A Project Report

on

Solar Tracking and Automatic Irrigation

Submitted in partial fulfillment of the requirements

for the award of degree of

BACHELOR OF TECHNOLOGY

in

Information Technology

by

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June, 2024

DECLARATION

We hereby declare that the work presented in this project entitled **"Solar Tracking and Automatic Irrigation"** submitted towards completion of in IV year II sem of B.Tech IT at "BVRIT HYDERABAD College of Engineering for Women",Hyderabd is an authentic record of our original work carried out under the esteemed guidance of Ms. R. Sravani, Assistant Professor, Department of Information Technology.

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CERTIFICATE

This is to certify that the Project report on **“ Solar Tracking and Automatic Irrigation ”** is a bonafide work carried out by **Rida Arshad Khan (20WH1A1210), R. Sangeetha (20WH1A1211), Madeeha Qamar (20WH1A1247)** and **G. Navvya Sri (20WH1A1253)** in the partial fulfillment for the award of B.Tech degree in **Information Technology , BVRIT HYDERABAD College of Engineering for Women, Bachupally, Hyderabad** affiliated to Jawaharlal Nehru Technological University, Hyderabad under my guidance and supervision.

The results embodied in the project work have not been submitted to any other university or institute for the award of any degree or diploma.

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ABSTRACT

Solar Tracking and Automatic Irrigation is a modern solution designed to enhance agriculture by improving water management, increasing crop yields, and reducing environmental impact. It addresses challenges such as water scarcity and climate change that affect traditional irrigation methods. The Solar Tracking and Automatic Irrigation integrates essential components: soil moisture sensors for precise scheduling, weather data for informed decisions, and real-time monitoring with intelligent algorithms for effective irrigation. This system focuses on conserving electricity and water. Automating the irrigation setup is to enable remote control and monitoring of the status of the setup even when farmer is away from the location.This paper proposes a new system with the use of advanced sensors and a Telegram Bot to provide SMS acknowledgment whenever there is any critical action that is initiated during the process. This includes water being pumped in excess to a crop, there is too much of sunlight for a sustained period and many other critical situations. The farmer will then have opportunity to, ARDUINO UNO,DC WATER PUMP,Moister Sensor, take necessary action It offers a sustainable solution for agriculture by optimizing water usage, improving crop yields, and reducing resource consumption.

Keywords: NODE MCU ESP8266, DHT 11 Sensor,DC WATER PUMP, Moister Sensor.

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LIST OF ABBREVATIONS

Abbrevation	Meaning
NODEMCU	Node MicroController Unit
ESP	Espressif modules
DHT	Digital Temperature And Humidity Sensor

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1. INTRODUCTION

The integration of cutting-edge technologies such as NODE MCU ESP8266, DHT 11 Sensor, ARDUINO UNO, DC WATER PUMP, and Moisture Sensor forms the bedrock of an innovative solution known as Solar Tracking and Automatic Irrigation. This groundbreaking system is poised to revolutionize the agricultural landscape by tackling the pressing challenges associated with water scarcity and the adverse impacts of climate change on conventional irrigation methods.

At its core, the Solar Tracking and Automatic Irrigation system leverages advanced components like the NODE MCU ESP8266 and DHT 11 Sensor, supplemented by the introduction of a Telegram bot, a departure from traditional messaging channels. This strategic integration empowers farmers with remote control and monitoring capabilities, ensuring seamless accessibility to critical agricultural processes even when they are physically distant from their fields.

The overarching goal of this pioneering system is to revolutionize water management practices, bolster crop yields, and mitigate the environmental ramifications inherent in conventional agricultural practices. By harnessing the capabilities of soil moisture sensors, sophisticated weather data analytics, and intelligent algorithms, the system orchestrates precise irrigation scheduling, thereby optimizing water utilization with unparalleled efficiency and precision.

The adoption of a DC water pump underscores the system's unwavering commitment to conserving vital resources such as electricity and water, thereby aligning seamlessly with sustainable agricultural practices. Moreover, the integration of a Telegram bot for communication purposes represents a significant departure from conventional messaging modalities. By furnishing farmers with real-time alerts and acknowledgments, the system ensures timely notification regarding pivotal actions, such as excessive water pumping or prolonged exposure to sunlight, thereby empowering farmers to make informed decisions.

In essence, the Solar Tracking and Automatic Irrigation system represents a paradigm shift in agricultural technology, harnessing the power of innovation to address pressing global challenges. By amalgamating state-of-the-art technologies with sustainable agricultural practices, the system not only enhances productivity but also fosters environmental stewardship and resilience in the agricultural sector.

Through its comprehensive suite of features, including remote monitoring, precision irrigation, and real-time communication via Telegram, the system empowers farmers with unprecedented control over their agricultural operations. By seamlessly integrating smart sensors, data analytics, and automation, it optimizes resource utilization, mitigates risks, and maximizes agricultural output in an era defined by uncertainty and volatility.

Furthermore, the system's reliance on renewable energy sources, such as solar power, coupled with its emphasis on water conservation, underscores its commitment to sustainability. By minimizing energy consumption and water wastage, the system not only reduces operational costs but also mitigates environmental impact, paving the way for a more resilient and ecologically sound agricultural ecosystem.

Solar Tracking and Automatic Irrigation system represents a transformative leap forward in agricultural technology. By harnessing the power of innovation and sustainability, it offers a viable solution to the complex challenges facing modern agriculture. As the global population continues to grow and environmental pressures intensify, solutions like these will play a pivotal role in ensuring food security, environmental sustainability, and economic prosperity for generations to come.

Figure 1: Smart Irrigation Using Solar panel

1.1. Objective

The objectives of the Solar Tracking and Automatic Irrigation project include optimizing water usage through moisture sensors, enhancing energy efficiency with solar tracking, ensuring climate resilience via weather analytics, enabling re- mote monitoring and control, improving crop yields through automated irrigation, emphasizing resource conservation, and promoting technological advancements in agriculture. The project aims to provide a holistic solution that addresses key challenges in farming while leveraging modern technologies for sustainability and increased productivity.

1.2. Problem Definition

The problem addressed by the proposed Solar Tracking and Automatic Irri- gation system lies in the inefficiencies and challenges inherent in traditional agri- cultural practices. Specifically, the issues of water scarcity and the adverse ef- fects of climate change pose significant obstacles to conventional irrigation meth- ods. Traditional approaches lack precision in water management and fail to adapt to changing environmental conditions. The reliance on manual intervention for monitoring and control further exacerbates the problem, especially when farm- ers are physically distant from their fields. The proposed system seeks to rectify these issues by introducing advanced components such as soil moisture sensors, weather data analytics, and intelligent algorithms, aiming to optimize water usage, increase crop yields, and reduce resource consumption. The identified problems revolve around the need for a sustainable and technologically advanced solution to address the limitations and inefficiencies of traditional agricultural practices in the context of evolving environmental challenges.

1.3 Modules

1) Solar Tracking Module
2) Moisture Sensing Module
3) Irrigation Control Module
4) Power Management Module

2. LITERATURE SURVEY

The reference paper titled ”Solar Tracking and Automatic Irrigation System”[1] authored by Manish Vasant Gurao and Prof. U. B. Vaidya and published in the International Journal of Engineering Research and Technology provides insights into an innovative solution designed to enhance agriculture. This system addresses key challenges in agriculture, such as water scarcity and the impact of climate change, by integrating solar tracking and automatic irrigation technologies. The paper begins by emphasizing the importance of improving water management, increasing crop yields, and reducing environmental impact in agriculture. It introduces the Solar Tracking and Automatic Irrigation System as a modern solution tailored to address these challenges. The integration of essential components is highlighted, including soil moisture sensors for precise scheduling, weather data for informed decisions, and real-time monitoring using intelligent algorithms for effective irrigation.

The paper titled ”Automatic Irrigation: A Comprehensive Review,” [2] authored by Arafat, A. M., Islam, M. A., Haque, M. E. and published in SN Computer Sci- ence in 2022, delves into the comprehensive landscape of automatic irrigation systems. This literature survey aims to explore and synthesize the knowledge pre- sented in the referenced paper, shedding light on the key aspects covered. The introduction of the paper likely sets the stage by emphasizing the importance of automatic irrigation in modern agriculture. The authors may highlight the sig- nificance of efficient water management, given the challenges posed by water scarcity and the need for sustainable agricultural practices. The review is likely to cover various automatic irrigation technologies, including sensor-based systems, smart controllers, and other innovative approaches. The literature survey would then explore the methodologies and technologies discussed in the paper. It is ex- pected to provide an overview of the existing automatic irrigation systems, detail- ing their functionalities, advantages, and limitations. The review may categorize these systems based on their sensing mechanisms, control strategies, and integra- tion with emerging technologies like the Internet of Things (IoT).

The referenced paper, ”Internet of Things (IoT) in Agriculture: A Comprehen- sive Review,” [3] authored by Maity, S., Naskar, S., Pradhan, A., and published in the Journal of Ambient Intelligence and Humanized Computing in 2021, provides an in-depth exploration of the applications and impact of the Internet of Things (IoT) in the agricultural domain. This literature survey aims to encapsulate the key insights presented in the paper, offering a condensed overview of the comprehen- sive analysis.The introduction of the paper likely establishes the significance of integrating IoT technologies into agriculture to enhance productivity, sustainabil- ity, and resource efficiency. The authors may emphasize the pressing challenges faced by the agricultural sector, such as climate change, population growth, and the need for more efficient farming practices. The review is expected to navigate through various aspects of IoT applications in agriculture, spanning from preci- sion farming to supply chain management. The literature survey would likely delve into the specific IoT technologies and devices discussed in the paper. This could include sensors for monitoring soil conditions, climate, and crop health, as well as actuators for automated irrigation and machinery control. The authors may categorize these technologies based on their functionalities and applications, illustrating the diverse range of IoT solutions available for modern agriculture

The paper authored by N. Kumar, G. Chauhan, and S. P. Singh, titled Ïnternet of Things (IoT)-based Smart Agriculture: A Comprehensive Review,”[4] published in the Journal of Ambient Intelligence and Humanized Computing in 2020, conducts a thorough examination of the integration of the Internet of Things (IoT) in the context of smart agriculture. The literature survey likely encompasses an extensive analysis of existing research, focusing on the application of IoT technologies to enhance various facets of agriculture. This review is expected to cover topics such as precision farming, crop monitoring, livestock management, and environmental sensing, exploring the ways in which IoT-driven solutions contribute to increased efficiency, sustainability, and productivity in agriculture. Additionally, the paper may discuss challenges associated with the implementation of IoT in smart agriculture and propose potential avenues for future research. The comprehensive nature of this literature survey is anticipated to provide valuable insights into the current state of IoT smart agriculture.

In their study published in Progress in Photovoltaics Research and Applications, T. Lee, J. Kim, S. Cho, S. Pyo, K. Song, and J. Lee [5] present a literature survey focusing on planar-type concentrating photovoltaics (CPV) with cylindrical lenses directly integrated with thin flexible GaAs solar cells. Their survey likely explores advancements in CPV technology, integration of cylindrical lenses with thin flexible GaAs solar cells, and the benefits of such integration. They may also discuss the potential improvements in light concentration and energy conversion efficiency achieved through this approach, contributing to the understanding and development of efficient solar energy harvesting methods.

The paper authored by Lagos et al.'s 2020 [6] study delves into the challenges associated with determining soil moisture and evaporation fluxes using distributed temperature sensing methods. They navigate through existing literature on the subject, addressing key issues such as spatial and temporal variability, sensor calibration, and data interpretation techniques. The survey encompasses a broad spectrum of research efforts aimed at understanding and overcoming the complexities inherent in utilizing distributed temperature sensing for accurate soil moisture and evaporation flux measurements.

Zhang et al.'s 2020 [7] research introduces a multifrequency-swept microwave sensing system designed for moisture measurement of sweet corn, utilizing deep neural network algorithms. Their work builds upon a growing body of literature exploring microwave sensing techniques for agricultural applications. Prior studies have investigated various methods for moisture detection in agricultural products, including microwave sensing, which offers advantages such as non-destructive measurement and sensitivity to moisture content. The integration of deep neural network algorithms represents a novel approach to enhance the accuracy and efficiency of moisture measurement systems, addressing challenges such as signal processing and data interpretation.

Gupta et al.'s 2020 [8] study introduces a novel autoscaling variable perturbation size maximum power point tracker (MPPT) applied to photovoltaic (PV) systems. This research builds upon a foundation of previous literature exploring MPPT techniques for optimizing the performance of PV systems. Numerous studies have investigated various MPPT algorithms, aiming to improve efficiency and reliability in harvesting solar energy. Gupta et al.'s approach represents an innovative contribution to this field, addressing challenges such as rapid changes in environmental conditions and fluctuations in solar irradiance.

Rocha et al.'s 2020 [9] study investigates the analysis of different tracking intervals for Parabolic Trough Collectors (PTCs) utilized in water disinfection for agricultural applications. Their research contributes to a broader literature exploring the utilization of solar thermal technologies for water treatment in agricultural settings. Previous studies have examined various solar-based disinfection methods, emphasizing the potential for sustainable and cost-effective water treatment solutions. Rocha et al.'s focus on tracking intervals for PTCs offers insights into optimizing system performance and energy efficiency, addressing practical considerations for implementing solar-driven water disinfection technologies in agricultural contexts.

Radwan and Mohamed's 2020 [10] study investigates grid-connected windsolar cogeneration employing back-to-back voltage-source converters (VSCs). Their research builds upon a foundation of prior literature exploring renewable energy integration and hybrid power generation systems. Previous studies have examined various aspects of wind and solar energy integration into the grid, emphasizing the importance of efficient power conversion and control strategies. Radwan and Mohamed's focus on back-toback VSCs represents a novel approach to enhancing the stability and reliability of grid-connected wind-solar systems, addressing challenges such as power quality issues and grid synchronization. Their work contributes to the ongoing efforts to advance renewable energy technologies and promote sustainable power generation solutions.

The paper authored by M. Tomar and T. Patidar, titled ”Development of a low Cost Soil Moisture Sensor,”[11] 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN), Vellore, India, 2019, The field of soil moisture sensing is crucial for agricultural practices and environmental monitoring. Traditional methods for measuring soil moisture have limitations, prompting the exploration of new, cost-effective sensor technologies. A comprehensive literature survey begins by introducing the significance of soil moisture and the current landscape of soil moisture measurement techniques. Existing soil moisture sensors, encompassing various types and technologies, are reviewed to establish a baseline understanding. This includes an exploration of working principles, advantages, and limitations, with a particular focus on the cost implications of commercially available sensors.

In their work published in the IET Power Electronics journal, S. Chauhan [12] and B. Singh present a literature survey focusing on grid-interfaced solar PV powered electric vehicle (EV) battery systems with a novel adaptive digital control algorithm. Their survey likely explores existing research related to grid-interfaced solar PV systems, electric vehicle charging infrastructure, and control algorithms for optimizing energy flow and battery management. They may discuss advancements in grid integration, renewable energy utilization, and the development of efficient and adaptive control strategies tailored for EV battery systems powered by solar photovoltaics. Through their survey, they aim to provide insights into the state-of-the-art technologies and approaches in this emerging field, contributing to the advancement of sustainable transportation and renewable energy integration.

3. SYSTEM DESIGN

3.1 Existing System

In the prevailing irrigation systems, drip irrigation and surface irrigation represent distinctive approaches with varying implications for agricultural practices. Drip irrigation, an advanced and targeted methodology, involves the precise delivery of water directly to the root zones of plants through an intricate network of tubes and emitters. This system is celebrated for its notable advantages, including heightened water conservation, minimized evaporation losses, and adaptability to diverse farming scales. Drip irrigation is particularly lauded for its efficiency in resource utilization, making it an attractive choice for farmers aiming to optimize crop yields while minimizing water consumption. Contrastingly, surface irrigation encompasses several traditional techniques, each characterized by the distribution of water over the soil surface. Methods such as furrow irrigation, where water flows in small channels along crop rows, basin irrigation, which involves forming basins around individual or groups of plants, and flood irrigation, submerging the entire field, are integral components of surface irrigation. While these methods are simpler and often more accessible, they pose challenges related to potential water wastage due to evaporation and runoff. The efficiency of surface irrigation is influenced by factors such as soil type, slope, and infrastructure. The choice between drip and surface irrigation hinges on various considerations, including the type of crops being cultivated, available resources, and the local agricultural landscape. As sustainable farming practices gain prominence, the ongoing evolution of irrigation systems reflects a continuous quest for methods that balance efficiency, resource conservation, and optimal crop production. Agricultural communities are increasingly tasked with navigating this dynamic landscape to implement irrigation solutions that meet the dual imperatives of productivity and sustainability.

Figure 2: Drip Irrigation

Figure 3: Surface Irrigation

3.2 Proposed System

The proposed system of the Solar Tracking and Automatic Irrigation project is a forward-looking solution that seeks to revolutionize conventional agricultural practices through the integration of cutting-edge technologies. At its core, the system incorporates a sophisticated solar tracking mechanism, powered by technologies such as NODE MCU ESP8266, to ensure the solar panels dynamically align with the sun, thereby maximizing energy absorption for efficient power generation. Complementing this, an automatic irrigation system is employed, utilizing moisture sensors and intelligent algorithms. This system continuously monitors real-time soil moisture levels, allowing for the automation of the irrigation process. By triggering irrigation only when necessary, the proposed system optimizes water usage, fostering resource efficiency and promoting healthy crop growth. Additionally, the integration of weather data analytics enhances the system's adaptability by considering external factors, ensuring a resilient and responsive approach to the challenges posed by variable climatic conditions. Overall, the proposed system strives to enhance agricultural productivity, reduce environmental impact, and pave the way for a more sustainable and technologically advanced approach to farming.With a focus on real-time data collection, the inclusion of the DHT11 sensor offers insights into temperature and humidity levels. This information allows for precise and adaptive irrigation scheduling, contributing to more efficient resource utilization.Temperature plays a pivotal role in determining crop health and growth rates. Extremes in temperature can stress plants, affecting their ability to photosynthesize and absorb nutrients efficiently. By monitoring temperature fluctuations with the DHT11 sensor, the system can adjust irrigation schedules accordingly. For instance, during hot periods, the system might increase irrigation frequency to prevent soil from drying out and plants from wilting. Conversely, during colder spells, it might reduce irrigation to prevent waterlogging and root rot. Humidity levels are equally significant, influencing plant transpiration rates and susceptibility to diseases. High humidity can create conditions favorable for fungal growth, while low humidity can accelerate water loss through transpiration. By monitoring humidity levels, the system can fine-tune irrigation schedules to maintain optimal moisture levels in the soil without promoting fungal diseases or excessive water loss.

3.3 Architecture

The system architecture for a combined solar tracking and automatic irrigation system is designed to seamlessly integrate hardware and software components for efficient solar energy utilization and automated irrigation processes. In the solar tracking subsystem, light sensors or photodiodes continually monitor sunlight intensity and direction, relaying real-time data to a microcontroller equipped with algorithms. The microcontroller calculates the deviation between the sun's current position and the optimal position for solar panels, initiating adjustments through an actuation mechanism, typically comprised of motors or servos. Simultaneously, the automatic irrigation subsystem employs soil moisture sensors that communicate with another microcontroller. This microcontroller processes data from the sensors and triggers irrigation when soil moisture falls below a specified threshold, utilizing a water delivery system with pumps, valves, and pipes.

Both subsystems share centralized components, including a microcontroller that integrates data from solar tracking and irrigation modules, ensuring coordinated decision-making. The power supply is sourced from solar panels, with energy storage options like batteries for continuous operation during periods of low sunlight. The system incorporates wireless connectivity for data exchange and remote monitoring/control, facilitated through a user interface such as a graphical display or mobile application. Weather sensors contribute to the system's adaptability by monitoring environmental conditions, influencing solar tracking and irrigation operations based on real-time weather forecasts. Algorithmic logic guides decision-making, considering factors such as weather conditions, solar tracking data, and soil moisture levels to optimize energy capture and irrigation efficiency.

Furthermore, the architecture includes data logging and analytics components, storing historical data related to solar tracking, irrigation, and environmental conditions for analysis. The analytics module processes this data to provide insights, optimize system performance, and identify potential enhancements. Safety measures, including fault detection mechanisms and emergency shutdown protocols, ensure the system's reliability. In summary, this integrated architecture addresses the dual

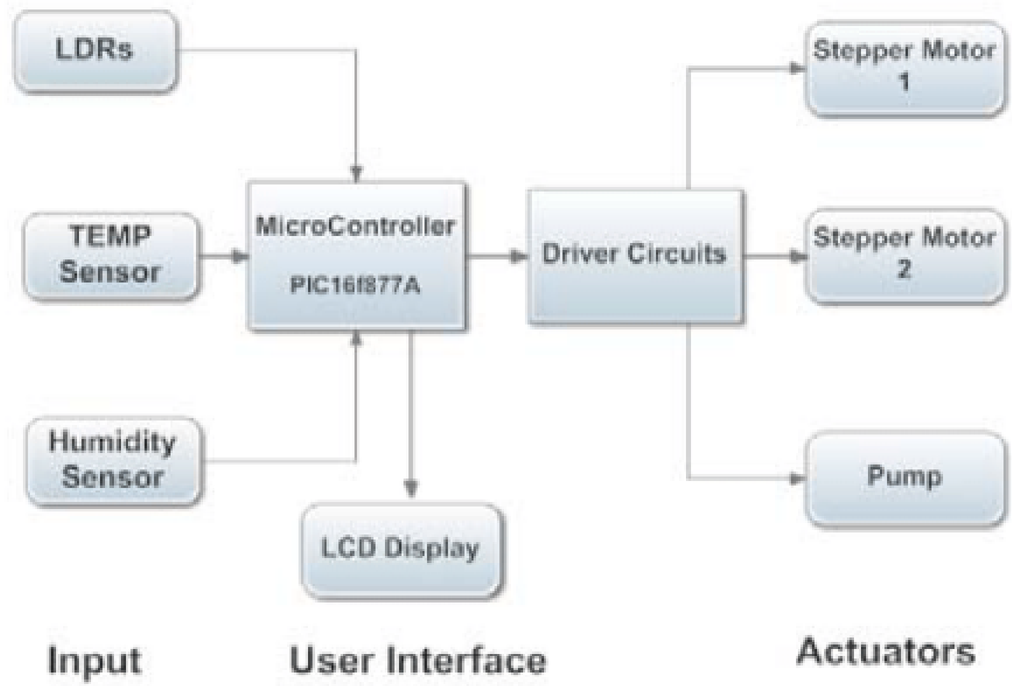

Figure 4: System Architecture

objectives of harnessing solar energy effectively and implementing automated irrigation, contributing to sustainable agriculture practices by promoting energy efficiency and water conservation.

3.4 Tools and Technologies

3.4.1 Microcontroller(ESP32)

The ESP32 microcontroller serves as the central processing unit of the system, responsible for executing programmed instructions and managing various tasks. With its dual-core architecture and built-in Wi-Fi and Bluetooth connectivity, the ESP32 is well-suited for handling the complex algorithms required for solar tracking, irrigation control, and data processing.

3.4.2 IoT (Internet of Things) Connectivity

IoT platforms play a crucial role in enabling remote monitoring and control of the system over the internet. In addition to the NodeMCU module mentioned, other IoT devices and platforms, such as MQTT (Message Queuing Telemetry Transport) brokers and cloud services like AWS IoT or Google Cloud IoT, can be integrated to facilitate seamless communication between the system and users or central servers.

3.4.3 Sensors (LDR, Soil Moisture Sensors, DHT11)

In addition to the Light Dependent Resistors (LDRs) used for solar tracking, various sensors provide essential data for efficient irrigation management. Soil moisture sensors measure the moisture content in the soil, allowing the system to determine when and how much to irrigate based on real-time moisture levels. Environmental sensors like the DHT11 monitor temperature and humidity, providing valuable insights for optimizing irrigation scheduling and ensuring ideal growing conditions for crops.

3.4.4 Power Management Systems

To ensure uninterrupted operation, especially in environments with fluctuating sunlight or during nighttime, robust power management systems are essential. This includes voltage regulators to stabilize the voltage supplied to the microcontroller and other components, as well as energy storage solutions such as batteries or supercapacitors to store excess energy generated by the solar panels for later use.

3.4.5 Wireless Communication

Wireless communication protocols, such as Wi-Fi, Bluetooth, or Zigbee, enable seamless connectivity between the system's components and facilitate data transmission to remote servers or user interfaces. By leveraging wireless communication, the system can transmit sensor data, receive commands for irrigation or solar tracking adjustments, and provide real-time updates to users or administrators.

3.4.6 Mechanical Components

Mechanical components, including mounts, gears, and actuators, are crucial for the physical assembly and operation of the solar tracking system. These components ensure precise alignment of the solar panels with the sun's position throughout the day, maximizing energy absorption. Additionally, durable materials and weatherproofing measures are essential to withstand environmental factors such as wind, rain, and temperature fluctuations, ensuring the longevity and reliability of the system.

3.5 UML Diagram

3.5.1 Class Diagram

A class diagram is a visual representation of the structure and relationships within a software system, essential for object-oriented design. Classes, depicted as boxes, encapsulate objects and contain attributes and methods. Relationships between classes, such as associations, inheritance, and dependencies, are illustrated with lines and symbols. Associations show how classes interact, inheritance depicts hierarchical relationships, and dependencies indicate reliance between classes. Aggregation and composition relationships describe whole-part associations. Class diagrams aid in understanding a system's architecture, facilitating effective communication among development teams.

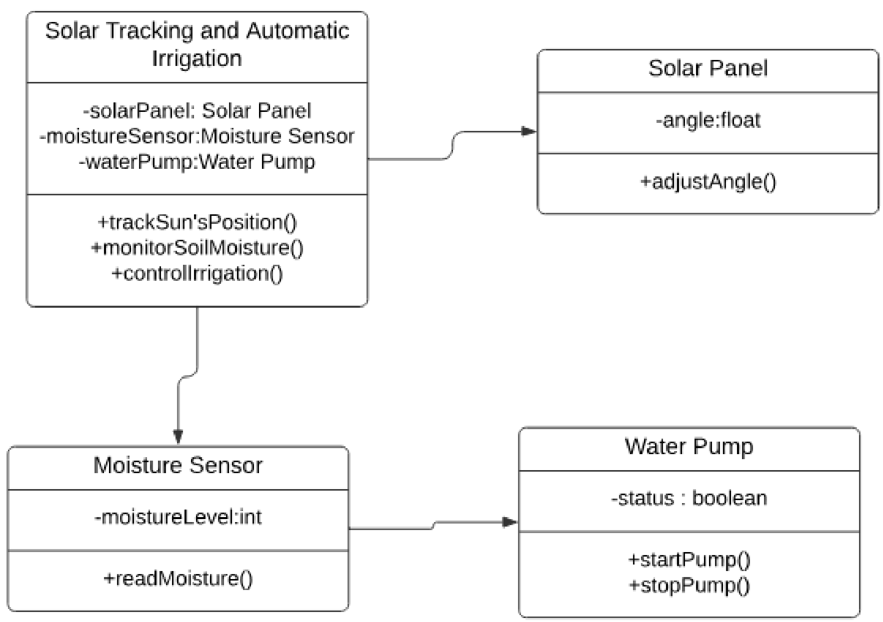

Figure 5: Class Diagram

3.5.2 Usecase Diagram

Use case diagrams in software design capture the interactions between users and a system, offering a visual representation of how different actors engage with the software to achieve specific goals. Actors, representing entities like users or external systems, are connected to use cases, which outline the functionalities of the system. Relationships between actors and use cases illustrate communication, and the system boundary defines the scope. Use case diagrams are instrumental in providing a high-level, user-centric overview of the software's behavior, helping stakeholders comprehend the system's functionality and how users interact with it as shown in Fig below

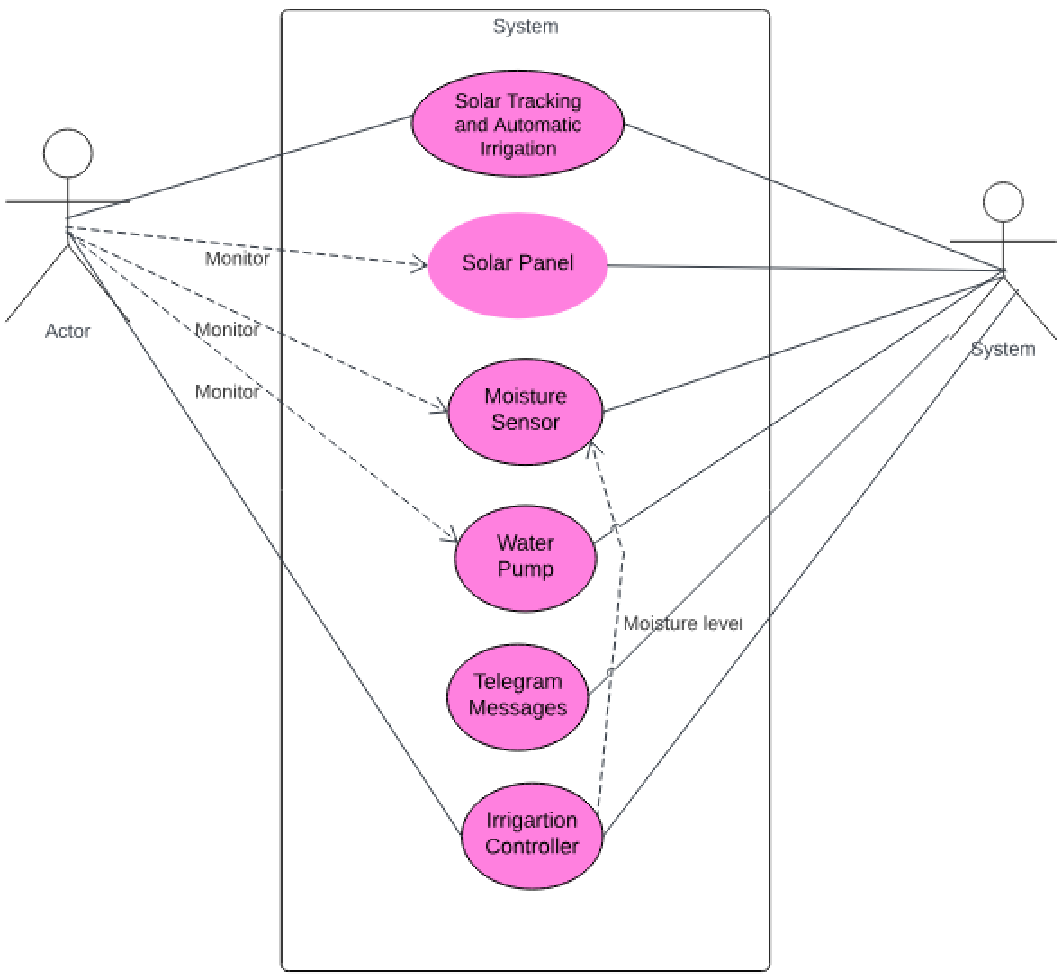

Figure 6: UML Diagram

3.6 Software and Hardware Requirements

3.6.1 Hardware

- Solar Panels- Photovoltaic panels that generate electricity from sunlight.
- Light Sensors (LDR sensors)- These sensors detect the intensity of light and help determine the position of the sun.
- Microcontroller- The brain of the system that processes data from sensors and controls the connected devices.
- Water Pump- A pump responsible for drawing water from a source and delivering it to the irrigation system.
- Relay Module- Controls the operation of devices such as the water pump based on signals from the microcontroller.
- LDR Sensor-A specific type of light sensor (Light Dependent Resistor) used to measure ambient light conditions.
- Battery-Stores excess energy generated by the solar panels for later use, ensuring continuous operation during low light conditions.
- LCD Screen-Provides a visual display for monitoring system status and information.

3.6.2 Software

- Libraries - Install and import required libraries in the Python environment, including WifiClientSecure,UniversalTelegramBot,ArduinoJson,LiquidCrystal.
- Solar Tracking - The isDaylight function checks if it's daytime based on the LDR reading. If it's daytime, the adjustSolarPanel function is called to move the solar panel.

- Automatic Irrigation - The soil moisture reading is checked against a threshold. If the soil moisture is below the threshold, the activateIrrigation function is called to start irrigation.
- Communication Module - Integrate a communication module to enable remote monitoring and control of the system.
- Safety Measures - The system only adjusts the solar panel during daylight to avoid unnecessary movements.
- Delay - A delay of 1 second is added to the loop to ensure stability and reduce unnecessary sensor readings. Control the Sprinkler through the Relay Module for timed water release.

4. METHODOLOGY

The Solar Tracking and Automatic Irrigation System operates through a comprehensive methodology that integrates solar tracking for efficient energy generation and automatic irrigation for optimal plant care. The process begins with the continuous collection of sunlight intensity data by Light Dependent Resistors (LDRs). This data is then processed by the microcontroller (ESP32), which calculates the sun's position and orchestrates mechanical adjustments to orient the solar panels for maximum exposure to sunlight throughout the day. Concurrently, soil moisture sensors and DHT11 environmental sensors gather real-time data on soil moisture, temperature, and humidity. The microcontroller analyzes this data to assess plant water needs, factoring in moisture levels and environmental conditions. Intelligent algorithms within the system make informed decisions regarding irrigation scheduling, triggering irrigation only when necessary to maintain optimal soil moisture levels and prevent both under and over-watering. By dynamically adjusting solar panel orientation and irrigation schedules based on real-time environmental data, the system maximizes energy generation efficiency and promotes healthy plant growth while conserving water resources.

4.1 Solar Tracking for Efficient Energy

The solar tracking component initiates the operation by employing light sensors or photodiodes to continually monitor sunlight intensity and direction. These sensors relay real-time data to a microcontroller equipped with algorithms. The microcontroller calculates the deviation between the current position of the sun and the optimal position, ensuring that the solar panels are oriented to capture maximum sunlight. The calculated adjustments are then communicated to an actuation mechanism, typically comprised of motors or servos, which repositions the solar panels accordingly. This dynamic solar tracking mechanism allows for the efficient harnessing of solar energy throughout the day, optimizing electricity generation.In addition to these fundamental functions, solar tracking systems often incorporate advanced features for enhanced performance. These include integration with weather sensors to adapt to changing weather conditions, mechanisms for detecting and mitigating dust or debris on solar panels, coordination with energy storage systems for optimal energy utilization, and remote monitoring capabilities for real-time data access and adjustments. Machine learning algorithms may also be employed to improve tracking accuracy over time. Dual-axis tracking systems further optimize efficiency by considering both azimuth and elevation angles. The integration of fault detection and diagnostics tools ensures prompt identification and resolution of potential issues, while energy yield monitoring provides valuable insights into system performance and aids in future project planning. Together, these features make solar tracking systems sophisticated, adaptable, and capable of maximizing energy production while maintaining operational reliability.Furthermore, solar tracking systems often integrate advanced features to enhance performance and adaptability. These enhancements include integration with weather sensors to dynamically adjust solar panel positioning in response to changing weather conditions, optimizing energy capture even during cloudy periods. Advanced systems may also incorporate mechanisms to detect and mitigate the accumulation of dust or debris on solar panels, ensuring optimal energy absorption and reducing maintenance requirements. By coordinating with energy storage solutions, such as batteries or capacitors, the system can store excess energy generated during peak sunlight hours for later use, thus optimizing energy utilization and providing consistent power output. IoT connectivity enables remote monitoring of system performance, real-time data access, and adjustments, empowering users to track energy production, monitor system efficiency, and receive alerts for maintenance or operational issues. Machine learning algorithms improve tracking accuracy over time by analyzing historical data and adjusting tracking parameters accordingly, thereby enhancing energy yield and system efficiency. Dual-axis tracking systems consider both azimuth and elevation angles, further optimizing energy capture by precisely aligning solar panels with the sun's position throughout the day and across seasons. Integration of fault detection tools ensures prompt identification and diagnosis of potential issues, minimizing downtime and maintaining operational reliability. Monitoring energy yield provides valuable insights into system performance, informing optimization strategies and guiding future project planning and expansion efforts. Together, these advanced features make solar tracking systems highly sophisticated, adaptable, and capable of maximizing energy production while ensuring operational stability and efficiency.

4.2 Automatic Irrigation for optimal plant care

Simultaneously, the automatic irrigation system complements the solar tracking functionality by incorporating soil moisture and temperature sensors. These sensors continuously measure the moisture content in the soil and the ambient temperature. The microcontroller processes this data and makes informed decisions based on predefined thresholds. If the soil moisture drops below a specified level or if the temperature conditions indicate the need for irrigation, the system activates control valves connected to the water supply. This triggers the automatic irrigation process, ensuring that plants receive water when necessary.

The microcontroller, acting as the central processing unit, orchestrates the synergy between the solar tracking and irrigation systems. It intelligently balances the energy generated by the solar panels with the plant's water requirements. For instance, during periods of abundant sunlight, the system may prioritize irrigating the plants to optimize both energy and water usage. Conversely, during low light conditions or at night, the system conserves energy by focusing on essential operations.The integrated system employs a feedback loop to enhance efficiency. After each irrigation cycle, the soil moisture sensors reassess the conditions. If the moisture level reaches the desired threshold, the system halts irrigation to prevent overwatering, conserving water resources and promoting sustainable agricultural practices.

Solar Tracking and Automatic Irrigation System seamlessly integrates solar tracking and automatic irrigation functionalities. It intelligently utilizes solar energy to generate electricity for the automatic irrigation of plants based on real-time soil moisture and temperature conditions. This holistic approach contributes to energy-efficient and water-conscious agricultural practices, offering an automated solution for sustainable farming.

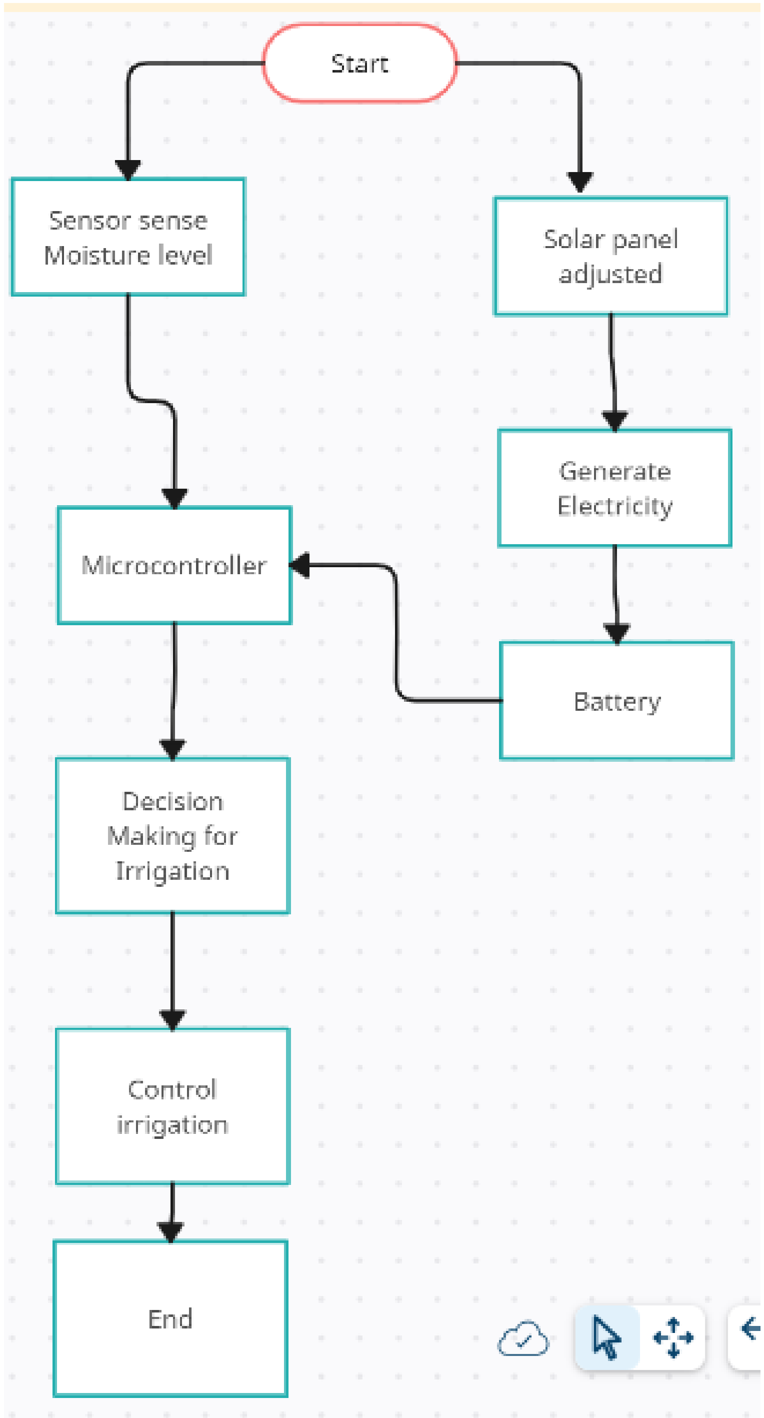

Figure 7: Flow Chart

4.3 Operation

In the decision-making flow chart for irrigation, the process begins with the crucial step of measuring soil moisture levels using specialized sensors. This initial assessment serves as a pivotal parameter in determining the irrigation requirements for the given agricultural environment. If the measured soil moisture falls below the predefined threshold, the system proceeds to additional checks to ensure a comprehensive evaluation of the irrigation needs.

Following this, the system incorporates a temperature assessment component to ensure that environmental conditions are conducive to effective irrigation. If the current temperature is within the suitable range for irrigation, the process advances to the evaluation of additional conditions. These conditions may encompass various factors such as the time of day, weather conditions, or other specific environmental parameters that could influence the decision-making process.

Upon the successful fulfillment of all conditions, the system initiates the irrigation process, strategically delivering water to the plants. Simultaneously, the system actively monitors both the duration of the irrigation cycle and the subsequent soil moisture levels. This continuous monitoring is essential for preventing under-irrigation, ensuring that the soil moisture reaches the desired level for optimal plant growth.

The decision-making flow chart incorporates a critical feedback loop, where the system checks whether the desired soil moisture level has been attained. If the desired level is not reached, the irrigation process continues to meet the specific moisture requirements of the soil. Conversely, if the soil moisture reaches the desired level, the system intelligently ceases irrigation to prevent overwatering, a practice that not only conserves water resources but also avoids potential harm to the plants caused by excessive moisture.

The iterative nature of the flow chart, looping back to the initial soil moisture measurement, highlights the adaptive and continuous nature of the decision-making process. This adaptability ensures that the system remains responsive to dynamic environmental changes, allowing for an efficient and sustainable approach to automatic irrigation within the Solar Tracking and Automatic Irrigation System. The ultimate goal is to optimize water usage, enhance agricultural productivity, and contribute to environmentally conscious farming practices.

5. IMPLEMENTATION

5.1 Code

```
#include <WiFi.h>
#include <WiFiClientSecure.h>
#include <UniversalTelegramBot.h>
#include <ArduinoJson.h>
#include <LiquidCrystal.h>

LiquidCrystal lcd(13,12,14,27,26,25);

// Network credentials
const char* ssid = "dell";
const char* password = "12345678";

// Initialize Telegram BOT Token and Chat ID
#define BOTtoken "5982198371:AAEL3cD2U6IyORf9zlOD_sl5-X85MXyhKbc"

// #define CHAT_ID "969506549"
#define CHAT_ID "5365066054"

WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);

const int LDRR = 16;
const int LDRL = 17;
```

```
const int moisturesensor = 4;

const int relay= 18;

const int motorP= 19;
const int motorN= 21;

const int TEMPSensor = 22;

int LDRStateR = 0;
int LDRStateL = 0;

int moistureState = 0;
int TempState = 0;

void setup() {

   Serial.begin(115200);

   pinMode(LDRR, INPUT);
   pinMode(LDRL, INPUT);
   pinMode(moisturesensor, INPUT);

   pinMode(TEMPSensor, INPUT);

   pinMode(relay, OUTPUT);
```

```
   pinMode(motorP, OUTPUT);
   pinMode(motorN, OUTPUT);

   WiFi.mode(WIFI_STA);
   WiFi.begin(ssid, password);

   // Add root certificate for api.telegram.org
  client.setCACert(TELEGRAM_CERTIFICATE_ROOT);

   // put your setup code here, to run once:
  lcd.begin(16, 2);
  lcd.print("SOLAR Tracking ");
  lcd.setCursor(0, 1);
  lcd.print("Sensor  SYSTEM ");

  bot.sendMessage(CHAT_ID, "Project started up", "");

}

void loop() {
  // put your main code here, to run repeatedly:
  LDRStateR     = digitalRead(LDRR);
  LDRStateL     = digitalRead(LDRL);
  moistureState = digitalRead(moisturesensor);

  TempState = digitalRead(TEMPSensor);
```

```
  if(LDRStateR == LOW)
 {
  Serial.print("Senosr Trigger");
  lcd.begin(16, 2);
  lcd.clear();
  lcd.print("LDR right sensor");
  lcd.setCursor(0, 1);
  lcd.print("  STATUS : ON   ");
  // bot.sendMessage(CHAT_ID, "LDR RIGHT", "");
  digitalWrite(motorP,HIGH);
  digitalWrite(motorN,LOW);
 }

else if(LDRStateL == LOW){
  Serial.print("Senosr Trigger");
  lcd.begin(16, 2);
  lcd.clear();
  lcd.print("LDR left sensor");
  lcd.setCursor(0, 1);
  lcd.print("  STATUS : ON   ");
  // bot.sendMessage(CHAT_ID, "LDR left", "");
  digitalWrite(motorP,LOW);
  digitalWrite(motorN,HIGH);
  }

else if(moistureState == HIGH){
```

```
  Serial.print("Moisture Trigger");
  lcd.begin(16, 2);
  lcd.clear();
  lcd.print("Moisture sensor ");
  lcd.setCursor(0, 1);
  lcd.print("  STATUS : ON   ");
  digitalWrite(relay,HIGH);
  bot.sendMessage(CHAT_ID, "Moisture Sensor Trigger", "");
  }


else if(TempState == LOW){
  Serial.print("Temperature Trigger");
   lcd.begin(16, 2);
  lcd.clear();
  lcd.print("Temperature sensor ");
  lcd.setCursor(0, 1);
  lcd.print("STATUS : Anormal");
  bot.sendMessage(CHAT_ID, "Temperature High", "");
  }

else
{
 lcd.begin(16, 2);
 lcd.clear();
 lcd.print("Checking Sensor ");
 lcd.setCursor(0, 1);
```

```
 lcd.print("Please wait.....");
 digitalWrite(relay,LOW);
 digitalWrite(motorP,LOW);
 digitalWrite(motorN,LOW);
}
}
```

5.2 Installation and Setup

- Connect Sensors to Microcontroller:

  Wire the LDR sensors to the microcontroller to measure light intensity. Program the microcontroller to interpret sensor data and determine the optimal position for the solar panels based on sunlight conditions.

- Connect Water Pump and Sprinkler to Relay Module:

  Establish connections between the water pump, sprinkler, and the relay module. The relay module, controlled by the microcontroller, manages the release of water for irrigation.

- Solar Panel Orientation Adjustment:

  Integrate a motorized system with the solar panels to adjust their orientation. The microcontroller calculates the sun's position and commands the motor to move the solar panels for optimal sunlight exposure

- Battery Integration:

  Connect the battery to the system, allowing it to store excess energy generated by the solar panels during peak sunlight hours. This stored energy ensures continuous operation during periods of low sunlight.

- LCD Screen Integration:

  Interface an LCD screen with the microcontroller to display relevant information such as solar panel orientation, energy levels, and irrigation status.

6. RESULTS & DISCUSSIONS

6.1 Connection to Microcontroller

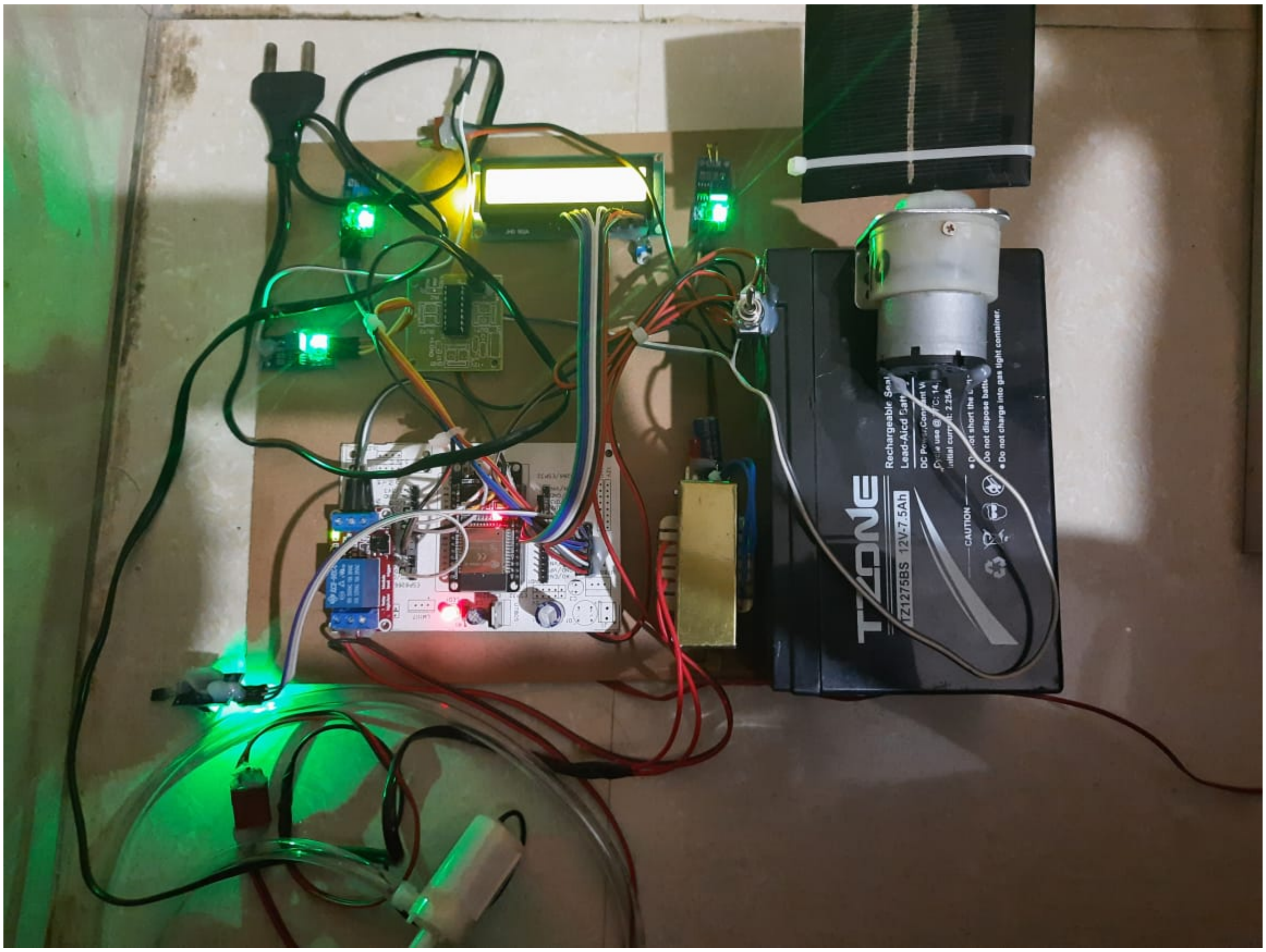

Figure 8: Connection to Microcontroller

6.2 Status of LCD

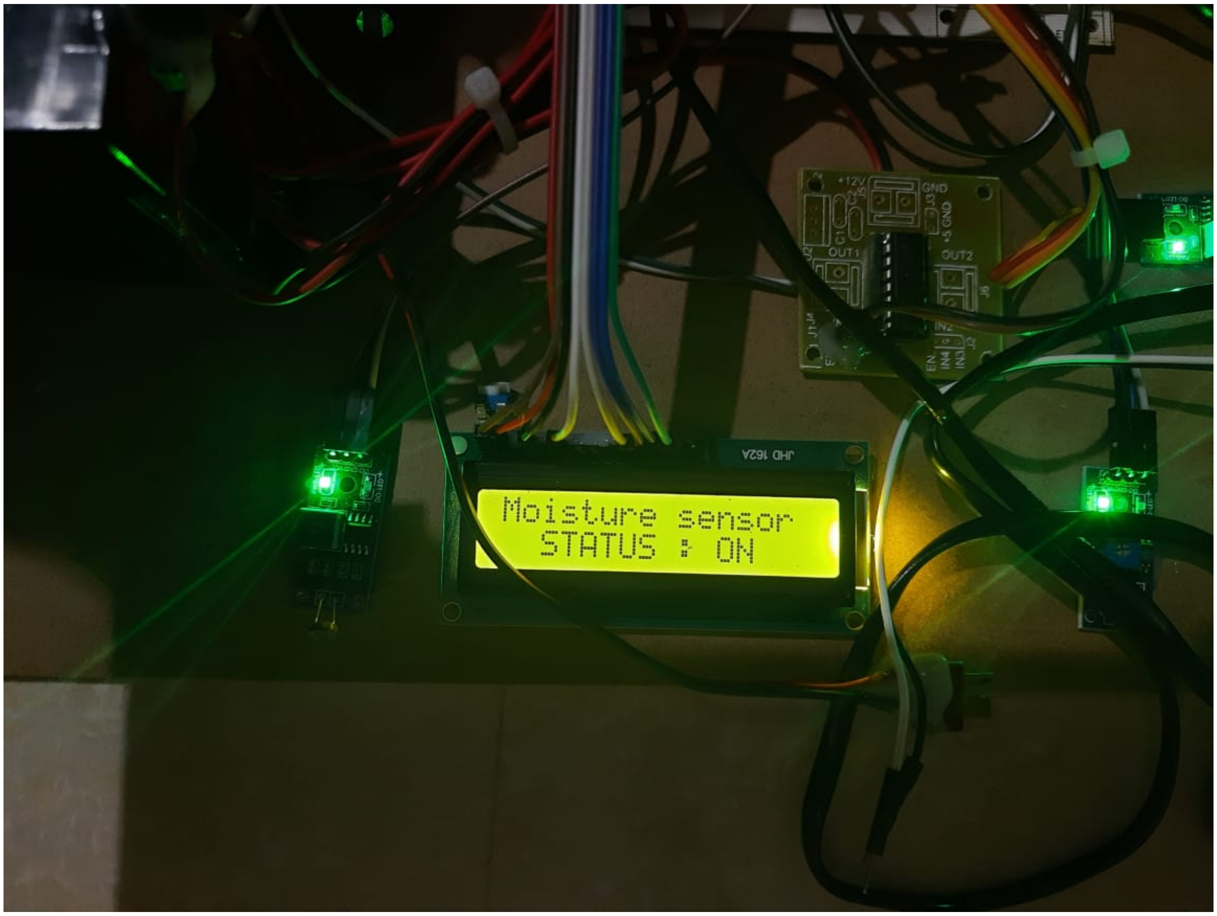

Figure 9: Status of LCD

6.3 Notification to Farmer

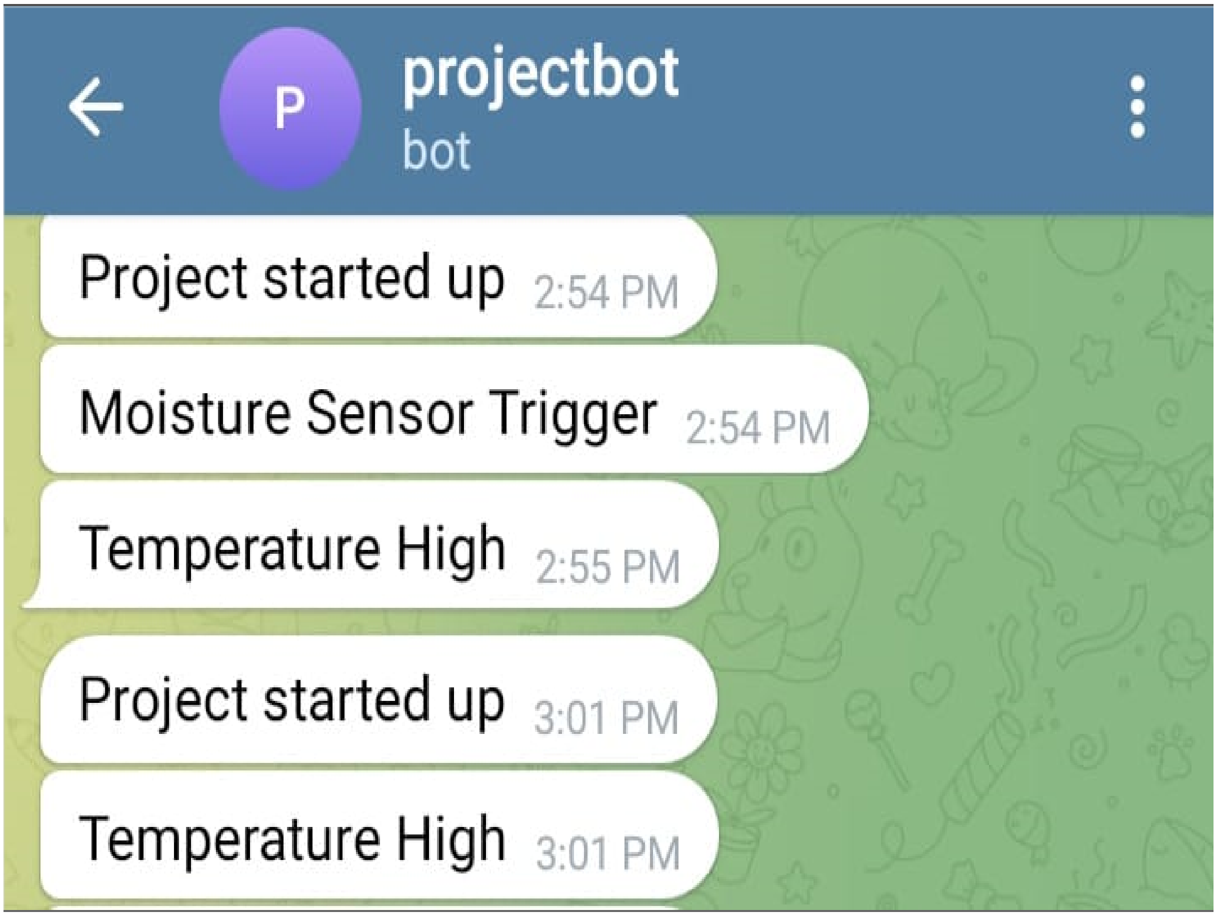

Figure 10: Notification to Farmer

6.4 Pumping of Water

Figure 11: Pumping of Water

7. CONCLUSIONS & FUTURE SCOPE

7.1 Conclusion

solar tracking and automatic irrigation systems represents a pivotal advancement in agricultural technology, offering a sustainable and resource-efficient solution. By dynamically aligning solar panels with the sun's trajectory, the system maximizes energy capture, reducing reliance on conventional power sources. Simultaneously, its automated irrigation functionality, responsive to real-time soil moisture levels, ensures judicious water usage, fostering optimal crop growth and yield. The convergence of these technologies not only enhances farm productivity but also contributes to environmental conservation. The system's adaptability, user-friendliness, and potential for future enhancements through advanced sensors and machine learning underscore its significance in addressing contemporary agricultural challenges. As agriculture continues to evolve, this integrated system stands as a beacon for precision farming, promising increased efficiency, reduced environmental impact, and a pathway towards sustainable and resilient agricultural practices.

7.2 Future Scope

1. Integration of Advanced Sensors:

   - Future iterations can incorporate advanced sensors for more comprehensive environmental monitoring. This may include the integration of soil quality sensors, nutrient level sensors, and advanced imaging systems for precise plant health assessment.

2. Smart Agriculture Platforms:

   - Integration with smart agriculture platforms can enhance connectivity and accessibility. Farmers could remotely monitor and control the system through mobile applications, providing real-time insights and control capabilities.

3. Weather Prediction Integration:

- Collaborating with meteorological services to integrate real-time weather prediction data can improve the system's ability to anticipate environmental changes and adjust its operations accordingly.

4. Energy Storage Solutions:

   - Exploring advanced energy storage solutions such as high-capacity batteries or innovative capacitor systems can improve the system's ability to store and utilize excess energy during periods of low sunlight.

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