GSM Based Canal Gate and Flood Monitoring and Control System

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Abstract

Technology based modern Irrigation systems are the recent requirement in every part of world today. The irrigation water is being used for agricultural, industrial and domestic purposes. Owing to mismanagement and inequitable distribution of water, it is necessary to have a fool-proof system where water is supplied to the end-users judiciously. Due to the variable atmospheric circumstances these conditions sometimes may vary from place to place, which makes very difficult to operate the canal gate manually and instantly. Therefore, we proposed. The "GSM based Canal gate and Flood monitoring and control system'' canal gates are monitored and controlled after sensing the water level and flow speed. In our project the water level and flow will be calculated automatically and send towards the operator through SMS and the Canal Gate is operated according to the collected data, this system also Announce flood in case of high level of water and speed of water in River or canals by the help of Alarming as well as lightning tower with green, yellow and red lights indication of normal, intermediate and flood conditions respectively.

Introduction

Starting from concepts by discussing introductory details of Canal system this research converges to its focused area. Our ultimate objective is to make the technology much more user-friendly, easily operates, simple to implement and robust, so that commercial companies can implement it rapidly and effectively in canal automation and irrigation of distribution of water. Introduction of this research is very complex, Because of various type of automation devices used.

The main purpose of this research "GSM based Canal gate and flood Monitoring and control system" is to control gates used for irrigation canals automatically by SMS and generate alarms in flood conditions, to optimize the water supply in order to match the expected water demands. During a rain event canal operators would be able to operate the gate remotely via mobile phone.

Gate Operation

The water level data is collected by (gate operators) and is transmitted to higher offices by Canal wires along the canal. Since fudging and wrong reporting of data is a common practice all over the world especially in far off and hazardous places, it should hardly be expected that the gauge heights data of the canal also collected throughout the year and reported by Tandels, who can be influenced by khatedars and landlords, would always be correct (Wahlin & Zimbelman, 2014). Moreover, since a Beldar is required to carry out several more functions daily like maintaining of service roads, banks and canal section etc. He may become too tired to walk or ride cycle to a far-off water level gauge twice daily to record water level readings especially when there is no supervisor available to all the time, therefore he may be inclined at

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times to report fictious data (Martin & Gates, 2014). The system in vague therefore, depends entirely on the honesty, integrity and hard work of Beldars and Tandels. In the prevailing socio-economic conditions, it should hardly be expected from a low paid Beldar that he remains honest and hardworking while others around him enjoy all sorts of illegal benefits. Therefore, the system of canal water management based on water level recording has many loopholes and cannot be relied upon any more (Kadpan et al., 2024).
Farmers at head of channels took more water than due share, whereas, at tail of channels Farmers suffer owing to shortage of water (Hasan, 2022). Ultimately, tail-end farmers have been worried for not receiving their due share in our country. This condition creates due to not equitable and judicious distribution of water in irrigation network (Kamal, 2023). Modern Water Technology Western countries though have much smaller canal systems and supply waters to much smaller land and few number of farmers, have been continuously upgrading their data collection and transmission techniques and have adopted state-of-art methods and technologies during every period (Jordán & Speelman, 2020). Pakistan is far behind the west in adoption of technology in nearly every field. However, it has the knowledge and capability to upgrades its technologies including water technologies (Ishaque et al., 2023).

Water Management Strategy

The water management strategy means, the distribution of water in line with design and available proportion of water. The water distribution strategy cannot be made without actual and proper available data. Therefore, the strategy relies on and takes in account the water availability (water level in reservoir, expected surface flow), the water demand (irrigation, urban/rural supply and industrial) (Xiang et al., 2021). The strategy results in the following major decisions:

- Diversion of water from dams/reservoirs/rivers/canals
- Allocation of water quota to the various stakeholders
- A reservoir/dam strategy (availability water target monthly)

Water Supply

Water supply is related to delivery of required quantity of water to stakeholders. It might be split in four tasks

Water Supply Management

Water Supply Management could be applied the results of availability of water on daily basis, taking into account the actual water situation. The objective is to ensure the supply of due share of water to each stakeholder (Minhas et al., 2020).

Operation of Infrastructure

The task consists in physically adjusting gates, opening and closing valves, and starting pumping stations, according to the of Water Supply situation (Predescu et al., 2020).

System Monitoring

The objective of this task is to monitor the operation of the system, and to check that daily water management decisions have been correctly implemented in the field. It relies on hydraulic measurements (flow, water level, and water quantity) (Giudicianni et al., 2020).

Water Supply Control

This task consists in analyzing field measurements in order to establish statistics. The objective is to follow-up and controls the implementation of the water management strategy, and to provide statistics for future water management planning (Reis et al., 2023).

Water Distribution

Water Distribution consists in the management of the irrigation network. It involves the operation of the network head structure, and the farm turnouts (Chaube et al., 2023b). Water Distribution activities may be divided into four tasks:

Organization Of Irrigation Schedule

The output of the task is a weekly calendar (or bi-weekly), which schedules the days and hours during which each farmer is entitled to receive water. This schedule takes into account the water quota resulting from the water management strategy, the crop water requirements, and the irrigation network physical constraints (Gu et al., 2020).

Water Delivery To Farmers

This task consists of opening and closing of farm turnouts in order to provide water according to the irrigation schedule. The schedule may be modified one day prior to irrigation: either according to farmer's requests in case of unexpected events (Gathala et al., 2020).

Water Demand Assessment

This task consists in checking farm crops, in order to establish a Planting Register. The Planting Register is used to compute present and future water needs, and farm quotas (Zubaidi et al., 2020).

The Water Management Information System (WMIS)

The Water Management Information System (WMIS) is an Information Technology tool developed to assist and achieve optimal water management. WMIS is an integrated system, as it covers all tasks related to water management, from management of water resources, down to water distribution to the farmer (Benbya et al., 2021).

Review of Literature

Irrigation system of Pakistan is one of the largest integrated networks in the world. There are 3 major storage reservoirs, 19 barrages, 12 inter-river link canals, 45 independent irrigation canal commands and over 1,22,268 watercourses. Canal operation is carried out with the help of water levels in the canal. To record water levels, staff gauges have been installed at every head regulator, cross regulator, bridges and along the canal at regular intervals. This enables the canal operation staff to observe and record water levels (Simons et al., 2020). Any abnormal variation in the water level indicates discharge variation in the canal. Abnormal decrease of water level along the canal may indicate abnormal withdrawal of supplies from a canal, which may result in reduced supplies to outlets downstream. However, an abnormal increase in the water levels may indicate abnormal entry or availability of water in canal (Hu et al., 2022). Sudden increase of water level in the canal may result in breaches in the canal bank. Breaches have often resulted in large-scale submergence of land, roads, villages and destruction of standing crops (Kyuka et al., 2020). However, if a canal is running at full supply discharge, then it is presumed that the canal is also carrying full supply discharge, which may not always be correct. Since silting of bed of the canal reduces the area of the canal section and consequently reduces the full supply discharges capacity of the canal, even if the water level in the canal remains at full supply level (Chaube et al., 2023a). Therefore, it is not correct to assume that if the canal is running at full supply level it is also carrying full supply discharge (Chaube et al., 2023a).

Microcontroller based irrigation and flood monitoring systems are very important for Pakistan. Government sectors have to create and implement such systems. Like the Project "Telemetry system in irrigation network" concluded that monitoring system installed in the offices of canal managers helps in proper regulation and management of water resources and controlling of water theft and canal breaches. The collection of sound data is beneficial in the planning and development of the irrigation system by Ali et al. (2024). According to Khan et al. (2022), advanced notifications for floods can be important for the life and death situations and in reduction of property losses. A one-hour lead-time concludes 10-percent reduction of damages due to flooding. Flood water real-time notification has proven to be a vital link for contributing economic benefits to a nation and must be continued to be improved. Another study called enhancement of SMS based flood monitoring system through the integration of Zigbee standard module and online database was made by Zakaria et al. (2023). The system has three parts: (a) water level monitoring using reed relays (b) GUI-based desktop application for the SMS notification (c) and the integration of Zigbee module for data transmission. The said study made flood water level notification easy for people who can afford to have computers in their homes to check the status of the flood water level of a certain area.

Another study entitled SMS based flood monitoring and early warning system by Siddique et al. (2023), the system uses barometric pressure sensor for the detection of flood water level. It sends an SMS if the water overtakes the threshold value defined by the user.

A project entitled GSM & Web based flood monitoring system by Bentoso et al. (2021), the project uses SMS notification to notify people in Mandaluyong. They developed a local real-time flood monitoring and warning system for communities near Mandaluyong River. In terms of efficiency, a test was conducted by recording the sending time or time delay of detection of the water level to be transmitted. An approach Real-Time Flood Water Level Monitoring System with SMS Notification by Buhion et al. (2022) also worked on water level monitoring and notification but there is no work done that is beneficial for both irrigation management and flood controlling at the same time.

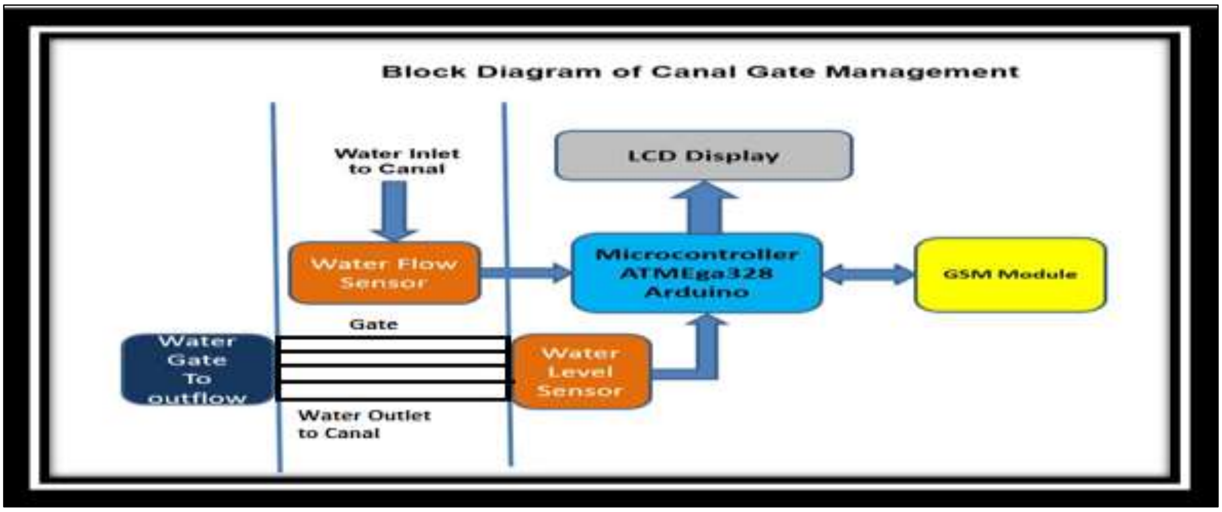
Methodology

Our Methodology is creating an advanced canal management system with an advanced sensor network and cutting-edge automated technologies. The system's main component is a strong canal model that has been equipped with modern flow and water level sensors that deliver real-time information on the level of water and speed. This essential data is sent to a clever microprocessor, which analyses it and uses a high-torque gear motor to precisely adjust the canal gates. This fine control makes it possible to manage water flow optimally, which guarantees effective irrigation and prevents flooding.

The system's greatest achievement is its precise connectivity with GSM technology, which makes advantage of the reliable GSM network to enable users to remotely monitor and manage the canal gates via SMS commands. The advanced characteristics of the microcontroller allow real-time data transmission to mobile devices, providing instant access to vital information. Furthermore, a high-visibility LCD display provides a clear and concise overview of the system's performance, ensuring effortless monitoring and management.

Figure 1: Canal Design

Figure 2: Block diagram

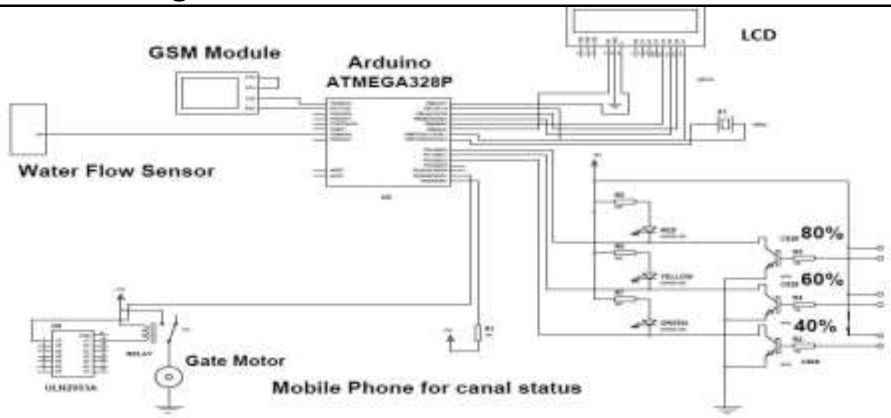


The block diagram shows that Microcontroller is the central part of project. We used simple devices to build this project. The above given figure consists of a microcontroller, GSM Module, water level sensor, water flow sensor, canal or water gate and LCD display. Water level sensor and water flow sensor are inputs to the microcontroller and LCD display is output device connected to the microcontroller. GSM Module is connected with microcontroller for both input and output functionalities.

Water flow sensor is placed in the water and sends data about water speed/flow in the canal to the microcontroller. Water level sensor is used to detect the level of water and signals the microcontroller about the level. There are three levels (i e level1, level2 and level3) defined for water level sensor for40%, 60% and 80% of water in the canal respectively.

In this project Microcontroller takes the data about the speed/flow and level of water from water flow and water level sensors and displays the current speed and level on LCD display at every instant of time. LCD display is also used to show the flood status when the water level approaches to 80% or the flow of water is 70%. Water gate used in this project is operated automatically or by commands through SMS.GSM Module is used to send the current status of the water level and water flow in the canal anywhere in the world. The main purpose of using GSM Module is to operate the canal gate in order to achieve modern irrigation system.

Figure 3: Circuit Diagram



Microcontroller Interface with GSM
The microcontroller interface with GSM is on pin 2/PD0, 3/PD1 for Receiver and Transmitter respectively.

Microcontroller Interface with LCD
The Microcontroller interface with LCD pin14 PB0/ICP1 is connected with the LCD pin 6, which is "Enable" i.e. Sends data to data pins when a high to low pulse is given. Microcontroller Pin15 which is PB1/OC1A is connected with the LCD pin 14 D7 use for data. The pin 16 PB2/SS/OC1B is connected with the LCD pin 13 which is also a data pin. The Pin 17 PB3/MOSI/OC2 is connected with pin 12 D6 and it is a data pin. The pin 18 PB4/MISO is connected with the LCD pin 11D4 and it is for data. The pin 19 PB5/SCK is connected with the LCD pin 4 and it is use for Selects command register when low; and data register when high. The pin 9 PB6/TOSC1/XTAL1 of microcontroller is connected with LCD crystal oscillator and LCD pin 14 D7 also it is Input to the inverting Oscillator amplifier and input to the internal clock operating circuit. The pin 10 PB7/TOSC2/XTAL2 is connected with the crystal oscillator and pin 14 D7 it is use for Output from the inverting Oscillator amplifier.

Microcontroller Interface with Water level sensor
Pin23 pc0/PCINT8IS CONNECTED With THE LED Diode Red light with shows the flood status in the project when water level above 80% in canal. The pin 24 PC1/ADC1 is connected with the Yellow LED diode and it shows the Alert situation when level at 60% in canal. The pin 25 PC2/ADC2 is connected with the Green LED diode shows the normal condition in canal. The microcontroller pin 28 PC5/ADC5/SCL is connected with the ULN-2003 IC use as a driver for Relay of 12 Gear motor connected for up and down of canal Gate. Pin 26 PC6/RESET is connected with R1 i.e. tri-stated when a reset condition becomes active, even if the clock is not running.

Microcontroller interface with Water flow sensor
The Pin 12, PD6/AIN0 is conned with the Water flow sensor to measure the speed of water in a canal and generate alert pulse when speed is high from 50km per hour as a flood status SMS.

Results
Results are categorized in two types of outputs

***A* General outputs**
The general output are the LCD outputs, and LED outputs.

1) **LCD outputs**
The LCD further displays two types of outputs i.e. water level outputs and water flow/speed output. It also shows the flood status on Display.

a) **Water level outputs**

Figure 4: Initial screen and level 1

The initial LCD output result is "canal gate Monitoring system" when the power is given to the system.

Level 1 output

We used three levels for sensing and monitoring of water level. Level 1 output shows the first level of water in the canal that is 40% .when the water level approaches this level the sensor will detect the level and sends to microcontroller.

Level 2 output

Level 2 output screen shows that the water in the canal has reached to the next level that is 60%. Microcontroller takes the information from sensors and switch on the yellow LED placed in tower to indicate the water level has reached 60%.

Figure 5: Level 2 and Danger alert

Level 3 output

The sensors detect the water level reached to 80% in level 3 Output. Because 80% level of water in the canal is risky therefore Microcontroller will switch on the red LED to show the danger alert and forward the danger alert SMS to the authorities by using GSM Module.

b. Water flow/Speed Outputs

Steady condition

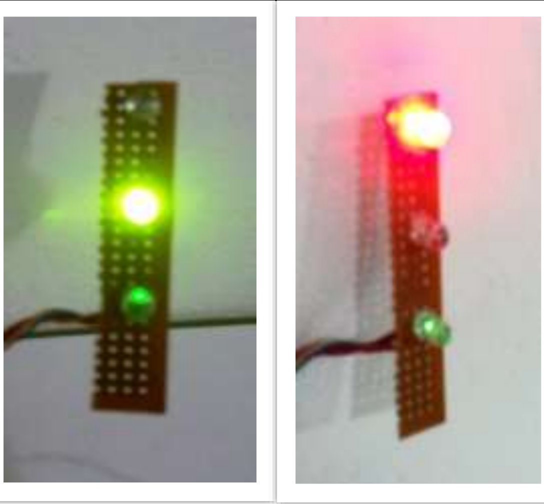
In steady condition the LCD shows the speed/flow of water as 0 and the flood status as ok.

Figure 6: Steady and Normal Flow

Normal condition
The normal condition is that condition when the water speed is neither in steady nor in danger condition. We assumed the danger condition at 70 Km/h for our project.

2) **LED OUTPUTS**
There are three LED lights (Green, Yellow, and Red) displayed in the tower for 40%, 60% and 80% of water level in the canal to indicate the normal intermediate and danger conditions. Figures show the Intermediate and Danger conditions respectively.

Figure 8: LED outputs



B. **Specific Outputs**
The Specific outputs are;
1) **Canal gate operation**
The main Output of our project is operating the canal gate through SMS by Microcontroller inputs i.e. the water level and water flow information the purpose of operating canal gates is to achieve proper management and distribution of water for irrigation system.

Benefits
- Enhanced water management and distribution efficiency.
- Reduced water waste and losses.
- Increased crop yields and agricultural productivity.
- Improved decision-making with real-time data.
- Reduced labor costs and increased convenience.

Potential Extensions
- Integration with weather forecasting systems for predictive water management
- Incorporation of soil moisture sensors for optimal irrigation scheduling
- Development of a user-friendly mobile app for farmers and water managers
- Expansion to larger-scale irrigation systems or multiple canal gate operations

2) **Automatic Flood Controlling**
The other specific output of this research work is to control the flood condition automatically by opening the gates of drainage ways /canals by SMS using GSM Module.

Benefits

- Reduced flood risk and damage to infrastructure
- Enhanced public safety and minimized risk to life
- Automated system ensures swift response to flood events
- Minimal manual intervention required, reducing labor costs
- Improved decision-making with real-time data

Potential Extensions

- Integration with emergency alert systems for public notification
- Incorporation of water quality sensors for monitoring pollution
- Development of a user-friendly dashboard for authorities to monitor and control the system
- Expansion to larger-scale flood management systems or multiple drainage way/canal operations
- Investigation of advanced technologies like IoT and AI for further enhancement.

Conclusion

This research is done to give proper management and distribution of water in the canals and flood alert system according to the accurate and instant measurement of the water level and water flow of a canal at a certain place being monitored remotely. Canals gates are operated automatically without requiring the presence of operator. The system is set to control flood directly before the flood condition occurs by operating canal gates. It also alarms the area to be affected by flood using LEDs in the tower placed in that area and buzzer. The warning will be given once the water level sensor detects 80% of water or water flow to 70%. The gates of the canal are operated to distribute water in canals to increase the water efficiency and in emergency situations minimize the effect of flood in Main River.

This project also helps in water management for irrigation purposes, reduce financial burden on government, minimize power and time wastage, it gives us flood warning in emergency situations, it helps to save precious human life and property, Human has evolved from time to time and to cope with the unpredictable disasters. Thus, technologies should always be used wisely to avoid the disasters laden on them.

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