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A Minor Project Report

On

ADVANCED STRATEGIES FOR MONITORING WATER CONSUMPTION PATTERNS IN HOUSEHOLDS BASED ON IOT AND MACHINE LEARNING

Submitted by

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BONAFIDE CERTIFICATE

Certified that this Report titled **"ADVANCED STRATEGIES FOR MONITORING WATER CONSUMPTION PATTERNS IN HOUSEHOLDS BASED ON IOT AND MACHINE LEARNING"** is the bonafide work of **GOKULNAATH M (927622BEE034) , KABILASRI S (927622BEE048), KIRUTHIKA S (927622BEE058)** who carried out the work during the academic year (2024-2025) 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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DECLARATION

We affirm that the Minor Project III report titled "**ADVANCED STRATEGIES FOR MONITORING WATER CONSUMPTION PATTERNS IN HOUSEHOLDS BASED ON IOT AND MACHINE LEARNING"** 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 Electrical and Electronics 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
Water Consumption Monitoring, Data Processing, Machine Learning ,Household, Internet Of Things	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 resource management represents a fundamental aspect of a modern society. Water consumption monitoring applications play a significant role in increasing awareness, while machine learning has been proven for the design of intelligent solutions in this field. This paper presents an approach for monitoring and predicting water consumption from the most important water outlets in a household based on a proposed IoT solution. Data processing pipelines were defined, by training classification methods for predicting consumption sources. Continuous water consumption monitoring offers multiple benefits toward improving decision support by combining modern processing techniques, algorithms, and methods.

CHAPTER 1

PROBLEM ANALYSIS

1.1 PROBLEM STATEMENT

Efficient water management is crucial for sustainability, yet most households lack real-time insights into their water usage. This project aims to develop an advanced system leveraging IoT sensors and machine learning algorithms to monitor and analyze water consumption patterns in households. The system will provide actionable insights and predictive analytics to optimize water usage, detect leaks, and promote conservation, ultimately contributing to water sustainability and reducing waste.

1.2 OBJECTIVE

The objective of this project is to design and implement a smart water monitoring system using IoT devices and machine learning techniques. The system will continuously track water usage in households, analyze consumption patterns, and identify inefficiencies. By providing real-time data and predictive insights, the system aims to optimize water usage, detect leaks early, and promote sustainable practices, ultimately reducing water wastage and supporting environmental conservation efforts.

CHAPTER 2

LITERATURE REVIEW

Paper 1

Title: Monitoring and forecasting water consumption and detection of leakage using an IOT system

Inference:

In this paper, a smart system based on Internet of Things (IoT) has been proposed to monitor the water consumption in an urban housing complex. Ultrasonic Sensor along with Arduino continuously monitors the water level of the Water Tanks on Rooftops and sends this data to a server through a Wi-Fi module. Using the data collected from the IoT system, average water requirement by households are calculated. The observed readings are divided into training and testing datasets. Error is recorded as the difference between the actual consumption and the predicted value, and it decreases as the number of days increase. An algorithm to monitor leakage of water in the tanks has also been proposed.

Paper 2

Title: Advances in machine learning and IOT for water quality monitoring

Inference:

This paper aims to provide a comprehensive review of the current state of the art in water quality monitoring, with a specific focus on the employment of IoT wireless technologies and ML techniques. The study examines the utilization of a range of IoT wireless technologies, including Low-Power Wide Area Networks, Wi-Fi, cellular networks, and Bluetooth, in the context of monitoring water quality. Furthermore, it explores the application of both supervised and unsupervised ML algorithms for analyzing and interpreting the collected data. In addition to discussing the current state of the art, this survey also addresses the challenges and open research questions involved in integrating IoT wireless technologies and ML for water quality monitoring.

Paper 3

Title: IoT Approach for Water Consumption Pattern Analysis in a Residential Area

Inference:

IoT-based water consumption analysis highlights the application of smart water meters, data analytics, and machine learning for sustainable water management. Studies show that IoT sensors allow for real-time monitoring of water usage, capturing detailed consumption data that enables the detection of anomalies such as leaks and excessive usage. Machine learning algorithms, particularly those tailored for time-series forecasting, have been effective in predicting water demand and identifying behavioral patterns among user. However, challenges remain, such as ensuring data accuracy and managing maintenance for sensors, which are critical for the long-term reliability and success of IoT-driven water management solutions.

Paper 4

Title: Decision Support Strategies for Household Water Consumption Behaviors on Advanced Recommender System

Inference:

This paper proposes a novel recommendation system design architecture that promotes water conservation behavior among residential consumers from urban areas. We analyzed 480000 data samples from several households with different profiles to generate personalized recommendations for each household and encourage consumers to adopt measures to raise awareness and reduce water consumption. Moreover, data were collected from three different measurement points in the household. The proposed recommendation system implements collaborative filtering combined with a set of rules to generate recommendations based on the consumption patterns of similar households. The results are promising, offering personalized feedback that could help change the consumption behavior of households if the recommendations made are followed.

Paper 5

Title: Monitoring Water Consumption Using Machine Learning

Inference:

This paper concerns one of the most important elements in economic life, which is water. Machine learning is used through clustering techniques to achieve the monitoring goal, which contributes towards decision making, fault prediction, and data management processes.in facility management. Artificial Neural Network is the specific part of the chosen technique and Python is used as a tool to implement the method. A case study is applied in one of the universities and a network including six locations is studied at a specific time. The method shows a significant result where the consumption at three locations were found high and accordingly, the user made further inspection and continuous monitoring about the network in discussion.

CHAPTER 3

PROPOSED METHODOLOY

3.1 BLOCK DIAGRAM

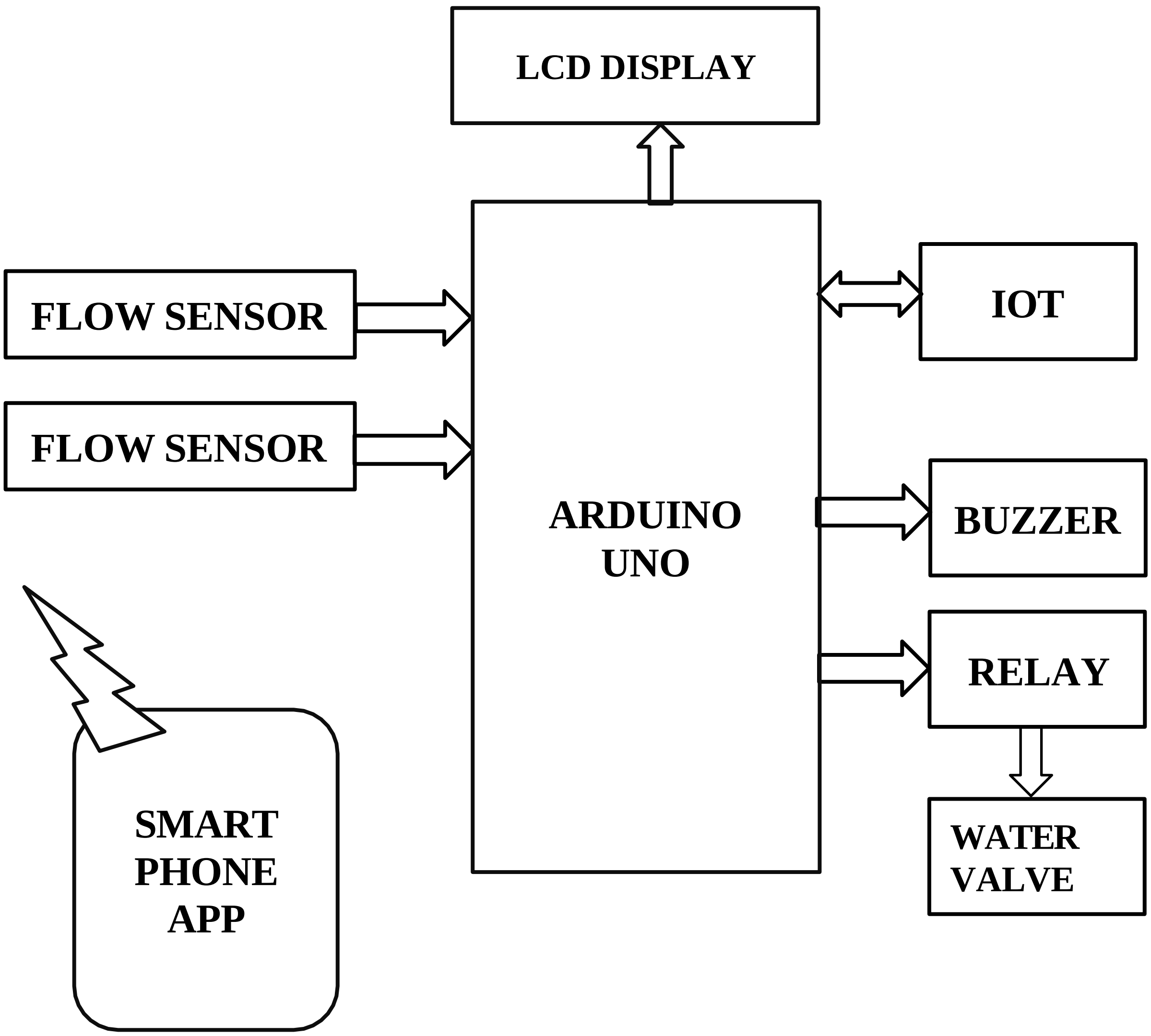


Figure 3.1 Block Diagram

3.2 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.

Figure 3.2 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.

Figure 3.3 Arduino UNO

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.

Figure 3.4 LC Display

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.

Figure 3.5 Relay Module

BUZZER

Buzzer meaning electronic component that generates sound through the transmission of electrical signals. Its primary function is to provide an audible alert or notification and typically operates within a voltage range of 5v to 12v.

Figure 3.6 Buzzer

3.3 PROJECT – TOTAL COST

Table 3.1 Project – Total Cost

S.NO	COMPONENTS	QUANTITY	COST (In Rupees)
1	Flow sensor	2	500.00
2	LC Display	1	100.00
3	Arduino UNO	1	600.00
4	Relay module	1	150.00
5	Buzzer	1	100.00
6	Jumper wires	10	100.00
		TOTAL	1,550.00

CHAPTER 4

RESULT AND DISCUSSION

4.1 HARDWARE KIT

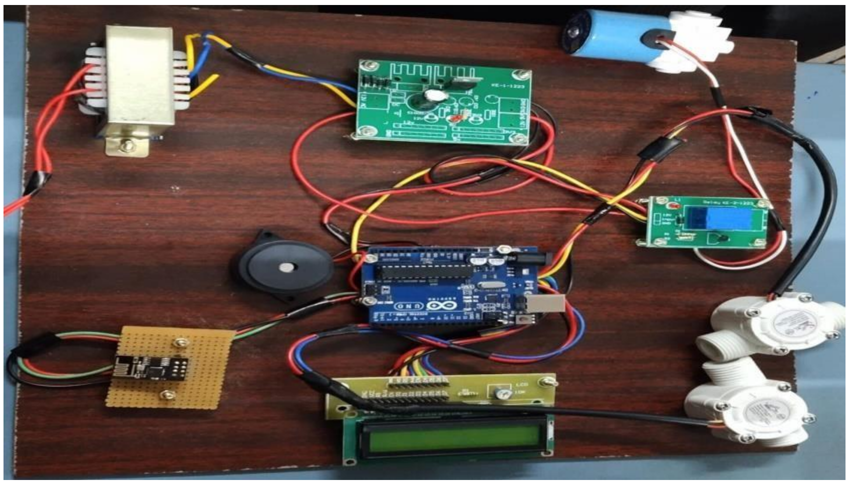


Figure 4.1 Hardware Kit

4.2 RESULT AND DISCUSSION

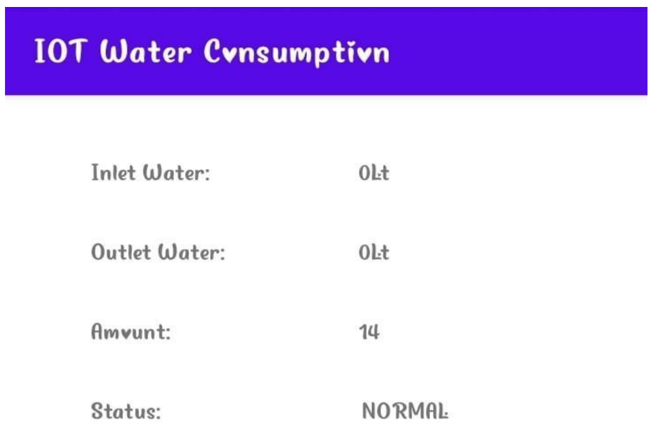
LC DISPLAY

NORMAL USAGE

WATER THEFT

SMART PHONE APP

NORMAL USAGE



WATER THEFT

CHAPTER 5

CONCLUSION

Monitoring water consumption is essential today for predicting leaks and eliminating water waste that can lead to water scarcity. The current paper proposes the evaluation of several methods for predicting water at consumer outlet types: hot tap water sink, cold tap water sink, toilet, and shower. The proposed architecture is based on scalable components and requires minimal configuration, which makes it possible to extend the study to multiple households. The proposed configuration using separate sensors for each consumption outlet allowed for evaluating different methods for characterizing consumer behavior in great detail. Moreover, the same methods can be applied to extract the consumption patterns from combined measurements, i.e., using sensors installed at the mains, and predict the consumption activities based on the overall water consumption data. Possible extensions include location-based clustering and demographic analysis in large-scale deployments. In contrast with other studies in this field, the four types of household activities were analyzed in this study, applying clustering, classification methods, and evaluation metrics. In the case of clustering methods, high accuracy was obtained by extracting the consumption events from the time series, as confirmed by the evaluation metrics. In the case of classification methods, using machine learning algorithms and good results were achieved in terms of prediction accuracy.

FUTURE SCOPE

Future advancements in monitoring household water consumption using IoT and machine learning are poised to enhance water conservation and sustainability through more precise, immediate, and personalized insights. By implementing data processing can happen directly on local IoT devices, enabling real-time feedback for households. This means that any detected anomalies, like leaks, can trigger immediate alerts, reducing potential wastage. Advanced machine learning models, including deep learning, enable, allowing each household to receive tailored water-saving recommendations based on unique usage patterns. Integrating environmental data further refines accuracy by anticipating water demand changes due to seasonal shifts or weather events, helping utilities better prepare for peak times. Meanwhile, predictive maintenance models ensure continuous system accuracy by forecasting when IoT sensors need repairs or recalibration, preventing data disruptions. Additionally, blockchain technology offers secure and transparent data sharing between residents, utilities, and researchers, building trust and promoting collective conservation efforts. Finally, AI – powered anomaly detection leverages neural networks to identify inefficient or excessive water use early on, giving users the opportunity to adjust habits before significant waste occurs. Collectively, these strategies not only empower households to manage water usage effectively but also support the broader vision of sustainable, resource-efficient urban communities.

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