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Agricultural Crop Recommendation System Using IoT and M.L.

Prof. Swati Dhabarde[1], Swapnil Bisane[2], Akshay Gupta[2], Devyani Pote[2], Arati Yadav[2]

Assistant Professor, Department of Computer Engineering[1]

B.E Students, Department of Computer Engineering[2]

Priyadarshini College of Engineering, Nagpur, Maharashtra, India

Abstract: *Agriculture is the backbone for a developing economy like India and there is an enormous need to maintain the agricultural sustainability. Hence it is a significant contribution towards the economic and agricultural welfare of the countries across the world. Effective utilization of agricultural land is crucial for ensuring food safety and security of a country. The aim of this paper is to propose an IoT and ML based Agriculture system that can assist farmers or agriculturist in crop prediction based on Metrological Agriculture theory by getting live Metrological data from the crop field using IoT technology and M.L for prediction which will enable smart farming and increase their overall yield and quality of products.*

Keywords: Agricultural Meteorology, Crop Prediction, Internet of Things, Machine Learning, Smart Farming.

I. Introduction

The development of Intelligent Smart Farming devices based on Internet of things and Artificial Intelligence is day by day turning the face of agriculture production by not only enhancing it but also making it cost-effective and reducing wastage. Agriculture and the food system had undergone a structural transformation in recent years, manifested by price hikes and driven by income and population growth, migration and urbanization, as well as speculation. There is no doubt that the world needs to invest in agriculture. As the world is trending into new technologies and implementations it is a necessary goal to trend up in agriculture also. The World Bank says we'll need to produce 50% more food by 2050 if the global population continues to rise at its current pace [1]. But the effects of climate change could see crop yields falling by more than a quarter. The implementation of smart technology in agriculture practices needs to be focused on for better land productivity. Such studies are conducted in natural outdoor environmental conditions and locations where crops are growing, by varying metrological and physical conditions. Internet of Things (IoT) and A.I technologies combinedly can lower the cost and increase the scale of such studies via the collection of related time series data from sensor networks and labs observations recorded by testing them chemically. The Agriculture system proposed in this paper is an integration of the concepts of Machine learning and IOT using IoT boards and various sensors, through which live data feed can be obtained and processed.

1.1 Agricultural Meteorology

Agricultural Meteorology[2] is a branch of applied meteorology which investigates the physical conditions of the environment of growing plant organisms and deals with the relationship between weather/climatic conditions and agricultural production. A science concerned with the application of meteorology to the measurement and analysis of the physical environment in agricultural systems. The word 'Agro Meteorology' is the abbreviated form of agricultural meteorology which is a study of interaction between meteorological and hydrological factors on the one hand and agriculture in the widest sense.

1.2 Meteorological Factors affecting Crop Production

Meteorological factors play a vital role in Crop Production. Nearly 50 % of yield is attributed to the influence of climatic/Meteorological factors. The following are the major atmospheric weather variables which influences the crop production.

1. Precipitation
2. Temperature
3. Humidity
4. Solar Light Intensity (/Radiation)

1.2.1 Precipitation

Precipitation includes all water which falls from atmosphere such as rainfall, snow, dew etc. Rainfall one of the most important factor influences the vegetation of a place. Total precipitation in amount and distribution greatly affects the choice of a cultivated species in a place. In heavy and evenly distributed rainfall areas, crops like rice in plains and tea, coffee and rubber in Western Ghats are grown. Low and uneven distribution of rainfall is common in dry land farming where drought resistance crops like pearl millet, sorghum and minor millets are grown. In desert areas grasses and shrubs are common where hot desert climate exists Though the rainfall has major influence on yield of crops, yields are not always directly proportional to the amount of Precipitation as excess above optimum reduces the yields Distribution of rainfall is more important than total rainfall to have longer growing period especially in dry lands. Many Farmers in the developing countries like India depend on the annual rainfall for Irrigation Purpose.

1.2.2 Temperature

Temperature is a measure of intensity of heat energy. The range of temperature for maximum growth of most of the agricultural plants is between 15 and 40ºC. The temperature of a place is largely determined by its distance from the equator (latitude) and altitude. It influences distribution of crop plants and vegetation. Germination, growth and development of crops are highly influenced by temperature. Affects leaf production, expansion and flowering. Physical and chemical processes within the plants are governed by air temperature. Diffusion rates of gases and liquids changes with temperature. Solubility of different substances in plant is dependent on temperature. The minimum, maximum (above which crop growth ceases) and optimum temperature of individual's plant is called as cardinal temperature. Some of the sample data is shown in Table-1.

Crops	Min. Temp (in ºC)	Optimum Temp (in ºC)	Max Temp (in ºC)
Rice	10	32	36-38
Wheat	4.5	20	30-32
Maize	8-10	20	40-43
Sorghum	12-13	25	40
Tobacco	12-14	29	35

Table 1: Sample Crop's Temp Favorable Conditions

1.2.3 Relative Humidity

Water is present in the atmosphere in the form of invisible water vapour, normally known as humidity. Relative humidity is ratio between the amount of moisture present in the air to the saturation capacity of the air at a particular temperature. If relative humidity is 100% it means that the entire space is filled with water and there is no soil evaporation and plant transpiration. Relative humidity influences the water requirement of crops. Relative humidity of 40-60% is suitable for most of the crop plants. Very few crops can perform well when relative humidity is 80% and above. When relative humidity is high there is chance for the outbreak of pest and disease.

1.2.4 Solar Light Intensity

From germination to harvest and even post-harvest crops are affected by solar radiation. Biomass production by photosynthetic processes requires light. All physical process taking place in the soil, plant and environment are dependent on light. Solar radiation controls distribution of temperature and there by distribution of crops in a region. Visible radiation is very important in photosynthetic mechanism of plants. Photosynthetically Active Radiation (PAR - 0.4 – 0.7µ) is essential for production of carbohydrates and ultimately biomass.

Some of the Edaphic factors considered for the proposal are:

1. Soil moisture
2. Soil mineral matter
3. Soil organic matter
4. Soil pH

1.2.5 Soil Moisture

Water is a principal constituent of growing plant which it extracts from soil. Water is essential for photosynthesis. The moisture range between field capacity and permanent wilting point is available to plants. Available moisture will be more in clay soil than sandy soil. Soil water helps in chemical and biological activities of soil including mineralization. It influences the soil environment e.g. it moderates the soil temperature from extremes. Nutrient availability and mobility increase with increase in soil moisture content.

1.2.6 Soil Mineral and Organic Matter

The mineral content of soil is derived from the weathering of rocks and minerals as particles of different sizes. These are the sources of plant nutrients E.g.: Ca, Mg, S, Mn, Fe, K etc It supplies all the major, minor and micro nutrients to crops. It improves the texture of the soil. It increases the water holding capacity of the soil, it is a source of food for most microorganisms. Organic acids released during decomposition of organic matter enables mineralisation process thus releasing unavailable plant nutrients. The chemical analysis of soils and is well recognized as a scientific means for quick characterization of the fertility status of soils and predicting the nutrient requirement of crops. Although plants absorb a large number of elements, all of them are not essential for the growth of crops. The elements are absorbed became they happen to be in the soil solution and those taking active part in the growth and developmental processes are called the essential ones. Some of these are required in large amounts and some in traces.

1.2.7 Soil pH Concentration (/Soil Reaction)

Soil reaction is the pH (hydrogen ion concentration) of the soil. Soil pH affects crop growth and neutral soils with pH 7.0 are best for growth of most of the crops. Soils may be acidic (<7.0), neutral (=7.0), saline and alkaline (>7.0). Soils with low pH is injurious to plants due high toxicity of Fe and Al. Low pH also interferes with availability of other plant nutrients. Soils formed under low rainfall conditions tend to be basic with soil pH readings around 7.0.

Intensive farming over a number of years with nitrogen fertilizers or manures can result in soil acidification. For example, which have soil pH of 5.0 and below, aluminum toxicity in wheat and good response to liming have been documented in recent years.

II. Literature Survey

This Proposed Project is based on IoT[3] and Machine Learning. Principles of Agronomy and Agricultural Meteorology are the key concepts which are implemented for the prediction of the favourable crop. Currently for this proposal the Meteorological data of Bidar, Karnataka is taken into consideration. Many Sensors are involved for collecting various Meteorological and Edaphic Factors data. The following are the Hardware and Software requirements involved for the execution of the concept. Climate changes and rainfall has been erratic over the past decade. Due to this in recent era, climate-smart methods called as smart agriculture is adopted by many Indian farmers. Smart agriculture is an automated and directed information technology implemented with the IOT (Internet of Things). IOT is developing rapidly and widely applied in all wireless environments [3].

III. System Design

The System is designed with various smart technologies. IoT for Sensors Sensing, M.L for Prediction Purpose, Web Technologies for Front End U.I design and Database Design are involved for this conceptual design. This system collects the sensor data for over a period of an Agri-Season (Min. 6 Months)

3.1 Flow of Events

The flow can be divided into multiple major sections as shown in the Figure 1:

1. A) Sensing of parameters using IoT Boards and Sensors.
   B) Lab Tested / Physical Parameters data need to be stored.
2. Storing of these data inputs received from the IoT boards and Testing Labs.
3. Optimizing these Input Data for further processing.
4. Processing this optimized data by the ML Model for the final Prediction.

3.2 Experimental Setup

A. IoT Configuration

Objective: Extracting Sensor Data from the Agricultural Field Land for over a period of time.

- This can be achieved using Arduino and NodeMCU ESP8266 Controller Boards.
- Various attributes can be accessed using Sensors through these boards.
- Boards can be programmed using Arduino IDE.

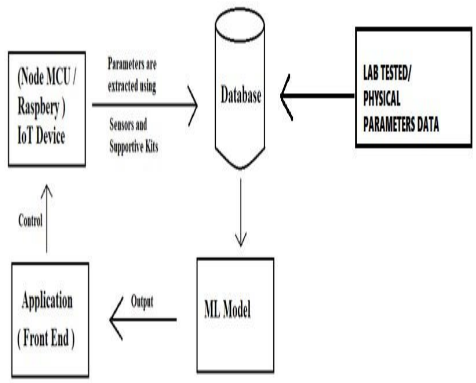

Figure 1: Proposed flow of Events

B. Database Configuration

Objective: Storing the sensor collected data.

- MySQL Server does the work of storing the sensor data.
- IoT Device connected to a local server can insert the inputs using POST/GET requests.
- This data can be minimized for optimal results.
- SQL (Structured Query Language) for data retrieval and storing.

C. Web Technology Configuration

Objective: U.I design for Lab-tested inputs along with sensor data

- Controlling Sensor data.
- Sensor data extraction from the Database.
- U.I for Lab-Tested parameters.
- Connecting to the Machine Learning Model
- Sending data to this trained M.L Model
- Receiving the Output responded by M.L Model Displaying the Predicted output
- Apache Server and Flask WSGI Server as the Web Servers are used.
- PHP, HTML, CSS languages as backend and U.I languages are used.

D. Machine Learning Model Configuration:

Objective: Training the model for prediction [5]

- Model to be trained using the dataset of past results based on metrological parameters

- Optimizing the Model for more accurate results
- Synchronizing with the inputs received from the Front end.
- Python along with SciKit Learn, Pandas libraries are used.

3.3 Machine Learning Algorithm and Dataset

3.3.1 Algorithm: Decision Tree Algorithm

Decision tree Algorithm plays a vital role in prediction by making decisions at every level in the binary tree. Decision tree can be used to visually and explicitly represent decisions and decision making. It uses a tree-like model of decisions. Though a commonly used tool in data mining for deriving a strategy to reach a particular goal, it's also widely used in machine learning. The Basic Decision tree learning algorithm:

1. INPUT: A set of learning instances.
2. OUTPUT: A regression tree.
3. If the stopping criterion is satisfied then
4. Create a leaf that corresponds to all remaining learning examples else
5. Choose the best (according to some criterion) attribute A_i
6. Label the current tree node with A_i
7. For each value V_j of attribute $A_i$do
8. Label an outgoing edge with value V_j
9. Recursively build a subtree by using a corresponding subset of learning examples
10. end for
11. end if

Training Dataset Source: Krishi Vignyana Kendra, Bidar

Currently the model is trained for three major crops widely grown in the regions of Bidar District. i.e. Toor Dal, Sugarcane, Soya bean. The Dataset was extracted from the Farmers Soil Health card [4] which was issued during a season period Metrological Data for over a period of time is used from the worldweatheronline.com portal for training purpose.

3.4 UML Diagram

In Diagram-1, we can see the flow of data between different technological modules.

IV. System Implementation

Figure 2 Shows the proposed flow of execution of events starting from info gathering to the

- Firstly, the Arduino UNO R3 connected with various Analogue sensors sends the sensor data to the ESP8266(NodeMCU) Module.
- ESP8266 along with other digitals parameters data and the data received from the Arduino board sends an HTTP POST Request to the Apache server to store the sensor data on to the MySQL Database [6]
- This Process of data insertion on to the database is done repeatedly for over a period of time/Seasons.
- Then this data from the database along with the other lab tested parameters is sent to the M.L Model for the Prediction
- The Predicted output is displayed on the Web portal which can be accessed from the Internet.

The ESP8266, Apache Server, Flask Framework WSGI Server and MySQL Server are configured with I.P address and Ports. All these devices are brought under a common platform. i.e. Local LAN Network. For every 30 seconds time interval a POST/GET request is sent from the ESP8266 to the Apache Server where the PHP code written for the database insertion of this sensor data is executed.

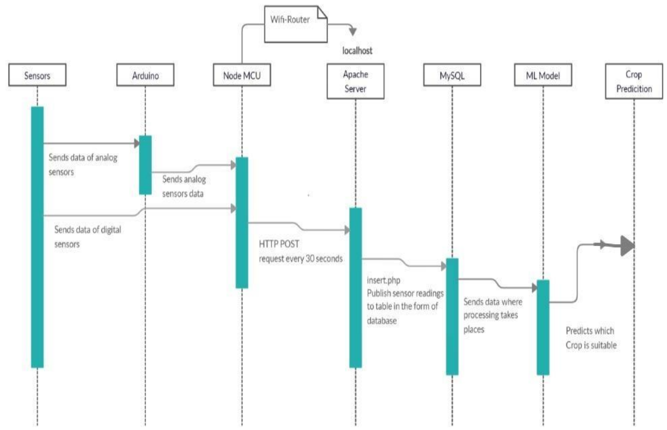

Diagram 1: UML Diagram for dataflow

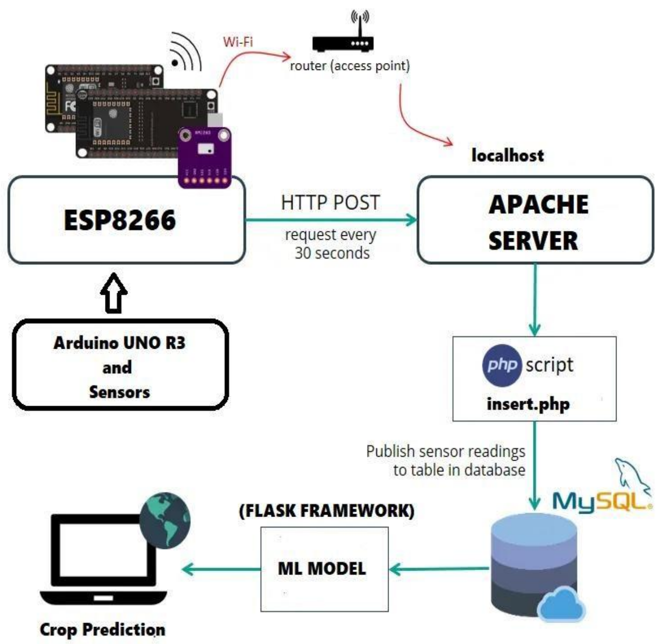

Figure 2: Proposed flow of Execution

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V. Output Screens

Figure-3 shows the IoT module where the ESP8266, Arduino UNO R3 are mutually connected along with the various IoT Analogue and Digital Sensors.

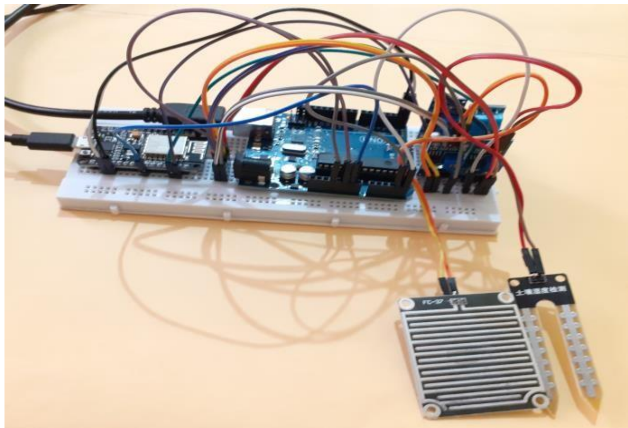

Figure 3: IOT Module

In Figure 4, we, can see the U.I Design from where the sensor data extraction from the database for further processing is initiated.

Figure 4: Front end U.I Design

In Figure 5, The Optimized sensor collected data from the database is displayed. Along with these, the Lab-Tested data is entered manually at the Front end.

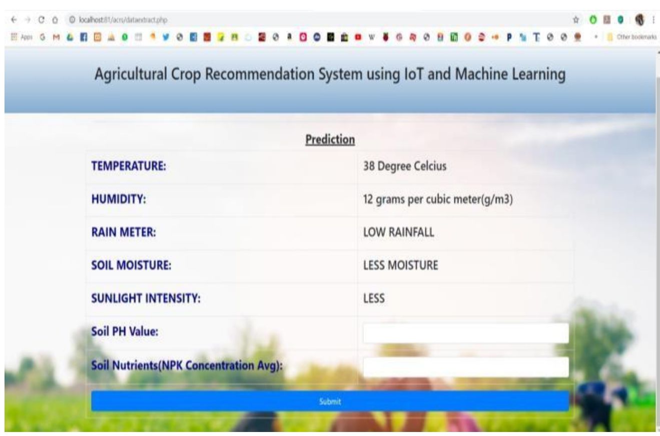

Figure 5: Optimized Sensor data.

In Figure 6, The Result is displayed after processing the sensor data through a trained M.L Model.

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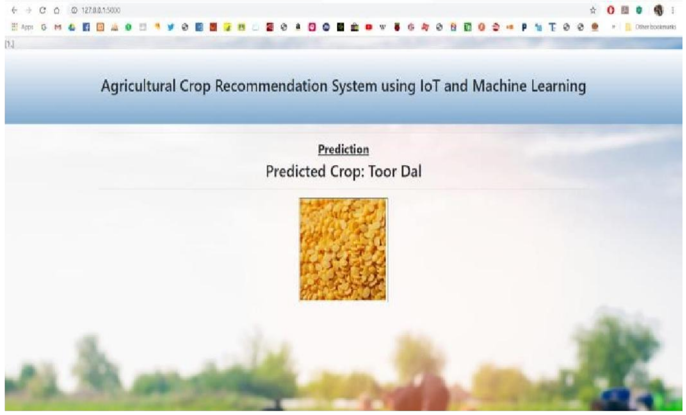

Figure 6: The Final Output

VI. Conclusion

The crop prediction is the toughest task for agricultural domain. Farmer or Agriculturist tends to choose the non-favorable crop without considering the market or weather risks and bears crop lose and sometimes it leads to bankrupt situation. Currently, The Crop Prediction is being done manually involving Mathematical and Statistical approaches. Farmers/Agriculturist approach the local agriculture officer or their co-agricultural colleagues for recommendations which doesn't involve any sort of accurate analysis. Many existing systems are currently working with various M.L Algorithms with manual data inputs. Considering all the parameters, this System helps in Predicting an efficient crop which can grown in a particular field area which results in a good crop yield, high Income eliminating weather risks. Based on this systems report, Crop and Soil Health cards to the agriculturist or farmers can be issued validating and Issuing of Crop Loans or Crop Insurance for the Banks becomes easier. This Data can also be used for various Educational or Research Purposes.

	A	B	C	D	E	F	G	H
1	TEMP	HUMIDITY	RAIN	SOILMOISTURE	SUNLIGHT	SOILPH	SOILNUT	CROP
2	30	10	0.5	0.5	0.5	6	5	1
3	31	10.5	0.5	0.5	0.5	7	8	1
4	32	10	0.4	0.5	0.4	6.5	5	1
5	33	11	0.6	0.5	0.6	6	4.5	1
6	34	11	0	0.4	0.5	5.5	6	1
7	35	14	0.1	0.3	0.7	7.5	8	1
8	36	9	0.2	0.2	0.4	4.5	4.5	1

Figure 7: Encoded Dataset Sample

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[6]. Journal - "Smart Agriculture Based on Cloud Computing and IoT" Internet of things and RFID technologies can help build plant factory and realize automatic control production of agriculture. Cloud computing is closely related to internet of things. A perfect combination of them can promote fast development of agricultural modernization, realize smart agriculture and effectively solve the issues concerning agriculture, countryside and farmers.