

Implementation of an Automated Drainage Cleaning System using IoT

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Abstract: The drainage system in urban centers frequently encounter blockages caused by the accumulation of waste, which can result in flooding and pose significant health hazards. Conventional cleaning techniques tend to be both inefficient and labor-intensive. This initiative presents an automated drainage cleaning system based on Internet of Things (IoT) technology, which employs sensors to detect water presence and waste levels within the filter basket, subsequently issuing alerts for waste disposal. Upon identifying blockages, the system engages automated cleaning mechanisms, including a DC motor and metal jaws. Furthermore, the system is integrated with an IoT platform, facilitating remote monitoring and control via a web or mobile application. Maintenance personnel receive notifications when the waste basket reaches capacity, allowing for prompt intervention. This innovative solution minimizes manual labor, mitigates flooding risks, and enhances the efficiency of drainage maintenance, thereby providing a scalable strategy for improving urban infrastructure.

Keywords: *Drainage, DC Motor ESP32, Relay, IoT*

I. INTRODUCTION

Water serves as a fundamental resource integral to various aspects of life, playing a critical role in human sustenance, agricultural practices, and the sustainability of the environment. The significance of water is underscored by the necessity for effective drainage systems, which are essential for the proper management of water resources. These drainage systems are pivotal not only for environmental conservation but also for economic benefits,

particularly in mitigating the adverse effects of waterlogging [1]. Drainage systems in agriculture play a vital role in enhancing crop yields by maintaining optimal soil and water conditions [2]. The provision of clean water is essential for public health and is intricately linked to sanitation efforts. Furthermore, the human right to water is a fundamental aspect of ensuring access to clean water for diverse applications, including domestic use and agricultural activities [3].

Water quality plays a vital role in the classification of fundamental water services, highlighting the importance of both monitoring and enforcing water quality standards [4]. The scarcity of water underscores the importance of implementing effective water management strategies, including integrated water resources management, to optimize water utilization and reduce dependence on external water supplies [5]. The significance of effective drainage systems is paramount, particularly when considering the essential role of water. Two sectors that are profoundly dependent on these systems are infrastructure development and agriculture. Efficient drainage systems enhance agricultural productivity by mitigating water-logging and ensuring optimal soil conditions conducive to plant growth [2].

For infrastructure to remain stable and functional, drainage systems are necessary [6]. This encompasses both roadways and railways. The maintenance of drainage systems for golf greens demonstrates that adequate drainage is crucial for the health of the turf [7]. Blockages in drainage systems resulting from plastic waste represent a significant issue that has been extensively researched. It is essential to ensure the proper disposal of items such as sachets, bottles, and other forms of plastic refuse to avert obstructions in drainage systems and waterways. Failure to do so can

lead to the accumulation of debris in rivers, exacerbating the impacts of pollution. According to [8], the accumulation of plastic waste in drainage systems not only impedes the flow of water but also contributes to flooding, natural disasters, soil degradation, and water pollution. The impact of plastic pollution, particularly from polyethylene and plastic bottles, on urban areas necessitates the implementation of effective waste management strategies, as it poses significant risks to human health and leads to the obstruction of drainage systems [9].

II. METHODOLOGY

A. System Architecture

This analysis enhances the overall environment by integrating a mechanical system, a primary electrical system, and IoT technology. Central to this system is the Node MCU microcontroller, which serves as its core processing unit.

In this initiative, we incorporate a variety of sensors, including ultrasonic and water sensors, along with a GSM Module. Additionally, a web-based application will be developed.

- The water sensor is responsible for detecting, measuring, and reporting the water level in the drainage system.
- The ultrasonic sensor gauges the distance to plastic bottles or debris within the waste collection bin, ensuring that the bin does not overflow. It communicates with the ESP32 microcontroller to trigger the alert system when necessary.
- An IoT cloud-based platform will be utilized for monitoring the accumulation and disposal processes associated with the project.

The system architecture diagram offers a visual depiction of the project's framework and the interactions among its components, including the ESP32, ultrasonic sensor, LCD, water sensor, relay module, and GSM Module. This diagram illustrates the data flow and communication protocols between these elements, serving as a crucial tool during the design, development, and testing stages of the project. It assists in identifying the project's requirements, constraints, and potential challenges.

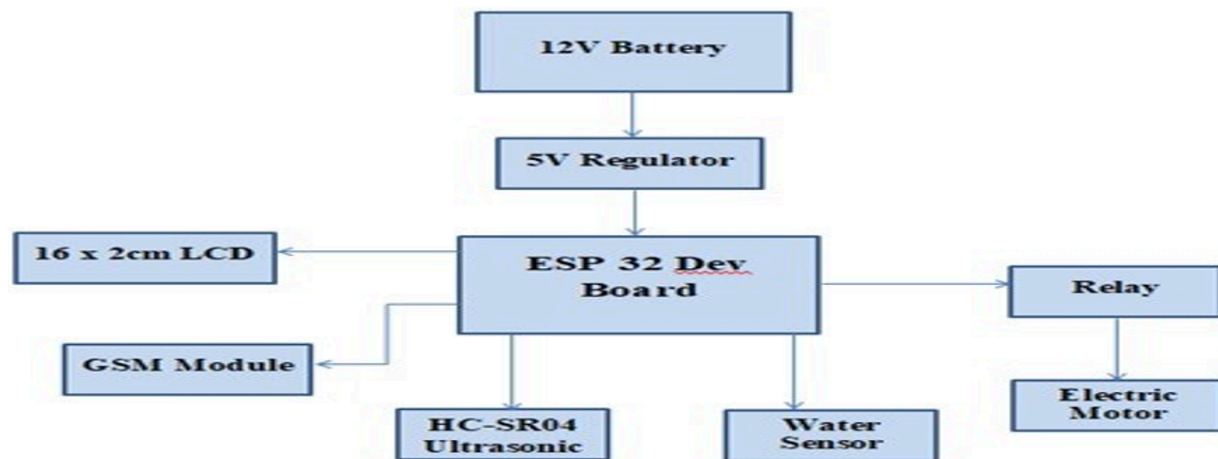


Fig. 1: The system architecture diagram

B. Working Principle

The operational framework consists of a sequence of interconnected procedures designed to efficiently oversee, evaluate, and sustain the drainage system. Environmental data, including water levels and waste accumulation, is continuously collected by sensors such as water and ultrasonic sensors. The ESP32 microcontroller serves as the central control unit, receiving real-time data from these sensors and processing it to identify any deviations from standard operating parameters. Utilizing the analyzed data, the microcontroller determines whether cleaning or maintenance is necessary, based on established

thresholds or conditions. When certain criteria are met—such as elevated humidity indicating water buildup or a full filter basket identified by an ultrasonic sensor—the microcontroller initiates the cleaning process by activating a 12V DC motor. This motor powers the cleaning mechanism, which typically consists of a rotating chain equipped with a filter basket, to clear the drainage system and remove solid waste from the channels. During this operation, the filter basket captures and retains solid waste, preventing it from re-entering the drainage system and causing blockages.

Throughout the cleaning operation, the system persistently monitors sensor data and operational metrics to evaluate the effectiveness of the cleaning cycles and identify any ongoing maintenance requirements. In cases of critical conditions or maintenance needs, such as a full filter basket, the microcontroller activates the GSM module to dispatch alerts or notifications through cellular networks to designated recipients. This enables maintenance personnel or system operators to remotely monitor the system's status and respond swiftly to alerts, ensuring prompt intervention and upkeep of the drainage cleaning system.

C. Stages of operation

During the implementation of the IOT-based automated drainage cleaning system, it is developed and operates in five stages.

Stage 1: The system is connected to a power source and the process begins with the switch turned ON.

Stage 2: Sensing and Data Collection:

- The water sensor monitors the presence of wastewater and conditions in the drainage system; data is sent to the microcontroller for analysis.

Stage 3: Decision-making and Control:

- The ESP32 microcontroller analyzes the data to decide when cleaning is needed.
- It activates the DC motor to start the cleaning process.

Stage 4: Cleaning Process:

- The DC motor drives the metal jaw attached to the chain joined to the sprocket to collect solid wastes.
- Solid wastes are collected in a filter basket to prevent clogs.

Stage 5: Monitoring and Adjustment:

- Continuous monitoring ensures effective cleaning.
- The ultrasonic sensor monitors the level of waste in the filter basket.

Stage 6: Alerts and Communication:

- If issues arise (I.e. a full filter), the microcontroller sends alerts via the GSM module.
- Maintenance personnel receive notifications for timely action.

Stage 7: Maintenance and Efficiency:

- Maintenance is prompted by alerts to keep the system running smoothly.
- The system optimizes based on sensor data for efficient operation.

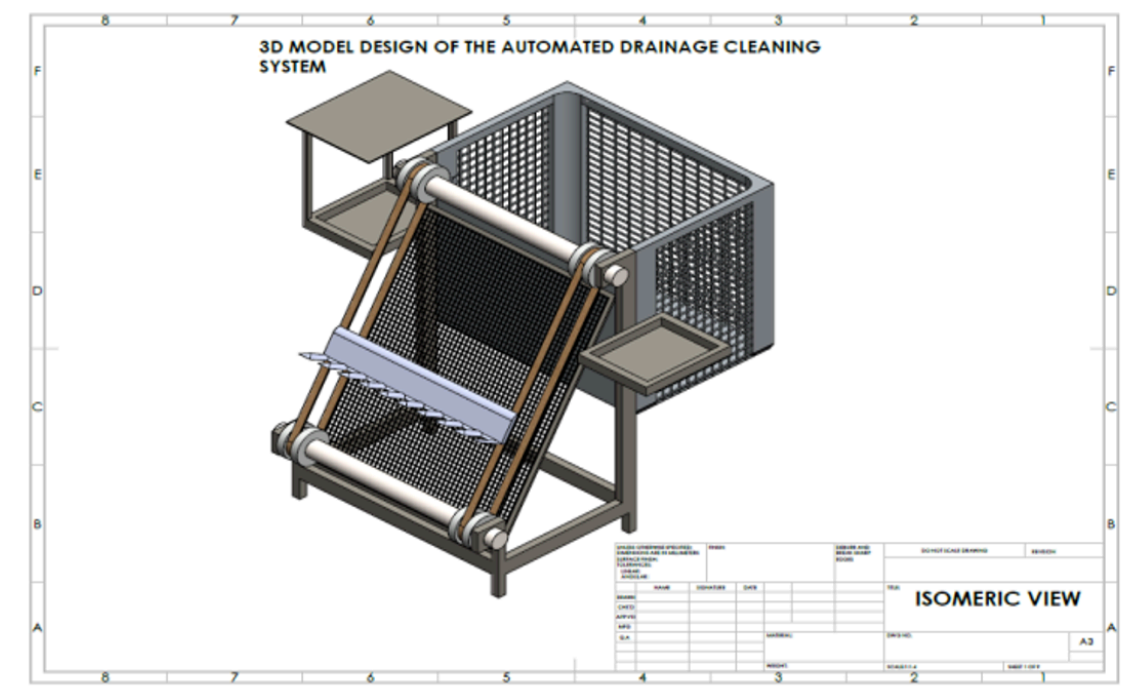


Figure 2: 3D Design of the Project

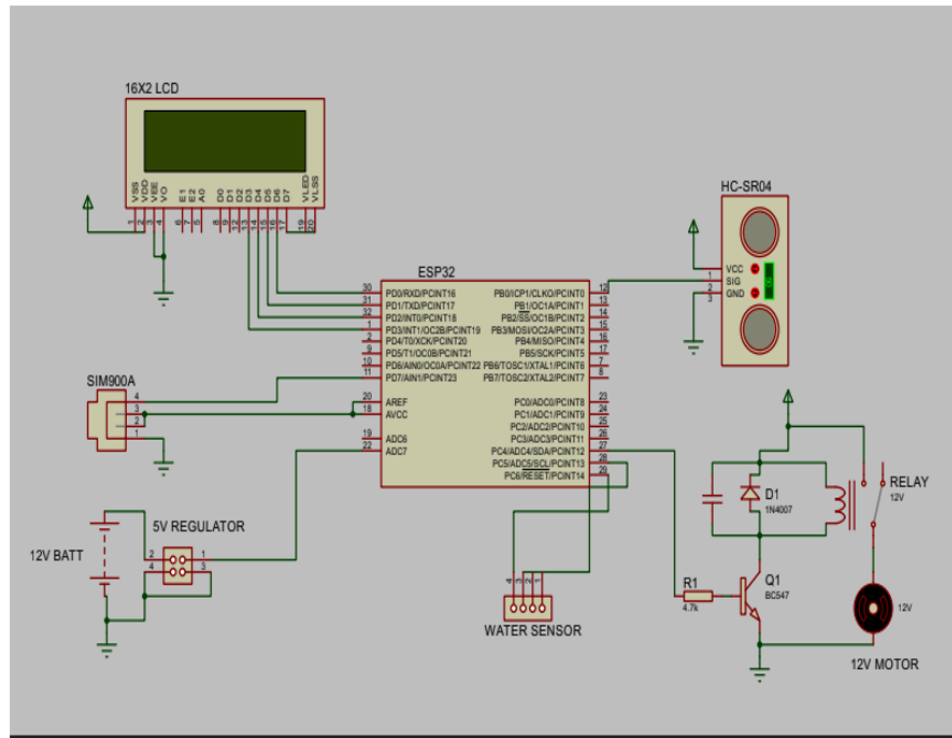


Figure 3: The circuit diagram of the designed system

D. Hardware Design

The hardware configuration involves using all the hardware accessories which comprise a computer system, a programming kit, the sensors, an electrical component integrated development environment, and all other peripheral devices as well as the circuit board, where we have the power supply unit.

The hardware unit comprises the sensing unit which are the ultrasonic and water sensors that obtain values of the presence of water in the drain as well as the distance from the filled level of the bin, the microcontroller will process all data received from the sensing unit and transmit it to the central server. The data will be displayed on the web application.

E. Blynk IoT App

The Internet of Things was the target market for Blynk. It has several fascinating features, including remote hardware control, sensor data display, data

storage, data visualization, and much more. The platform consists of three main parts:

- The Blynk app lets you use a variety of offered widgets to create stunning interfaces for your projects.
- All of the communications between the smartphone and hardware are handled by the Blynk Server. Utilizing the Blynk Cloud can operate a local Blynk server on your own. It can run on a Raspberry Pi, is open-source, and can easily handle thousands of devices.
- Libraries in Blynk: – It allows all of the widely used hardware platforms to communicate with the server and process all incoming and outgoing commands.

When a user hits the button in the Blynk application, data is transferred to the Blynk Cloud and then somehow makes its way to the installed hardware.

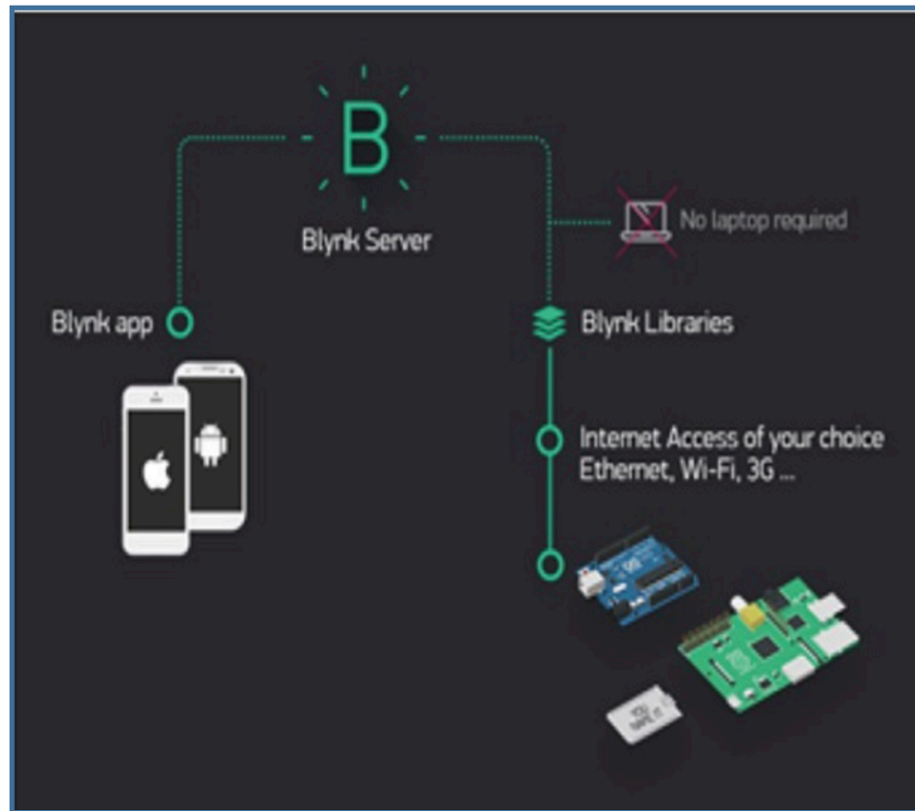


Figure 4: How the Blynk App works

F. Calculations

DC Motor

- Voltage: 12V DC
- Power Rating: 15W
- Total Power Consumption: $15 \div 12 = 1.25A$
- Speed: 1500 RPM
- Torque = $(\text{Power} \times 60) \div (2 \times \pi \times \text{Speed}) \approx 0.095 \text{ Nm}$

GSM Module

Operating Voltage: 4.8V - 5V

- Current Consumption: 2A (during transmission)
- Power Consumption: $(\text{Power} = \text{Voltage (V)} \times \text{Current (I)}) = 5V \times 2A = 10W$

Battery and Motor Selection: a 12-volt system:
Battery:

Choose a 12V battery with sufficient capacity (Ah) based on the motor's power requirements. Motor: Select a 12V DC motor with suitable torque and speed characteristics for the gutter cleaner mechanism.

III. RESULTS AND DISCUSSIONS

The IoT-based automated drainage cleaning system offers a self-sufficient solution that simplifies and enhances safety for cleaning personnel. This system integrates hardware and software to autonomously detect, track, and remove debris from drainage systems. To ensure efficient and dependable performance, synchronization among various hardware components, including sensors, a microcontroller, a DC motor, and a GSM module, is essential.

The sensors continuously monitor the drainage channels, providing real-time data on conditions such as debris accumulation and water levels. This information is processed by the microcontroller, which makes informed decisions and regulates the motor that operates the cleaning device as needed. Additionally, the GSM module facilitates remote monitoring, improving the system's functionality by sending alerts regarding any technical malfunctions via SMS to the system operators.



Figure 5: Project Outlook

IV. CONCLUSION

The creation of an automated drainage and gutter cleaning system utilizing Internet of Things (IoT) technology marks a notable progress in the management of urban and agricultural infrastructure. This innovation effectively addresses the issue of drainage obstructions by automating the removal of waste and debris from drainage channels. The system is capable of identifying blockages through sensors, while microcontrollers enable the activation of cleaning mechanisms. Additionally, communication modules notify operators regarding the necessity for waste disposal and maintenance, all without requiring human intervention.

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