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IoT Based Dam Monitoring and Pre-Disaster Management

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Abstract – *Dams play a vital role in harvesting energy and utilizing the energy for electrification and irrigation purposes. Apart from that dam protect against flooding by collecting and holding waters when they reach a certain level. Once collected, a dam might be designed to release the water back into the river at a controlled speed or divert the water elsewhere for other uses. Due to unforeseen situations mismanagement of dams would lead to catastrophic damages, which is very evident in the case of 2018 Kerala floods, where 35 of its 54 dams were let open without prior warnings and early action plans leading to loss of lives, property damages etc. Majority of countries are still using manual systems for controlling and monitoring the dams which is time consuming, and inaccurate. To solve this problem, an IoT based dam monitoring system and its role in pre disaster management is proposed. The dams are remotely monitored using real time data's such as temperature, water level, rainfall and water flow rate along with receiving danger warnings and alerts which can be set based on the capacity of the dam as blue, orange or red alert through a mobile application. The dam operator is given the privilege to manually or automatically control the gates based on the scenarios and requirements. Similarly, 'n' number of dams can be monitored and operated which reduces the complexity in controlling or monitoring the dams and the data's collected can be studied for effective predictions in the future. Similarly, drought is also an integral part of disaster which can be overcome to an extent using Dams. The proposed system also demonstrates how drought can be prevented.*

Key Words: IoT, NodeMCU, Blynk, DHT11 sensor, MG996R Servomotor, HCSR04 ultrasonic sensor etc.

1.INTRODUCTION

IoT in disaster management can help us in predicting calamities, alerting authorities at an early stage, and rescuing people affected by disasters, thus potentially saving lives, money, and resources. IoT devices hold the power to transform the reactive disaster management techniques into predictive ones. Hence an effective dam monitoring system with monitoring screen and a gate control function built onto a mobile application will allow the user to monitor the level of water on a real time basis along with other vital parameters, for better disaster mitigation and water management using Water level monitoring, Live weather status, risk reduction using alert system and dam gate control. The proposed system should leave its users in control of the gate. Several dams and major water bodies can be monitored and synchronized based on the data's retrieved and early warning systems can be integrated. Precise decisions can be taken well in hand thus averting the last-minute rush. The exclusive control and operation of the dam is restricted for the dam operator whereas the alerts and few major monitoring parameters are made available to the general public. Dams also play a vital role in irrigation purposes through which disasters like drought can be prevented. In the proposed system, the scenario of drought and how it can be compensated is also demonstrated.

2. LITERATURE REVIEW

A thorough analysis of literature was carried out on how IoT can be integrated to monitor and control dams [1] An overview of water level monitoring used and its integration to IoT is given for monitoring purpose along with gate control mechanism by checking the water levels of three different locations. The platform used is a web-based system. All the control mechanisms are automated [2] An advanced version with multiple sensors to monitor vital parameters such as temperature, rainfall, flow rate etc. with IoT, GSM and cloud-based technologies involved to ease the involvement of the operator. Our system provides three levels of alert and monitoring through a user-friendly application at the fingertip and makes use of mobile data or Wi-Fi which has a much better response time. Also, the case of drought management is being taken care of by balancing the water level of dams with surplus water and that of dams with water shortage, which is distinct from the above systems.

3. PROPOSED METHOD

The proposed system concentrates on five major areas

(i) Water level monitoring
(ii) Live weather status
(iii) Risk reduction using alert system
(iv) Gate control (manual & automated)
(v) Drought control

The system comprises of two dams namely DAM 1 and DAM 2 with DAM1 at higher level than DAM 2. Two dedicated ultrasonic sensors are used to measure the water level and flow rate of both the dams. DHT11 temperature sensor is used to monitor the live temperature and humidity of the locality, which is used for monitoring purpose. The threshold water levels are preset in the program code based on the dimensions of the dam and three level of alerts i.e., blue, orange and red alert is given to the users via Blynk App. The gates can be controlled automatically or manually by the operator. Gate are controlled through a servomotor which is integrated as a virtual slider in the App. For drought control a scenario is created where water from the bottom Dam is drained out using a pump setup and artificial drought is created. The ultrasonic sensors detect the drop in water level and releases the water from top dam and ensure that water levels in both the dams are equally maintained.

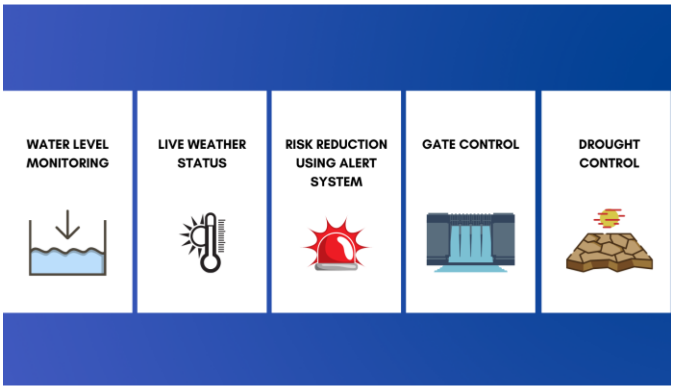

Fig -1: Focus Areas

4. IMPLEMENTATION

4.1 Block diagram and working

As shown in Fig 2. the hardware side consist of ESP8266 NodeMCU as the heart of the system with seven sensors integrated to it for monitoring and control purposes. Two HCSR-04 ultrasonic sensors are used to monitor the water levels and both the dams as well as the rate of flow of water. Two MG996R servomotors are used for the control mechanism of gates of both dams and can be varied at different step angles between 0° and 180°. DHT11 sensor is used to measure the temperature and humidity as they are vital parameters to monitor and predict adverse weather conditions. Rainfall interface is coupled with rainfall sensor to obtain the output between a scale of 0-100%. The NodeMCU is connected to the IoT platform via Wi-Fi. Fig 3. A mini pump control system is used externally for the purpose of demonstrating drought and it comprises of two mini pumps, L2989 motor driver units interfaced with NodeMCU.

The IoT platform used in the system is Blynk platform. Blynk is a full suite of software required to prototype, deploy, and remotely manage connected electronic devices at any scale: from personal IoT projects to millions of commercial connected products. The IoT architecture is shown in Fig 4. NodeMCU is connected over the internet via Wi-Fi hotspot. Blynk libraries can be made used for the coding purpose. Access token is assigned for the system and virtual widgets are made used to virtually control the various functions. Each widget performs a specific input/output function when communicating with hardware or end-user. Blynk app is used to monitor and control all the functions defined earlier. Blynk.App is a multi-functional native iOS and Android mobile application that serves these major functions:

1. Remote monitoring and control of connected devices that work with Blynk platform
2. Configuration of mobile UI during prototyping and production stages
3. Automate work of connected devices.

Arduino IDE is made used for programming purpose. The proposed system comprises of fifteen widgets namely

- Virtual slider (for top and bottom dam)
- Virtual level monitor (for top and bottom dam)
- Rain Gauge
- Super chart
- LED indication of alerts (Green, Blue, Orange and Red)
- Labelled values (Temp., Humidity, flow rate)
- Notification setting and eventor setting

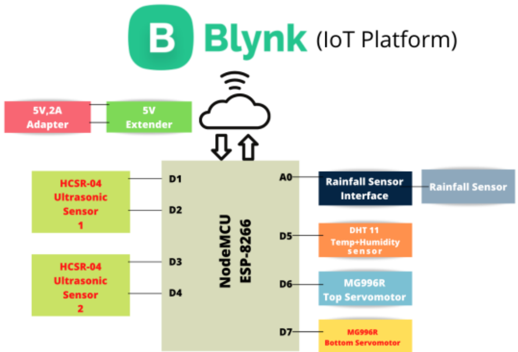

Fig -2: Block Diagram

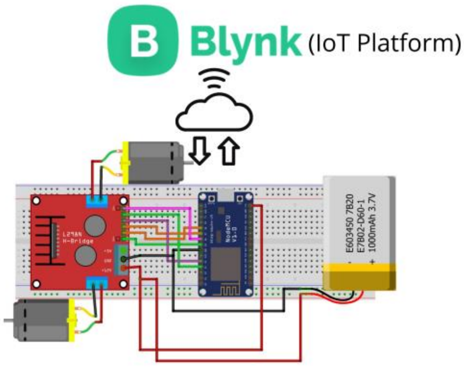

Fig -3: Pump Control System

Similarly, the pump control unit is interfaced to ESP8266 and Blynk for demonstration of drought through the same app, but on a different tab.

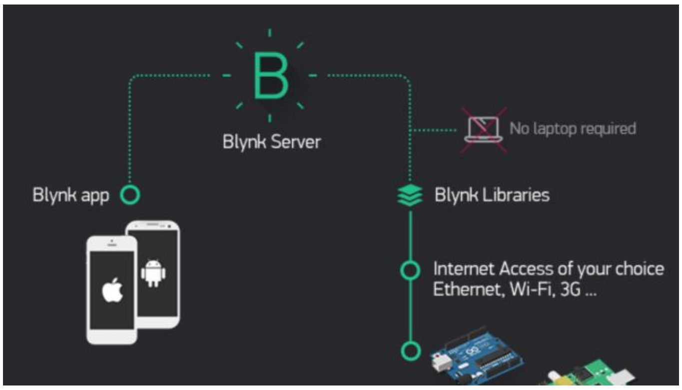

Fig -4: IoT Architecture

5. HARDWARE SETUP

Fig 5. Shows the final hardware setup of the proposed system.

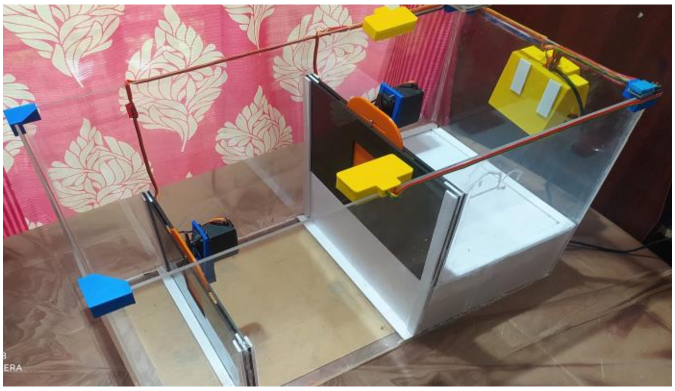

Fig -5: Hardware Setup

Two identical dams are constructed using acrylic and forex sheets with the top dam (DAM1) higher than that of the bottom dam (DAM2) depicting two dams at different location with a common source of water body. The water holding capacity is 836 $cm^{3.}$ Each dam comprises of 3D printed gate which is controlled by the servomotor. The gate can be controlled at various angles to increase the area of opening to let out the water based on the incoming supply The mini pumps are immersed in both the dams to pump the water out for demonstrating drought scenario. Each dam consists of ultrasonic sensors for level monitoring and flow rate measurement. Rainfall sensor and temperature sensor modules are placed on the top corners for better proximity. All the sensors and other devices are connected to the NodeMCU via jumper wires to the respective pins. 5V, 2A adapter is used for providing the supply to NodeMCU. A 1000mAh, 3.7V battery is used to provide supply to the NodeMCU and mini pump via the motor driver unit.

6. RESULT

Three different scenarios are considered to demonstrate the results:

1) *Excess water is supplied to DAM1*

In this case, the water level in the catchment area of DAM1 increases, which is monitored by the level sensor and the NodeMCU is triggered based on the threshold levels set earlier. NodeMCU then initiates the servomotor to open the gates so that excess water is given to catchment area of DAM2 thus preventing flooding of DAM1 and its nearby localities. Simultaneously the alert messages are given to the Dam operators, SDMA, nearby inhabitants etc. via Blynk app, ensuring prior evacuations,

2) *Excess water is supplied to both DAM1 and DAM2*

In this case, the water level in catchment areas of both DAM1 and DAM2 increases rapidly depicting heavy rainfall. Both the ultrasonic sensors are triggered and gates of both the dams are opened. In real world, the excess water passes to the spillways via tributaries and finally to the sea or ocean, reducing the probability of flooding. Alert messages are sent, and the authorities must be more cautious in this case as the substantial chances of flooding is very high. Once the water level drops below the threshold value, the gates close3s automatically

3) *Water shortage at DAM2*

An artificial shortage of water is created at DAM2 by pumping out the water using the pumping system to demonstrate drought management using dams. The surplus water from DAM1 is supplied to DAM2 without excess drop in the water level of DAM1 so that the water level is balanced ate DAM1 and DAM2. The ultrasonic sensor is reprogrammed to detect the drop in water levels and triggers the gate opening mechanism of DAM1 to supply water. When the water levels are balanced in both the dams, the gates automatically close.

Fig 6. Represents the user interface of the Dam status application made using Blynk App. All the data's obtained from the system are stored in databases at the Blynk server side and can be used for further analysis. The time delay is very few milli seconds which eventually does not affect the operating efficiency of the system. The super chart gives a pattern of water levels of both the dams helpful to determine the flood patterns of a dam and its nearby locality, potentially helpful in pre disaster risk reduction. Any changes or additions can be easily incorporated.

Fig -6: App Interface

7. CONCLUSION

The proposed system makes use of IoT to efficiently control and monitor the vital parameters of a dam. Five focus areas are covered which makes it easier for the dam operators to take decisions based on advanced predictions rather than manually relying for the information's which might cause mismanagement of the dams. All the required data and controls are available at the fingertips and can be accessed anywhere from the world via internet access. Alerts are given well in advanced so that pre disaster risk reductions can be implemented in advance to reduce the impact of flood. Disaster risk reduction (DRR) is an integral part of social and economic development and is essential if development is to be sustainable for the future. Water shortages and drought are also an integral part of disaster management, and it is rightly dealt with in this system. For a large-scale application, several hundreds of parameters can be precisely monitored, measured and controlled for any 'n' number of dams.

8. FUTURE SCOPE

1) Advanced prediction models can be created by combining the data's retrieved from this system and flood patterns using Artificial intelligence, Data science and Machine learning tools.

2) All the dams and major water bodies of a locality, state or country can be modelled with this approach, which makes it easier for pre disaster management.

3) Effective water grid concept can be introduced to avoid shortages of water supply during adverse weather conditions.

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