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Project Title

"Crop Recommendation and Irrigation System Using ML with Integrated IoT"

Embedded System – BCE305 L

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1. AIM:

Aim of the proposed work

AIM OF this paper is to develop an efficient and automated irrigation system that can recommend the appropriate crop based on the environmental and soil conditions. By using various sensors to collect data on NPK levels, humidity, temperature, and soil moisture, the system utilises machine learning algorithms to recommend the most suitable crop for the given conditions. The system then integrates weather APIs and water level sensors to determine the irrigation requirements for the recommended crop at different growth stages, ensuring that the crop receives the optimal amount of water. The project aims to optimise the yield of crops, reduce water wastage, and promote sustainable agriculture practices.

2. Problem Analysis:

Problem Analysis

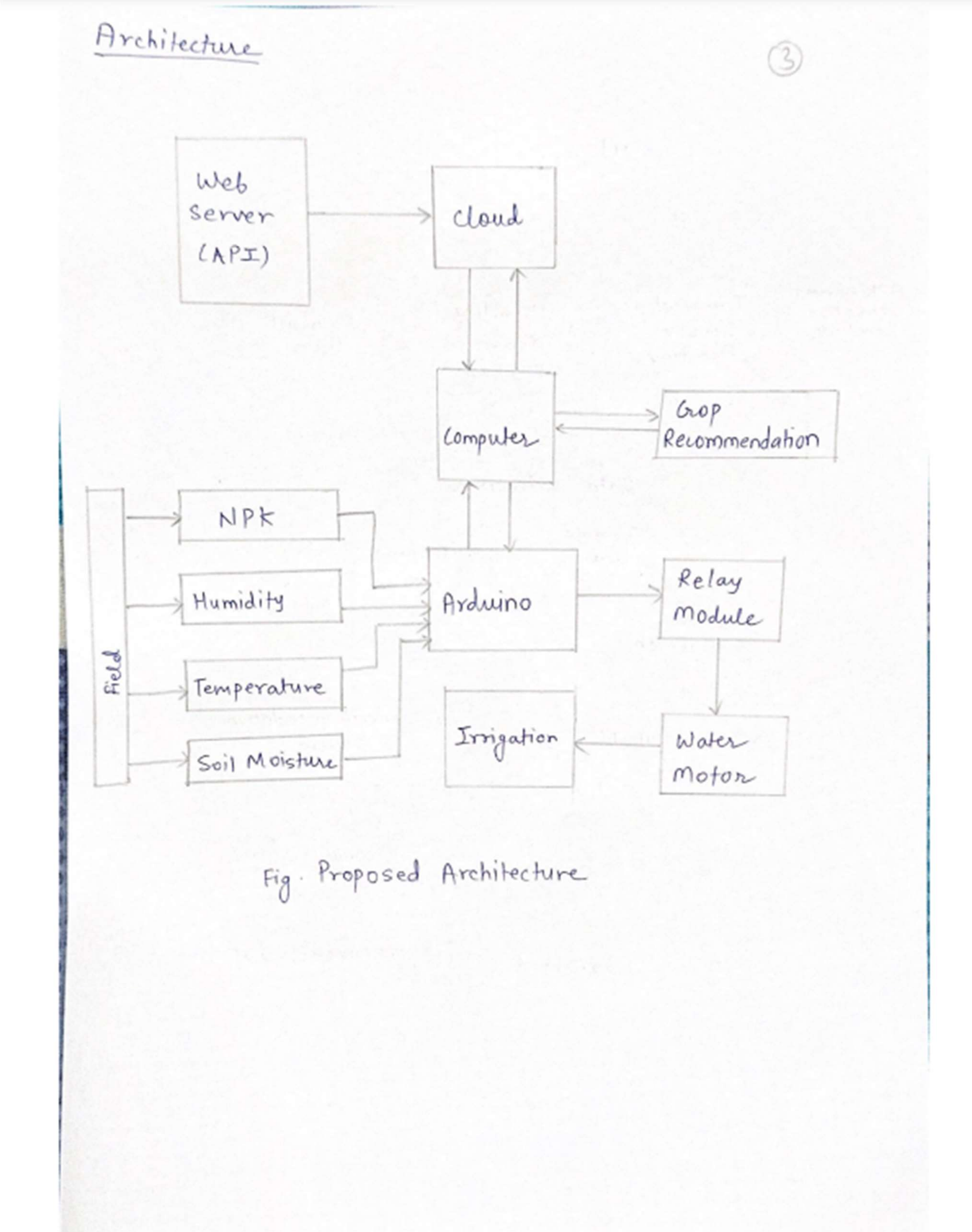
The survey highlights a shift from traditional forming practices towards data-driven agriculture, leveraging IoT devices and machine learning algorithms for improved crop yield and irrigation management. Previous models predominantly relied on variables like humidity, temperature, rainfall, and pH for decision making. However, the pH value was found to be less informative, leading to the adoption of NPK soil values, which significantly enhanced model accuracy.

Among machine learning algorithms, XG Boost emerged as a preferred choice due to its superior performance in terms of both speed and accuracy, especially for structured datasets. Its scalability, faster computation speed, and regularization techniques make it particularly suitable for agricultural applications.

Integration of IoT devices, such as water level sensors and weather APIs, provides real-time data for enhanced monitoring and management. This comprehensive approach not only recommends the best crops based on soil attributes but also automates irrigation processes based on dynamic environmental conditions.

While some previous studies focused solely on crop recommendation or smart irrigation systems, the combined approach addresses both aspects, offering a more holistic solution to optimize agricultural practices. This integration ~~et~~ enhances efficiency, productivity, and sustainability in farming practices.

3. Architecture:



3.3. **PROPOSED SYSTEM**

Proposed system Model

4

A crop recommendation and irrigation system is a complicated system that includes data collection, processing, analysis, and decision-making, among other things. The following elements make up the suggested system model for this kind of system:

- Data collection: This step entails gathering pertinent information from numerous sources, including weather stations, soil moisture sensors, and crop growth stages. The information gathered needs to be precise, dependable, and timely.

- Data processing: It includes preparing the raw data for analysis by cleaning, verifying, and converting it into a specific format. A database should be used to hold the processed data so that it can be retrieved and edited quickly.

- Data analysis: This step entails looking at the data that has been processed to produce conclusions and suggestions. The data can be analysed using machine learning algorithms to forecast crop production, soil moisture content, and irrigation needs.

- Making decisions: This step entails selecting crops, planning irrigation, and applying fertiliser after carefully considering the insights and suggestions gleaned from data analysis.

- User interface: This part entails giving farmers a simple way to communicate with the system. The user interface needs to be simple to use, intuitive, and available on a variety of gadgets including tablets and smartphones.

- Implementation: In this step, the system's recommendations are put into practise on the farm. Other farming technology and automated irrigation systems can be used for this.

In order to give farmers accurate and timely information on crop selection, irrigation planning, and fertilisation, the suggested system model for a crop recommendation and irrigation system integrates numerous technologies and procedures. The system can assist farmers in making decisions that will improve crop production, conserve water, and raise crop yields.

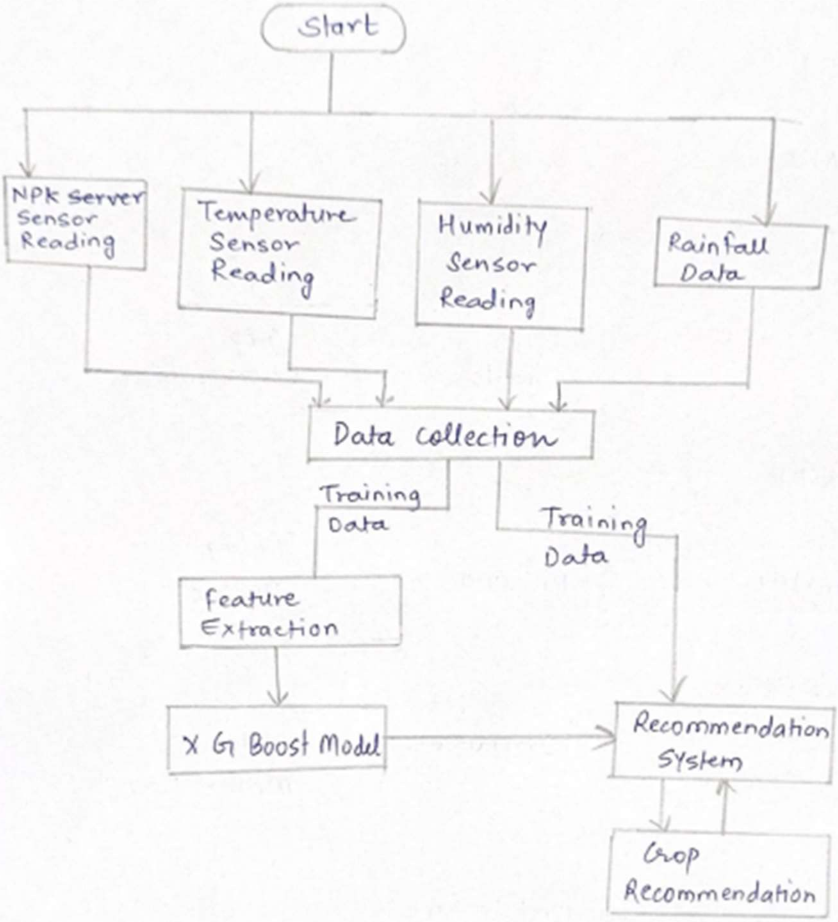
(7)

The proposed system integrates sensor data from the soil, including NPK values, humidity, temperature, and soil moisture, which is then processed using machine learning models to recommend suitable crops. Once recommended, the system initiates irrigation based on the crop's growth stages.

Irrigation requirements vary across five stages:

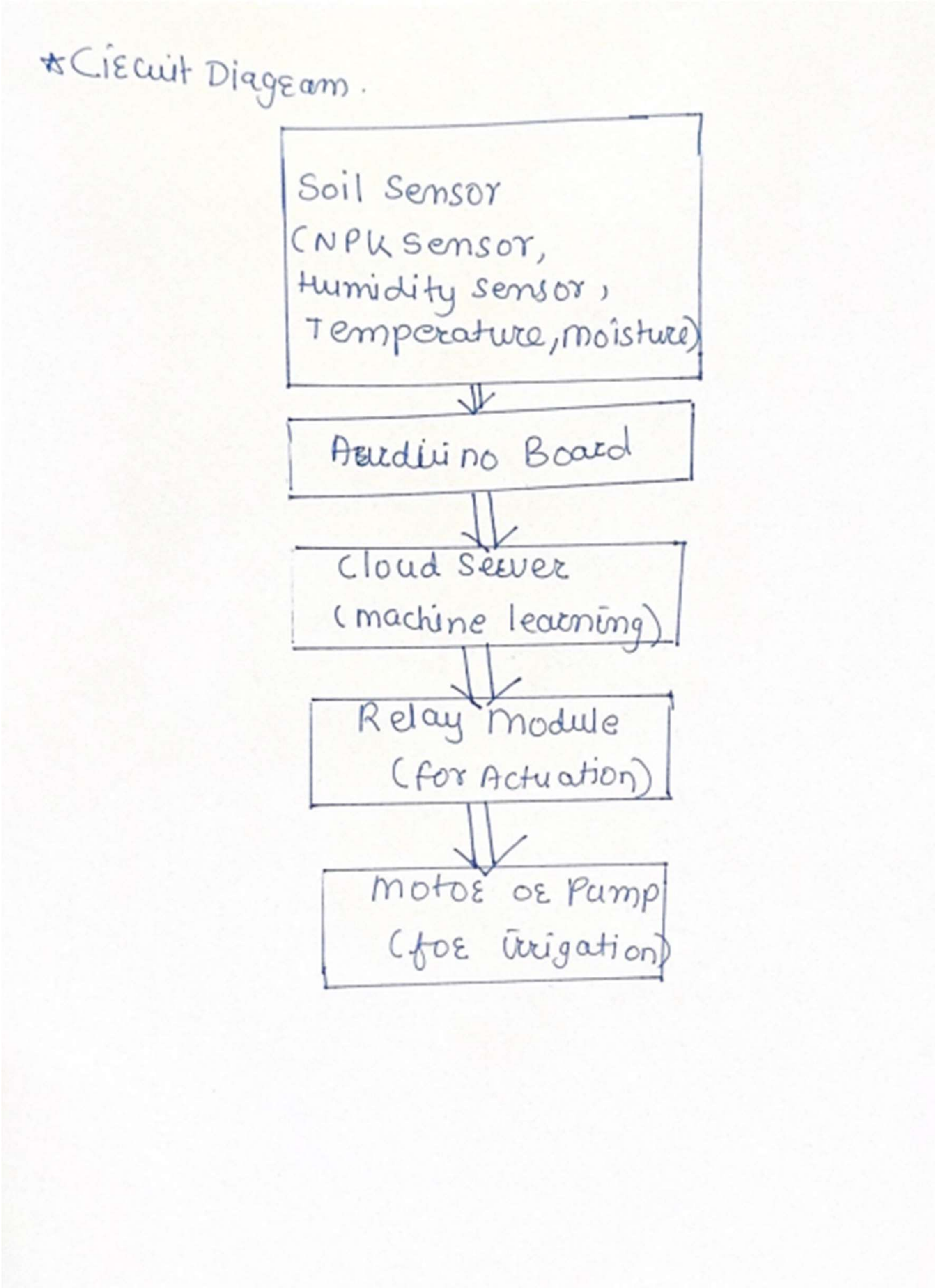
1. Nursery: keep soil moist without overwatering.
2. Transplanting: Thoroughly water soil for root establishment.
3. Vegetative: Regular watering to maintain soil moisture
4. Reproductive: Increased water for flower and fruit growth.
5. Ripening: Reduced water as crop matures.

By understanding these stages, farmers can optimize irrigation for better crop growth and yield. IoT devices and machine learning enhance this process, leading to improved productivity and resource efficiency.



Flow Diagram for crop recommendation

4. Circuit Diagram:



5. CODE

* Implementation: Code:

when soil moisture reaches the required threshold then the motor turns off.

```
print("Crop stage :", i)
print ("Day :", cal_day)
prec_mm = sum(new1("prec_mm"]/10
soil_moisture_Tomorrow = sum(new1["soil
 moisture"] /24)
soil_moisture_Total = , soil_moisture_Tomorrow
print (" precipition Tomorrow:", prec_mm)
print ("Total soil moisture:", soil_moisture_Total)
print("Ideal soil moisture:", new["soil_moisture"]
 [i-1])
```

```
Crop state : 3 ←—— Crop state
                   determined
Day : 85
Soil moisture: 0.13
Precipitation Tomorrow: 0.0
Total soil moisture : 0.13
Ideal soil moisture : 0.25695369
```

[34]

```
if (new["soil moisture"] [i-1] > ["soil_moisture"]
_Total):
    print(1)
else:
    print(0)
```

soil moisture found HAW the required.

[35]

```
import serial as s
import time as t
ser = s.Serial ('COM5' , 9600, timeout = 0)
t.sleep(2)
print(ser.name, "connected")
if (new ["soil_moisture"] [i-1] <= soil_moisture
_Total):
    ser: write(b'0')
    print("MOTOR OFF")
elif(new("soil moisture") [i-1] > soil_moisture
                                   Total):
    ser.write(b'1'):
    Print ("MOTOR ON")
    t.sleep (20)
else:
    ser.close()
```

* Code:

PSEUDOCODE.

Crop Recomendation:

```
# Import required libraries
import serial
import time
import requests
import json
import pandas
# set meteum API Access key.
# make API Request to metum API
# parse JSON response
# print JSON data.
# get current date and store in 'today'
                                  variable.
# print 'forecast' key from data 'dictionary' 'dict'.
# convert 'dict' dictionary to pandas Dataframe...
```

coms connected

MOTOR ON ← motor turns on

moisture percentage= 3.71%

moisture percentage: 3.81%.

moisture percentage: 3.91%.

moisture percentage: 3.91%.

moisture percentage: 3.81%.

moisture percentage: 3.62%.

moisture percentage: 52.49%.

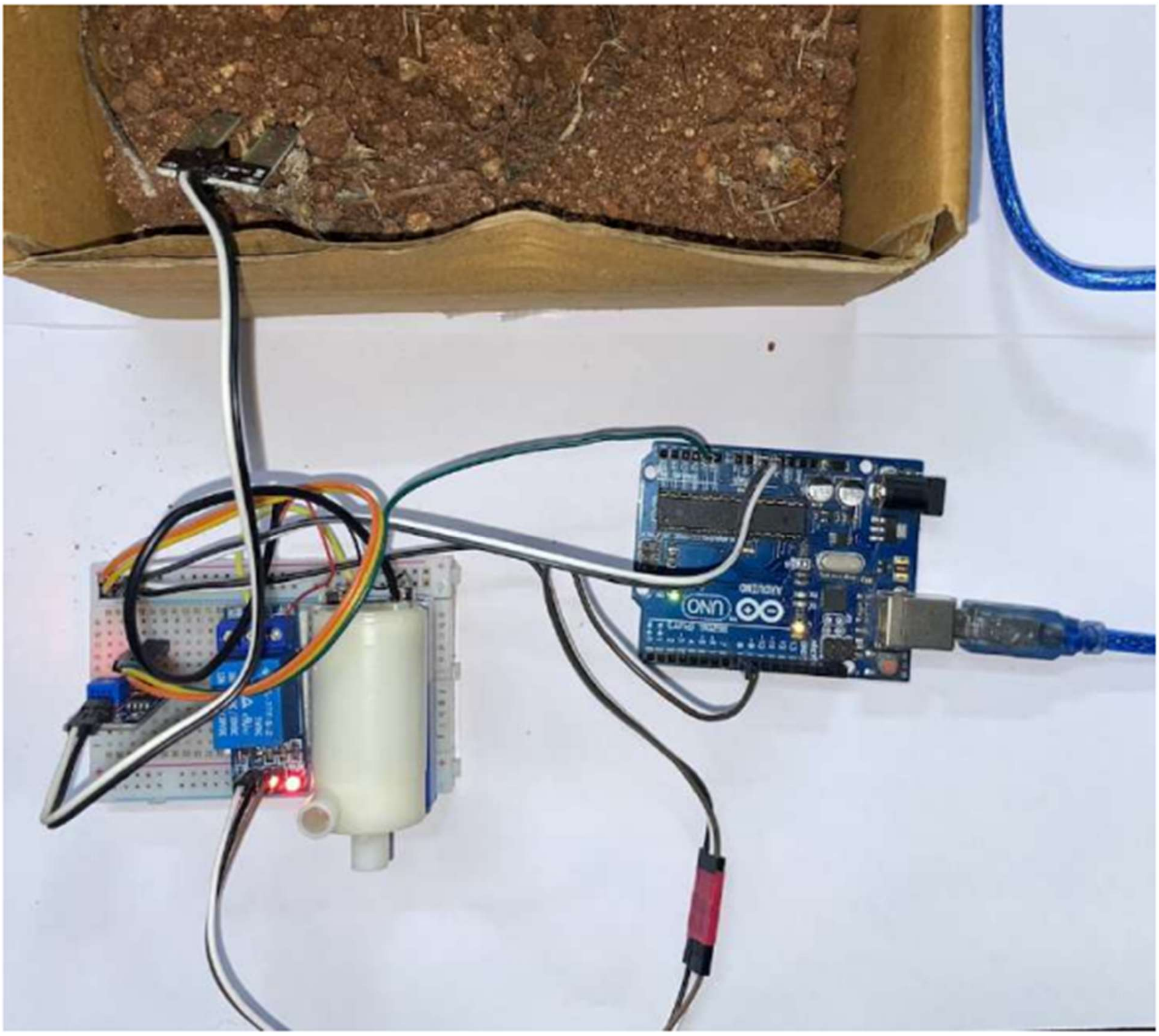
0.2569 89369 5358871 = % Ideal moisture reached, turning off motor.

Irrigation code:

```
#Import required libraries
from numpy import loadtxt
from xgboost import XGBClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
import pandas as pd
dataset = pd.read_csv('Downloads/Crop_recommendation.csv')
x = dataset[["N","P","K","temperature",
 "humidity","ph","rainfall"]]
Y= dataset[["label"]]
# Replace lables
a= Y['lables'].unique()
i=0
for x in a:
    Y.replace(x,i,inplace=True)
    i +=1
```

```
seed = 7
testsize = 0.2
X_train, X_test, y_train, Y_test = train_test_split
  (X, y, test_size = test_size, random_state=seed)
model = XGBClassifier()
model.fit (X_train, y_train)
Y_pred = model.predict (X_test)
Predictions = [round(value) for value in
              y_pred]
accuracy = accuracy_score (y_test, prediction)
print ("Accuracy: %.2f%%" % (accuracy * 100.0))
```

6. Implementation



When the soil moisture reaches the required threshold then the motor turns off.

[33]:

```python
print("Crop Stage : " , i)
print("Day : " , cal_day)
Prec_mm = sum(new1["prec_mm"]/10)
Soil_Moisture_Tomorrow = sum(new1["soil_moisture"]/24)
Soil_Moisture_Total = Soil_Moisture_Tomorrow + Prec_mm
print("Soil Moisture  : " , Soil_Moisture_Tomorrow)
print("Precipitaion Tomorrow : " , Prec_mm)
print("Total Soil Moisture : " , Soil_Moisture_Total)
print("Ideal Soil Moisture : " , new["Soil_Moisture"][i-1])
```

```
Crop Stage :  3
Day :  85
Soil Moisture  :  0.13
Precipitaion Tomorrow :  0.0
Total Soil Moisture :  0.13
Ideal Soil Moisture :  0.2569893695358871
```

Crop stage determined

[34]:

```python
if(new["Soil_Moisture"][i-1]>Soil_Moisture_Total):
    print(1)
else :
    print(0)
```

Soil Moisture found low the required

[35]:
```
import serial as s
import time as t
ser = s.Serial('COM5', 9600, timeout=0)   # check your com port
t.sleep(2)
print(ser.name,"connected")
if(new["Soil_Moisture"][i-1]<=Soil_Moisture_Total):
    ser.write(b'0')
    print ("MOTOR OFF")
elif(new["Soil_Moisture"][i-1]>Soil_Moisture_Total):
    ser.write(b'1')
    print ("MOTOR ON")
    t.sleep(20)
else:
    ser.close()
```

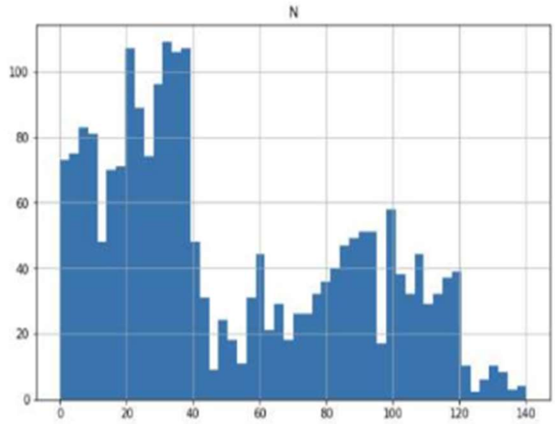
Motor Turns ON

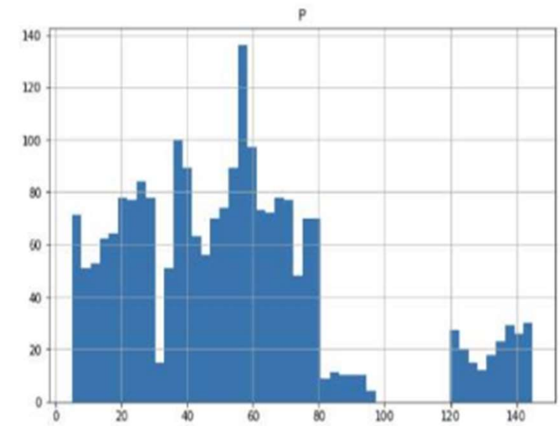
```
COM5 connected
MOTOR ON
```

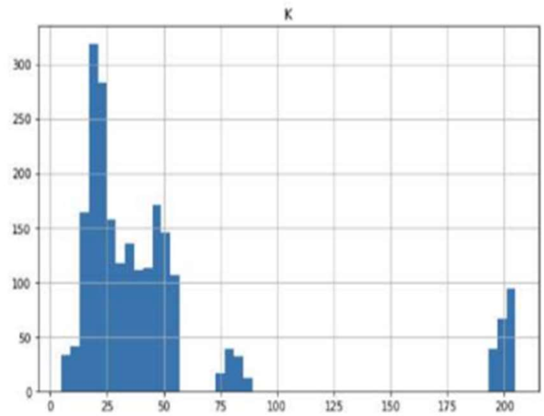
Soil Moisture exceed required threshold, so Motor turns OFF

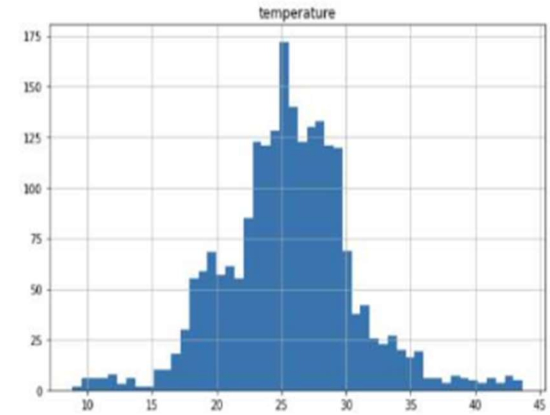
```
Moisture Percentage = 3.71%
Moisture Percentage = 3.81%
Moisture Percentage = 3.91%
Moisture Percentage = 3.91%
Moisture Percentage = 3.81%
Moisture Percentage = 3.62%
Moisture Percentage = 52.49%
0.2569893695358871  = % Ideal Moisture reached, turning off motor
```

Here is data distribution of NPK, temperature, humidity and rainfall data.









7. **Test Cases:**

Test cases.

1. Sensor Data Integration Test:

=) Ensure that the system accurately collects and integrates sensor data from soil, including NPK values, humidity, temperature and soil moisture.

2. machine learning model Accuracy test:

=) Validate the accuracy of machine learning model in recommending suitable crops based on the integrated sensor data. This ~~da~~ can be done by comparing the recommended crop with known succesfull crop for given conditions.

3. Irrigation management Test:

=) The test ~~the~~ system's ability to manage irrigation effectively based on the recommendation system, recommen-ded crops and their respective growth stages.

verify that the irrigation schedule aligns with the specific water requirements at each stage of crop growth.

8. **Future Scope:**

* Future scope/improvements.

1. Crop Disease Detection:
Expand the system to incorporate senso
and machine learning algorithms for
early detection of crop diseases. This woul
enable proactive measures to prevent
disease outbreaks and minimize crop
losses.

2. market price prediction:
=> Integrates market data and historical
pricing information to predict future
crop prices.
Farmers can uses this information to
make informed decisions about crop
selection and timings of harvest for
maximum profitability.

9.

3. optimization of mutiple locations:
Extend the system to support recommendation and irrigation management for mutiple locations with diverse models to account for regional variations in soil types, climate, and crop preferences.

8. RESULTS AND DISCUSSION

* Result and Discussion

Our crop-recommendation and irrigation system utilizes XGBoost algorithm to provide highly accurate crop recommendations, with a success rate of 99.1%.
To determine the appropriate amount of irrigation for each crop, we use the number of days since planting to determine its growth phase.

Because crops take approximately 150 days to mature, we divide this priod into five distinct phases of around 30 days each

The growth is a critical factor indetermining the necessory moisture level required for optimal crop growth Once we have established the current growth phase and this corresponding soil moisture requirements, we gather data on precipitation using APIs in our current latitude and longitude, which adds up with the existing moisture and determines the total moisture level in the soil. This information allows us to calculate the precise amount of irrigation needed to maintain the ideal moisture level for the crop. Our system incorporates a water motor that start working once the required moisture level ensurring that the irrigation levels remains within the required parameters.

9.Suggestion and Improvements

Suggestions for Improvement:

Here are some suggestions for improvement on the topic of the proposed crop recommendation and irrigation system:

1.Enhanced Data Collection: Consider expanding the sources of data collection beyond just weather stations and soil moisture sensors. Integration with satellite imagery, remote sensing technologies, and historical crop yield data can provide a more comprehensive understanding of the agricultural landscape.

2.Data Quality Assurance: Implement robust data quality assurance measures during the data collection phase to ensure the accuracy, reliability, and timeliness of the collected data. This may involve sensor calibration, validation procedures, and data validation checks to identify and rectify any anomalies or discrepancies.

3.Advanced Data Processing Techniques: Explore advanced data processing techniques such as data fusion, feature extraction, and outlier detection to enhance the quality and relevance of the processed data. Additionally, consider

consider utilizing big data analytics platforms for scalable and efficient data processing.

4.Model Refinement and Validation: Continuously refine and validate the machine learning models used for data analysis to improve their accuracy and performance. This may involve incorporating feedback from farmers, calibrating model parameters, and validating model predictions against ground truth data.

5.Dynamic Decision-Making Algorithms: Develop dynamic decision-making algorithms that can adapt to changing environmental conditions and crop requirements in real-time. This may involve integrating feedback loops, adaptive control mechanisms, and optimization algorithms to optimize crop selection and irrigation scheduling dynamically.

6.Enhanced User Interface Design: Enhance the user interface design to provide farmers with intuitive and actionable insights. Incorporate interactive visualizations, real-time alerts, and personalized recommendations to facilitate informed decision-making and improve user engagement.

7.Scalability and Interoperability: Ensure that the system is scalable to accommodate large-scale farming operations and interoperable with existing agricultural infrastructure and technologies. This may involve adopting open standards, APIs, and modular architecture to facilitate seamless integration with third-party systems and devices.

8.Customization and Localization: Provide options for customization and localization to cater to the specific needs and preferences of different farmers and regions. Allow farmers to customize crop recommendations, irrigation schedules, and fertilization plans based on their individual requirements, preferences, and constraints.

9.Education and Training: Offer training and educational resources to farmers to help them understand and utilize the system effectively. Provide tutorials, user guides, and workshops to familiarize farmers with the system's features, functionalities, and best practices for maximizing crop productivity and resource efficiency.

Continuous Improvement and Feedback Loop: Establish a continuous improvement process

Establish a continuous improvement process by soliciting feedback from farmers, monitoring system performance, and incorporating lessons learned from field trials and real-world deployments. This iterative approach will help identify areas for improvement and drive ongoing innovation and optimization of the system.

By incorporating these suggestions, you can enhance the effectiveness, usability, and impact of the proposed crop recommendation and irrigation system, ultimately empowering farmers to make informed decisions and optimize their agricultural practices for improved productivity and sustainability.

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