A Minor Project Report

On

ML BASED WATER LEAKAGE DETECTION IN IRRIGATION SYSTEM TUBES USING REAL TIME SENSOR DATA

Submitted by

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BONAFIDE CERTIFICATE

Certified that this Report titled **"ML BASED WATER LEAKAGE DETECTION IN IRRIGATION SYSTEM TUBES USING REAL TIME SENSORS DATA"** is the bonafide work of **GOKULNAATH M (927622BEE034) , KABILASRI S (927622BEE048), KIRUTHIKA S (927622BEE058)** who carried out the work during the academic year (2023-2024) under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other project report.

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Submitted for Minor Project II (18EEP202L) viva-voce Examination held at M.Kumarasamy College of Engineering, Karur-639113 on ………………..

DECLARATION

We affirm that the Minor Project II report titled "**ML BASED WATER LEAKAGE DETECTION IN IRRIGATION SYSTEM TUBES USING REAL TIME SENSORS DATA"** being submitted in partial fulfillment for the award of **Bachelor of Engineering in Electrical and Electronics Engineering** is the original work carried out by us.

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VISION AND MISSION OF THE INSTITUTION

VISION

- ✓ To emerge as a leader among the top institutions in the field of technical education

MISSION

- ✓ Produce smart technocrats with empirical knowledge who can surmount the global Challenges.
- ✓ Create a diverse, fully-engaged, learner - centric campus environment to provide Quality education to the students.
- ✓ Maintain mutually beneficial partnerships with our alumni, industry, and Professional associations.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION

To produce smart and dynamic professionals with profound theoretical and practical knowledge comparable with the best in the field.

MISSION

- ✓ Produce hi-tech professionals in the field of Electrical and Electronics Engineering by inculcating core knowledge.
- ✓ Produce highly competent professionals with thrust on research.
- ✓ Provide personalized training to the students for enriching their skills.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

- ✓ **PEO1:** Graduates will have flourishing career in the core areas of Electrical Engineering and also allied disciplines.
- ✓ **PEO2:** Graduates will pursue higher studies and succeed in academic/research careers
- ✓ **PEO3:** Graduates will be a successful entrepreneur in creating jobs related to Electrical and Electronics Engineering /allied disciplines.
- ✓ **PEO4:** Graduates will practice ethics and have habit of continuous learning for their success in the chosen career.

PROGRAMME OUTCOMES (POs)

After the successful completion of the B.E. Electrical and Electronics Engineering degree program, the students will be able to:

PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/Development of solutions:
Design solutions for Complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety,and the cultural, societal and environmental considerations.

PO4: Conduct Investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6:The Engineer and Society: Apply reasoning in formed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7:Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and Team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multi-disciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

The following are the Program Specific Outcomes of Engineering Students:

- **PSO1:** Apply the basic concepts of mathematics and science to analyse and design circuits, controls, Electrical machines and drives to solve complex problems.
- **PSO2:** Apply relevant models, resources and emerging tools and techniques to provide solutions to power and energy related issues & challenges.
- **PSO3:** Design, Develop and implement methods and concepts to facilitate solutions for electrical and electronics engineering related real-world problems.

Abstract (Key Words)	Mapping of POs and PSOs
Wireless sensor network, water distribution, irrigation system, Random Forest, water flow sensor	PO1,PO2,PO3,PO4,PO5,PO5,PO6, PO7,PO8,PO9,PO10,PO11,PO12, PSO1,PSO2,PSO3

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TABLE OF CONTENT

ABSTRACT

Water is a crucial natural resource, and it is widely mishandled, with an estimated one third of world water utilities having loss of water of around 40% due to leakage. Water leakage in irrigation systems can lead to significant water wastage and decreased agricultural productivity. This project presents a proposal for a system based on a wireless sensor network designed to monitor water distribution systems, such as irrigation systems, which with the help of an machine learning algorithm, allows for precise location of water leaks. The complete system architecture is detailed, including hardware, communication, and data analysis. A study to discover the best machine learning algorithm between Random Forest interfaces with the water flow sensors , preprocesses the data, and utilizes a trained machine learning model to analyze patterns in real-time. Finally, the developed system is validated in a real case implementation that shows that it is able to detect the leak.

CHAPTER 1

SURVEY FORM ANALYSIS

1.1 NAME AND ADDRESS OF THE COMMUNITY:

1. Saraswathi S, Poolampalayam, Karur
2. Sivakumar R, Kalipalayam, Karur
3. Logambal S ,Chinnamaruthur, Karur
4. Subramaniam M, Annanagar, Karur
5. Kuppusami ,Kallipalliyam, Namakkal

1.2 PROBLEM IDENTIFICATION:

Water leakage in irrigation systems can stem from various issues such as pipe corrosion, physical damage, poor installation or even excessive pressure, pipe cracks, aging infrastructure can lead to water leaks, causing wastage of water and reduced system efficiency.

1.3 PROBLEM SOLUTION:

Detecting water leakage in irrigation systems using real-time sensor data involves several steps:

1. Sensor Installation: Deploy water flow or pressure sensors at strategic points along the irrigation tubes.

2. Data Collection: Collect real-time data from these sensors, monitoring water flow rates, pressure levels, or any anomalies that might indicate leakage.

3. Data Analysis: Implement algorithms to analyze the sensor data. Look for deviations from normal patterns that might signal leaks, such as sudden drops in pressure or unexpected variations in flow rates.

4. Leakage Identification: Develop a model or algorithm that can differentiate between normal system behavior and potential leaks. Machine learning models or statistical analysis can aid in this, where patterns indicating leaks trigger alerts.

5. Localization of Leaks: Explore ways to pinpoint the location of the leak. Pressure and flow rate variations across sensors can help triangulate the area where the leakage might be occurring.

6. Continuous Monitoring and Improvement: Regularly update and fine-tune the detection algorithms based on historical data.

CHAPTER 2

LITERATURE REVIEW

Paper 1

Title: Monitoring Water Distribution Network using Machine Learning

Inference:

It is proposed to use this feature extraction procedure at every sensor node locally, which reduces the transmitted data to the central hub over the cloud thereby reducing the energy consumption for the IoT sensor in real world. For water leakage detection and localization, a procedure for obtaining training data is proposed, which serves as a basis for recognition of patterns and regularities in the data using supervised Machine learning techniques. Random Forest algorithm is trained and its performance is compared to the obtained ensemble of earlier models. Also, it is noticed that Random Forest algorithm performs better than the ensemble model except for the low leakage scenario. Thus, it is concluded to estimate the leak size first, based on this estimation for small leakage case ensemble models can be applied while for large leakage case only Random Forest can be used.

Paper 2

Title: Machine Learning Model for Leak Detection Using Water Pipeline Vibration Sensor

Inference:

This paper is organized to provide detailed information about leak detection data and machine learning models for it. In this study, we conducted an analysis of essential features based on data collected from leak detection sensors installed at water meter boxes and water outlets of pipelines. The water pipeline data collected through the vibration sensor were preprocessed by converting it into a tabular form by frequency band and applied to various machine learning model. The decision trees algorithm is trained and its performance is compared to the obtained ensemble of earlier models. These systems can effectively reduce leak detection and response time, minimize water waste, and minimize economic losses. The developed system is validated in a real-case implementation that shows that it is able to detect leaks with the high accuracy.

Paper 3

Title: Water Pipeline Leakage Detection and Monitoring System Using Machine learning

Inference:

This paper presents a smart water pipeline monitoring system to control the water leakages occurring in it. To overcome from this, a smart monitoring system with the help of machine learning is designed and proposed. In this system, to monitor the flow of water, the water flow sensor is used in the pipeline. Nodemcu microcontroller, is one of the most common microcontrollers used in the model. The values measured by the water flow sensors are uploaded to the cloud server. For storing the data in the cloud, the Thing Speak cloud server has been used for this system, because Thing Speak cloud server is open and free to use. With the values measured by the water flow sensor the data is displayed in the Thing Speak cloud webserver. So, monitoring of the water flow in the pipeline will be done very easily.

Paper 4

Title: Water Pipeline Leakage Detection Based on Machine Learning and Wireless Sensor Networks

Inference:

This paper designs a leakage detection method based on machine learning and wireless sensor networks. The system employs wireless sensors installed on pipelines to collect data and utilizes the network to perform remote data transmission. To enhance the precision and intelligence of leakage detection, we propose a leakage identification with the help of sensor and machine learning algorithm. A study to discover the best machine learning algorithm between Random Forest interfaces with the water flow sensors , preprocesses the data, and utilizes a trained machine learning model to analyze patterns in real - time. Finally, the developed system is validated in a real case implementation that shows that it is able to detect the leak.

Paper 5

Title: Precise Water Leak Detection Using Machine Learning and Real-Time Sensor Data

Inference:

This paper presents a proposal for a system based on a wireless sensor network designed to monitor water distribution systems, such as irrigation systems, which, with the help of an autonomous learning algorithm, allows for precise location of water leaks. The complete system architecture is detailed, including hardware, communication, and data analysis. A study to discover the best machine learning algorithm between random forest, decision trees to fit leak detection is presented, including the methodology, training, and validation as well as the obtained results. Finally, the developed system is validated in a real-case implementation that shows that it is able to detect leaks with the high accuracy.

CHAPTER 3

PROPOSED METHODOLOGY

3.1 BLOCK DIAGRAM

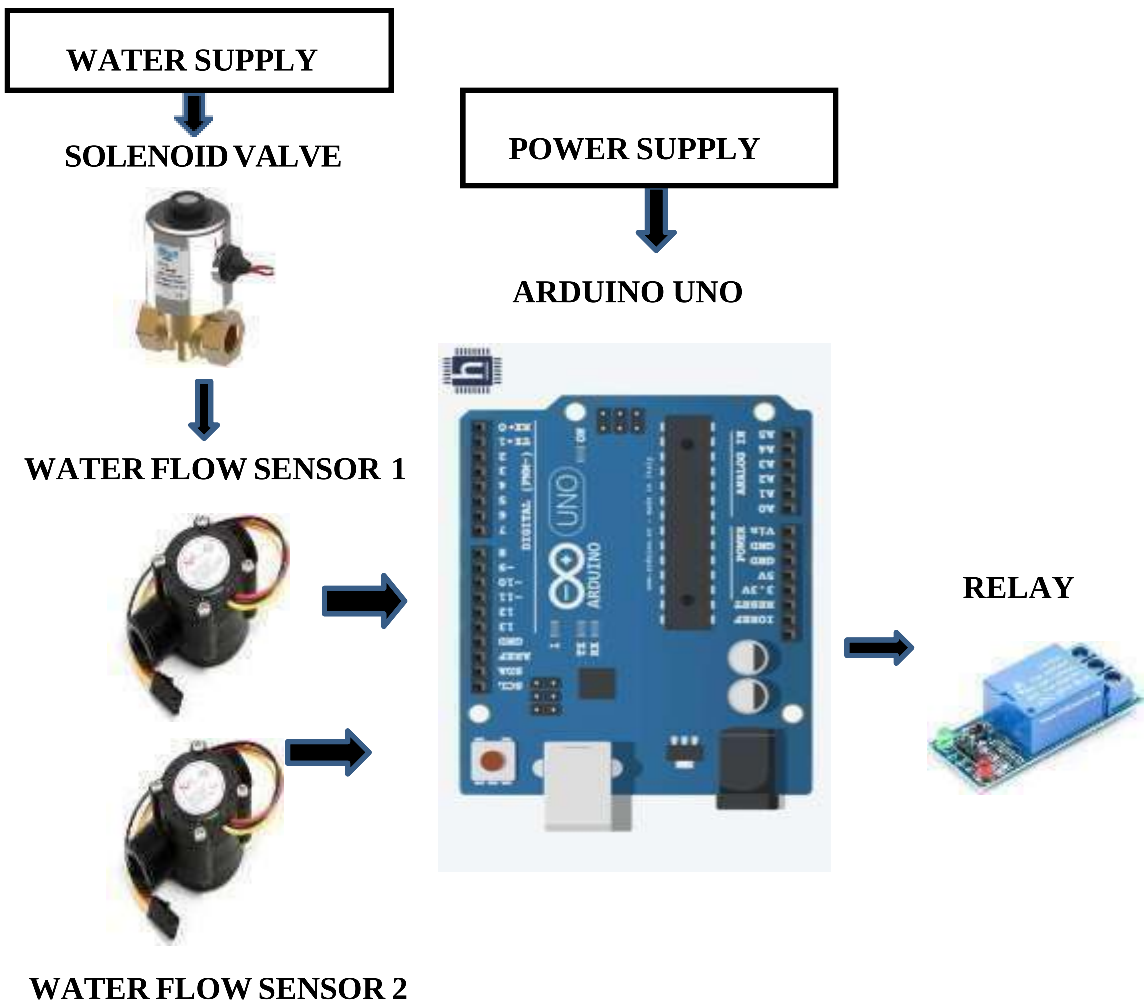

Fig.3.1 Block Diagram

3.2 DESCRIPTION

The detection of water leakage in irrigation systems using machine learning involves the utilization of real-time sensor data to identify anomalies that indicate leaks. Sensors monitoring parameters like pressure, flow rate, and temperature provide continuous data streams. This data is processed, extracting key features relevant to leak identification. Machine learning algorithms, including anomaly detection and classification models, are then employed to analyze patterns and deviations in the sensor data, allowing for the identification and localization of leaks within the irrigation system tubes. This approach aims to offer early detection of leaks, enabling timely settings.

3.3 PROJECT – TOTAL COST

S.NO	COMPONENTS	QUANTITY	COST (In Rupees)
1	Flow sensor	2	500.00
2	Solenoid valve	1	300.00
3	Relay module	1	250.00
4	LCD screen	1	100.00
5	Arduino UNO	1	500.00
6	Water pipe	4	150.00
7	9V Battery	1	50.00
8	Jumper wires	1	50.00
		TOTAL	1,900.00

Table No. 3.3 Project – Total Cost

CHAPTER 4

RESULT AND DISCUSSION

4.1 HARDWARE COMPONENT DISCRIPTION

WATER FLOW SENSOR

Water flow sensor consists of a plastic valve from which water can pass. A water rotor along with a hall effect sensor is present the sense and measure the water flow. When water flows through the valve it rotates the rotor. By this, the change can be observed in the speed of the motor. This change is calculated as output as a pulse signal by the hall effect sensor. Thus, the rate of flow of water can be measured.

The main working principle behind the working of this sensor is the Hall effect. According to this principle, in this sensor, a voltage difference is induced in the conductor due to the rotation of the rotor. This induced voltage difference is transverse to the electric current. When the moving fan is rotated due to the flow of water, it rotates the rotor which induces the voltage. This induced voltage is measured by the hall effect sensor and displayed on the LCD display. These sensors can be easily interfaced with microcontrollers like Arduino. The sensor is placed at the water source inlet or at the opening of the pipe. The sensor contains three wires. Red wire to connect with supply voltage. Black wire to connect to ground and a yellow wire to collect output from Hall effect sensor. For supply voltage 5V to 18V of DC is required.

Fig. No. 4.1 Water Flow Sensor

ARDUINO UNO

Arduino UNO board has 6 ADC input ports. Among those any one or all of them can be used as inputs for Analog voltage. The Arduino Uno ADC is of 10-bit resolution (so the integer values from (0-(2^10) 1023)). This means that it will map input voltages between 0 and 5 volts into integer values between 0 and 1023. So, for every (5/1024= 4.9mV) per unit. The UNO ADC channels have a default reference value of 5V. This means we can give a maximum input voltage of 5V for ADC conversion at any input channel. Since some sensors provide voltages from 0-2.5V, with a 5V reference we get lesser accuracy, so we have a instruction that enables us to change this reference value.

Fig No. 4.2 Arduino UNO

RELAY MODULE

The primary function of a relay module is to switch electrical devices or systems on and off. It also serves to isolate control circuits, ensuring that low-power devices, such as microcontrollers, can safely control higher voltages and currents. This capability is particularly beneficial in scenarios where a small control signal from a microcontroller needs to switch higher currents. In essence, a relay module amplifies this control signal, enabling it to manage more substantial electrical loads.

Fig.No.4.3 Relay Module

SOLENOID VALVE

Solenoid valves are electromechanically operated valves that convert electric energy into mechanical energy. Their main purpose is to regulate the movement of gas or liquid and eradicate the need for an engineer to manually control the valve, saving time and money. Solenoid valves work by employing the electromagnetic coil to either open or close the valve orifice. When the coil within the solenoid is energized, the plunger is lifted or lowered to open or close the orifice. This is what in turn controls flow, regulating the movement of gas or liquid.

Fig.No.4.4 Solenoid Valve

LCD DISPLAY

The liquid crystal display (LCD) panel is designed to project on-screen information of a microcomputer onto a larger screen with the aid of a standard overhead projector, so that large audiences may view on-screen information without having to crowd around the TV monitor.

Fig.No.4.5 LCD Display

4.2 HARDWARE KIT

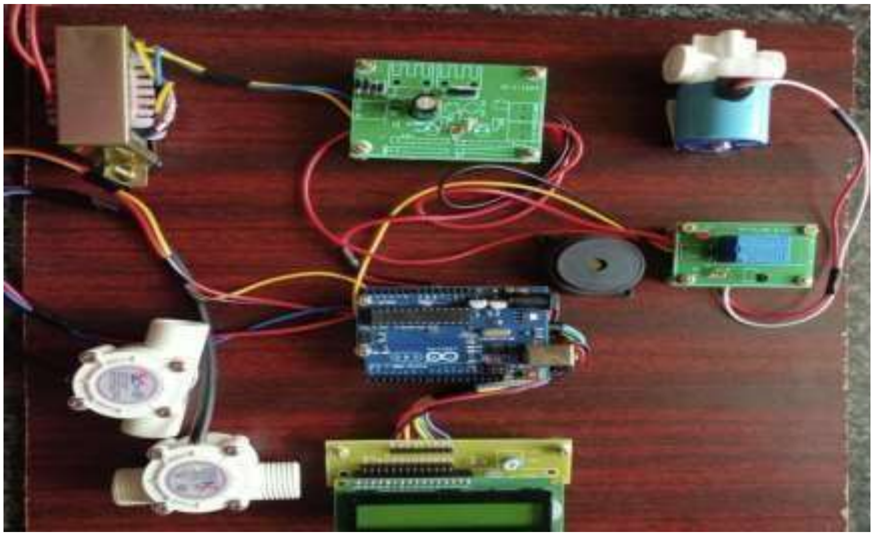

Fig.No. 4.2 Hardware Kit

4.3 WORKING PRINCIPLE

A leak detection system monitors the flow of water through a pipeline. When abnormal behavior is detected, the system cuts off the water flow to the entirety of the irrigation tubes by closing a valve within the leak detector. Water leakage detection in irrigation systems involves the use of sensors and technology to identify and address leaks in tubes These systems typically employ water flow sensors along the irrigation network. When a leak occurs, it disrupts the expected water flow levels. Use a suitable ML algorithm to train the model on the labeled dataset. The goal is for the model to learn patterns associated with normal and leaky conditions. Advanced systems may integrate with control units to automatically shut off water flow to the affected section, minimizing water wastage. Additionally, technologies like acoustic sensors or soil moisture monitoring may complement pressure-based detection methods, providing a comprehensive approach to identifying and managing leaks. Overall, the integration of smart sensors enhances the efficiency of irrigation systems, conserving water resources and optimizing agricultural practices.

CHAPTER 5

CONCLUSION

The implementation of water leakage detection in irrigation system tubes using real time sensors data are capable of monitoring water distribution systems and of finding and locating with precision water leaks by using low-cost sensors and by collecting data in real time. The main goals of the system were achieved, and the system proved to be efficient and reliable. Every part of the system was previously and properly tested before reaching the final prototype and its implementation. Through the ML test scenarios, it was possible to study which is the best algorithm to use in this scenario. Multiple models were tested in various configurations and different datasets in order to achieve the best configuration possible. It was possible to conclude not only that, when using more features, the accuracy increases but also that random forest achieves the best accuracy in almost every scenario, making it the best classification algorithm to use, with more accuracy**.** Besides the theoretical implementation and machine learning study, an experimental implementation was also presented to validate the methodology used and the results obtained in our study in a real case scenario.

5.1 PROJECT IMPLEMENTATION

Fig.No.5.1 Geotag Photo

IMPLEMENTATION VIDEO LINK

https://drive.google.com/file/d/1-lFeHhPN3Tjw3S8DGj79mKwcCrbjnRzM/view?usp

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