

Smart Plant Irrigation System (2)

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Value Creation

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Introduction

The increasing adoption of smart technologies has transformed the way everyday tasks are managed, enabling greater automation, efficiency and convenience across domestic and commercial environments. Embedded systems and microcontroller-based solutions have become particularly significant due to their affordability, reliability and ease of implementation. These technologies allow environmental conditions to be monitored continuously and enable automated responses that improve resource management while reducing the level of required human intervention. One practical application of embedded systems is intelligent plant care. Many individuals struggle to maintain regular watering schedules due to work commitments, university studies, travel or other personal responsibilities. As a result, plants may suffer from inconsistent watering practices, leading to poor growth, reduced health and unnecessary water consumption. Although commercial smart irrigation systems are available, many solutions are costly and provide functionality beyond the requirements of users who only need a simple indoor plant monitoring system [1].

Project Management

1. Project Management & Planning

1.1 Project scope

The proposed project involves the design and development of a low-cost Smart Plant Irrigation System capable of automatically monitoring soil moisture levels and activating irrigation when necessary. The project aims to address the common problem of inconsistent plant watering by providing an automated solution that reduces human intervention while supporting healthier plant growth. The system will continuously monitor soil conditions using a moisture sensor connected to an Arduino Uno microcontroller. When moisture levels fall below a predefined threshold, the Arduino will activate a relay module connected to a miniature water pump. Once acceptable moisture levels are restored, irrigation will automatically stop. This approach ensures that plants receive adequate water only when required, helping to reduce water waste and improve plant health [2].

The project scope is intentionally limited to supporting a single indoor plant to maintain a realistic development target within the available timeframe and resources. Advanced features such as wireless communication, cloud connectivity, smartphone applications, and multi-plant support have been identified as future enhancements.

1.2 Proposed solution

The proposed solution combines affordable hardware and embedded software technologies to create an intelligent irrigation system that operates autonomously. By utilizing sensor-driven decision-making, the system removes the need for continuous manual watering and provides a practical demonstration of automation principles within a domestic environment. The prototype will first be developed and tested within the Tinkercad simulation platform before any physical implementation takes place. Simulation-based development reduces risks by allowing hardware configurations and software functionality to be validated before physical deployment [3].

1.3 Required technologies and resources

The successful completion of the project requires a combination of hardware, software, and research resources. The hardware components include an Arduino Uno microcontroller, which serves as the main control unit, a soil moisture sensor for monitoring soil conditions, a relay module to control the water pump, a mini water pump for irrigation, a breadboard with connecting wires for circuit assembly, and an external power supply to provide the necessary electrical power [1].

The software resources required for the project include the Arduino IDE, which is used to program and upload code to the microcontroller, and the Tinkercad Circuit Simulator, which enables circuit design and testing in a virtual environment [1], [2].

To support the research and development process, several academic and information resources are necessary. These include academic journals for accessing peer-reviewed studies, online engineering databases for technical information, Google Scholar for locating relevant scholarly literature, and UWTSD Library resources for obtaining additional books, articles, and research materials related to the project [4].

1.4 Project Timeline

The Smart Plant Irrigation System has been planned over twelve months to ensure sufficient time for research, design, development, testing, and final evaluation. The project timeline has been structured to allow each phase to be completed systematically while reducing development risks and ensuring that project objectives are achieved within the available timeframe [3].

Phase	Duration	Description
Literature review	Jan - Mar	Review existing research on smart irrigation systems and Arduino applications
Requirements analysis	Jan - Apr	Identify system requirements and user needs
Research	Jan - May	Develop project proposals and supporting research
System design	Mar - Apr	Design hardware architecture and software logic
Prototype development	Apr - Jul	Build and simulate the system prototype
Software development	Apr - Sep	Develop Arduino code and control algorithms
System integration	Jul - Sep	Integrate hardware and software components
Testing & Evaluation	Aug - Nov	Test system functionality and performance
Documentation	Jul - Dec	Prepare project documentation and report
Final review	Nov - Dec	Complete final evaluation and submission

1.5 Schedule

The project schedule has been organised into a series of interconnected phases, including research, design, development, testing and documentation, providing a structured framework for achieving the project objectives within the planned twelve-month period [3].

1.6 Constraints

Several constraints may affect the development of the Smart Plant Irrigation System. Time constraints arise from balancing project activities with other academic commitments and assessment deadlines. Budget limitations restrict hardware selection to low-cost and readily available components. Technical constraints include sensor accuracy, hardware reliability, and potential software integration issues [2],[5].

1.7 Gantt Chart

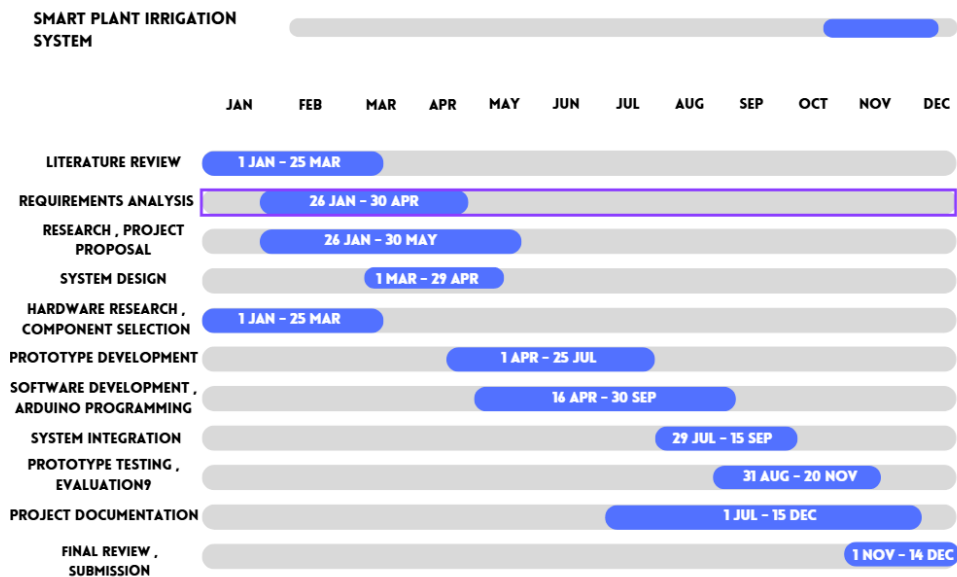


Figure 1. Gantt Chart

Link available online: <https://canva.link/83cyn100cv0u3ci>

1.8 Development Method

An Agile development methodology has been selected for the Smart Plant Irrigation System project because it supports iterative development, continuous testing, and regular improvements throughout the project lifecycle. Agile allows project requirements, software functionality, and hardware configurations to be refined gradually as testing progresses, reducing risks and improving the quality of the final prototype [6].

2. Project Design

The design phase is an important stage of the Smart Plant Irrigation System project because it translates the project requirements into a structured solution. Design documentation helps define how the system will operate and provides a blueprint for the development and testing stages. Three designs have been produced to support the project: a requirements specification, a system flowchart, and an ERD diagram [7].

2.1 Requirements Specification

The requirements specification defines the key functions and performance expectations of the Smart Plant Irrigation System. The system must monitor soil moisture levels, automatically activate the water pump when moisture levels fall below a predefined threshold, and stop irrigation once sufficient moisture has been restored. In addition, the solution should remain low-cost, reliable, and easy to maintain while supporting future enhancements such as wireless connectivity and multi-plant monitoring [1].

2.1.1 Functional requirements

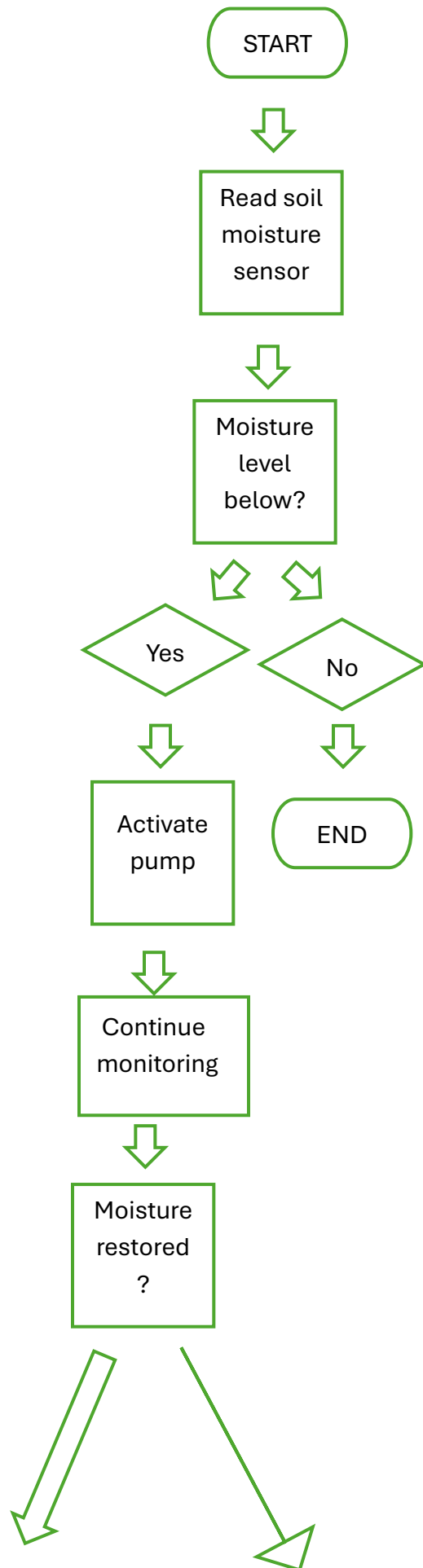
ID	Requirement
FR1	Monitor soil moisture levels continuously
FR2	Compare moisture readings against a predefined threshold
FR3	Activate the water pump when soil moisture is too low
FR4	Stop irrigation when adequate moisture levels are achieved
FR5	Display system status through the Arduino serial monitor

2.1.2 Non-Functional requirements

ID	Requirement
NFR1	The system should be low-cost and affordable
NFR2	The system should operate reliably with minimal maintenance
NFR3	The design should be easy to use and understand
NFR4	The system should use resources efficiently
NFR5	The prototype should be scalable for future improvements

2.2 System Flowchart

The system flowchart illustrates the decision-making process performed by the Arduino microcontroller. It demonstrates how sensor data is collected, analyzed, and used to control irrigation automatically [8].



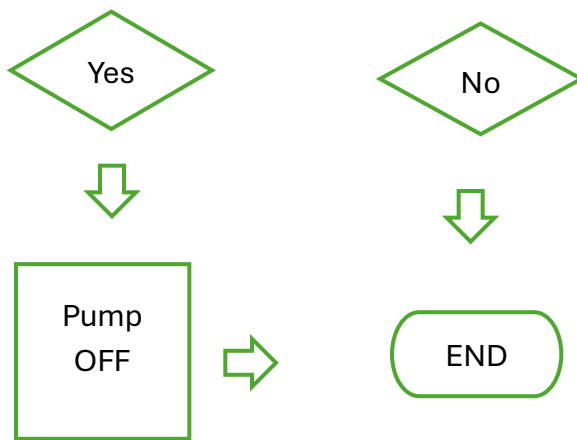


Figure 2. Flowchart

2.3 ERD Diagram

Figure 3 illustrates a simple one-to-many relationship between the monitored plant and the sensor readings generated by the system. A single plant can produce multiple sensor readings over time, supporting future data logging and analysis capabilities [8].

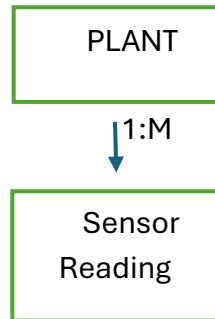


Figure 3. Simple ERD Diagram

Enterprise & Innovation

1. Innovation

Innovation involves applying new ideas and technologies to create practical solutions that improve efficiency, sustainability and overall user experience.

1.1 PEST & SWOT Analysis of Arduino

Arduino is a technology company that develops open-source hardware and software platforms used in education, embedded systems, automation, and Internet of Things projects. The company plays an important role in supporting innovation by providing affordable and accessible development tools for students, researchers, and technology professionals [9], [5].

1.1.1 PEST Analysis

Factor	Key Considerations
Political	Government support for STEM education and digital innovation encourages the adoption of Arduino-based technologies
Economic	Low-cost microcontrollers make Arduino products affordable for students, hobbyists and businesses
Social	Growing interest in smart homes, automation and IoT solutions increase demand for Arduino platforms
Technological	Advances in embedded systems, sensors and cloud technologies create new opportunities for Arduino-based applications

1.1.2 SWOT Analysis

Strengths	Weaknesses
Open-source platform	Limited processing power compared to industrial systems
Large global community	Not always suitable for large-scale enterprise solutions
Affordable hardware	Dependence on third-party hardware suppliers

1.1.3 Legal and ethical considerations

Several legal and ethical factors should be considered when developing solutions using Arduino technology. Data collected from sensors must be stored and processed responsibly in accordance with data protection regulations such as GDPR. Security measures should be implemented to prevent unauthorised access to connected devices. From an ethical perspective, technology should be used to improve efficiency and sustainability while minimizing environmental impact through responsible use of resources [10], [11].

1.2 Concepts, methods, practices and tools

If the Smart Plant Irrigation System were implemented within a large organization, a structured software engineering and project management approach would be required to support development, deployment, maintenance and future evolution.

An Agile development methodology would be used to divide the project into smaller development iterations, allowing continuous testing, improvement, and stakeholder feedback throughout the project lifecycle [12]. The system would be developed using Arduino IDE for embedded programming and Tinkercad for circuit simulation and prototype validation. Hardware integration would involve Arduino microcontrollers, soil moisture

sensors, relay modules, and water pumps. Before deployment, extensive testing would be conducted to ensure reliability, accuracy and system stability.

For deployment within a large organisation, IoT device management platforms would be used to monitor devices remotely and distribute software updates when required.

Continuous monitoring tools would collect performance data and detect system failures or abnormal behaviours. Maintenance activities would include sensor calibration, software updates, security patching and hardware replacement when necessary [13].

To support long-term evolution, cloud technologies and data analytics could be incorporated to enable remote monitoring, historical data storage and predictive irrigation recommendations. Additional enhancements could include mobile applications, wireless communication, multi-plant support and integration with smart building management systems.

Project reflection

The Smart Plant Irrigation System provides an opportunity to develop several valuable technical and professional skills that can be applied to future computing and engineering projects. Through the design and implementation of the system, I intend to improve my knowledge of embedded systems, Arduino programming, circuit design and hardware integration. In addition, the project will help strengthen my research, problem-solving and project management skills, which are essential within the computing industry [1].

The project also has the potential to contribute positively to society. By automating the plant watering process, the system can help users maintain healthier plants while reducing unnecessary water consumption. As concerns regarding environmental sustainability and resource management continue to increase, smart technologies such as automated irrigation systems can support more efficient use of water in homes, offices and educational environments. Furthermore, the skills developed throughout this project could be applied to future Internet of Things (IoT) and smart agriculture solutions that address larger environmental and agricultural challenges [5].

Despite its potential benefits, the project may face several risks and challenges. One key challenge is the reliability of soil moisture sensors, as inaccurate readings may result in overwatering or underwatering plants. This risk can be reduced through regular sensor calibration and repeated testing before deployment [7]. Another challenge involves technical issues related to hardware integration and software development. These risks can be minimised by adopting an Agile development approach, which supports continuous testing, iterative improvements and early identification of problems.

Time management may also represent a challenge due to academic commitments and project deadlines. To reduce this risk, a structured project plan and Gantt Chart have been developed to monitor progress and ensure that project milestones are completed on schedule. By addressing these challenges proactively, the project can be completed successfully while providing valuable learning experiences and a strong foundation for future development.

Conclusion

The Smart Plant Irrigation System demonstrates how affordable embedded technologies can be used to address practical everyday challenges. Through effective planning, design and iterative development, the project provides a foundation for future enhancements while supporting the development of valuable technical and professional skills. Although several challenges have been identified, careful project management and continuous testing can contribute to the successful implementation of the proposed solution.

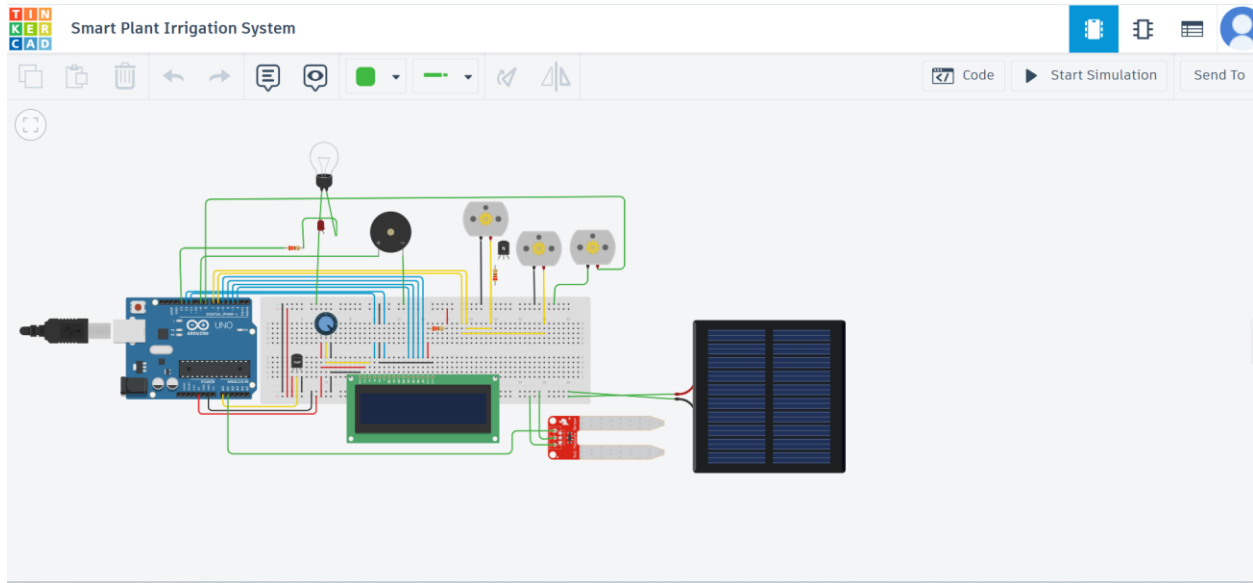
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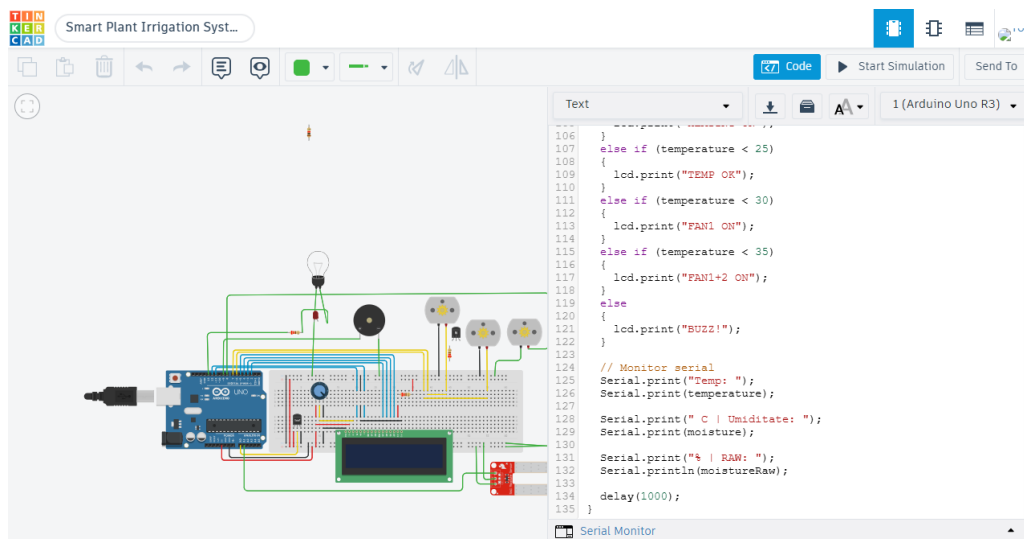
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Appendices

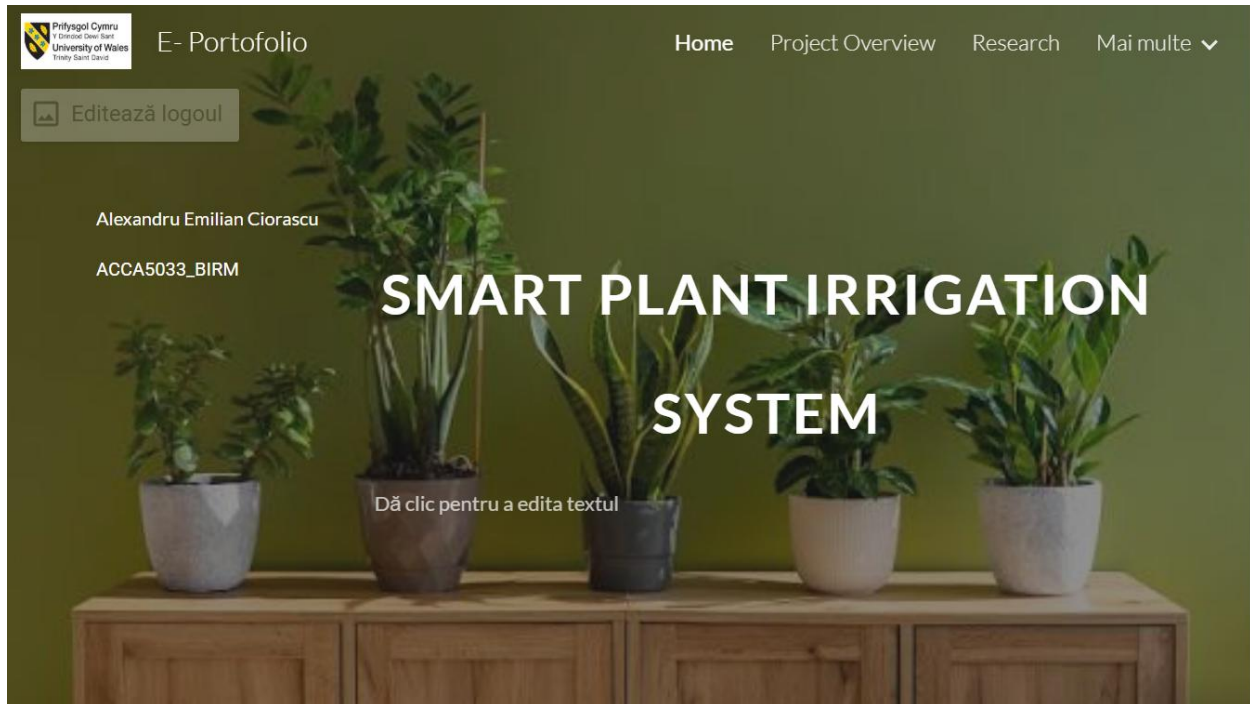
1. Tinkercad design-based Arduino



2. Software code



3. E-Portfolio & Component 1



Link available online: <https://sites.google.com/view/smart-plant-irrigation-system/home>