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AI-Based Irrigation System with Integrated Manufacturing Design and Predictive Analytics with the help of Mobile Application-A Review

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Abstract: This project presents the design and development of an AI-based smart irrigation system integrated with manufacturing technology. India is recognized as a diverse and agriculture-based country. Therefore, continuous efforts are being made to increase agricultural productivity and improve farming practices. Nowadays, farming operations are carried out with the help of advanced agricultural machinery in many countries. Information regarding crop requirements at different stages is obtained through sensors and Artificial Intelligence (AI). However, even with these technologies; a considerable amount of time is still consumed in certain processes. Since mobile phones are now widely available, the functions performed by sensors and AI can be integrated into mobile applications. By doing so, agricultural technology can be further enhanced, and the time required for decision-making and farm management can be significantly reduced.
Keywords: Developed Irrigation, Automatics indicates pipes design, Short time process.

I. INTRODUCTION

Food is supplied to us through agricultural cultivation. Therefore, proper care and maintenance of agricultural land are required. Necessary resources such as water and pesticides are provided according to the needs of the crops. However, these activities are time-consuming and often result in lower productivity.To address these challenges, various technologies, including sensors, have been introduced. At present, efforts are being made to further enhance agricultural practices through the use of Artificial Intelligence (AI) within a short period of time. In addition, efficient water supply is being ensured through pipe design developed using manufacturing techniques.In this project, it has been demonstrated how the functions of various sensors can be integrated into mobile applications. Furthermore, suitable manufacturing designs for pipe systems have been proposed so that irrigation can be carried out efficiently and agricultural productivity can be improved in less time.Agriculture consumes a large amount of water, and inefficient irrigation leads to wastage. Traditional irrigation methods depend on manual operation or fixed scheduling. This project introduces an intelligent irrigation system that automates and optimizes watering by utilizing AI and sensors with mobile application.

II. LITERATURE REVIEW

Global water scarcity and rising agricultural demand necessitate efficient irrigation management. Since irrigation accounts for nearly 70% of all freshwater withdrawals worldwide, it is essential to develop water management systems that are intelligent and long-lasting [1]. Overuse of water, soil degradation, and inefficient crop production are common outcomes of traditional irrigation methods. Earth Observation (EO) technologies have significantly improved irrigation planning and monitoring. The PLEIADeS project demonstrated that EO data combined with ICT tools can estimate irrigation water requirements and enhance decision-making across different climatic regions [2]. Similarly, satellite-based spectral analysis using VIS and NIR bands enables estimation of crop evapotranspiration and water demand, reducing dependency on field measurements [3].Wireless Sensor Networks (WSNs) and IoT-based irrigation systems have revolutionized precision agriculture. Automated irrigation control is made possible by these systems, which collect real-time data on temperature, soil moisture, and environmental conditions. By delivering water based on real-time sensor inputs, IoT-enabled smart irrigation systems improve water efficiency and crop productivity, according to research [4, 5]. Predictive analytics and decision-making are made possible by artificial intelligence (AI) and machine learning (ML).

AI-based systems can analyze historical and real-time data to forecast irrigation requirements and optimize resource utilization. Using satellite and sensor data, studies show that ML models can predict and classify irrigation with high accuracy (up to 90% or more) [6], [7]. Irrigation mapping and performance evaluation make extensive use of technologies like geographic information systems (GIS). These technologies aid in the detection of irrigation system inefficiencies, the monitoring of water distribution, and the identification of irrigated areas.
Using satellite imagery, it has been possible to map irrigated lands with high accuracy (up to 98 percent) [8]. Additionally, GIS-based evaluation methods provide insights into water distribution and agricultural performance at regional levels [9].In order to make smart irrigation systems accessible to small-scale farmers, recent advancements also focus on low-cost and energy-efficient sensor technologies. With their high accuracy and low power consumption, inductive soil moisture sensors and inexpensive IoT devices have demonstrated promising results [10, 11]. Integration of solar energy systems has been suggested to overcome power limitations in rural areas.For real-time monitoring and control, advanced systems also incorporate mobile applications, cloud computing, and decision support systems. Smart irrigation platforms using cloud-based analytics and weather forecasting can automatically adjust irrigation schedules, improving efficiency and reducing labor requirements [12]. Satellite-based models and hydrological approaches have also been developed to estimate irrigation water usage at large scales. Soil moisture, evapotranspiration, and rainfall data are used by these models to identify patterns in irrigation and optimize water allocation [13]. Despite significant advancements, challenges remain, including high initial costs, data reliability issues, and technical complexity. In order to create irrigation systems that are scalable, cost-effective, and self-learning, recent research suggests combining AI, EO, and IoT with manufacturing design.
Overall, the literature indicates that AI-driven smart irrigation systems combining Earth sensors, IoT, and remote sensing technologies offer a sustainable solution for modern agriculture by improving water efficiency, crop yield, and environmental sustainability.

III. SYSTEM COMPONENTS

Smart irrigation is made possible by the proposed system's combination of hardware and software components. The hardware setup includes a soil moisture sensor, temperature and humidity sensors, and a sensor to measure the amount of water in the soil. The central processing unit for the collection and analysis of sensor data is the ESP32 or Arduino microcontroller. The water pump, which is used to provide the field with water as needed, is controlled by a relay module integrated into the system. A dependable power source, like a battery or solar energy, powers the entire system, making it suitable for rural agricultural areas. The AI-based model that enables intelligent decision-making is developed with Python, and the microcontroller is programmed with Embedded C or the Arduino IDE on the software side. Additionally, the irrigation system's efficiency and usability can be enhanced by incorporating an Internet of Things platform that enables remote control and monitoring.

IV. MANUFACTURING TECHNOLOGY USED

Important manufacturing and design procedures are also incorporated into the development process to ensure the system's long-term viability and practicality in the real world. A waterproof casing is 3D printed to protect electronic components from the elements following the creation of the enclosure design through CAD modeling, which enables precise visualization and customization of the system housing. During fabrication, a sturdy metal frame is constructed for the proper mounting of all components. To guarantee structural stability and ease of installation in agricultural fields, welding and drilling techniques are used. In addition, careful soldering and component assembly are part of the PCB design process to ensure the system's reliable operation. Next, circuit layout planning is used to organize electronic connections in an efficient manner.

V. WORKING PRINCIPLE

Intelligent decision-making and continuous monitoring underpin the system's operation. Real-time data on soil moisture, temperature, and environmental conditions are gathered by sensors in the field. This data is then received by the microcontroller, the system's central processing unit. The AI algorithm processes the data it has collected, looks for patterns, and makes predictions about the crops' exact irrigation needs. The system automatically turns on or off the water pump in response to these predictions to provide the required quantity of water. The system's capacity to store feedback data from each irrigation cycle also makes the process of irrigation more adaptable and effective.

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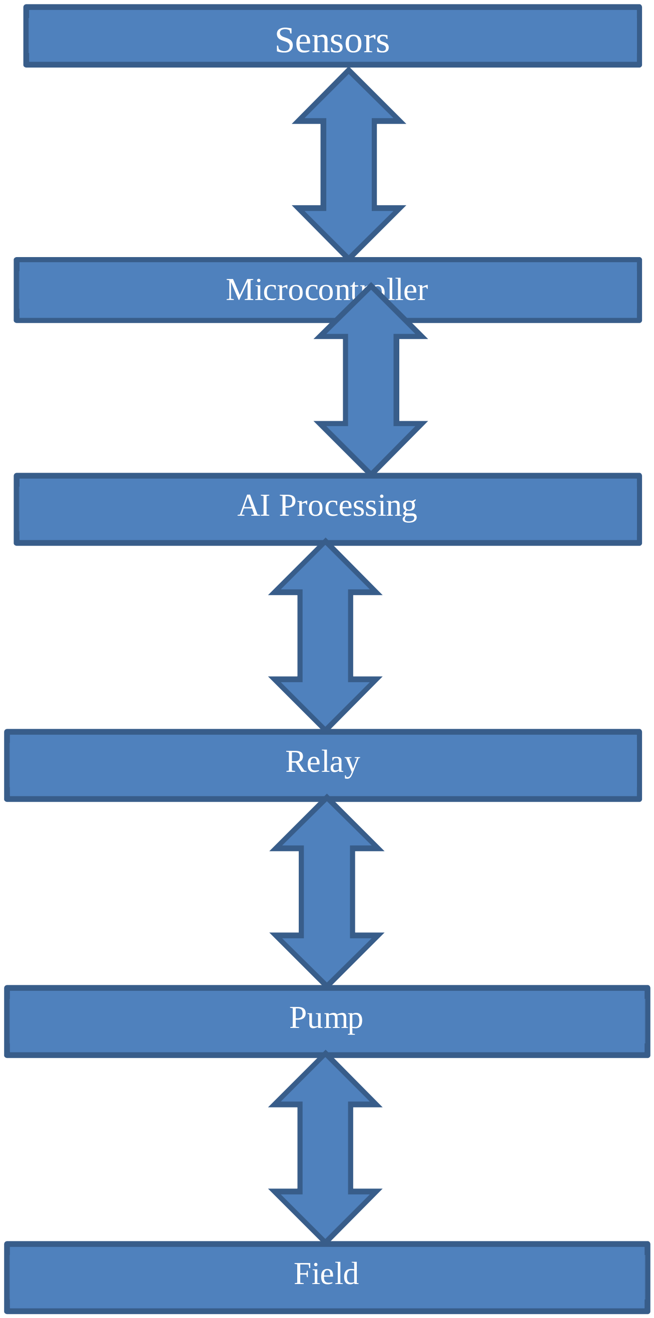
VI. BLOCK DIAGRAM



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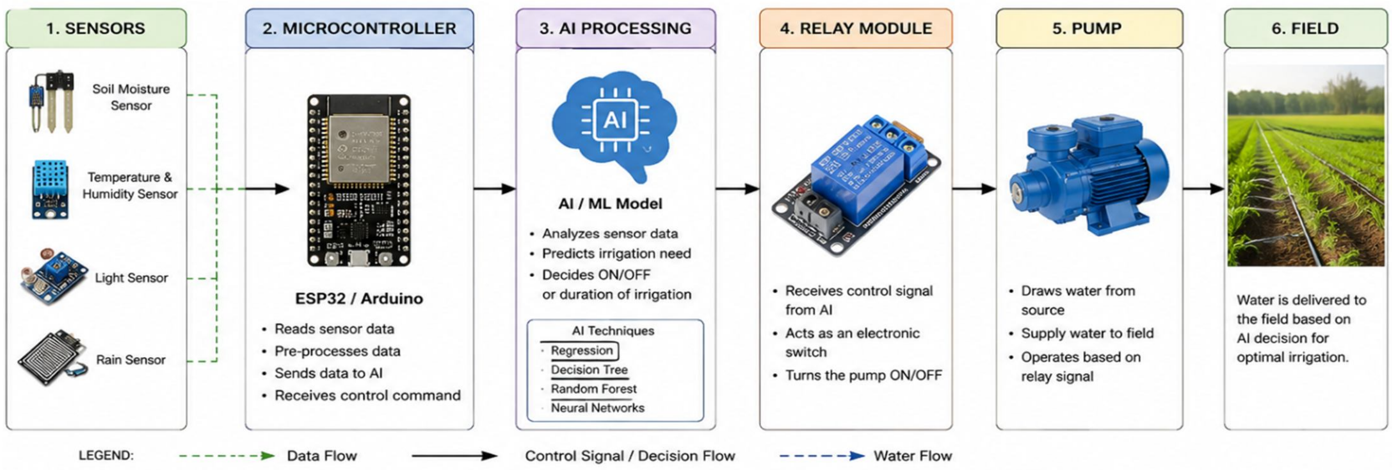

VII. AI ALGORITHM

The system operates using a data-driven AI model that takes key environmental parameters as input, including soil moisture, temperature, and humidity collected from sensors. These inputs are processed using a simple machine learning model such as regression or a decision tree to analyze patterns and predict the soil's moisture condition. The system produces an output in the form of an irrigation decision based on this prediction. The control logic is straightforward: the system automatically turns the pump ON to supply water if the predicted soil moisture level falls below a predefined threshold; otherwise, if the moisture level is sufficient, the pump remains OFF. This intelligent decision-making process ensures efficient water usage and optimal crop growth.

VIII. ADVANTAGES

The proposed system offers several significant advantages in modern agriculture. It helps in conserving water by supplying only the required amount based on real-time soil and environmental conditions, thereby reducing unnecessary wastage. The system operates automatically, minimizing human intervention and making irrigation more efficient and reliable. By maintaining optimal moisture levels, it contributes to improved crop yield and better plant health. Additionally, the system is scalable in nature, meaning it can be easily expanded or adapted to different farm sizes and varying agricultural requirements, making it suitable for both small-scale and large-scale applications.

IX. APPLICATIONS

The smart irrigation system that was developed can be used in many different fields. It can be effectively used in agriculture to optimize water usage and improve crop productivity through precise and automated irrigation. The system in smart gardens maintains ideal moisture levels with minimal human intervention to ensure proper plant care. Additionally, it is highly suitable for greenhouses, where controlled environmental conditions require accurate and consistent irrigation to support healthy plant growth and maximize yield.

X. FUTURE SCOPE

The future scope of the system includes several advanced enhancements to further improve its efficiency and functionality. The irrigation system can be remotely monitored and controlled in real time via mobile app integration. Advanced AI models can improve prediction accuracy and make it possible to make more intelligent decisions based on intricate environmental patterns. Additionally, drone-based monitoring can be incorporated to provide aerial insights into crop health, soil conditions, and irrigation effectiveness, enabling better management and large-scale agricultural optimization.

XI. CONCLUSION

The project successfully demonstrates an intelligent irrigation system combining AI and manufacturing technology. It provides efficient water management and can be developed into a commercial product.

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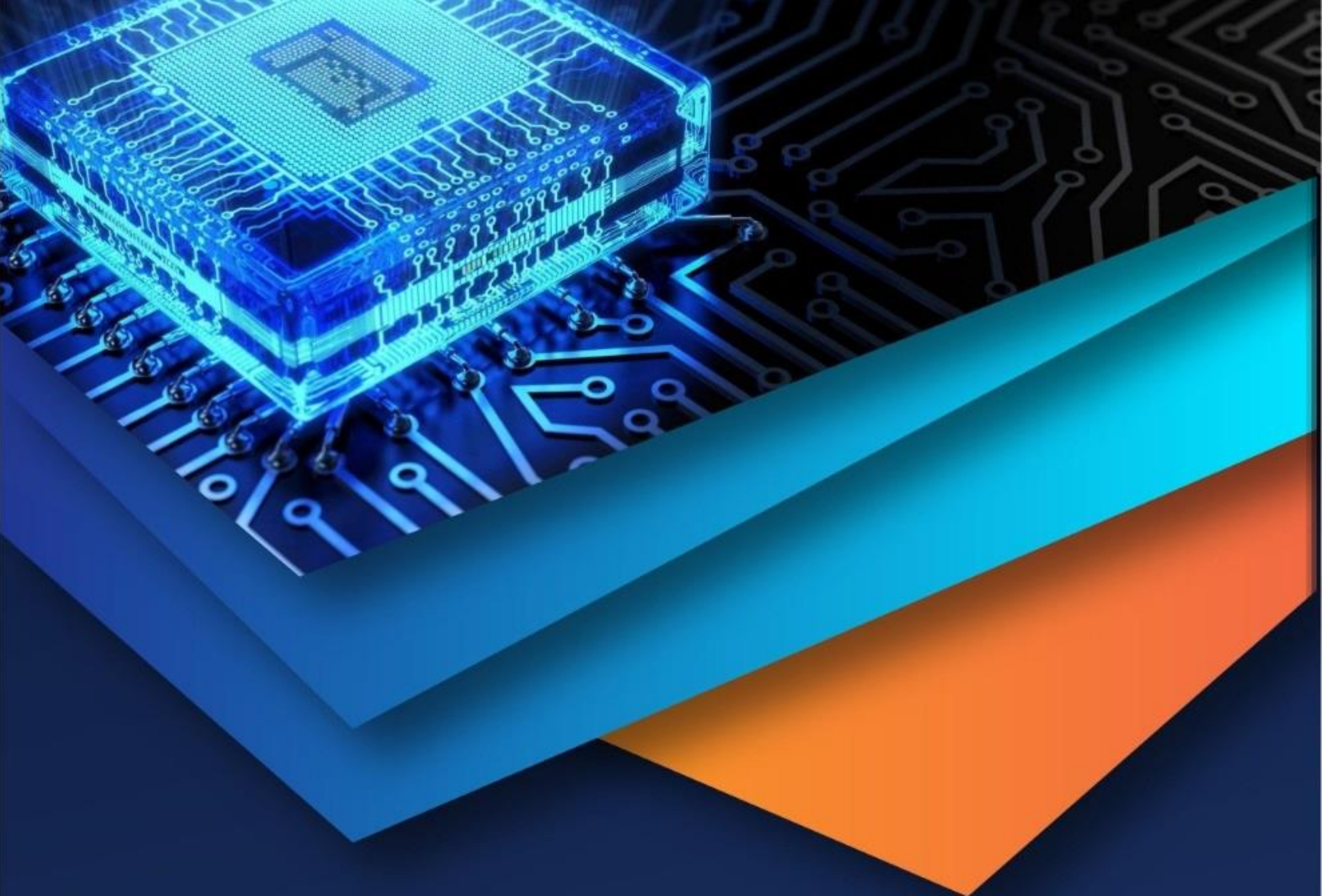

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