

Automatic flood barrier system: an approach for detection and control of storm water overflow during flood

Jayaprakash M C^{1*}, Sri Krishna Shastri C¹, and Rinaldi Ekaputra²

¹Department of Civil Engineering, Mangalore Institute of Technology and Engineering, Mangaluru, Karnataka, India

²Department of Sociology, Faculty of Social and Political Sciences, Universitas Andalas, Padang, Indonesia

Abstract. Flooding is one of the major disasters occurring in various parts of the world. Due to the high density of buildings, flash floods are prevalent in cities. In such scenarios, there is a possibility of a drainage overflow. Therefore, implementation of an intelligent analysis of drainage leakage detection during flood using sensors are necessitated for the field of research in disaster management. The growth of Indian economy has largely affected due to flash floods. Unplanned urbanization also has a huge impact on drainage and garbage disposal system. Overflow of drainage water has become the common problem that one living in the cities usually face. To minimize the effect of drainage overflow and to alert the drainage overflow system, the paper proposes an automated mechanism. The proposed system is developed with ultrasonic sensor fitted with microcontroller to detect the overflow in the drainage system and sends an early alert warning message to the concerned authorities to take preventive measures. The implementation of proposed system at large scale will surely help to tackle the flood related issues at a larger extent.

1 Introduction

Flash floods are a common problem in metropolitan cities especially during rainy season. A blockage in the drainage pipe will significantly impair the flow of rainwater during the rainy season because of an inadequate drainage system. Cities frequently experience flash floods because of the high building density. There is a chance of a drainage overflow in certain situations. Therefore, the subject of disaster management research requires the adoption of an automated analysis of drainage leakage detection during flood employing sensing elements [1].

In order to keep the city clean, the majority of Indian cities have subterranean drainage systems, which are typically overseen by the municipal corporation. People's health is harmed when sewage water overflows onto the streets and occasionally contaminates drinking water due to inadequate sewage system maintenance. It is common for drainage to become obstructed during the rainy season, and the situation worsens during floods. The most frequent issue that flood-prone localities deal with is sewage water seeping into the floodwater. Hence to overcome this scenario we have introduced model called Drainage Overflow Contro System.

This proposed method will identify the sewage water blend into the flood water and the sensor used will send required data straight away to the nearest managing station using transmitters. This proposed system will detect the sewage water mixture into the flood water and the sensor sends information immediately to the nearest managing station as SMS via transmitter.

2 Literature review

K Subramanya Chari et. al. 2020 [1]: Suggested a Raspberry Pi-based Internet of Things flood monitoring and alert system. Every year, the loss of live people and property is increased as a result of the dynamic changes in weather patterns that lead to severe flooding. Therefore, the subject of disaster management research requires the application of an intelligent analysis of flood risk. This article uses a Raspberry Pi model to create an intelligent Internet of Things (IoT)-based flood monitoring and alerting system. Water and rain sensors are used to monitor the water level in a lake or river and notify authorities of heavy rainfall. Because it makes use of an Internet of Things system, this system notifies the residents of neighbouring villages.

Debasis Parinda, 2021 [2]: Suggested an IoT-based sewage monitoring and protection alert. Undoubtedly, sewage management has an impact on our everyday hygiene and is a crucial component of municipal infrastructure. Urban floods, which are most common in densely populated cities, can be caused by poor sewage and drainage management. An IoT and sensor-based smart sewage management device can be used to solve this issue. Here, a smart device detects when the drainage system becomes clogged, and if the water overflows as a result, will notify the local government so they may take the appropriate measures. Moreover, the drainage system's condition will be tracked in real time with the Android app. Similar to a typical water level indicator

* Corresponding author: jayaprakash@mite.ac.in

project we have previously constructed, this one will use the Internet of Things to detect sewage overflow and track it online.

Ryan Hanson, 2020 [3]: Overpopulation, climate transformation, and outdated water facilities—where majority water leaks are caused by deteriorating pipes—have all contributed to the recent increase in the scarcity of water supplies. The length of time it takes to find the leak is the issue, not its size. This document describes the installation of a water leak detection system in a home's hydraulic facilities. An SMS alarm message, an electrical actuator to cut off the main water supply to prevent leaks, a processor to understand the data and determine whether or not there is a water leak, and a water sensor placed beside a water reservoir of attention make up the system.

Giri Srinivaas Ranga Rao, 2017 [4]: In the suggested Drainage Overflow Monitor System using IoT (DOMS) concept, the gadget could measure the water and gas levels in the sewage system, record the computed parameters in the cloud storage, and use the GSM module to send an SMS to the corporate office with the sewage system's condition.

Qinggong Ma, 2017 [5]: IOT technology's security architecture and requirements have been examined by the survey. The need for an IoT-assisted urban waterlogging prevention management system is discussed in the article. This article describes the fundamental model for preventing urban water logging.

U.S. De, G.P. Singh, 2013 [6]: Due to unemployment and other factors, people are moving from rural to urban areas. Cities are dealing with a lot of new issues as a result of the growing population. One of the major issues made worse by the unchecked expansion of megacities is the state of flooding. The article details the number of people living in four Indian megacities and the number of people killed by flooding.

3 Methodology

Majorly two sensors were installed to measure as input parameters, i.e. Ultrasonic sensor which helps to detect the blockage, and the Water level sensor which identifies the overflow of water. The data sensed from these transducers will be processed in the ESP8266 processor which acts as both controller and Wi-Fi modem.

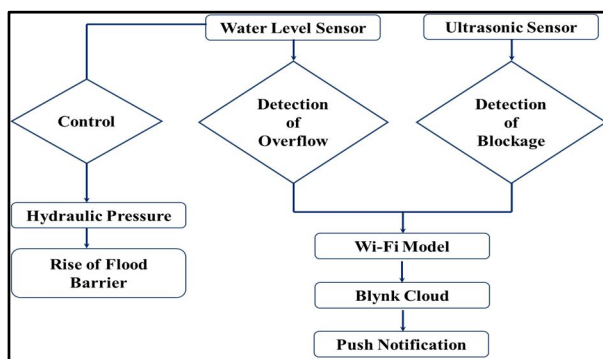


Fig. 1. Block diagram

The ESP8266 performs all the arithmetic and logical operations inside and transfers the appropriate data to the

Blynk cloud for the necessary operations. Here, the real-time ultrasonic measurement is sent to the Blynk application and also a notification is sent to the user mobile in case of Blockage or Overflow.

Figure 1 shows the sensors to measure water level at the upper edge of the drainage, monitors the overflow of the water and will send the information to the respective agency people through the proper notification. As a consequence of this, a necessary action will be taken by the authority members. Immediate action may involve pushing the barrier above to protect the flow of water to the ground level. This can be achieved using the hydraulic pressure formed inside the compartment constructed as shown in the 2D diagram which indicates the physical components of the projected system.

The proposed system can be successfully achieved by fragmenting the methodology into different stages: Identify potential overflow areas: The first step is to identify the areas in the drainage system where overflow is most likely to occur. This could be areas with high levels of rainfall or areas where the drainage system is most susceptible to blockages.

Install sensors: Once the potential overflow areas have been identified, sensors can be installed to detect when water levels in the drainage system reach a certain threshold. This could be done using water level sensors or other types of sensors that can detect when water is backing up in the system. We have used the ultrasonic sensors to detect the blockages.

Activate barriers: When the sensors detect that water levels are rising to a critical point, barriers can be activated to prevent overflow. Barriers can take many different forms, such as gates, flaps, or inflatable bladders, and can be designed to fit the specific needs of the drainage system.

Monitor system performance: Once the barriers have been activated, it is important to monitor the system's performance to ensure that it is working as intended. This could involve monitoring the water levels in the drainage system to make sure that they are not rising too high or too quickly, or monitoring the performance of the barriers themselves to make sure that they are holding up under the pressure of the water.

Alert system activation: If any issues are identified, then along with the immediate measure of upliftment of the barriers, an alert system activation also should go hand in hand. The authorities need to be immediately alerted on this issue so that immediate action is taken before the water level reaches the barrier height.

Control unit: This is the central processing unit that receives the information from the sensors and controls the operation of the system. This should be compatible and communicable with both the sensors and the communication network. The control unit used here is ESP8266 which acts both as Microcontroller and Wi-Fi module. This performs all the logical and mathematical operations inside.

User interface: This should be provided in order to allow the module operators to monitor the status of the module and receive alerts in case of overflow. This could be the web-based interface or a mobile application. The following project includes the Expo Go Application

which is readily available to download from the google play store.

3.1 Communication system

In order to effectively manage drainage systems, it is vital to have a communication system in place that can detect and notify the relevant authorities about the overflow conditions. This section hence outlines the communication system that has been proposed for the project.

The communication system between an ESP8266 device and the Expo Go app plays a crucial role in enabling data exchange and interaction. Here's how the communication system works in the context of ESP8266 and Expo Go.

3.2 ESP8266 device

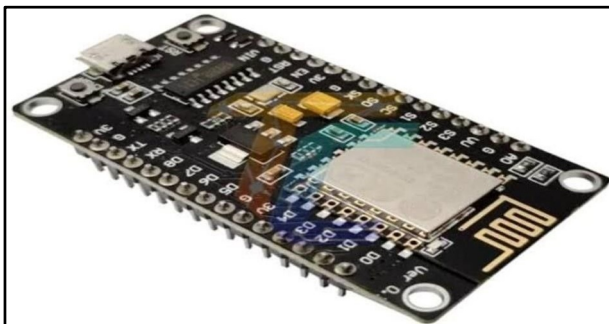


Fig. 2. ESP8266

Figure 2 shows the ESP8266 which is a famous Wi-Fi module commonly used for Internet of Things (IoT) applications. It can connect to Wi-Fi networks and exchange information with other devices over the network. The ESP8266 can be programmed with custom firmware or using platforms like Arduino to perform various tasks, such as sensor data collection, data processing, and network communication.

Sensor integration: The HC-SR04 ultrasonic sensor may be used to monitor the water level in the drainage system. The sensor can be connected to the ESP8266 using the GPIO pins, and the measured distance can be read by the ESP8266.

Control algorithm: The ESP8266 can be programmed to control the drainage system based on the water level measurements. For example, if the water level reaches a critical point, the ESP8266 can trigger an alarm or activate a pump to prevent overflow.

Communication: The ESP8266 can be connected to a Wi-Fi network to send data to a cloud service or a mobile app. This can enable remote monitoring and control of the drainage system.

Power management: The ESP8266 can be powered using a battery or a solar panel to enable long-term, autonomous operation.

Overall, the ESP8266 microcontroller can provide a cost-effective and flexible solution for drainage overflow detection and control. With the integration of sensors, actuators, and communication capabilities, the ESP8266

can enable efficient and reliable operation of the drainage system

Expo Go application: Expo Go is a mobile app used for developing and running cross-platform applications built with the Expo development framework. The app allows users to access and interact with Expo Go powered projects on their mobile devices. Expo Go provides a runtime environment for running JavaScript code and rendering user interfaces.

3.3 Communication between ESP8266 and Expo Go

The ESP8266 device and the Expo Go app can communicate through a combination of Wi-Fi and network protocols. The ESP8266 can send data to the Expo Go app by acting as a server or by making HTTP requests to an API endpoint hosted by the Expo server. The Expo Go app can receive data from the ESP8266 by making HTTP requests to the IP address and port of the ESP8266 server or by subscribing to a WebSocket connection provided by the ESP8266.

3.4 Data exchange

The ESP8266 will collect sensor data or perform specific actions based on its programming. It can send the collected data to the Expo Go app by packaging it in HTTP requests or WebSocket messages.

3.5 Interaction and control

The Expo Go app can also send commands or instructions to the ESP8266 device. It can make HTTP requests or send WebSocket messages to control the behavior of the ESP8266 or request specific actions. The ESP8266 receives the commands from the Expo Go app and performs the corresponding actions based on its programming, such as controlling actuators, updating its internal state, or responding with data.

Overall, the communication system between the ESP8266 device and the Expo Go app allows for bidirectional data exchange and interaction. It enables the Expo Go app to receive real-time sensor data from the ESP8266 and control the behavior of the ESP8266 device based on user interactions within the app. This communication system forms the foundation for building IoT applications that integrate with the Expo Go platform.

4 Results and discussion

The aim of our work is to build up an IoT based system which is competent enough to predict the drainage situation and alert the officers within no time when the drainage water is found overflow or during flood conditions. Developing the short time hydraulic pressure barrier system would be immediate control system, so that corrective measures for the nearby people's property damage and inundation of the area is taken care of [3].

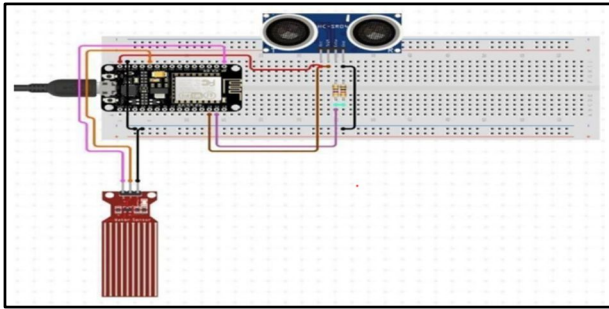


Fig. 3. Software circuit simulation

Figure 3 shows the water level sensors mounted at the top edge of the system, monitors the overflow of the water and sends proper information to the respective members of the authority through the notification. As a consequence of this, a corrective measure can be expected until the authority member arrives for the recovery. The sudden measures involve upliftment of the situated barriers to protect the flow of water to the ground level. This could be performed using the hydraulic pressure created inside the compartment formed in the 2D diagram which indicates the physical components of the expected system as shown in Fig. 4. Additionally, we have also mounted the water level sensors into the tip of the barrier edge to sense if the water exceeds that height too.

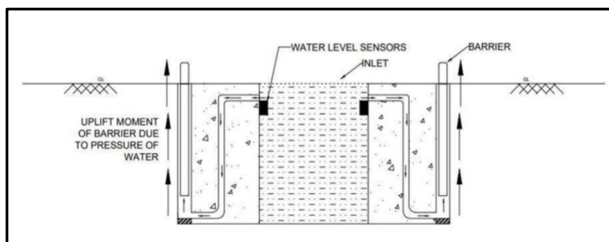


Fig. 4. 2D diagram

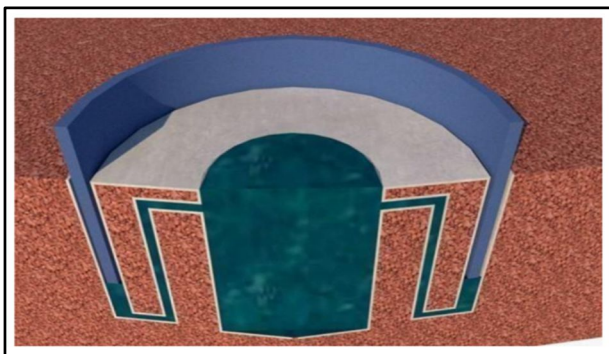


Fig. 5. 3D diagram

Figure 5 shows that 3D drawings serve as a powerful communication tool by providing a common language for project participants. They can convey complex ideas, concepts, and technical details in an easily understandable format. This is particularly beneficial when engaging with non-technical stakeholders who may have limited knowledge of technical drawings or specifications. 3D drawings facilitate effective communication by presenting a realistic and tangible representation of the project, reducing ambiguity, and ensuring a shared understanding among all parties involved.



Fig. 6. Ultrasonic sensor

Figure 6 shows the HC-SR04 which is an ultrasonic sensor that can be used for drainage applications to measure the water level in a tank or drainage system. The sensor emits high frequency sound waves that bounce off the surface of the water and return to the sensor. The time it takes for the sound waves to travel to the surface and back is used to determine the water level. The sensor requires 5V DC power supply and can operate at a frequency of 40 kHz. The sensor can measure water level from range of 2 cm to 400 cm.



Fig. 7. Water level sensor

Figure 7 shows the water level sensor which is device that used to measure the level or depth of water in a container, tank, or body of water. These are commonly used in applications such as water tanks, wells, sewage systems, and irrigation systems. They can help to prevent overflow or underflow, monitor water usage, and optimize water management. The sensor we used works with DC voltage of around 3-5 V and working current is less than 20 mA with detection area of around 40 mm*16 mm.

4.1 Circuit simulation

Before construct any hardware circuit connections, circuit simulation is a crucial and essential step to verify the components' computability and operation.

Accessibility: Online circuit simulation tools are easily accessible from anywhere with an internet connection, which makes it easier for team members to collaborate on the project remotely. This can save time

and increase efficiency during the design and testing phases.

Real-time results: Online circuit simulation tools provide real-time results, which can help designers quickly identify and troubleshoot issues in the circuit design. This can save time and reduce the risk of errors during the construction phase.

Scalability: Online circuit simulation tools can be easily scaled to accommodate larger and more complex circuit designs. This allows designers to test and optimize the performance of the circuit before construction, which can help reduce the risk of costly mistakes during the construction phase.

Flexibility: Online circuit simulation tools can be used to test a variety of circuit designs and configurations, which can help designers optimize the performance of the circuit and meet the required specifications for the project.

Remote collaboration: In today's globalized economy, many projects involve team members working remotely from different parts of the world. Online circuit simulation tools can provide a centralized platform for collaboration, allowing team members to share and test circuit designs in real-time, no matter where they are located.

Limited resources: If a project has limited resources or a small budget, purchasing and maintaining specialized simulation software might not be feasible. Online circuit simulation tools can provide a more cost-effective solution, allowing designers and engineers to test and optimize their circuit designs without the need for expensive software.

The proposed system identifies the overflow or leakage over the drainage water to the flood water and informs the neighbouring managing authorities. This can be further extended by informing the locality people. This system is very effective for flood affected areas. The proposed multifunctional model will help in improving the community preparedness for extreme weather conditions such as flash floods. The system also minimizes safety and infrastructure hazards. As part of the warning, the prototype will also provide a prediction of the scale, timing, location and possible damages of the impending flood.

5 Conclusion

The developed proposed system would accurately identify drainage overflow and inform the concerned authorities. The adoption of ultrasonic sensors and an Arduino based controller makes the system efficient and cost-effective. The model can be further extended by adding some other additional sensors to cover a wide land cover. Also, the parameters measured could be stored and utilized as a data for further analysis. The system can also be utilised in other applications such as water level monitoring in huge water supply unit.

The multifunctional system would enhance the community preparedness for extreme weather events such as floods, in terms of both alarm and added understanding of risks, appropriate flood responses and hydraulic pressure real time barrier. The current increase in the number and degree of extreme weather events such as floods would make the technology relevant for climate change detection also.

References

1. K. Subramanya Chari et. al., IoT-based flood monitoring and alerting system using raspberry pi, IOP Conf. Ser.: Mater. Sci. Eng. **981**, 042078. (2020). <https://circuitdigest.com/microcontroller-projects/sewage-monitoring-and-aintenancealertusing-nodemcu-esp8266-and-ultrasonic-sensor/>.
2. Debasis Parida, Sewage monitoring and maintenance alert using IoT, Microcontroller Based Projects, Published (2021).
3. Ryan T. Hanson, Water leak detection system (2020). <https://digitalcommons.calpoly.edu/eesp/389>.
4. R Girisrinivaas and V Parthipan, Drainage overflow monitoring system using IoT (DOMS), IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI-2017), Chennai, India (2017).
5. Qinggong Ma, Bo Yang, and Jipeng Wang, Application of Internet of Things in Urban Flooding Prevention Management System, Scientific Research Publishing, Advances in Internet of Things, ISSN Print: 2161-6817, (2017).
6. U.S. De, G. P. Singh and D. M. Rase, Urban flooding in recent decades in four mega cities of India, J. Ind. Geophys. Union, **17**, 153-165 (2013)