to detect the values of temperature and humidity.
- The sensor is connected to the Node MCU to give the output values of the sensor to it.
- Then we interface NodeMCU and send the values to it.
- Then using the API keys of the chosen cloud platform, we send the temperature and
humidity values to the cloud for NodeMCU.

For NodeMCU:

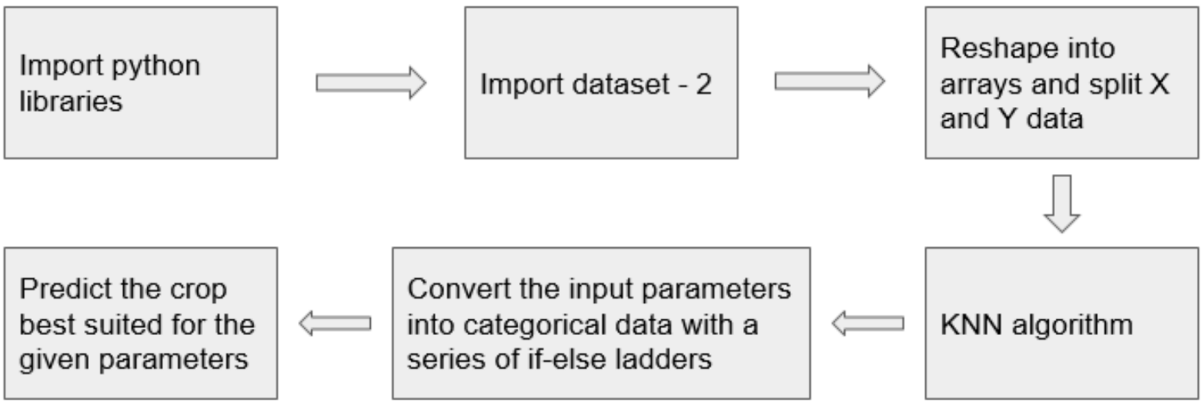
1. Import required libraries
2. Setup or initialize port used
3. Begin serial communication and receive values from DHT11. Convert the values to de-json format.
4. Initialize the cloud platform to be used.
5. Input WIFI SSID and Password.
6. Import values to the cloud.

4.4 Algorithm improvement & Justification of the proposed methodology

In KNN algorithm, the distance measurement is the only factor that influences the algorithm's forecast. For applications with access to adequate area information, this method's KNN calculation makes sense. The choice of a suitable course of action is supported by this data. The basis for KNN calculation is the lazy learning strategy. Even though this method raises computing costs, KNN is still the better choice for applications where accuracy is crucial but forecasts are not frequently discussed.

KNN is appropriate for data with fewer dimensions. It is really simple to understand and put into action. Due to its extremely near results, the KNN calculation can compete with the most reliable models. You can also use the KNN calculation for applications that need high precision but don't require a defined model. The nature of the expectations is influenced by the dimensions and distance.

It is to be noted that the method is dimensionality-cursed and is especially vulnerable to noisy inputs, outliers, missing data, and outlier identification. In order to optimize the KNN method, a pre-processing layer must be added before the final data is classified.



5. Simulations (Experiments)

5.1 Evaluation Criteria

Parameters used -

The crop would be suggested based on the following characteristics of the soil: 1. Nitrogen content

2. Phosphorus content

3. Potassium content

4. Temperature 5. Humid

5. pH

6. Rainfall

Performance metrics used -

- Accuracy
- Precision
- Recall
- F1 score

Sample data set :

	NITROGEN	PHOSPHORUS	POTASSIUM	TEMPERATURE	HUMIDITY	PH	RAINFALL	CROP
0	90	42	43	20.879744	82.002744	6.502985	202.935536	rice
1	85	58	41	21.770462	80.319644	7.038096	226.655537	rice
2	60	55	44	23.004459	82.320763	7.840207	263.964248	rice
3	74	35	40	26.491096	80.158363	6.980401	242.864034	rice
4	78	42	42	20.130175	81.604873	7.628473	262.717340	rice
...	...	...	...	...	...	...	...	...
2195	107	34	32	26.774637	66.413269	6.780064	177.774507	coffee
2196	99	15	27	27.417112	56.636362	6.086922	127.924610	coffee
2197	118	33	30	24.131797	67.225123	6.362608	173.322839	coffee

Different categories of crops :

```
In [15]: print(excel['CROP'].unique())

['rice' 'maize' 'chickpea' 'kidneybeans' 'pigeonpeas' 'mothbeans'
 'mungbean' 'blackgram' 'lentil' 'pomegranate' 'banana' 'mango' 'grapes'
 'watermelon' 'muskmelon' 'apple' 'orange' 'papaya' 'coconut' 'cotton'
 'jute' 'coffee']
```

5.2 Application interface & Experimental setup

Hardware Setup -

To monitor our crops, hardware was implemented.

Overview:

The temperature and humidity values from the soil are measured using DHT11 sensor which are sent to the Node MCU. Then, these values are sent to the Node MCU board through which we can upload these values to a cloud platform for further usage of the values.

Components required:

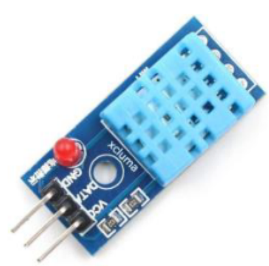
1. DHT 11

2. Node MCU

3. Connecting wires

DHT11:

The DHT11 sensor is an efficient and cost-effective sensor which helps in sensing temperature and humidity. It has a temperature range from 0–50-degree Celsius with chances of error of ±1 degree Celsius and humidity range of 20%-90% with chances of error of ±1%. It also has a power supply of 3.5-5.5 V.



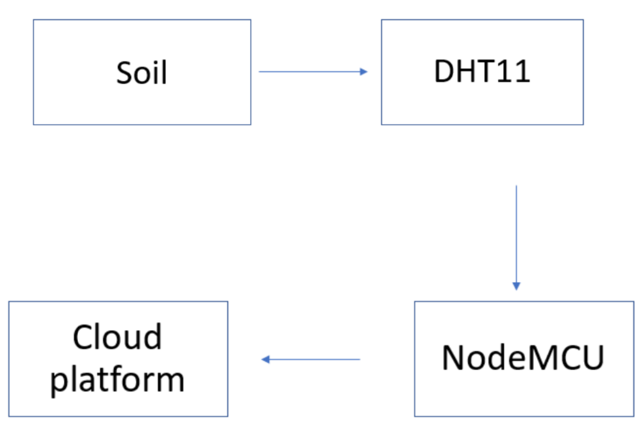
Node MCU:

NodeMCU is an open-source LUA based firmware developed for the ESP8266 WIFI chip. By exploring functionality with the ESP8266 chip, NodeMCU firmware comes with the ESP8266 Development board/kit i.e., NodeMCU Development board. NodeMCU Dev Kit/board consists of ESP8266 WIFI enabled chip. The ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol.

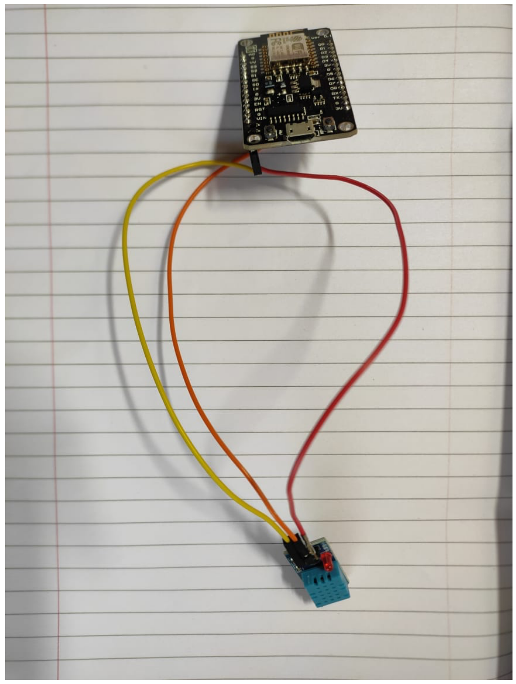
About Thingspeak

ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. You can send data to ThingSpeak from your devices, create instant visualization of live data, and send alerts.

Flow chart:



Hardware Setup:



The VCC of DHT to Vin of ESP8266. The GND of DHT to GND of ESP8266. The data pin of DHT to D4 of ESP8266.

Code for NodeMCU:

new_mcu

```
#include <ESP8266WiFi.h>
#include <DHT.h>
#include <ThingSpeak.h>

DHT dht(D5, DHT11);

WiFiClient client;

long myChannelNumber =1709546;
const char myWriteAPIKey[] = "6FRZNRT4ZFVI5K21";
```

```
void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  WiFi.begin("JioFi2_C68DEF", "aia44sfg5r");
  while(WiFi.status() != WL_CONNECTED)
  {
    delay(200);
    Serial.print("..");
  }
  Serial.println();
  Serial.println("NodeMCU is connected!");
  Serial.println(WiFi.localIP());
  dht.begin();
  ThingSpeak.begin(client);
}

void loop() {
  // put your main code here, to run repeatedly:
  float h = dht.readHumidity();
  float t = dht.readTemperature();
  Serial.println("Temperature: " + (String) t);
  Serial.println("Humidity: " + (String) h);
  ThingSpeak.writeField(myChannelNumber, 1, t, myWriteAPIKey);
  ThingSpeak.writeField(myChannelNumber, 2, h, myWriteAPIKey);
```

Software Setup - LIBRARIES USED:

pyttsx3: pyttsx3 is a text-to-speech conversion library in Python. Unlike alternative libraries, it works offline, and is compatible with both Python 2 and 3.

Pandas: Pandas is a Python library for data analysis. Pandas is usually imported under the pd alias. alias: In Python alias are an alternate name for referring to the same thing. Now the Pandas package can be referred to as pd instead of pandas.

Pre-processing: The sklearn. pre-processing package provides several common utility functions and transformer classes to change raw feature vectors into a representation that is more suitable for the downstream estimators. In general, learning algorithms benefit from standardization of the data set.

KNeighboursClassifier: It returns indices of and distances to the neighbors of each point. The query point or points. If not provided, neighbors of each indexed point are returned.

NumPy: NumPy is usually imported under the np alias. alias: In Python alias are an alternate name for referring to the same thing. Now the NumPy package can be referred to as np instead of numpy .

PySimpleGUI: PySimpleGUI is a python library that wraps tkinter, Qt (pyside2), wxPython and Remi (for browser support), allowing very fast and simple-to-learn GUI programming. PySimpleGUI defaults to using tkinter, but the user can change to another supported GUI library by just changing one line.

Python code :

```
pip install pyttsx3

pip install PySimpleGUI

import pyttsx3 # Importing pyttsx3 library to convert text into speech.

import pandas as pd # Importing pandas library

from sklearn import preprocessing # Importing sklearn library. This is a very
powerfull library for machine learning. Scikit-learn is probably the most useful
library for machine learning in Python. The sklearn library contains a lot of
efficient tools for machine learning and statistical modeling including
classification, regression, clustering and dimensionality reduction.

from sklearn.neighbors import KNeighborsClassifier # Importing Knn Classifier from
sklearn library.

import numpy as np # Importing numpy to do stuffs related to arrays

import PySimpleGUI as sg # Importing pysimplegui to make a Graphical User Interface.

engine = pyttsx3.init('sapi5') # Defining the speech rate, type of voice etc.

voices = engine.getProperty('voices')
```

```
rate = engine.getProperty('rate')

engine.setProperty('rate', rate-20)

engine.setProperty('voice',voices[0].id)

le = preprocessing.LabelEncoder() # Various machine learning algorithms require
numerical input data, so you need to represent categorical columns in a numerical
column. In order to encode this data, you could map each value to a number. This
process is known as label encoding, and sklearn conveniently will do this for you
using Label Encoder.

crop = le.fit_transform(list(excel["label"])) # Mapping the values in weather into
numerical form.

NITROGEN = list(excel["N"]) # Making the whole row consisting of nitrogen values to
come into nitrogen.

PHOSPHORUS = list(excel["P"]) # Making the whole row consisting of phosphorus values
to come into phosphorus.

POTASSIUM = list(excel["K"]) # Making the whole row consisting of potassium values to
come into potassium.

TEMPERATURE = list(excel["temperature"]) # Making the whole row consisting of
temperature values to come into temperature.

HUMIDITY = list(excel["humidity"]) # Making the whole row consisting of humidity
values to come into humidity.

PH = list(excel["ph"]) # Making the whole row consisting of ph values to come into ph.

RAINFALL = list(excel["rainfall"]) # Making the whole row consisting of rainfall
values to come into rainfall.

features = list(zip(NITROGEN, PHOSPHORUS, POTASSIUM, TEMPERATURE, HUMIDITY, PH,
RAINFALL)) # Zipping all the features together

features = np.array([NITROGEN, PHOSPHORUS, POTASSIUM, TEMPERATURE, HUMIDITY, PH,
RAINFALL]) # Converting all the features into a array form

features = features.transpose() # Making transpose of the features

print(features.shape)

print(crop.shape)
```

```
model = KNeighborsClassifier(n_neighbors=3) # The number of neighbors is the core deciding factor. K is generally an odd number if the number of classes is 2. When K=1, then the algorithm is known as the nearest neighbor algorithm.

model.fit(features, crop) # fit your model on the train set using fit() and perform prediction on the test set using predict().

layout = [[sg.Text(' Crop Recommendation Assistant', font=("Times New Roman", 30), text_color = 'Black')],

[sg.Text('Please enter the following details :-', font=("Times New Roman", 20))],

[sg.Text('Enter ratio of Nitrogen in the soil :', font=("Times New Roman", 20)), sg.Input(font=("Times New Roman",20), size = (20,1) )],

[sg.Text('Enter ratio of Phosphorous in the soil :', font=("Times New Roman", 20)), sg.Input(font=("Times New Roman", 20),size = (20,1))],

[sg.Text('Enter ratio of Potassium in the soil :', font=("Times New Roman", 20)), sg.Input(font=("Times New Roman", 20),size = (20,1))],

[sg.Text('Enter average Temperature value around the field :', font=("Times New Roman", 20)), sg.Input(font=("Times New Roman", 20),size = (20,1)), sg.Text('*C', font=("Times New Roman", 20))],

[sg.Text('Enter average percentage of Humidity around the field :', font=("Times New Roman", 20)), sg.Input(font=("Times New Roman", 20),size = (20,1)), sg.Text('%', font=("Times New Roman", 20))],

[sg.Text('Enter PH value of the soil :', font=("Times New Roman", 20)), sg.Input(font=("Times New Roman", 20),size = (20,1))], [sg.Text('Enter average amount of Rainfall around the field :', font=("Times New Roman", 20) ), sg.Input(font=("Times New Roman", 20),size = (20,1)),sg.Text('mm', font=("Times New Roman", 20))],

[sg.Text(size=(50,1),font=("Times New Roman",20) , text_color = 'yellow', key='-OUTPUT1-')],

[sg.Button('Submit', font=("Times New Roman", 20)),sg.Button('Quit', font=("Times New Roman", 20))]]

window = sg.Window('Crop Recommendation Assistant', layout)

while True:

   event, values = window.read()
```

```
    if event == sg.WINDOW_CLOSED or event == 'Quit':

        # If the user will press the quit button then the program will end up.

        break

    print(values[0])

    nitrogen_content = values[0]

    # Taking input from the user about nitrogen content in the soil.

    phosphorus_content = values[1]

    # Taking input from the user about phosphorus content in the soil.

    potassium_content = values[2]

    # Taking input from the user about potassium content in the soil.

    temperature_content = values[3]

    # Taking input from the user about the surrounding temperature.

    humidity_content = values[4]

    # Taking input from the user about the surrounding humidity.

    ph_content = values[5]

    # Taking input from the user about the ph level of the soil.

    rainfall = values[6]

    # Taking input from the user about the rainfall.

    predict1 = np.array([nitrogen_content,phosphorus_content, potassium_content,
temperature_content, humidity_content, ph_content, rainfall]) # Converting all the
data that we collected from the user into a array form to make further predictions.

    print(predict1) # Printing the data after being converted into a array form.

    predict1 = predict1.reshape(1,-1) # Reshaping the input data so that it can be
applied in the model for getting accurate results.

    print(predict1) # Printing the input data value after being reshaped.
```

```python
predict1 = model.predict(predict1) # Applying the user input data into the model.

print(predict1) # Finally printing out the results.

crop_name = str()

if predict1 == 0: # Above we have converted the crop names into numerical form, so that we can apply the machine learning model easily. Now we have to again change the numerical values into names of crop so that we can print it when required.

    crop_name = 'Apple(सेब)'

elif predict1 == 1:

    crop_name = 'Banana(केला)'

elif predict1 == 2:

    crop_name = 'Blackgram(काला चना)'

elif predict1 == 3:

    crop_name = 'Chickpea(काबुली चना)'

elif predict1 == 4:

    crop_name = 'Coconut(नारियल)'

elif predict1 == 5:

    crop_name = 'Coffee(कॉफी)'

elif predict1 == 6:

    crop_name = 'Cotton(कपास)'

elif predict1 == 7:

    crop_name = 'Grapes(अंगूर)'

elif predict1 == 8:

    crop_name = 'Jute(जूट)'

elif predict1 == 9:

    crop_name = 'Kidneybeans(राजमा)'
```

```
elif predict1 == 10:

    crop_name = 'Lentil(मसूि की दाल)'

elif predict1 == 11:

    crop_name = 'Maize(मक्का)'

elif predict1 == 12:

    crop_name = 'Mango(आम)'

elif predict1 == 13:

    crop_name = 'Mothbeans(मोठबीन)'

elif predict1 == 14:

    crop_name = 'Mungbeans(मूंग)'

elif predict1 == 15:

    crop_name = 'Muskmelon(खिबूजा)'

elif predict1 == 16:

    crop_name = 'Orange(संतिा)'

elif predict1 == 17:

    crop_name = 'Papaya(पपीता)'

elif predict1 == 18:

    crop_name = 'Pigeonpeas(कबूति के मटि)'

elif predict1 == 19:

    crop_name = 'Pomegranate(अनिा)'

elif predict1 == 20:

    crop_name = 'Rice(चावल)'

elif predict1 == 21:

    crop_name = 'Watermelon(तिबूज)'
```

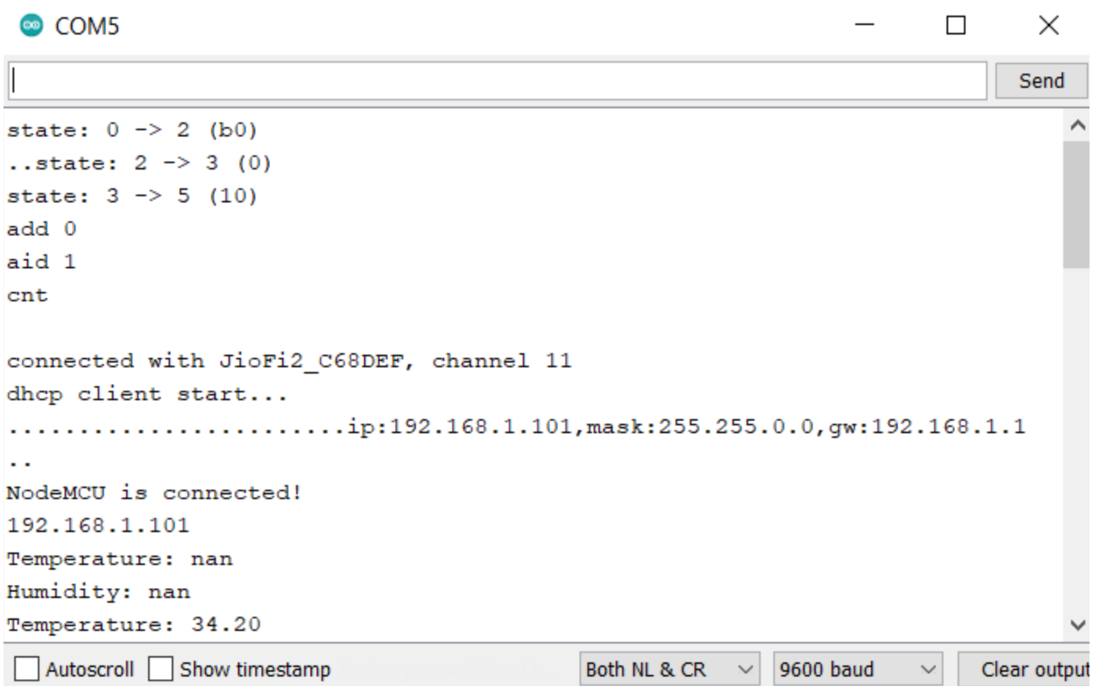
```
   if int(humidity_content) >=1 and int(humidity_content)<= 33 : # Here I have divided
the humidity values into three categories i.e low humid, medium humid, high humid.

       humidity_level = 'low humid'

   elif int(humidity_content) >=34 and int(humidity_content) <= 66:

       humidity_level = 'medium humid'

   else:

       humidity_level = 'high humid'

   if int(temperature_content) >= 0 and int(temperature_content)<= 6: # Here I have
divided the temperature values into three categories i.e cool, warm, hot.

       temperature_level = 'cool'

   elif int(temperature_content) >=7 and int(temperature_content) <= 25:

       temperature_level = 'warm'

   else:

       temperature_level= 'hot'

   if int(rainfall) >=1 and int(rainfall) <= 100: # Here I have divided the humidity
values into three categories i.e less, moderate, heavy rain.

       rainfall_level = 'less'

   elif int(rainfall) >= 101 and int(rainfall) <=200:

       rainfall_level = 'moderate'

   elif int(rainfall) >=201:

       rainfall_level = 'heavy rain'

   if int(nitrogen_content) >= 1 and int(nitrogen_content) <= 50: # Here I have
divided the nitrogen values into three categories.

       nitrogen_level = 'less'

   elif int(nitrogen_content) >=51 and int(nitrogen_content) <=100:

       nitrogen_level = 'not to less but also not to high'
```

```
    elif int(nitrogen_content) >=101:

        nitrogen_level = 'high'

    if int(phosphorus_content) >= 1 and int(phosphorus_content) <= 50: # Here I have
divided the phosphorus values into three categories.

        phosphorus_level = 'less'

    elif int(phosphorus_content) >= 51 and int(phosphorus_content) <=100:

        phosphorus_level = 'not to less but also not to high'

    elif int(phosphorus_content) >=101:

        phosphorus_level = 'high'

    if int(potassium_content) >= 1 and int(potassium_content) <=50: # Here I have
divided the potassium values into three categories.

        potassium_level = 'less'

    elif int(potassium_content) >= 51 and int(potassium_content) <= 100:

        potassium_level = 'not to less but also not to high'

    elif int(potassium_content) >=101:

        potassium_level = 'high'

    if float(ph_content) >=0 and float(ph_content) <=5: # Here I have divided the ph
values into three categories.

        phlevel = 'acidic'

    elif float(ph_content) >= 6 and float(ph_content) <= 8:

        phlevel = 'neutral'

    elif float(ph_content) >= 9 and float(ph_content) <= 14:

        phlevel = 'alkaline'

    print(crop_name)

    print(humidity_level)
```

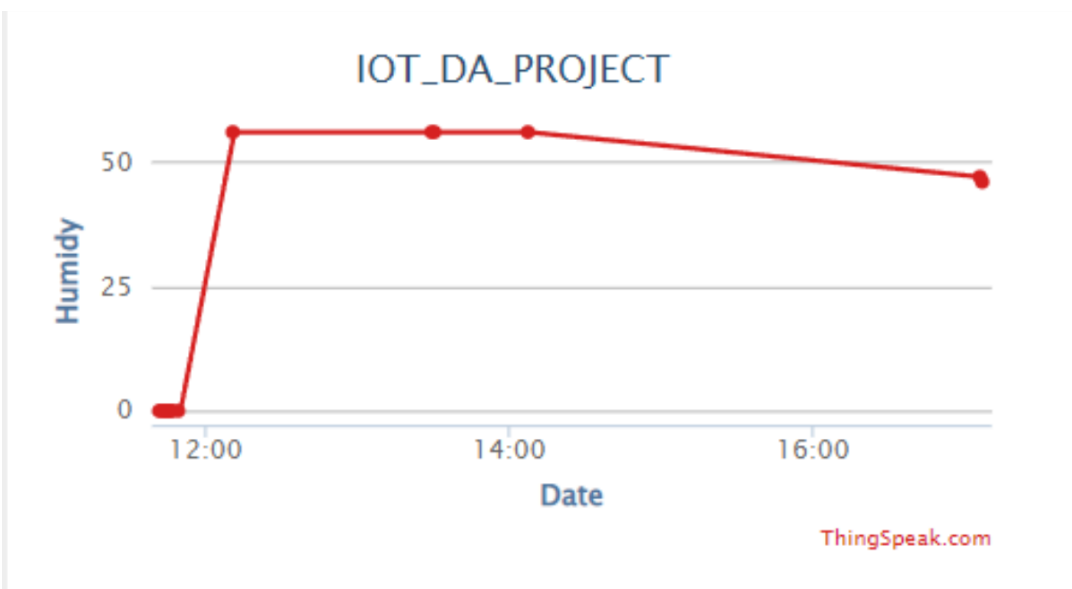
```
   print(temperature_level)

   print(rainfall_level)

   print(nitrogen_level)

   print(phosphorus_level)

   print(potassium_level)

   print(phlevel)

   speak("Sir according to the data that you provided to me. The ratio of nitrogen in
the soil is " + nitrogen_level + ". The ratio of phosphorus in the soil is " +
phosphorus_level + ". The ratio of potassium in the soil is " + potassium_level + ".
The temperature level around the field is " + temperature_level + ". The humidity
level around the field is " + humidity_level + ". The ph type of the soil is " +
phlevel + ". The amount of rainfall is " + rainfall_level ) # Making our program to
speak about the data that it has received about the crop in front of the user.

   window['-OUTPUT1-'].update('The best crop that you can grow : ' + crop_name)

   # Suggesting the best crop after prediction.

   speak("The best crop that you can grow is " + crop_name)

   # Speaking the name of the predicted crop.
```

5.3 Results obtained through proposed approach Compiling -

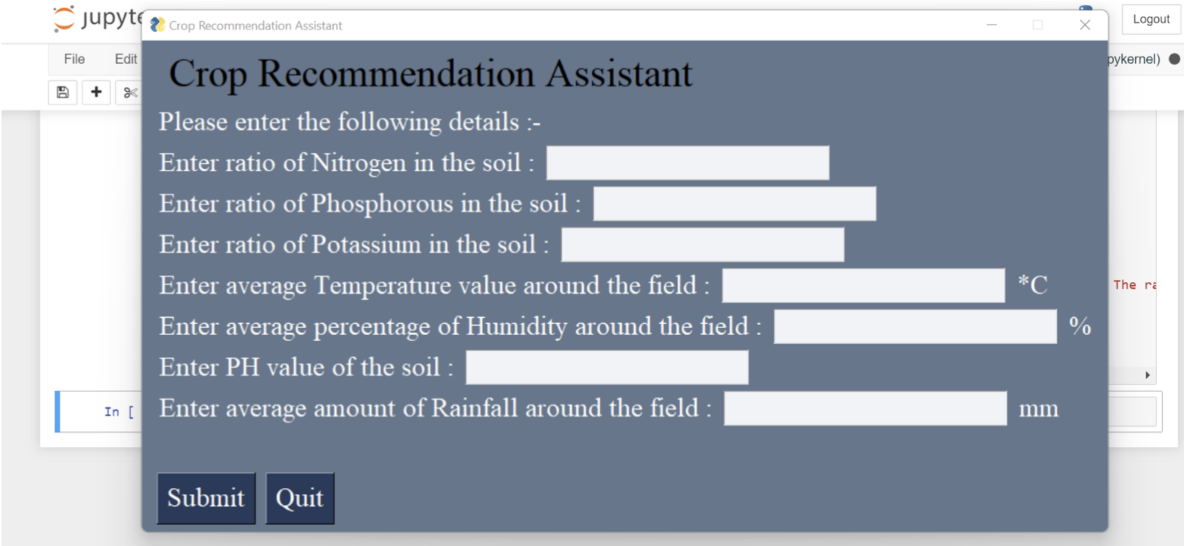
Output Image of Serial Monitor:



Images from Thingspeak (cloud platform):

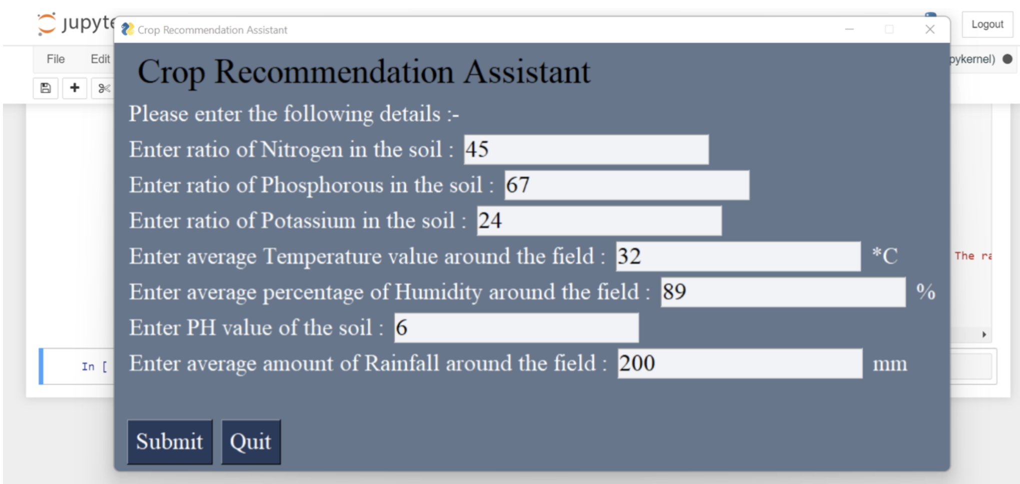


Application Interface:

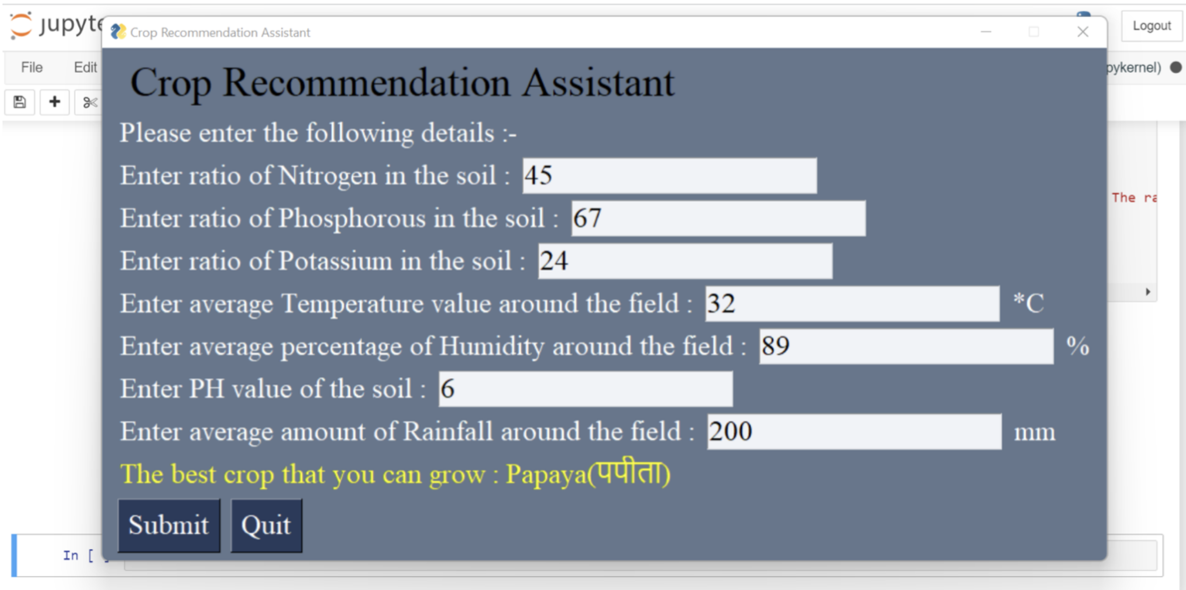


The User interface that we've designed takes inputs from the user and returns with the best crop suited for the soil. Our interface supports text to speech as well.

User giving Inputs:



User Interface showing the best crop suited:



Conclusion and Future Scope:

This system bridges the gap between uneducated farmers and modern agricultural technologies. We have successfully implemented our ideas and made a simple yet user friendly interface for recommending the best crop. It also supports text to speech conversion. We have implemented KNN algorithm to find the trend of the good crops grown in that soil and recommend the crop accordingly. We have fetched the data from IoT sensors and uploaded it on cloud platform.

The farmer may develop more, earn more, and live longer as he has a greater awareness of his property and acreage, as well as the possible risks to his land and productivity. Despite the fact that farmers are unaware of it, the country will face major crises for many years to come. Small landowners should be targeted by the government, who should be educated and encouraged to conserve the plant's genetic resources for a brighter future. The FAO's unification of resources and information can undoubtedly assist in bettering public education.

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