Disaster Monitoring and Management System for Dams

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Abstract-Dams are of major importance, primarily because of their use for generating hydroelectricity and irrigation purposes. This has resulted in the construction of a number of dams in potential areas over the years. As there are a lot of risk factors associated with the existence of these dams, it has become the need of the hour to develop a proper monitoring and regarding the opening of the shutters thereby management system for maintaining a safe water level in dams. Mismanagement of dams can lead to manmade disasters. Currently dams in our state are being monitored and controlled manually. This manual intervention can increase the probability of error and also results in time lag in decision making. The aim of this project is to design and implement an IoT based Disaster Monitoring and Management System for Dams (IDMMSD). The proposed system involves real-time monitoring of water levels of a group of dams under study. Water levels may vary due to drastic changes in water levels of connected rivers or lakes, or due to excessive rainfall in the catchment area. The proposed project includes a mechatronics system to open the shutters at the heights pre calculated. The system comprises of sensor nodes, smart controller and communication system. The proposed system is an app based IoT system which will monitor and send real time parameters related to Dam (gate position, water discharge, water level) and weather conditions (rain fall, temperature, humidity). There will be two modes for operating the software i.e. Autopilot mode and Manual data mode. The system also includes features like SMS alert to the people of the locality and SOS to rescue operations in case of adverse weather conditions.

Keywords-IoT, Cloud, Autopilot mode, microcontroller

1. Introduction

In 2018, Kerala has experienced the largest disaster due to flood after 1924. The continuous rain since first week of August'18, accumulated huge rain water in several dams. Consequently, on 10th August 2018, 35 dams were opened by KSEB. Water discharged from these 35 dams in addition to the excessive rain water created deluge and natural disasters in a number of districts of the state. The development of this system requires collecting information of the existing dam facilities, establishment of a robust communication network (between sensors and controllers) and development of a mechatronics system for shutter control. The complexity of the system increases in considering extreme weather conditions, such as droughts and floods. Literature is rich with researches on water level monitoring systems for various applications; using wireless networks [10,13], IoT based systems for water tank monitoring [11,14], Water quality monitoring [6], water level monitoring system [4] and water level control system in steam generator for nuclear power plants [15]. An automated dam for irrigation is presented in [12]. We present a novel disaster monitoring and management system for dams that continuously monitors the water level of the dam and also estimates the water inflow rate to the dam (considering various sensor measurements). It controls the movement of gates using IoT on a real-time basis. The Internet of Things (IoT)[9] is a system in which various physical objects are interconnected through web [1]-[2]. The proposed system includes features like SOS alarms for police, fire force, disaster management team, emergency team, and SMS alerts for common people who lives near the dam and flood prone areas in case of any foreseen disaster. The SMS alert facility helps common people to evacuate to safe locations.

2. Proposed System

Sensor technology, network technology and computer technology are advancing together while the demand grows for connecting information systems with the real world. Internet of Things, as a technology that is in trend, allows sensors to become intelligent by connecting them to the Internet.
This allows sensors to communicate with each other. All technologies produce a lot of data, which requires massive data storage. Cloud, as a form of technology, that gains momentum storage of large amounts of data on the Web. The model diagram of our proposed system is shown in Fig. 1. The sensors gather the data from the environment and dam. All data are given to a smart controller. A microcontroller is used to control the overall system automatically, which helps to reduces the design of system and control complexity. At back end of the system, it takes parameter information from the related sensors and dumps it into the database. The dumped data is analyzed for web-portal hosting and further decision making. The proposed system works on Internet of Things (IoT), so that data sharing is possible utilizing web data base as IoT, could allow

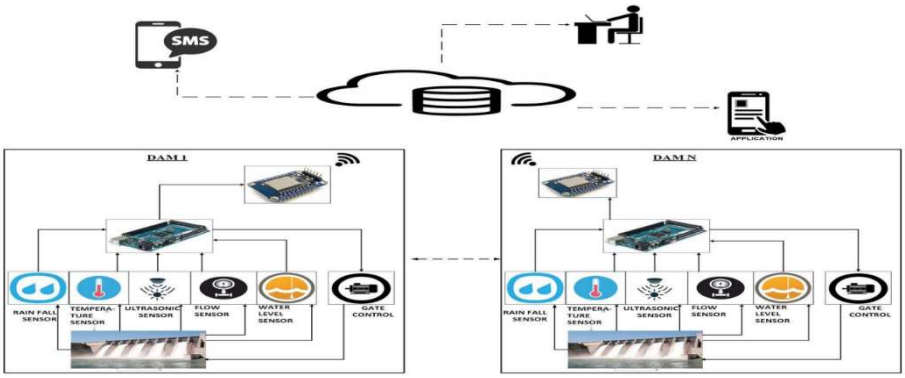


Fig. 1. Model Diagram

The sensor data from the database is analysed and the resulting signals are sent to dam control station. The project also includes an SMS warning system for farmers and common people and special SOS signals are sent to local fire station, disaster management team, police team and emergency response team as the water level increases due to continuing rainfall. Any number of dams can be connected with this database and it is possible to control these dams from anywhere based on the sensor inputs. Illustrated below is the flow chart of the proposed system for controlling two dams [3]. This can be extended to 'N' dams, thus highlighting the flexibility of the system. In a two-dam case, based on the database, i.e information received from sensors, the levels of the two dams (baby dam and main dam) is analyzed and a corresponding action is chosen, as to whether the shutter of the dam should open or close. The system will send out timely alerts in the event that the dam nears overflow levels. The data stored on cloud or database can be used for future reference also. The system is designed to monitor both the rate of

change of water level and water level on dams. There could be a situation in which the water level is normal but the rate of change of water is high or both the water level and rate of change is at a high value, in these situations, the water level can increase to reach the emergency level. With increase in the rate of change of water level, the system will have to increase the frequency at which the water level is being monitored.

3. Hardware Design of the System

The hardware design of the system mainly includes sensor node and network node. They are composed of wireless communication module, control and the related functional modules. A. Sensor Node The hardware structure of the sensor node mainly consists of six parts: water level sensor, humidity and temperature sensor, gate level sensor, flow sensor, rain fall sensor. All sensors are directly

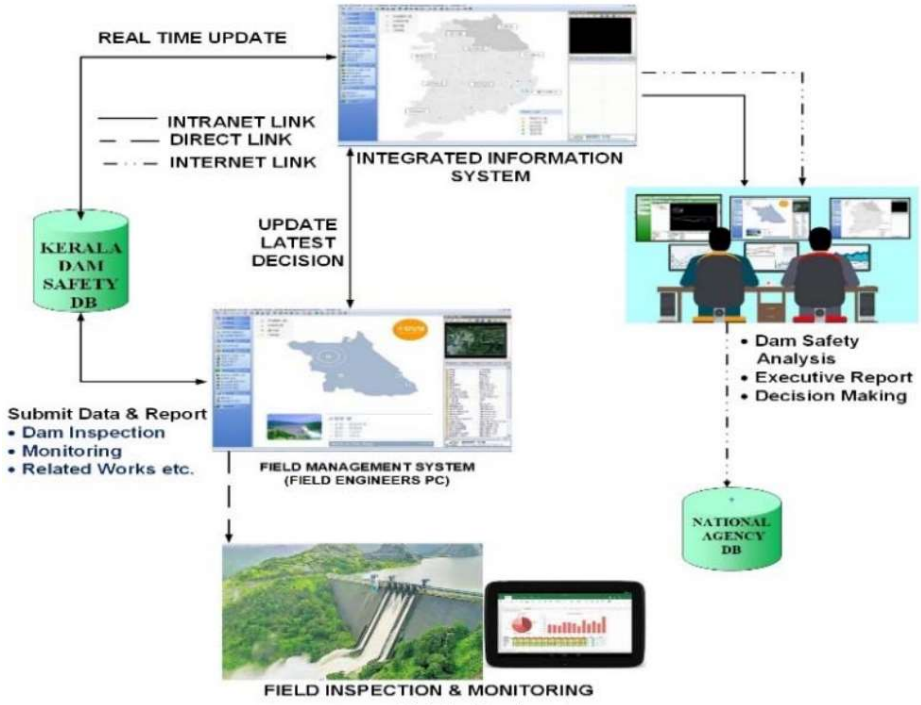


Fig.2. Cloud Operation

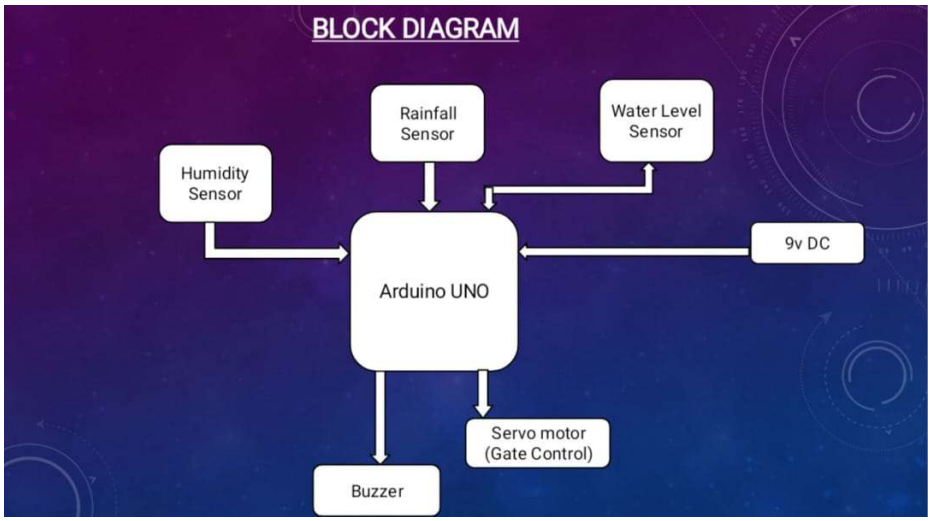
connected to Arduino. B. Control and Communication Module Control and communication module node consist of two parts, one is gate level control and one is GSM module [7]. GSM module is used for sending messages to nearby inhabitants. The control and communication module is the core unit which responsible for controlling dam and providing SMS with nearby peoples. C. Network Node The network node is the major module responsible for communicating hardware section with cloud. A Wi-Fi based microcontroller is used for the connectivity. Through this node data from hardware section transfers to cloud. This system uses Wi-Fi module (Esp8266) to send the sensor data to the cloud.

4. Software Design of the System

IoT [1] has become an emerging research area because of need for connecting things, sensors and other smart technologies. Information related to physical objects can be immediately accessed by IoT and results into novel system having high efficiency and outputs. IoT offers a number of technologies like ubiquitous computing, RFIP, wireless sensor network, cloud computing. Cloud
computing is a large-scale, low cost processing unit and also an IP based connection mostly used for calculation and storage purpose.
The utilization A. Cloud Computing Cloud computing is the on demand availability of computer system resources, especially data storage and computing power, without direct active management by the user [8]. The term is generally used to designate data centers available to many users over the Internet. Clouds may be limited to a single organization or may be available to many organizations or a combination of both. B. Cloud Analytics Cloud analytics is a service model in which elements of the data analytics process are provided through a public or private cloud [5]. Cloud analytics applications and services are typically offered under a subscription-based pricing model.

5. Working of the System

The system proposed here consists of many components which together put the system in action. It consists of sensors and microcontrollers. The sensors used here are temperature sensor, rain fall sensor, gate level sensor, flow sensor, water level sensor and humidity. The system monitors water level and many other parameters and take appropriate actions to sidestep an emergency situation from arising. The output of each component is responsible for the working of the device. The various sensors that are described above collect data and are given to the Arduino. The data received at the Arduino from the various sensors are then stored in the cloud. The data gathered from the sensor that are placed on various parts of the dam are sent to the Arduino which has got internet connection. These data are uploaded to the cloud by means of the Wi-Fi based microcontroller HUZZAH. Node MCU is an Opensource, Interactive, Programmable, Low cost, Simple, the ESP 8266 Wi-Fi SoC from Espressif Systems. The water level of two nearby dams is calculated for analyzing. The various data collected is then compared with the previous data that is available. The data that are recorded is displayed on an application that works with cloud. Authorities can send alert SMS to the cell phones of nearby inhabitants. The algorithm used in our system is shown in Fig. 3.
This system can be extended for monitoring of n dams. As the cloud can analyze the statistics of large number of dams, we can easily compare and decide which dam should be opened first to reduce the water level. These stats are displayed on the application which is given to the authorities. Our proposed system can work on automatic and manual mode. In manual mode, the authorities are taking decision based on the stats provided by the application and manually controls gate. If the water level is beyond the control then an alert SMS is sent to the nearby inhabitants using GSM module, while automatic mode controls the gate automatically.



6. Experimental Results

The water level and all other values from sensors are displayed on the ThingSpeak Dashboard. The data readings are taken in real time. Readings are obtained for every two seconds. The data is displayed in the dashboard in the graph format. The water level from ultrasonic sensor and amount of rainfall from rain gauge is converted to cm in the program. The experimental results obtained from the prototype model developed are shown in Fig. 4. From the graph we can easily identify the amount of rainfall, water level, and other parameters like temperature and humidity. The time is represented on X- axis in IST and measurement is on Y- axis. All the values are displayed in real time. This helps the user in continuously knowing the status of the parameters related to dam.

7. Conclusion

The conventional dam monitoring system is by physical means. In order to solve the issues related to manual monitoring and control, we have designed an IoT based disaster monitoring and management system for dams. In this system we make use of different sensors for real time monitoring of data. These are send to the cloud server via WiFi module ESP8266 for monitoring and control. The proposed system will be helpful to solve all the water related problems. The system also sends messages for public safety. Thus our proposed system can effectively manage dams and prevent a disaster.

8. Future Scope

The system is capable of incorporating more dams that may be constructed in near future. In future a new application can be developed in which the people can easily access and find spots which are prone to flooding or in areas where flood may occur with the help of Google maps. This helps people to avoid the places which are in the verge of flooding. This system can also be extended to a complete disaster management system by combining all major natural disasters like landslides, earthquakes etc.

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