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Smart Water Meter System for Leakage Prediction and Automatic Flow Control Using AIoT

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Abstract Water is a vital global resource, yet substantial amounts are lost daily due to undetected pipeline leakages and human negligence. Traditional mechanical water meters lack the capability to detect abnormal water flow, shifting the financial burden of wasted water onto consumers. To address this critical issue, this research aims to develop an intelligent smart water meter system capable of monitoring water usage, preventing unnecessary water loss, and autonomously cutting off the water supply when an anomaly occurs.
To achieve this, the proposed system integrates Internet of Things (IoT) technologies with an artificial intelligence (AI) predictive model. The hardware architecture utilizes a NodeMCU ESP8266-12E microcontroller to manage a YF-S201 Water Flow Sensor, a Pressure Transmitter Sensor, and a Solenoid Valve. Furthermore, a Mini Hydro Generator Turbine is incorporated to harvest kinetic energy and recharge the system's battery during active water usage. On the software side, a cross-platform mobile application developed using Flutter allows users to monitor real-time sensor data, review historical usage, and remotely configure operational modes. The core autonomous anomaly detection is driven by a rule-based AI model that calculates the Simple Moving Average (MA) and Standard Deviation (SD) of historical fluid pressure data over a rolling four-week period to continually establish a dynamic pressure threshold.
Experimental testing demonstrated the high reliability and efficiency of the proposed system. Hardware functionality tests yielded a 0% error rate for user commands and data synchronization via RESTful APIs. The water flow measurement maintained a highly accurate Mean Absolute Error (MAE) of 2.67% at low and medium flow capacities. Crucially, the predictive AI model was evaluated across 105 distinct real-world events over a continuous 7-day period. The model achieved an impressive average accuracy of 92.29%, successfully ordering the microcontroller to close the solenoid valve without human intervention whenever the real-time pressure dropped below the dynamic baseline. Ultimately, this intelligent system provides a sustainable, highly effective solution for autonomous water management and leakage prevention.

Keywords: Smart Water Meter, Internet of Things (IoT), Artificial Intelligence (AI), Anomaly Detection, Moving Average.