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SMART IRRIGATION SYSTEM USING AI POWERED SENSORS

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ABSTRACT

"Smart Irrigation System Using AI Powered Sensors" presents an intelligent water management solution designed to optimize irrigation practices in agriculture using artificial intelligence and sensor-based technology. Traditional irrigation methods often lead to water wastage due to over-irrigation or inefficient scheduling, which negatively impacts crop growth and resource sustainability. The proposed system integrates AI-powered sensors to continuously monitor soil moisture, temperature, humidity, and environmental conditions in real time. These sensor readings are processed using machine learning algorithms to predict the precise water requirements of crops and automatically control irrigation systems. The framework enables smart decision-making by adjusting water supply based on soil conditions and weather forecasts, ensuring optimal irrigation levels. This approach helps in conserving water resources, reducing manual intervention, and improving crop yield efficiency. Experimental analysis shows that AI-based irrigation systems significantly enhance water usage efficiency compared to conventional irrigation methods. The proposed system contributes to sustainable agriculture by promoting precision farming techniques and intelligent resource management.

INTRODUCTION

Water is one of the most essential resources for agriculture, directly influencing crop growth, yield quality, and overall productivity. However, traditional irrigation methods often rely on manual judgment or fixed schedules, which can lead to inefficient water usage, either through over-irrigation or under-irrigation. This not only wastes a significant amount of water but can also negatively affect soil health and crop performance.

With the increasing demand for food production and the growing impact of climate change, efficient water management has become a critical requirement in modern agriculture. Precision agriculture technologies have emerged as a solution to address these challenges by using data-driven approaches to optimize farming practices. Among these, smart irrigation systems play a vital role in ensuring the right amount of water is supplied at the right time.

Artificial Intelligence (AI) and sensor technologies have transformed traditional irrigation systems into intelligent and automated solutions. AI-powered sensors continuously monitor environmental parameters such as soil moisture, temperature, humidity, and weather conditions. These data inputs are analyzed using machine learning algorithms to make accurate irrigation decisions in real time.

The proposed system focuses on developing a smart irrigation model using AI-powered sensors to automate water management in agriculture. By analyzing real-time environmental data, the system determines crop water requirements and controls irrigation accordingly. This approach helps conserve water, reduce manual effort, improve irrigation efficiency, and support sustainable farming practices through intelligent and precise resource management.

LITERATURE SURVEY

1. "IoT-Based Smart Irrigation System for Agriculture"

Author: S. K. Divya and R. R. Rao

Description:

This study proposed an IoT-enabled irrigation system that uses soil moisture sensors to monitor field conditions and automate water supply. The system reduces water wastage by ensuring irrigation is performed only when required based on real-time sensor data.

2. "Smart Irrigation System Using Machine Learning Techniques"

Author: Anil Kumar et al.

Description:

The research introduced a machine learning-based irrigation model that predicts water requirements using environmental factors such as temperature, humidity, and soil moisture. Algorithms like regression models and decision trees were used to improve irrigation accuracy.

3. "Automated Irrigation System Based on Sensor Networks"

Author: M. R. Patel and J. S. Shah

Description:

This paper focused on wireless sensor networks for monitoring agricultural fields. The system automatically controls irrigation pumps based on sensor readings, improving water efficiency and reducing manual intervention.

4. "Artificial Intelligence in Smart Agriculture Systems"

Author: R. Venkatesh and P. Kumar

Description:

The authors explored the application of AI in agriculture, particularly for irrigation management. The study highlighted how AI models can analyze environmental data and optimize water distribution for better crop yield.

5. "Precision Irrigation Using IoT and Data Analytics"

Author: N. Sharma and A. Gupta

Description:

This research proposed a precision irrigation framework using IoT sensors and data analytics. The system collects real-time soil and weather data to make intelligent irrigation decisions, ensuring efficient water usage.

SYSTEM ARCHITECTURE

IMPLEMENTATION

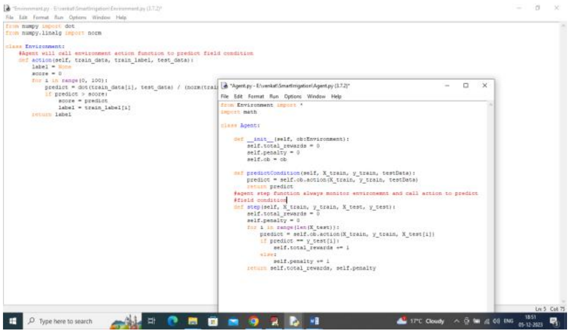
Smart Irrigation System Using AI powered sensors

Worldwide all countries economy and progress heavily dependent of agriculture and this agriculture crops must be irrigated properly by giving suitable amount of waters and essential ingredients but it's difficult to monitor and provide required essentials to crop manually so governments are coming up with new ideas such as IOT and UAV (unmanned aerial vehicles) based technologies to monitor crop. This IOT and UAV will inform farmer about required ingredients and amount of water. IOT and UAV required manual farmer to provide water and other ingredients which is hard and time consuming process.

To overcome from above issues we are combining IOT and Reinforcement Learning (RL) algorithm where IOT will sense current field condition and then input to RL algorithm which will predict weather field is Dry, Wet, Very Dry and Very wet. Based on predicted values IOT will switch ON or OFF water and can provide other ingridients. By employing RL algorithm manual process can be avoided and IOT will give required amount of water to crop.

Reinforcement learning algorithms takes decision using Environment, Agent and Actions. Here Current Field Condition is the Environment and Agent will always monitor environment and call Action function to predict field condition. If RL manages to predict correct value then it will get rewarded else get penalised. To earned rewards RL will predict accurate values and prediction error will be avoided.

In below screen we are showing code for AGENT and Environment

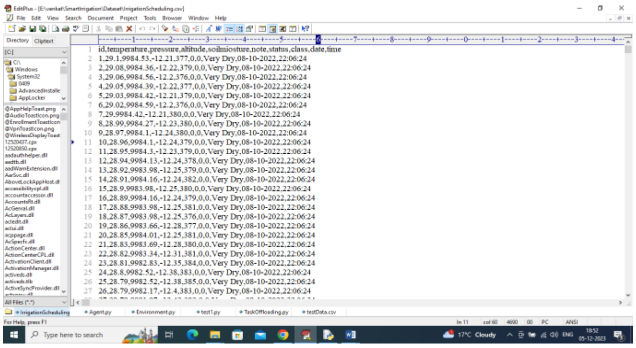


```
from numpy import dot
from numpy.linalg import norm

class Environment:
    #Agent will call environment action function to predict field condition
    def action(self, train_data, train_label, test_data):
        label = None
        score = 0
        for i in range(0, 100):
            predict = dot(train_data[i], test_data) / (norm(trai
            if predict > score:
                score = predict
                label = train_label[i]
        return label
```

```
from Environment import *
import math

class Agent:

    def __init__(self, ob:Environment):
        self.total_rewards = 0
        self.penalty = 0
        self.ob = ob

    def predictCondition(self, X_train, y_train, testData):
        predict = self.ob.action(X_train, y_train, testData)
        return predict
    #agent step function always monitor environemnt and call action to predict
    #field condition
    def step(self, X_train, y_train, X_test, y_test):
        self.total_rewards = 0
        self.penalty = 0
        for i in range(len(X_test)):
            predict = self.ob.action(X_train, y_train, X_test[i])
            if predict == y_test[i]:
                self.total_rewards += 1
            else:
                self.penalty += 1
        return self.total_rewards, self.penalty
```

In above screen Agent and Environment will operate on agriculture field data to predict status.

To predict field statues we are training Reinforcement Learning algorithm with below dataset



```
id,temperature,pressure,altitude,soilmiosture,note,status,class,date,time
1,29.1,9984.53,-12.21,377,0,0,Very Dry,08-10-2022,22:06:24
2,29.08,9984.36,-12.22,379,0,0,Very Dry,08-10-2022,22:06:24
3,29.06,9984.56,-12.2,376,0,0,Very Dry,08-10-2022,22:06:24
4,29.05,9984.39,-12.22,377,0,0,Very Dry,08-10-2022,22:06:24
5,29.03,9984.42,-12.21,379,0,0,Very Dry,08-10-2022,22:06:24
6,29.02,9984.59,-12.2,376,0,0,Very Dry,08-10-2022,22:06:24
7,29,9984.42,-12.21,380,0,0,Very Dry,08-10-2022,22:06:24
8,28.99,9984.27,-12.23,380,0,0,Very Dry,08-10-2022,22:06:24
9,28.97,9984.1,-12.24,380,0,0,Very Dry,08-10-2022,22:06:24
10,28.96,9984.1,-12.24,379,0,0,Very Dry,08-10-2022,22:06:24
11,28.95,9984.3,-12.23,379,0,0,Very Dry,08-10-2022,22:06:24
12,28.94,9984.13,-12.24,378,0,0,Very Dry,08-10-2022,22:06:24
13,28.92,9983.98,-12.25,379,0,0,Very Dry,08-10-2022,22:06:24
14,28.91,9984.16,-12.24,382,0,0,Very Dry,08-10-2022,22:06:24
15,28.9,9983.98,-12.25,380,0,0,Very Dry,08-10-2022,22:06:24
16,28.89,9984.16,-12.24,379,0,0,Very Dry,08-10-2022,22:06:24
17,28.88,9983.98,-12.25,381,0,0,Very Dry,08-10-2022,22:06:24
18,28.87,9983.98,-12.25,376,0,0,Very Dry,08-10-2022,22:06:24
19,28.86,9983.66,-12.28,377,0,0,Very Dry,08-10-2022,22:06:24
20,28.85,9984.01,-12.25,381,0,0,Very Dry,08-10-2022,22:06:24
21,28.83,9983.69,-12.28,380,0,0,Very Dry,08-10-2022,22:06:24
22,28.82,9983.34,-12.31,381,0,0,Very Dry,08-10-2022,22:06:24
23,28.81,9982.83,-12.35,384,0,0,Very Dry,08-10-2022,22:06:24
24,28.8,9982.52,-12.38,383,0,0,Very Dry,08-10-2022,22:06:24
25,28.79,9982.52,-12.38,385,0,0,Very Dry,08-10-2022,22:06:24
26,28.79,9982.17,-12.4,383,0,0,Very Dry,08-10-2022,22:06:24
```

In above dataset screen first row represents dataset column names and remaining rows represents dataset values and dataset contains field temperature, pressure, status and other values. So by using above dataset will train RL algorithm and calculate rewards and penalties.

To implement this project we have designed following modules

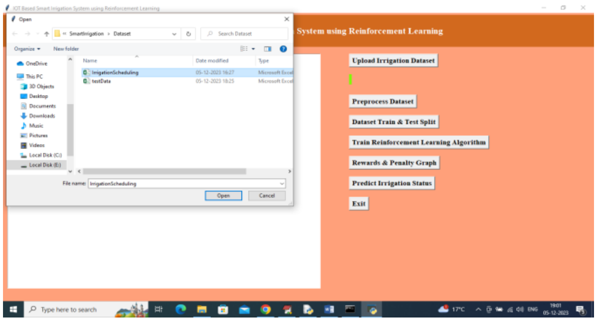
1) Upload Irrigation Dataset: using this module we will upload dataset to application and then extract class labels and features available in dataset
2) Preprocess Dataset: using this module will remove missing values and then normalized all values using Standard Scaler algorithm
3) Dataset Train & Test Split: split dataset into train and test where RL get trained on 80% dataset and then perform prediction on 20% test data and RL will get rewards for all correct prediction

4) Train Reinforcement Learning Algorithm: using this module RL will get trained on 80% dataset and evaluate performance on 20% test data
5) Rewards & Penalty Graph: will plot rewards and penalties graph earned by RL algorithm
6) Predict Irrigation Status: upload test data and then RL will predict field condition as Wet, DRY etc.

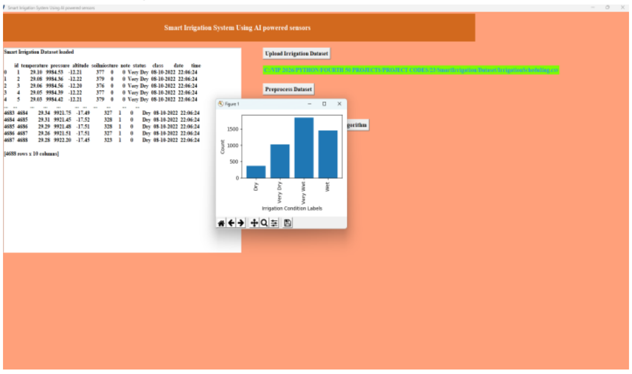
SCREEN SHOTS

To run project double click on ‘run.bat’ file to get below screen

In above screen click on ‘Upload Irrigation Dataset’ button to upload dataset and get below output



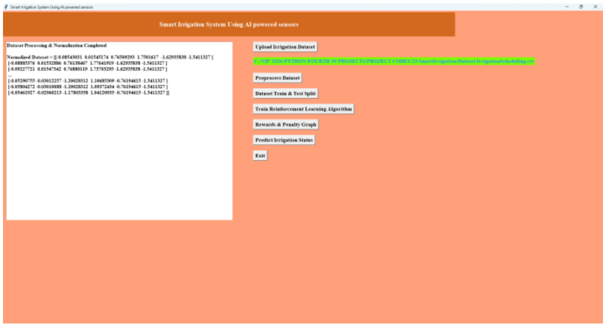
In above screen selecting and uploading Irrigation dataset and then click on ‘Open’ button to load dataset and get below output



```
Smart Irrigation Dataset loaded

      id  temperature  pressure  altitude  soilmiosture  note  status     class        date      time
0      1        29.10   9984.53    -12.21           377     0       0  Very Dry  08-10-2022  22:06:24
1      2        29.08   9984.36    -12.22           379     0       0  Very Dry  08-10-2022  22:06:24
2      3        29.06   9984.56    -12.20           376     0       0  Very Dry  08-10-2022  22:06:24
3      4        29.05   9984.39    -12.22           377     0       0  Very Dry  08-10-2022  22:06:24
4      5        29.03   9984.42    -12.21           379     0       0  Very Dry  08-10-2022  22:06:24
...  ...          ...       ...       ...           ...   ...     ...       ...         ...       ...
4683 4684       29.34   9921.75    -17.49           327     1       0       Dry  08-10-2022  22:06:24
4684 4685       29.31   9921.45    -17.52           328     1       0       Dry  08-10-2022  22:06:24
4685 4686       29.29   9921.48    -17.51           328     1       0       Dry  08-10-2022  22:06:24
4686 4687       29.26   9921.51    -17.51           327     1       0       Dry  08-10-2022  22:06:24
4687 4688       29.28   9922.20    -17.45           323     1       0       Dry  08-10-2022  22:06:24

[4688 rows x 10 columns]
```

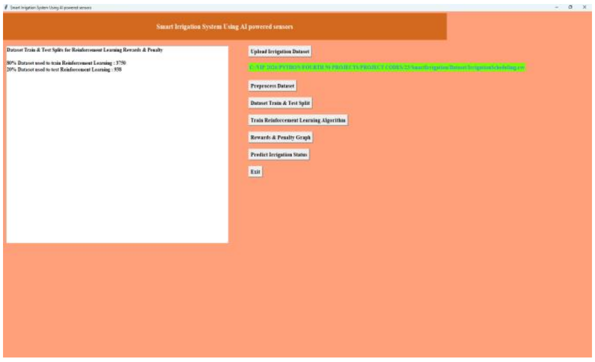
C:/VIP 2026/PYTHON/FOURTH 50 PROJECTS/PROJECT CODES/23/SmartIrrigation/Dataset/IrrigationScheduling.csv

In above screen dataset loaded and in graph can see types of field condition where x-axis represents Condition and y-axis represents number of instances that condition hold in dataset and now close above graph and then click on “Pre-process Dataset” button to clean and normalized dataset and get below output



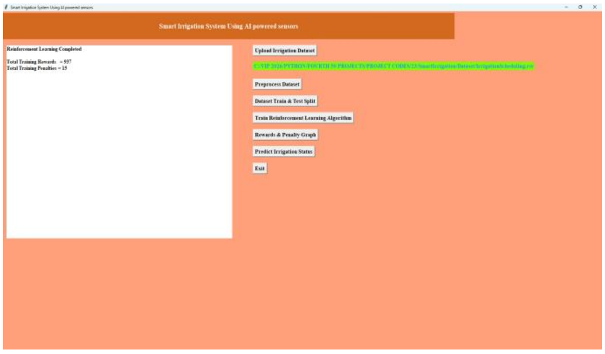
```
Dataset Processing & Normalization Completed

Normalized Dataset = [[-0.08543031  0.01545174  0.76509293  1.7501617  -1.62935838 -1.5411327 ]
 [-0.08885376  0.01532886  0.76138467  1.77641919 -1.62935838 -1.5411327 ]
 [-0.09227721  0.01547342  0.76880119  1.73783295 -1.62935838 -1.5411327 ]
 ...
 [-0.05290755 -0.03012257 -1.20028312  1.10685309 -0.76194615 -1.5411327 ]
 [-0.05804272 -0.03010088 -1.20028312  1.09372434 -0.76194615 -1.5411327 ]
 [-0.05461927 -0.02960213 -1.17803358  1.04120935 -0.76194615 -1.5411327 ]]
```

In above screen can see normalized dataset values and then click on 'Dataset Train & Test Split' button to split dataset into train and test and then will get below output



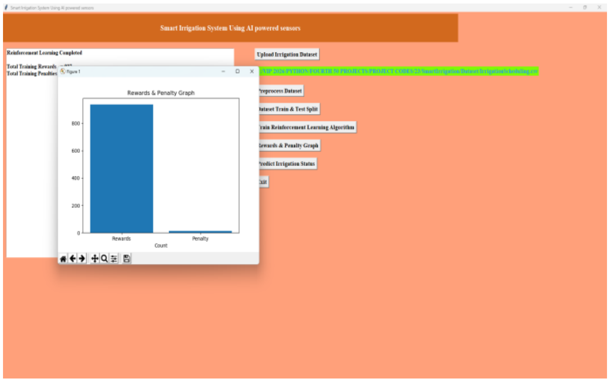
```
Dataset Train & Test Splits for Reinforcement Learning Rewards & Penalty

80% Dataset used to train Reinforcement Learning : 3750
20% Dataset used to test Reinforcement Learning : 938
```

In above screen can see train and test size and now click on 'Train Reinforcement Learning Algorithm' button to train RL and get below output



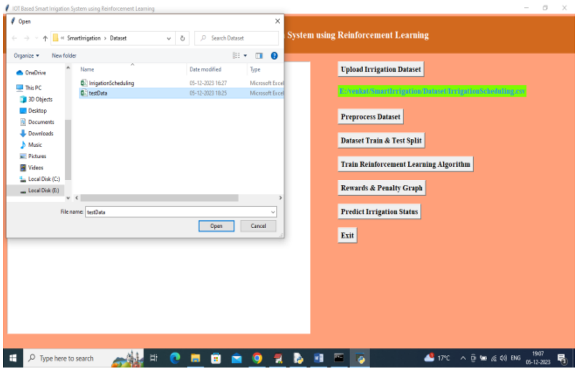
```
Reinforcement Learning Completed

Total Training Rewards  = 937
Total Training Penalties = 15
```

In above screen can see number of rewards and penalties earned by RL by predicting on test data and can see penalties are very few compared to rewards so RL can predict field condition accurately and now click on Rewards & penalty Graph' to get below graph



```
Reinforcement Learning Completed

Total Training Rewards
Total Training Penalties
```

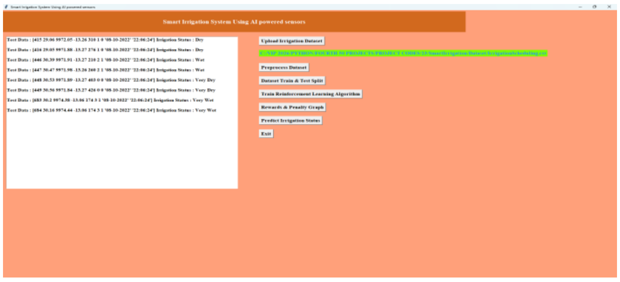
In above graph x-axis represents earned type and y-axis represents values and can see Rewards are more compare to Penalties and now close above graph and then click on 'Predict Irrigation Status' button to upload test data and get prediction



File name: testData

E:/venkat/SmartIrrigation/Dataset/IrrigationScheduling.csv

In above screen uploading test data and then click on 'Open' button to load test data and get below prediction



C:/VIP 2026/PYTHON/FOURTH 50 PROJECTS/PROJECT CODES/23/SmartIrrigation/Dataset/IrrigationScheduling.csv

```
Test Data : [415 29.06 9972.05 -13.26 310 1 0 '08-10-2022' '22:06:24'] Irrigation Status : Dry
Test Data : [416 29.05 9971.88 -13.27 276 1 0 '08-10-2022' '22:06:24'] Irrigation Status : Dry
Test Data : [446 30.39 9971.91 -13.27 210 2 1 '08-10-2022' '22:06:24'] Irrigation Status : Wet
Test Data : [447 30.47 9971.98 -13.26 260 2 1 '08-10-2022' '22:06:24'] Irrigation Status : Wet
Test Data : [448 30.53 9971.89 -13.27 403 0 0 '08-10-2022' '22:06:24'] Irrigation Status : Very Dry
Test Data : [449 30.56 9971.84 -13.27 426 0 0 '08-10-2022' '22:06:24'] Irrigation Status : Very Dry
Test Data : [683 30.2 9974.38 -13.06 174 3 1 '08-10-2022' '22:06:24'] Irrigation Status : Very Wet
Test Data : [684 30.16 9974.44 -13.06 174 3 1 '08-10-2022' '22:06:24'] Irrigation Status : Very Wet
```

In above screen in square bracket can see test data and after square bracket can see predicted field condition as Wet, Dry, Very Wet or Very Dry and based on above prediction IOT will give water to crop

CONCLUSION

The proposed Smart Irrigation System using AI-powered sensors provides an efficient and automated solution for modern agricultural water management. By continuously monitoring environmental parameters such as soil moisture, temperature, humidity, and weather conditions, the system ensures that irrigation is carried out only when necessary, thereby avoiding water wastage and improving resource utilization.

The integration of artificial intelligence and machine learning enables the system to make accurate and data-driven irrigation decisions in real time. This reduces the dependency on manual intervention and traditional fixed-schedule irrigation methods, which are often inefficient and inconsistent. As a result, crop health and yield are improved while conserving valuable water resources.

Overall, the system promotes precision agriculture by optimizing irrigation processes and ensuring sustainable farming practices. It contributes to better water management, increased agricultural productivity, and reduced operational costs, making it a reliable and effective solution for future smart farming applications.

FUTURE WORK

Future enhancements of the Smart Irrigation System using AI-powered sensors can focus on improving accuracy, scalability, and real-world adaptability in diverse agricultural environments. One major improvement is the integration of advanced deep learning models that can better analyze complex weather patterns, soil behavior, and crop water requirements over time.

The system can also be extended by incorporating real-time weather forecasting APIs and satellite-based climate data to improve irrigation decision-making. This would allow the system to proactively adjust irrigation schedules based on upcoming rainfall or temperature changes, rather than relying only on current sensor readings.

Future work may include integrating IoT-enabled drip irrigation controllers and smart valves for fully automated water distribution at the field level. The inclusion of mobile and web-based dashboards can help farmers monitor soil conditions and control irrigation systems remotely.

Additionally, expanding the system to support different crop types, soil regions, and climatic zones will improve its generalization capability. Research can also focus on reducing energy consumption of sensor networks and improving battery life for long-term field deployment.

Finally, incorporating predictive analytics for crop growth stages and water requirement estimation, along with edge computing for faster decision-making, will make the system more efficient, scalable, and suitable for large-scale smart agriculture applications.

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