Autonomous Water Flow Control And Monitoring System

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***Abstract*—Water conservation and management has become an important topic in recent times due to rapid decline of water resources across the globe. Water scarcity is a looming crisis brought on by climate changes, population explosion and wasteful water usage practices. There is need to design and implement cost-effective and user friendly systems for water management which require little or no manual intervention. In this paper an autonomous system is presented that can mitigate water wastage using real time water flow control and monitoring. The designed prototype uses IR sensors to automatically cease water discharge from overflowing faucets and taps. The system uses water flow sensor for water usage monitoring. This real time water consumption data in an area can be stored in cloud server for analytics purposes.**

***Index Terms*—Water management, Water scarcity, Autonomous system, Micro-controller, Sensors**

I. INTRODUCTION

Water is a highly valuable resource and the very basis of life on earth. Nearly 97% of earth's water is present in oceans and only 3% is freshwater. Out of that almost almost 2.5% of fresh water is unavailable for human consumption since it is confined in glaciers, polar ice fields and atmosphere of earth. Only 0.5% of freshwater is available for human use and consists of groundwater, freshwater lakes and rivers [1].

Due to the exponential population explosion around the globe and rapid urbanization, there has been rise in water consumption across all aspects of human life. According to water facts from United Nations, 72% water is used for agriculture purposes,16% water utilization is by municipalities for household and other services and 12% water is used by industries [2]. Severe water scarcity affects almost 4.0 billion people for at least a month of the year and nearly 50% of those people are from India and China [3]. India has 16% of world population but access to only 4% of freshwater resources due to which 76 million people are without access to safe drinking water [4]. India has water resource of 1123 bcm and 80% of water for domestic use comes from ground water reserve. Rapid industrialization in states of Delhi, Punjab, Haryana and Uttar Pradesh has led to water crisis while the arid climate of states such as Rajasthan and Gujarat leads to water stressed conditions [5]. Freshwater scarcity is further exacerbated due to rampant water pollution [7]. In addition to this, the agricultural sector is also facing crisis due to hydrologic constraints brought on by water scarcity [8].

In-spite of such dire situation, an average Indian wastes 0-45 litres of water everyday which leads to daily wastage of 125 million litres of water in India [6]. Most of this wastage is due to negligent behavior such as keeping the tap open while doing household chores, leaky water discharging outlets etc. There is an urgent requirement to devise adequate water resource management and monitoring systems to avoid the colossal wastage of water resources. Smart water management systems can use Internet of Things, Artificial Intelligence and Big Data technologies for effective monitoring, control of water sources and pipelines as well as quality testing and analysis of water used for domestic consumption.

This paper proposes a working model of an autonomous system that aims to reduce water wastage by managing water flow from faucets, taps and other water discharging sources and also provide real time data about water usage in a residential or commercial building.

II. LITERATURE SURVEY

Current water management systems use variety of technology to monitor water flow, quality of water, leakage detection, water metering. Anjana et.al proposed a system using 6LoWPAN enabled WSN where flow sensor was used for measuring water usage [9]. Nanda et.al implemented a smart water management system where NI myRIO processes the data from pH, turbidity, electrical conductivity sensors to access the quality of water, soil moisture sensor to reduce water wastage during irrigation and water flow sensor to analyze water consumption [10].

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Anisha et.al developed a water restrictor system using Arduino micro controller which processes water usage data from water flow sensor and restricts the water flow by sending signal to solenoid electro-valve if water usage exceeds a limit [11]. Gunde et.al. proposed an IOT based water flow control system which switches on/off the submersible pump based on water level data fetched using an ultrasonic sensor placed on top of a water tank [12]. Aron et.al. developed a WUSN based architecture that uses water flow sensor to monitor water flow rates through pipes and turbidity sensor to detect water quality parameters and processes this data through Raspberry Pi and Arduino microcontrollers in order to send SMS notifications to appropriate authority about any damage in water pipelines [13]. Srihari proposed a smart water distribution system using the data collected by water flow sensor and processing it through Arduino Uno microcontroller. The system also uses a pressure sensor to detect water leakage and pH sensor to measure water quality [14].

III. IMPLEMENTATION

A. Architecture of the system :

The proposed autonomous water flow control system comprises of Node MCU microcontroller which processes the signal sent by IR sensor to detect any object placed under faucet or taps. In case of absence of the object, the controller uses relay module to actuate solenoid valve which stops the water flow from faucet without any delay. The system also uses a water flow sensor to collect information about water consumption in any establishment and an LCD display to indicate real time water usage and flow rate of water in a pipe. This water utilization data can be stored in cloud server for analytics purpose and would be helpful in implementing effective water management strategies.

Figure 1 displays the block diagram of the proposed model. The microcontroller is used to process signals from IR and water flow sensor and actuate the relay unit which controls the water pump. The rate of water flow and amount of water expended would be displayed in the LCD module display unit. This IOT enabled system can send water usage data into cloud based server and also has a built-in battery to provide back-up power enabling operation during night time.

Figure 2 displays the schematic diagram of the system with pin connections between Node MCU and the sensors, display and relay components of the system.

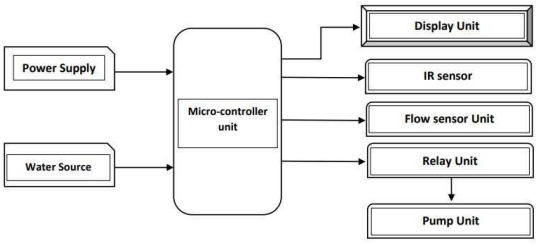

Fig. 1. Block Diagram

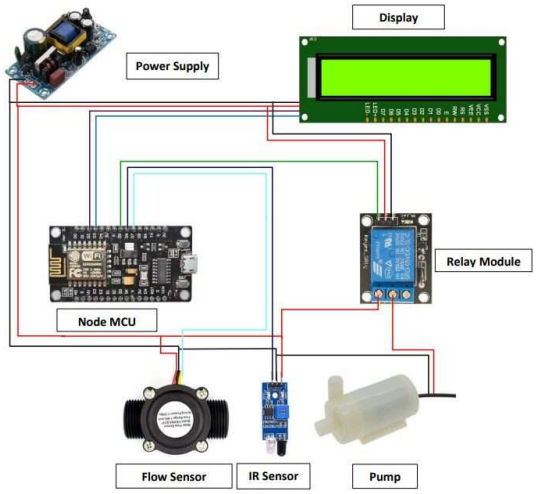

Fig. 2. Schematic Diagram

B. Hardware Used :

1) Microcontroller: Node MCU is an open-source firmware unit built around ESP8266 which has in-built CPU, RAM, Wi-Fi module and SDK. The Node MCU has 30 pins with a clock speed of 80MHz, input voltage of 4.5V-10V and can receive input from sensors (e.g - data related to moisture content, light) or computer and send electronic signal that can control devices such as motors, valves, LED's, LCD's. The Node MCU board can be programmed using Arduino IDE where a program can be compiled and uploaded using USB serial cable.

2) Water Flow Sensor: The Fig 3 depicts YF-S201 water flow sensor which measures the rate of water flowing through a pipe or any water source. The sensor has a plastic valve, water rotor and hall effect sensor. When water passes through the valve it moves the rotor and changes its speed which is sensed as a pulse signal output by the hall effect sensor. The sensor measures the voltage difference induced in the conductor due to the rotor's rotation and this provides a measure of the rate of flow of water.

Fig. 3. YF-S201 Water Flow Sensor

3) IR Sensor: The Fig 4 depicts LM393 IR sensor commonly used for object or obstacle detection. The IR sensor has an IR LED which acts as the transmitter and an IR photodiode which acts like the receiver. The transmitter emits radiation which hits the object placed in front of sensor and some of the radiation is reflected back to the IR receiver. The resistance

and hence output voltage of IR receiver changes due to the received IR light and this detects the presence of an object or obstacle.

In the prototype, the IR sensor detects the presence of any object (can be hand or container) placed under the faucet, tap or showerhead and helps to cease water supply upon removal of the object. The sensor is immune to corrosion and hence can be easily used in water fixtures for prolonged period of time.

Fig. 4. LM393 IR Sensor

4) Relay Module: Relay module is an electromechanical device that can open or close a circuit. The prototype in this paper uses a 5V Single-Channel relay module as shown in Fig 5 to activate solenoid valve which can regulate the flow of water from faucet or taps. The module can also avoid a power surge and protect the microcontroller.

Fig. 5. Relay Module

5) Liquid Crystal Display: LCD as shown in Fig 6 is an electronic display device which shows the real time data related to water flow rate as sensed by water flow sensor. This data provides an estimate of the water consumed in residential or commercial establishment.

Fig. 6. LCD

C. Algorithm :

The algorithm implemented in the system is shown in Fig 7 below. After the system starts, it waits for sensor data from IR and water flow sensor. As long as there is an object positioned under the faucet, water will be discharged. Upon removal of the object, the microcontroller processes the signal sent by IR sensor and activates the relay unit to cease water flow by closing the faucet and the amount of water discharged till that point of time is displayed in LCD module.

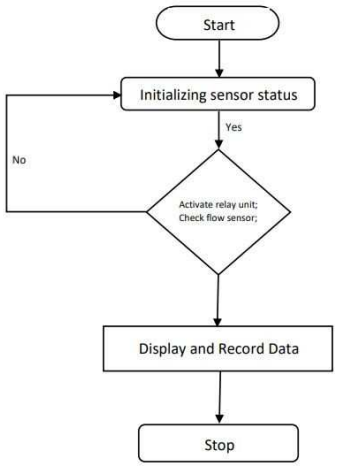

Fig. 7. Algorithm for the system

IV. RESULTS & DISCUSSIONS

A. Prototype :

Fig 8 shows the hardware prototype of the proposed system. An LM393 IR sensor is used for its effectiveness in sensing the object placed under a flowing tap or faucet and sending the output signal to Node MCU microcontroller for processing. This signal can actuate the tap with the aid of relay module. The microcontroller is further interfaced with YF-S201 water flow sensor to monitor rate of water flow and display the result in LCD module.

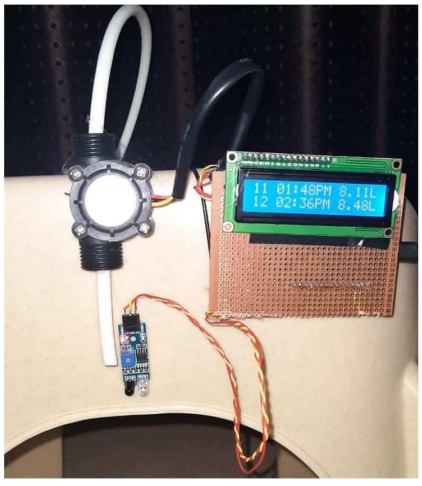

Fig. 8. Hardware setup

B. Testing of Prototype :

The prototype was tested by placing and removing hand under the water discharging outlet. The IR sensor unit detected the removal of hand and water discharge from faucet was ceased immediately. Figure 9 displays the rate of water flow as detected by water flow sensor and read via serial connection of Arduino board. The second column shows the timestamp and the third column shows the water flow rate at that particular point of time.

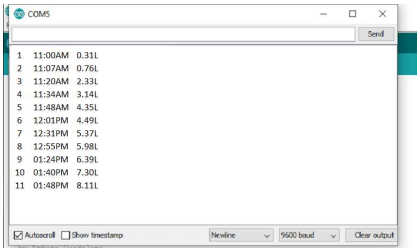

Fig. 9. Output at Arduino IDE

V. CONCLUSIONS

An autonomous water flow control and monitoring system is designed and implemented in this paper. The system is a cost effective, energy efficient and automated solution to minimize water wastage incurred due to faulty taps and faucets and provides a mechanism to automatically shut off water supplied to a faucet upon detection of removal of object placed under the faucet. The system displays water usage in real time which can be helpful in analytics required for smart water management.

VI. FUTURE WORK

This project can be further enhanced by implementing a web and android application to access the data collected by the system. The water usage data collected with help of sensors can be displayed in an android and web application thus providing users with a low cost, open-source interface to monitor and analyse water utilization statistics of an area. Machine learning algorithms can be applied on the data saved in cloud server in order to predict and analyze water usage behavior such as time of the day when maximum water consumption takes place.

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