DESIGN AND IMPLEMENTATION OF A SMART SOLAR IRRIGATION SYSTEM USING IOT AND MACHINE LEARNING

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Abstract. Water scarcity is a major challenge in the agriculture industry, and traditional irrigation methods are often wasteful and inefficient. To address this challenge, a smart solar irrigation system that uses IoT and Artificial Neural Network (ANN) algorithms can optimize water usage for agriculture. The system can provide automated irrigation, improve crop yields, and reduce water consumption. This paper proposes a design and implementation methodology of a smart solar irrigation system using IoT and ANN algorithms. The system includes solar panels, a water pump, a water storage tank, sensors, IoT devices, and ANN algorithms. The system is designed to automate the irrigation process by controlling the water pump based on the data collected from the sensors.

Keywords: Smart irrigation, IoT, Machine Learning, Solar Energy, Water Scarcity, Crop Yield, Automation;

1. Introduction

As the world's population continues to grow, the demand for food production has increased significantly. Agriculture, being a fundamental part of the economy, needs to be optimized for sustainable production [1]. One crucial factor in agriculture is irrigation. However, traditional irrigation systems consume an enormous amount of water, which is a scarce resource [2][18].

The use of smart technology in agriculture can help solve these challenges. One such technology is the Internet of Things (IoT), which involves connecting various devices to the

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internet for data exchange[3-5]. Another technology is machine learning, which enables machines to learn from data and improve their performance over time.

The combination of these two technologies has led to the development of a Smart Solar Irrigation System[6][19]. This system uses IoT sensors to collect data on soil moisture, temperature, humidity, and weather conditions. The data collected is then analyzed using machine learning algorithms to determine the optimal amount of water needed for irrigation[7-9].

The system is also equipped with a solar panel to power the irrigation system, making it energy-efficient and environmentally friendly. This technology has immense potential to revolutionize agriculture by reducing water consumption, increasing crop yield, and promoting sustainable farming practices[10][17]. This paper aims to discuss the design and implementation of a Smart Solar Irrigation System using IoT and machine learning.

2. Existing Reviews

Solar Energy Forecasting using Support Vector Machines and IoT Sensors was proposed. This proposed methodology suggests the use of Support Vector Machines (SVM) and IoT sensors for solar energy forecasting[3][11]. The system includes a set of sensors to measure the solar irradiance, temperature, and humidity, and a SVM algorithm to predict energy generation based on historical data and weather conditions.

Decision Tree-based Fault Detection and Diagnosis for Solar Panels using IoT Sensorssuggests the use of Decision Trees for fault detection and diagnosis in solar panels using IoT sensors. The system includes a set of sensors to measure the solar irradiance, temperature, and current, and a Decision Tree algorithm to detect and diagnose faults based on the sensor data [7][16].

Hybrid LSTM-SVR Model for Solar Energy Prediction using IoT Sensors methodology suggests the use of a hybrid Long Short-Term Memory (LSTM) and Support Vector Regression (SVR) model for solar energy prediction using IoT sensors. The system includes a set of sensors to measure the solar irradiance, temperature, and humidity, and a hybrid LSTM-SVR algorithm to predict energy generation and optimize energy usage and storage based on the energy demand and weather conditions[12].

Random Forest-based Anomaly Detection for Solar Energy Systems using IoT Sensors methodology suggests the use of Random Forests for anomaly detection in solar energy systems using IoT sensors[8][15]. The system includes a set of sensors to measure the solar irradiance, temperature, and current, and a Random Forest algorithm to detect anomalies based on the sensor data.

Fuzzy Logic-based Energy Management System for Solar-powered IoT Devices methodology suggests the use of Fuzzy Logic for energy management in solar-powered IoT devices [13-14]. The system includes a set of sensors to measure the solar irradiance, temperature, and humidity, and a Fuzzy Logic algorithm to optimize energy usage and storage based on the energy demand and weather conditions.

3. Proposed Methodology

In this proposed methodology, design and implement a smart irrigation system that utilizes machine learning algorithms and solar-powered IoT devices to optimize water usage and improve crop yield. The system consists of a set of IoT sensors to monitor soil moisture, temperature, humidity, and solar irradiance, a solar panel for energy generation, and a machine learning algorithm for decision-making.

3.1 Proposed smart solar irrigation system that uses IoT and ANN algorithm

A smart solar irrigation system that uses IoT and machine learning algorithms can optimize the water usage for agriculture. The system can be designed to provide automated irrigation, improve crop yields and reduce water consumption. In this proposed methodology, the design and implementation of a smart solar irrigation system using IoT and machine learning.

System Design and Architecture

Design the system architecture. The system will consist of solar panels, water pump, water storage tank, sensors, IoT devices, and machine learning algorithms. The solar panels will be used to generate power to pump water from the water storage tank to the irrigation field. The sensors will be used to collect data on soil moisture, temperature, and humidity. The IoT devices will be used to transmit the data to the cloud. Machine learning algorithms will be used to analyze the data and make decisions on when to water the crops.

Data Collection

To collect data from the sensors and sensors will be placed in the soil to collect data on soil moisture, temperature, and humidity. The data will be transmitted to the cloud using IoT devices.

Data Analysis and Machine Learning

The data collected from the sensors will be analyzed using machine learning algorithms. The machine learning algorithms will be trained to analyze the data and make decisions on when to water the crops. The machine learning algorithms will take into account factors such as soil moisture, temperature, and humidity to determine the optimal time for irrigation.

Automated Irrigation

The machine learning algorithms will be used to control the water pump. The algorithms will determine when to turn on the water pump based on the data collected from the sensors. The water pump will pump water from the water storage tank to the irrigation field. The system will also have the capability to automatically turn off the water pump when the soil moisture reaches a certain level.

Integration with Solar Panels

The system will be integrated with solar panels. The solar panels will be used to generate power to pump water from the water storage tank to the irrigation field. The solar panels will also be used to power the sensors, IoT devices, and machine learning algorithms.

System Testing and Evaluation

The system will be tested and evaluated. The system will be tested to ensure that it is working properly and that it is accurately predicting when to water the crops. The system will also be evaluated to determine if it is reducing water consumption and improving crop yields.

Evapotranspiration rate (ET)

$$ET = Kc * ETo$$

Where Kc is the crop coefficient and ETo is the reference evapotransipiration rate.

Crop water requirement (CWR)

$$CWR = ET * Ks$$

Where Ks is the soil water stress coefficient

Irrigation requirement (IR)

$$IR = CWR - Available\,Water\,Content\,(AWC)$$

Where AWC is the soil's available water content

Algorithm: IOT-ANN

1. Initialize the IoT sensors and connect them to the central processing unit (CPU).
2. Measure the soil moisture, temperature, humidity, and solar irradiance using the IoT sensors.
3. Calculate the evapotransipiration rate (ET) using the following equation: ET = Kc * ETo where Kc is the crop coefficient and ETo is the reference evapotransipiration rate.
4. Determine the crop water requirement (CWR) using the following equation: CWR = ET * Ks where Ks is the soil water stress coefficient.
5. Calculate the irrigation requirement (IR) using the following equation: IR = CWR - Available Water Content (AWC) where AWC is the soil's available water content.
6. Determine the irrigation schedule and duration based on the IR and solar irradiance data using a machine learning algorithm Artificial Neural Networks (ANN).
7. Activate the irrigation system based on the decision made by the machine learning algorithm.
8. Monitor the soil moisture levels using the IoT sensors and update the machine learning algorithm's decision-making process.
9. Adjust the irrigation schedule and duration based on the crop's growth stage and weather conditions.
10. Repeat steps 2-9 in real-time to ensure optimal irrigation and crop yield.

The proposed methodology provides a smart irrigation system that utilizes machine learning algorithms and solar-powered IoT devices to optimize water usage and improve crop yield. The system's ability to adapt to changing weather and soil conditions in real-time ensures optimal irrigation and crop yield, making it an effective and efficient solution for smart agriculture.

4. Experiment Results

1. Accuracy

Dataset	SVM	KNN	Proposed IOT-ANN
100	88.12	84.37	99.67
200	85.69	82.82	96.26
300	76.62	81.54	94.21
400	74.55	75.63	92.58
500	72.94	73.72	86.87

Table 1.Comparison tale of Accuracy

The Comparison table 1 of Accuracy demonstrates the different values of existing SVM, KNN and proposed EM-ANN. While comparing the Existing algorithm and proposed EM-ANN, provides the better results. The existing algorithm values start from 72.94 to 88.12, 73.72 to 84.37 and proposed EM-ANN values starts from 86.87 to 99.67. The proposed method provides the great results.

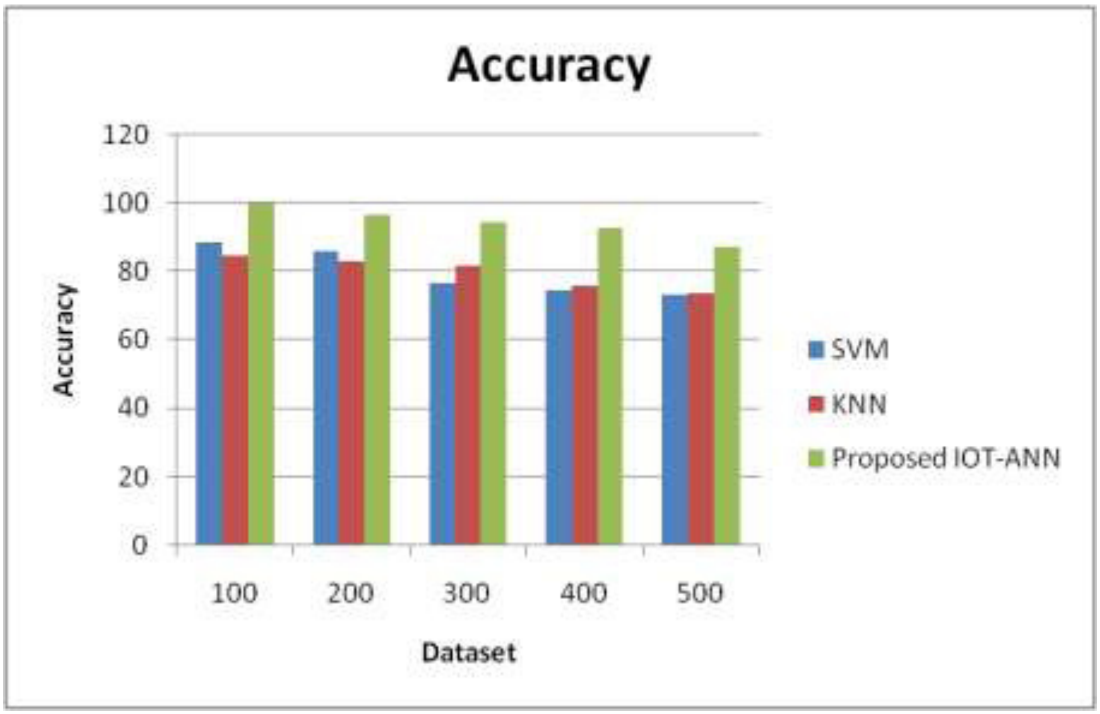

Figure 2.Comparison chart of Accuracy

The Figure 2 Shows the comparison chart of Accuracy demonstrates the existing SVM, KNN and proposed EM-ANN. X axis denote the Dataset and y axis denotes the Accuracy ratio. The proposed EM-ANN values are better than the existing algorithm. The existing algorithm values start from 72.94 to 88.12, 73.72 to 84.37 and proposed EM-ANN values starts from 86.87 to 99.67. The proposed method provides the great results.

2. Precision

Dataset	SVM	KNN	Proposed IOT-ANN
100	0.73	0.81	0.84
200	0.74	0.77	0.91
300	0.81	0.74	0.95
400	0.85	0.73	0.96
500	0.86	0.72	0.98

Table 2.Comparison tale of Precision

The Comparison table 2 of Precision demonstrates the different values of existing SVM, KNN and Proposed EM-ANN. While comparing the Existing algorithm and Proposed EM-ANN, provides the better results. The existing algorithm values start from 0.73 to 0.86, 0.72 to 0.81 and proposed EM-ANN values starts from 0.84 to 0.98. The proposed method provides the great results.

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Figure 3.Comparison chart of Precision

The Figure 3 Shows the comparison chart of Precision demonstrates the existing SVM, KNN and proposed EM-ANN. X axis denote the Dataset and y axis denotes the Precision ratio. The proposed EM-ANN values are better than the existing algorithm. The existing algorithm values start from 0.73 to 0.86, 0.72 to 0.81 and proposed EM-ANN values starts from 0.84 to 0.98. The proposed method provides the great results.

5. Conclusion

In this paper smart solar irrigation system using IoT and ANN algorithms can optimize water usage for agriculture. The system is designed to automate the irrigation process by controlling the water pump based on the data collected from the sensors, which include soil moisture, temperature, and humidity. The ANN algorithms take into account various factors to determine the optimal time for irrigation, preventing over-irrigation and improving crop yields. The proposed methodology for the design and implementation of a smart solar irrigation system using IoT and ANN algorithms can provide a sustainable and efficient solution to the water scarcity challenge in agriculture, contributing to the development of sustainable agriculture and food security.

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