IOT BASED SMART IRRIGATION SYSTEM USING DUAL AXIS SOLAR TRACKER

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Introduction

Agriculture is the backbone of many societies worldwide, providing food for billions of people. However, it is also a major consumer of water, accounting for about 70% of global freshwater withdrawals. In many regions, water scarcity is a growing problem, threatening food security and sustainable agricultural practices.

Traditional irrigation methods, such as flood irrigation and furrow irrigation, are often inefficient and wasteful. They can lead to waterlogging, soil salinization, and nutrient leaching, causing significant environmental damage. Additionally, these methods often require significant labour and energy inputs, increasing costs and reducing profitability.

For the irrigation system atomization is very much essential because of the shortage of water in soil and lack of rain. Automatic irrigation system with solar tracking is the alternative solution for this type of situation. Agricultural system in world is always in need and depends on the presence of water in the soil.

The continuous pulling out of soil water will reduce the moisture level of the soil. To overcome this issue intended irrigation system has to be followed. The better utilization of the available water will reduce the amount of wastage of water significantly. For this reason, automatic irrigation system is to be designed which will use the solar energy. The automatic irrigation with solar tracking system receives sun light through photo-voltaic cells.

Therefore this system is not dependent on electric power. This automatic irrigation with solar tracking system uses solar energy to power the irrigation pump and the circuit comprises of sensors which will sense the soil for its dry or wet condition.

Smart irrigation systems offer a promising solution to address the challenges of traditional irrigation methods. These systems use technology to improve water management and optimize irrigation processes. Key components of smart irrigation systems include:

- Sensors: These monitor soil moisture, weather conditions, and other relevant data to determine the precise water needs of the crops.
- Controllers: These use the data from the sensors to automatically activate and deactivate irrigation systems, ensuring the optimal delivery of water.
- Communication networks: These connect the sensors, controllers, and other devices, allowing for remote monitoring and control of the irrigation system.

The main objective of this project is to rotate the solar panels according to the sun’s position automatically and to use the water in most efficient ways. By using some hardware and software components we can design dual axis solar trackers with irrigation systems.

Dual Axis Solar Trackers: Optimizing Energy Efficiency

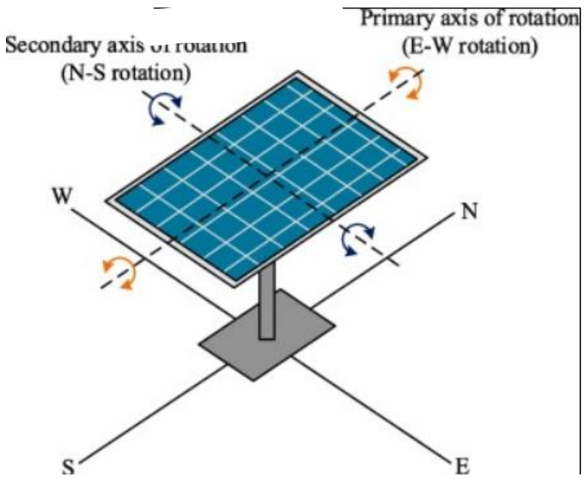

Figure 1.1 : Rotation of solar panel

Solar energy is a clean and renewable resource that can be used to power smart irrigation systems. Dual axis solar trackers further enhance the efficiency of solar power generation by maximizing the amount of sunlight captured by the solar panels. These trackers move the solar panels throughout the day to follow the sun's path across the sky, generating up to 40% more energy than stationary panels.

Advantages of a Smart Irrigation System with Dual Axis Solar Tracker are:

- Reduced water consumption: By precisely targeting irrigation based on real-time data, water usage is optimized, leading to significant water savings.
- Increased crop yield: Optimal water delivery ensures that crops receive the water they need to grow and flourish, resulting in higher yields.
- Reduced labor costs: Automation of the irrigation process significantly reduces the need for manual labor, freeing up time and resources for other tasks.
- Lower energy consumption: Dual axis solar trackers maximize solar energy generation, reducing reliance on the grid and minimizing energy costs.
- Environmental benefits: Reduced water consumption and energy use contribute to a more sustainable agricultural sector, minimizing environmental impact.

Objectives

- Suitable for various farm size from small to large scale agricultural operations.
- Adaptable to Different Crops: Tailored irrigation programs can be developed for specific crop needs.
- Remote Monitoring and Control: Allows farmers to manage their irrigation systems from anywhere with an internet connection.
- -Improved Food Security: Increased crop yields contribute to a more secure food supply for a growing population.
- Innovation for a Brighter Future: Smart irrigation systems represent an innovative approach to modern agriculture, paving the way for a more sustainable and productive future.
- Collect data on soil moisture levels over time to generate insights for better decision-making, such as optimizing irrigation strategies.
- Sustainability: Promote sustainable agriculture practices by reducing water wastage, energy consumption, and environmental impact associated with traditional irrigation methods.

Methodology used

- Dual Axis Solar Tracker:

  The dual axis solar tracking system is placed over the support which can move the solar panel according to our application. This support will move the plate by using two Servo motor. Servo motor is the DC motor which helps to rotate the solar panel. Over the solar plate, four LDR placed which helps to track the high intensity light according to which the solar panel starts moving. The LDR and resistors are connected in parallel with each other to provide the sufficient current to the electronic device. The input stage is designed with a voltage divider circuit so that it gives desired range of illumination for bright illumination conditions or when there is dim lighting. This made it possible to get readings when there is cloudy weather.

GSM based irrigation system:

The second method of the project, the energy generated through the solar panel will be sent to a DC battery. The battery will store the energy for further applications. Now we are connecting a water pump to the battery so that the motor should run on the power generated by the solar panel. We are making the irrigation system an intelligent one. In this system the water supply will be an automated one that means the pump will supply the water only when the land needs it. And the water pump will be controlled by a cellular phone from any remote location. In order to achieve this task we are making use of a moisture sensor and a GSM Module or device.

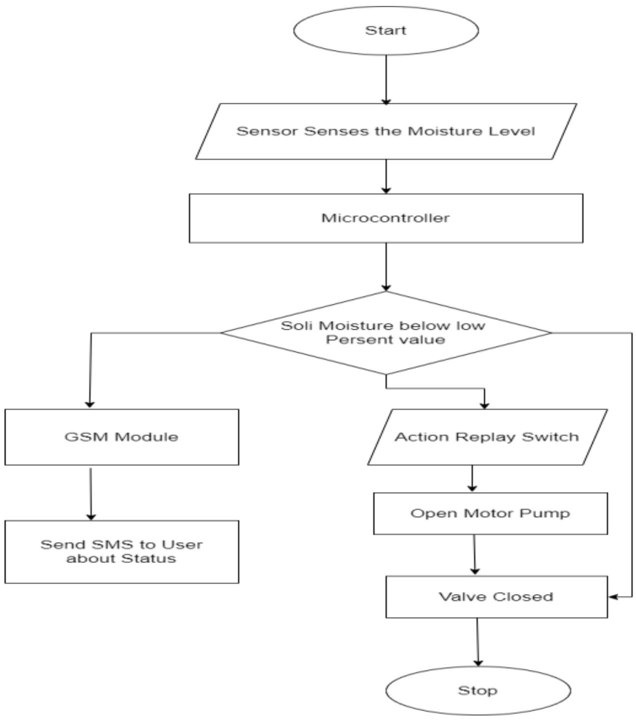

Figure 2: Flow chart of Smart irrigation System

Requirements can be verified against following conditions –

- Whether the product is implementing practically
- Whether the product is valid according the software domain and its functions
- Whether the project development facing difficulties ambiguities.

- Whether the project is complete.
- Whether the product will be demonstrated practically.

SOFTWARE REQUIREMENTS

- Operating System : Microsoft Windows 7 or Higher
- Coding Language : Embedded C
- Software Platform : Arduino IDE

HARDWARE REQUIREMENTS

- Arduino UNO
- GSM Module
- Soil Moisture sensor
- Servo Motor
- LCD 16x2 Display
- LDR sensor
- Solar panel

Result

The implementation of an IoT-based smart irrigation system utilizing a dual-axis solar tracker marks a significant leap forward in agricultural technology. By seamlessly integrating real-time data from a network of sensors with the precision of solar tracking technology, this system revolutionizes the way farmers manage their fields. Through constant monitoring of soil moisture levels, weather forecasts, and crop requirements, the system intelligently adjusts irrigation schedules to ensure that plants receive precisely the amount of water they need, exactly when they need it. This precision not only conserves water resources but also maximizes crop yield by promoting optimal growth conditions. Moreover, by harnessing solar energy through the dual-axis solar tracker, the system achieves unparalleled energy efficiency, reducing reliance on traditional power sources and lowering operational costs. This renewable energy source not only powers the irrigation system but also contributes to sustainability efforts, mitigating the carbon footprint associated with agriculture. The remote monitoring and control capabilities offered by the system provide farmers with unprecedented flexibility and insight into their fields' environmental conditions. Whether they're on-site or miles away, farmers can access real-time data and make informed decisions to optimize resource management and crop production. Overall, the IoT-based smart irrigation system with a dual-axis solar tracker represents a transformative solution for modern agriculture. By enhancing efficiency, productivity, and sustainability, it empowers farmers to meet the challenges of feeding a growing population while stewarding the planet's resources for future generations.

Conclusion

In conclusion, the implementation of a smart irrigation system utilizing a dual-axis solar tracker represents a significant leap forward in sustainable agriculture practices. The integration of advanced solar tracking technology ensures optimal utilization of sunlight, enhancing energy efficiency for powering irrigation processes.

By incorporating real-time data from soil moisture sensors and weather monitoring devices, the system intelligently adapts irrigation schedules, promoting water conservation and improving crop yield. The user-friendly interface, coupled with robust safety features, makes this solution accessible and reliable for farmers. In essence, this innovative approach not only maximizes resource efficiency but also exemplifies a harmonious blend of renewable energy and smart technology in agriculture, contributing to a more sustainable and productive future.

Scope for future work

- Advanced Data Analytics: Develop more sophisticated algorithms and machine learning models to analyze the vast amount of data collected by the system. This could include predictive analytics for anticipating crop water needs, disease detection, and optimizing energy generation from solar panels.
- Integration with IoT Ecosystems: Explore integration possibilities with other IoT devices and agricultural technologies to create a comprehensive farm management system. This could involve interoperability with drones, satellite imagery, and crop monitoring sensors to provide a holistic view of farm operations.
- Water Quality Monitoring: Expand the capabilities of smart irrigation systems to include monitoring water quality parameters such as pH levels,

salinity, and nutrient concentrations. This would enable farmers to adjust irrigation strategies based on water quality, ensuring optimal crop health and yield.

- Climate Resilience: Develop adaptive irrigation strategies that can respond to changing climate patterns, such as prolonged droughts or heavy rainfall events. This may involve dynamic adjustments to irrigation schedules and water distribution based on real-time weather forecasts and climate data.
- Energy Storage Solutions: Investigate the integration of energy storage solutions, such as batteries or capacitors, to store excess energy generated by the solar panels. This would enable continuous operation of the irrigation system during periods of low sunlight or at night, further enhancing energy efficiency and reliability.
- Scalability and Accessibility: Design the system to be easily scalable and accessible to farmers of all scales and regions. This could involve developing affordable and user-friendly hardware and software solutions tailored to the specific needs and resources of different agricultural communities.
- Remote Sensing Technologies: Explore the integration of remote sensing technologies, such as satellite imagery and LiDAR, to provide detailed insights into soil moisture distribution, crop health, and terrain characteristics. This would enhance the system's ability to make precise irrigation decisions and optimize resource allocation.
- Regulatory and Policy Support: Advocate for policies and regulations that support the adoption of smart irrigation technologies and renewable energy solutions in agriculture. This could include incentives for farmers to invest in sustainable practices and infrastructure, as well as regulatory frameworks for data privacy and cybersecurity.
- Collaborative Research Initiatives: Foster collaboration between researchers, industry stakeholders, and agricultural communities to co-create and validate innovative solutions. This interdisciplinary approach would leverage diverse expertise and perspectives to address complex challenges and drive meaningful impact in agriculture.
- Education and Outreach: Invest in education and outreach initiatives to raise awareness about the benefits of smart irrigation systems and

renewable energy technologies among farmers, policymakers, and the general public. This would facilitate broader adoption and uptake of sustainable practices in agriculture, contributing to long-term environmental and economic sustainability.