Abstract

Water is one of the fundamental resources that aid life and there are speculations that estimate at 2025 almost half of the urban population will live under short supply and water stress. With the usage of new technological advancements in IoT (Internet of Things) powered smart devices for water management, it can become a worthy implementation towards avoiding the predicted water depletion. In the past years up until recently, water monitoring and management were manually carried out with intensive power requirements and high capital expense with low efficiency recorded. Overflow of water overhead tanks in residential, commercial, cooperate and educational settings, as well as broken pipes resulting in spillage, contribute to wastage at large. Regular reservoirs for water cannot monitor nor give analytics and automated water level detection in the tank. Vandalization or transmission blockages on distributions pipes may take so long to discover. The proposed model addresses problems mentioned above by the application of portable smart systems with interoperability and easily configurable to handle automated management of water supply with energy efficiency and a reduction in power cost in both homes and enterprise environment within smart cities as well as reduction of the rate of building degradation as a result of overflow from overhead tanks. Our model also integrates the application of Natural Language Processing for speech recognition as an alternate medium useful in operating the system.

Keywords

Internet of Things (IoT), Sensors, Smartphones, Transmitter, Wireless networks, Water management, Overhead tank.

1 Introduction

Overflowing tanks and reservoirs are arguably amongst the biggest cause of water wastage across urban and rural areas. Often time results from forgetful control of the pump switches and the absence of timely human presence to turn off the running motto when the overhead tank begins to overflow. Water which is one of the most important resources for daily existence [1][5] is fast depleting and falling in supply to meet the growing demand by rising population. Thus the need to proffer cost-effective smart automated systems for water management. A lot of buildings degrade over a short period due to consistent overflow of high rise tanks and reservoirs.

Other than the overall worries of freshwater shortage for a household reason, there are rising worries for the shortage of water for agrarian purposes [2, 3]. To handle the difficulties of water shortage, Smart water management and automation can greatly address the water crisis by eliminating endless running of pumping motors even after water tanks are filled to maximum.

This smart management model is conceivable principally by constant observing of water level and quantity. [8] Constant water level observation can essentially decrease the wastage of water subject to flooding from tanks or reservoirs. The smart management framework [13, 14, 15, 16, 17] can likewise assist with identifying water spills in a savvy home by examining water levels during various hours of the day. A smart water management framework as such is a desperate requirement for the drive toward green IoT on our planet.

Several years ago, the high cost of implementing automated water management systems led to the low adoption of such technologies. Lately, with the advent of the Internet of Things (IoT) for smart urban areas [4], the expense has decreased altogether. Web 2.0 and [6] the development of low-powered smart devices at relatively low prices has made associated gadgets with the capacity to exchange information accessible to just anyone.

Fig.1 presents an outline of functionalities obtainable with IoT based water management system. It, by and large, indicate tank state sensing capability using sensors [9, 10], the ability of smart meters useful in measuring usage over time, real-time analysis is also a notable function obtainable in smart water management, spillage or hardware damage can also be detected as well as remotely controlling the pumping motto through a web interface or automated switching of the motor based on water level [18, 19, 20, 21, 22, 23, 24, 25]. Smart valves for schedule irrigation is another exciting functionality possible with automated water management.

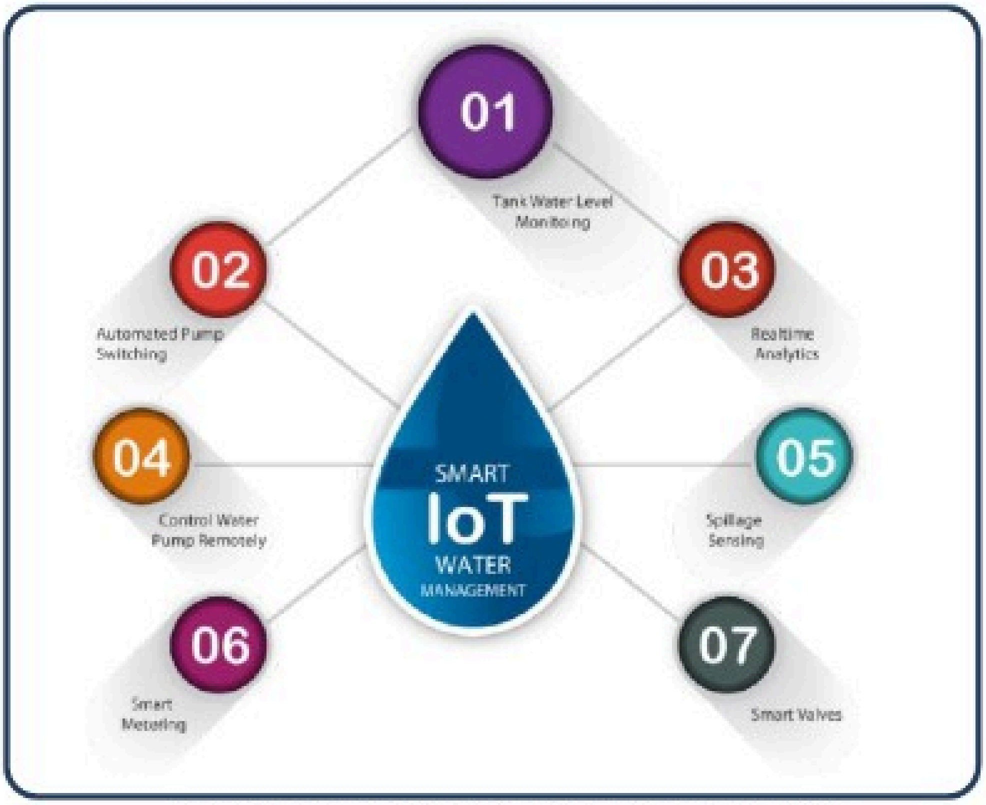

Fig.1 Smart water management obtainable functions

2 Literature Survey

In [26] the authors pointed out the lack of standardization of IoT devices to allow smooth interoperability amongst varying vendors. My proposed model combines low-cost and low-power hardware that interoperates seamlessly. An ultrasonic sensor was used by [27] for water level sensing with reliance on the sound bombarding the water surface from the sensor consisting of a speaker which generates ultrasonic sound waves and a mic to detect the resonance from the water surface; this approach is prone to erroneous reading as surrounding sound external to the tank could trigger the sensor reading. I proposed in this paper the use of a laser sensor which gives a more reliable water level sensing independent of the external environment of the overhead tank.

3. Proposed Work

Proposed in this paper is a description of the setup of a smart water management system using an IoT control console connected to a cloud management dashboard as illustrated in Fig.2 Showcasing IoT devices like water level indicator sensors, smart switch for the pumping motor hardware, wireless transceivers for device connectivity, and a management dashboard that can be accessed and controlled from a user's smartphone or PC. The dashboard shows real-time analytics on water level and usage metrics.

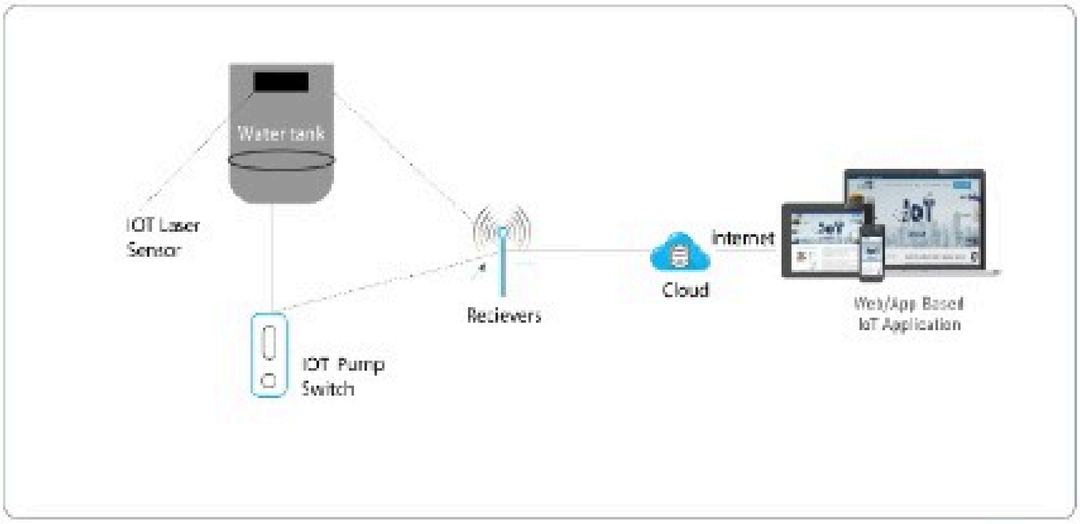

Fig.2 Block Diagram for Proposed Smart Water Management System

2.1 Hardware and Software Requirements

A laser sensor of VL53LOX for precise water level indication in storage tanks can be utilized. This type of sensor can sense the water level in real-time and with an attached HC12 transmitter for data transfer to the cloud platform.

Components within the transmitter can comprise of an Arduino and NodeMcu utilizing low power and transmitting data using any of the wireless technology such as Zigbee, Low Power Wide Area Networks (LPWANs), RFID or Wi-Fi / Wi-Fi HaLow. The use of such transmitters combined can enable automated water level detection and system controlled refilling of water storage tanks.

Incorporating a VL53L0X sensor module positioned at the topmost part inside the reservoir opposite the fluid level uses a laser-based time-of-flight (ToF) distance ranging technique. Invisible infrared laser rays are bounced from any surface thus measuring the time taken for the light to reach the detector. The values obtained from the sensor recordings at varying time intervals are transmitted to the cloud Ardafruit implementation.

A minimum threshold can be taken as V_1 at time t_1 and maximum water height defined as V_2 at time t_2, actualtime T taken to fill the tank when empty is determined by equation (1).

$$T = V_2 t_2 - V_1 t_1 \qquad (1)$$

In equation (2) the pump switch is activated A_i automatically when the water level in the tank detected by the sensor is equal to V_1.

$$A_i = V_1 \qquad (2)$$

and deactivate D_i in equation (3) when the water level equals V_2.

$$D_i = V_2 \qquad (3)$$

Let the varying water level measured during fill up or usage time be n, thus $V_n$indicates the current water level at time t_n. Tank water level L in equation (4) at a particular time is given by

$$L = V_2 t_2 - V_n t_n \qquad (4)$$

The values received from the laser sensor are communicated to the cloud platform from which users can gain analytical insights of water status in the tank. The Adafruit dashboard can also indicate the pump status to users allowing for turn on/off of the pump remotely. Values received from the sensor are transmitted to the pumping motor through the HC12 wireless transmitter to activate or deactivate the pump motor remotely. Power consumption is greatly reduced by using automated switching dependent on the sensor values thus preventing the motor pump from running endlessly when the tank is filled to the defined maximum V_2.

NodeMCU [11, 12, 13] which is useful for the deployment of IoT applications connects the system to cloud storage. The Adafruit cloud platform is a useful implementation for such a purpose. The platform can show the real-time value received and compute the current water level. The continuous level measured by the laser sensor is transmitted to the NodeMcu and to the Adafruit cloud platform from which graphical representation of water level at a given time can be visualized and further analyze water usage.

The combination of Arduino [12, 13] Uno hardware, Relay, HC12 receiver connected to the motor can serve as receiver unit of the setup. When the data received from the sensor is V_1 then the motor is activated to running mode by a smart Relay switch and deactivated when the value is V_2.