REPORT

WIRELESS BASED DATA TRANSMISSION SYSTEM FOR GATE CONTROL IN DAMS ALONG WITH DATA ANALYSIS

Delivered by:

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in partial fulfillment for the award of the degree of

Bachelor of Technology in

ELECTRONICS AND TELECOMMUNICATION OF SAVITRIBAI PHULE PUNE UNIVERSITY

under the guidance of
Prof. Sagar Vanarase

Sponsored by: - Central Water and Power Research Station ,Pune

In the Department of Electronics and Telecommunication of CUMMINS COLLEGE OF ENGINEERING FOR WOMEN, KARVE NAGAR, PUNE - 411052

Academic Year: - 2022-23

a) Project title : - Wireless based data transmission system for gate control in Dams along with Data Analysis.

b) Subject area : - Multidisciplinary

c) Nature of the Project : - Hardware & Software

CERTIFICATE

This is to certify that

Tanvi Kulkarni C22019771836
Aditi More C22019771840
Shubhra Jain C22019331522
Isha Patil C22019331536

have successfully completed the work on their PROJECT TOPIC WIRELESS BASED DATA TRANSMISSION SYSTEM FOR GATE CONTROL IN DAMS ALONG WITH DATA ANALYSIS

in partial fulfillment for the award of the degree of

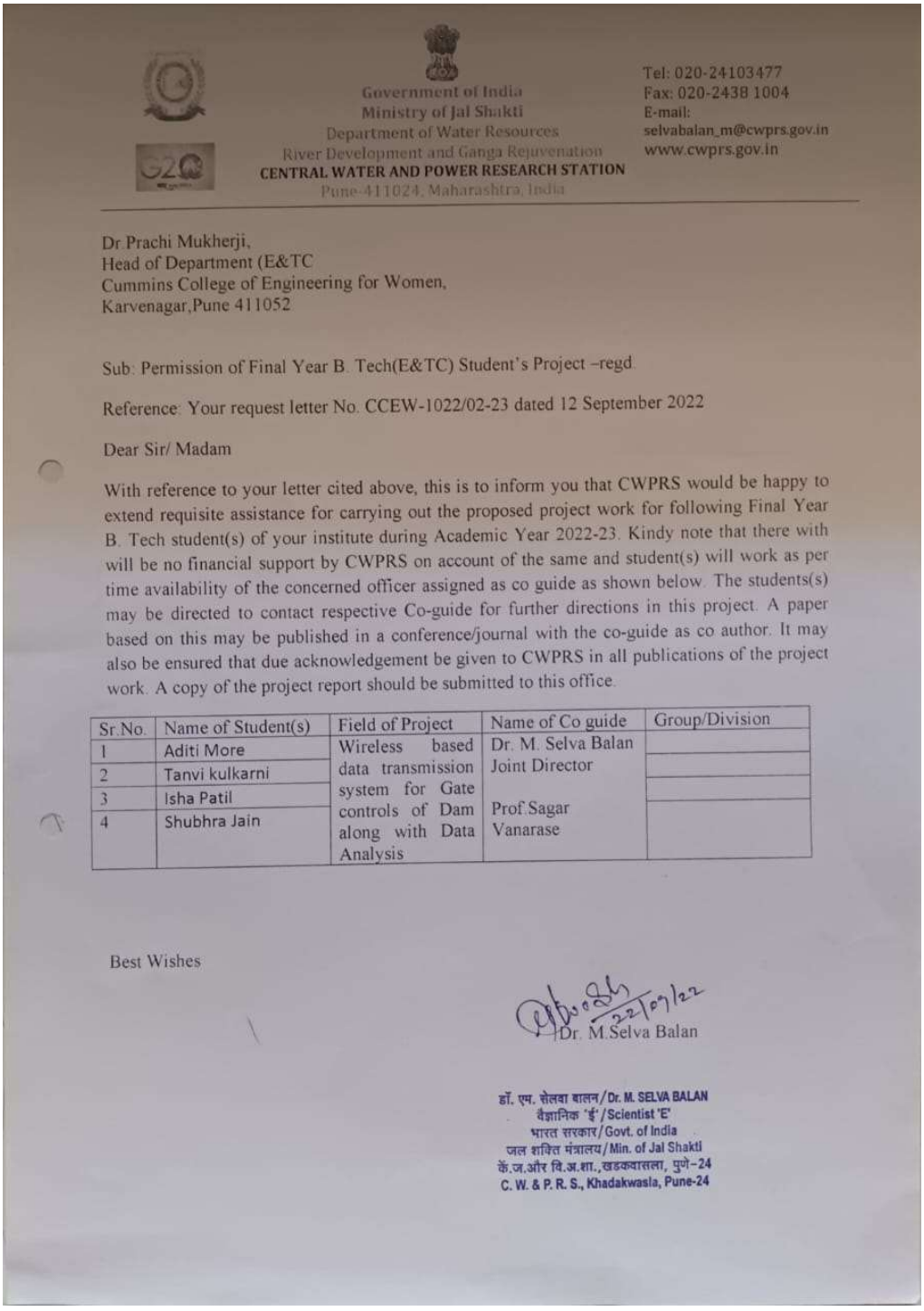
Bachelor of Technology in ELECTRONICS AND TELECOMMUNICATION Of SAVITRIBAI PHULE PUNE UNIVERSITY,

in

M.K.S.S.S's CUMMINS COLLEGE OF ENGINEERING FOR WOMEN,KARVENAGAR, PUNE – 411052.

Internal Guide	**Head of the Department**	**Principal**
Prof. Sagar Vanarase	Dr. Prachi Mukherji	Dr.M.B Khambete

Sponsorship Letter



Government of India
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Dr Prachi Mukherji,
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Karvenagar,Pune 411052

Sub: Permission of Final Year B. Tech(E&TC) Student's Project –regd

Reference: Your request letter No. CCEW-1022/02-23 dated 12 September 2022

Dear Sir/ Madam

With reference to your letter cited above, this is to inform you that CWPRS would be happy to extend requisite assistance for carrying out the proposed project work for following Final Year B. Tech student(s) of your institute during Academic Year 2022-23. Kindy note that there with will be no financial support by CWPRS on account of the same and student(s) will work as per time availability of the concerned officer assigned as co guide as shown below. The students(s) may be directed to contact respective Co-guide for further directions in this project. A paper based on this may be published in a conference/journal with the co-guide as co author. It may also be ensured that due acknowledgement be given to CWPRS in all publications of the project work. A copy of the project report should be submitted to this office.

Sr.No.	Name of Student(s)	Field of Project	Name of Co guide	Group/Division
1	Aditi More	Wireless based data transmission system for Gate controls of Dam along with Data Analysis	Dr. M. Selva Balan Joint Director Prof.Sagar Vanarase	
2	Tanvi kulkarni			
3	Isha Patil			
4	Shubhra Jain			

Best Wishes

22/09/22
Dr. M.Selva Balan

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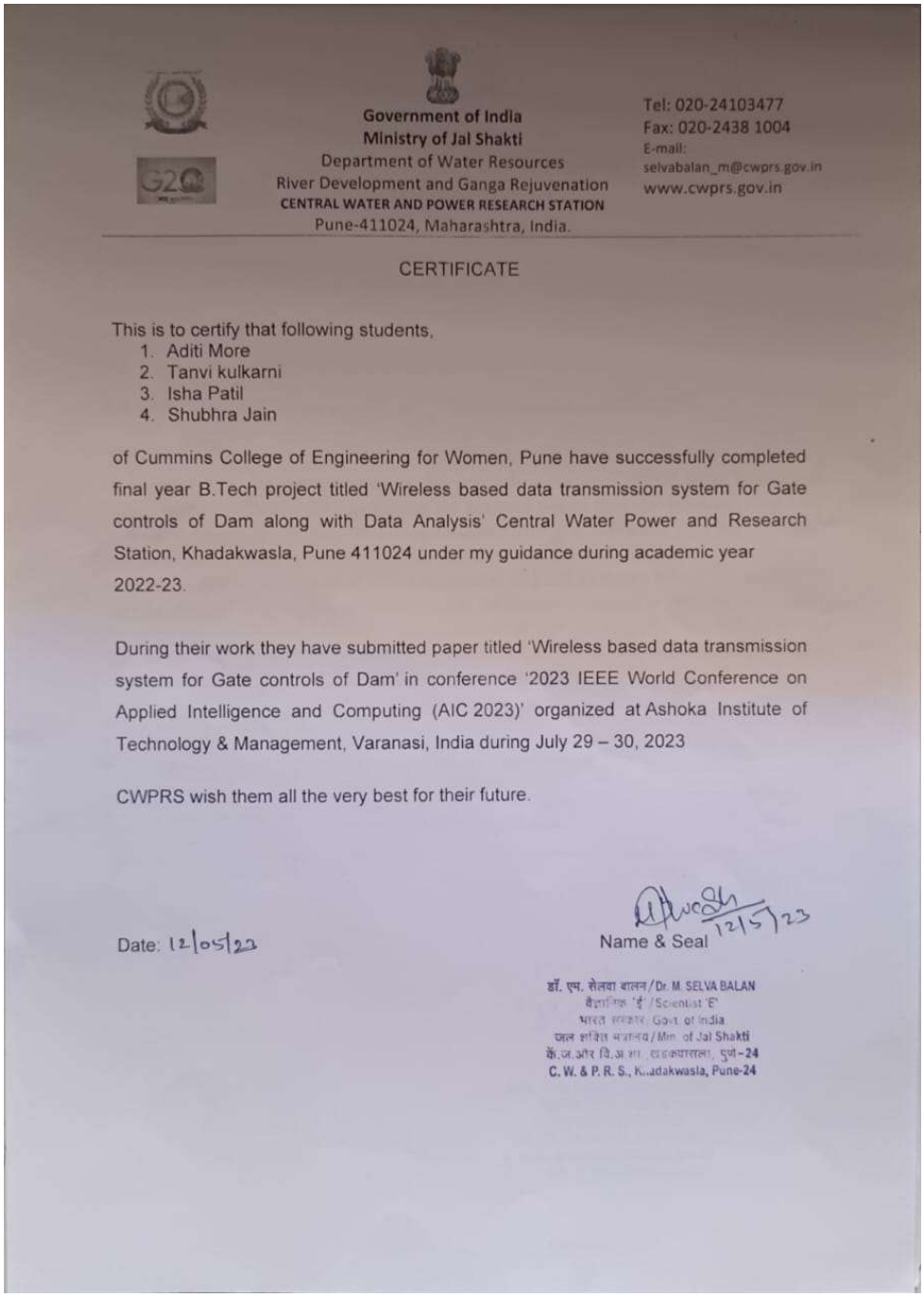
C. W. & P. R. S., Khadakwasla, Pune-24

Completion Certificate



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CERTIFICATE

This is to certify that following students,

1. Aditi More
2. Tanvi kulkarni
3. Isha Patil
4. Shubhra Jain

of Cummins College of Engineering for Women, Pune have successfully completed final year B.Tech project titled 'Wireless based data transmission system for Gate controls of Dam along with Data Analysis' Central Water Power and Research Station, Khadakwasla, Pune 411024 under my guidance during academic year 2022-23.

During their work they have submitted paper titled 'Wireless based data transmission system for Gate controls of Dam' in conference '2023 IEEE World Conference on Applied Intelligence and Computing (AIC 2023)' organized at Ashoka Institute of Technology & Management, Varanasi, India during July 29 – 30, 2023

CWPRS wish them all the very best for their future.

Date: 12/05/23

Name & Seal 12/5/23

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Acknowledgement

We would like to thank Dr. M. Selva Balan, from CWPRS for giving us the opportunity to work with CWPRS and for his valuable guidance. We would like to thank Dr. Prachi Mukherji (H.O.D., E&TC) for her continuous support, valuable suggestions and her precious time in every possible way in spite of her busy schedule. We would like to express our sincere gratitude towards our project guide Prof. Sagar Vanarase, for his constant encouragement and valuable guidance during this project .We take this opportunity to express our sincere thanks to all the staff members of E&Tc. Department for their constant help whenever required. We express our sincere thanks to all those who helped us directly or indirectly in many ways during our project work.

Student Names :

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Abstract

Every aspect of our lives has some connection to the control systems. Hardware and software are combined to create these control systems. Some dams still carry out dam gate control processes manually, even in the age of cutting-edge technologies. Manual processing will result in human error and less efficient processing. This project aims to develop a "Wireless-based Data Transmission System for Gate Control in Dams". The objectives are to propose a wireless control system for gate opening based on water level using Long Range (LoRa) as the level sensor has to be placed few kilometers away from the dam gates(near the water inflow) for accurate water level measurement, design a control system of dam gate that can work fully automated by using Arduino and fabricate a prototype of the dam gate control system. With the use of ultrasonic sensors, the opening and closing of the dam gate can be controlled by sending a signal to the servo motor through wireless transmission using LoRa to control the dam gate's movement. The gate operation is controlled based on the various water level ranges.

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1. Introduction

A dam is a substantial structure created to prevent water overflows while also serving other purposes like irrigation of land, recreation, and the production of hydroelectricity. However, there are not many automated dam systems that are more useful and effective than manual ones. Manually controlling a dam is difficult, time-consuming, and extremely dangerous in the event of extreme weather conditions. Consequently, automatic monitoring of reservoir and dam safety turns out to be a practical choice. It refers to the installation of corresponding observation instruments in the reservoir and dam and carrying out on-site measurements and obtaining relevant data to judge and analyze the changes in the dam structure. To run an automatic monitoring system water level data must be transmitted to the motorized gate. But the research investigation found that the automated monitoring system had some problems:

[1] high cost of wiring, high power consumption and weak scalability;

[2] unattended remote measurement points;

[3]the traditional wireless transmission distance is short; signal penetration is not strong.

For overcoming these shortcomings, communication hardware components which can enable wireless data transmission are required. In this project we have used LoRa which has long-distance transmission, strong penetration ability, strong anti-interference ability and ultra-low electric current consumption. In our proposed system, a water level sensor measures the level and transmits water level data via LoRa, which is controlled by a micro-controller, to a receiver LoRa module that, in turn, keeps track of the gate's operation. It ensures stable and efficient data transmission.

2. Literature Survey

Sr. no.	Title	Authors	Name of the journal/conference
1.	Algorithms for automatic control of Diversion dams	Clark P. Buyalski	United States Department of the interior Bureau of Reclamation Engineering and Research Center Denver, Colorado
2.	Fuzzy Logic Based Hydro-Electric Power Dam Control System	M. Abbas, M. Saleem Khan, Nasir Ali	International Journal of Scientific & Engineering Research Volume 2, Issue 6, June-2011 1 ISSN 2229-5518
3.	Simulation of Water Level Control in a Tank Using Fuzzy Logic	1Disha, 2Mr. Pawan Kumar Pandey3 Rajeev Chugh	IOSR Journal of Electrical and Electronics Engineering (IOSRJEEE) ISSN: 2278-1676 Volume 2, Issue 3 (Sep-Oct. 2012), PP 09-12 www.iosrjournals.org
4.	Water level control based fuzzy logic controller: simulation and experimental works	M Khairudin1 , AD Hastutiningsih2, THT Maryadi3 and HS Pramono 4	International Conference on Technology and Vocational Teacher (ICTVT-2018)
5.	Liquid level control with	Mehmet Yumurtacı	Yumurtacı and Verim, International Advanced

	different control methods based on Matlab/ Simulink and Arduino for the control systems lesson	a,* and Özgür Verim b	Researches and Engineering Journal 04(03): 249-254, 2020
6.	Role of Spread Spectrum Based Lora in Advanced Flood Monitoring and Warning System	Shaneel Saurabh Sao, M. Selva Balan and Prajakta A. More	26th International Conference on Hydraulics, Water Resources and Coastal Engineering (HYDRO 2021 INTERNATIONAL) at SVNIT Surat, Gujarat, India during December 23-25, 2021
7.	Impact of Temperature Variations on the Reliability of LoRa	Carlo Alberto Boano, Marco Cattani, and Kay Romer ¨	Institute of Technical Informatics, Graz University of Technology, Austria {cboano, m.cattani, roemer}@tugraz.at
8.	The Application of Fuzzy Control in Water Tank Level Using Arduino	Fayçal Chabni, Rachid Taleb, Abderrahmen Benbouali, Mohammed Amin Bouthiba	(IJACSA) International Journal of Advanced Computer Science and Applications,
9.	Wireless Automatic Water Level Controller	Suraj S, Bharath V, Sridhar N.K	2018 Third International Conference on Electrical, Electronics, Communication, Computer Technologies and Optimization

			Techniques (ICEECCOT) 14-15, December 2018

Suraj et al. [9] proposed an automatic water level controller using Bluetooth wireless technology and Ultrasonic water level sensor. The wireless controller was compared with the wired controller and the performance was found to be superior in wireless controller.

Khairudin et al. [4] presents an automatic control system for Water Level Control using Fuzzy Logic Controller. The objective of their work was to regulate the water pump using different sensors.

Sao et al. [6] implemented a flood monitoring & warning system with a spread spectrum based LoRa module with predefined algorithms. Authors concluded that LoRa needed lower power consumption compared to other wireless solutions along with very high range transmission.

Boano et al. [7] conducted an experimental evaluation on the impact of Temperature Variations on the Reliability of LoRa Link. Their findings include effects of temperature on the performance of LoRa, useful to mitigate the challenges posed by temperature variations in outdoor systems.

Chabni et al. [8] implemented PI (Proportional, Integral) and fuzzy logic controllers for water level control systems using Arduino. They have compared the fuzzy logic controllers with PI controllers and the fuzzy logic controllers were found to be superior.

Disha et al. [3] MATLAB software & simulation package, which includes the Fuzzy Logic Toolbox and Simulink, was used to design a simulation system of a fuzzy logic controller for water tank level control. The stability in output of the fuzzy controller was found to be better than PI controller in this software-based project.

Buyalski [1] discusses the typical diversion dam and the two basic operational concepts. The recommendations include local automatic control along with monitoring in extreme cases for manual operations.

Abbas et al. [2] this paper proposes a fuzzy logic-based architecture concept for a hydroelectric power dam control system. Water level and flow rate are employed as two input parameters in this design, and release valve control and drain valve control are used as two output parameters.

Mehmet Yumurtacı and Özgür Verim [9] the research article discusses the developed Liquid level control with different control methods such as On-Off Controller, PID Controller, ANN- PID Controller .

3. Specifications:

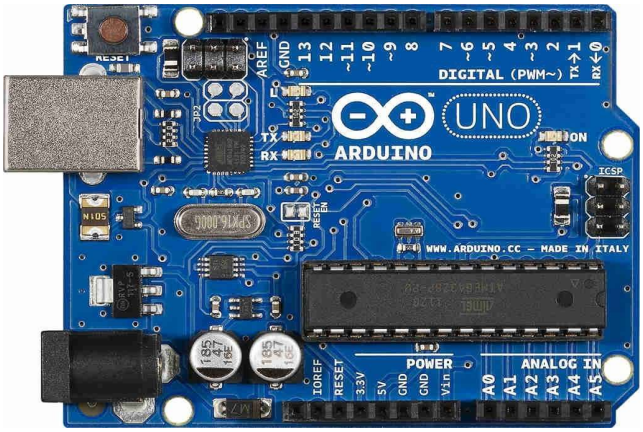
a) LoRa (SX 1278)

- Communication distance: 15KM
- Sensitivity: down to -148dBm
- Programmable bit rates: up to 300kbps
- RSSI dynamic range: 127dB
- Wireless frequency: 433MHz
- Working voltage: 1.8-3.7v
- Working temperature: -40-+80 ℃
- When compared with the traditional modulation technology, LoRa modulation technology has obvious advantages in anti-blocking and selection, which solves the problem that the traditional design scheme cannot consider the distance, interference, and power consumption at the same time.
- It can be covering thousands of people in the district environment, particularly suitable for meter reading, smart home, burglar alarm equipment.
- Supports FSK, GFSK, MSK, GMSK, LoRa ™ and OOK modulation modes.
- Automatic RF signal detection, CAD mode and very high-speed AFC
- Packet engine with CRC up to 256 bytes.

b) Ultrasonic sensor

- Ultrasonic sensors emit high-frequency sound waves, usually above 20 kHz, that bounce off the surface of the water and return to the sensor. By measuring the time, it takes for the sound waves to travel to the water surface and back, the sensor can calculate the distance between the sensor and the water surface.
- This distance can be used to determine the water level in a tank or other container. We have used HCSR-04 for this project. The HC-SR04 module consists of an ultrasonic transmitter, a receiver, and a control circuit.
- To measure the distance to an object, the module sends out an ultrasonic wave, which then reflects off the object and returns to the sensor. The module measures the time it takes for the wave to return and uses this information to calculate the distance to the object. It is less costly, easy to use and accurate.
- To measure the distance, we send a trigger signal to the sensor using the trigger pin, and then wait for the echo signal to be received on the echo pin. Distance is then calculated based on the time it takes for the echo signal to be received.

c) Arduino UNO



- The micro-controller board named Arduino UNO is based on the ATmega328P. It contains 6 analogue inputs, a 16 MHz ceramic resonator, 14 digital input/output pins (six of which can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button.
- It comes with everything needed to support the micro-controller; to get started, just plug in a USB cable, an AC-to-DC adapter, or a battery. You can experiment with your UNO without being overly concerned that you will make a mistake; in the worst case, you can replace the chip for a few dollars and start over.

d) Servo motor

- A metal gear servo motor with a maximum stall torque of 11kg/cm is the MG996R. The motor rotates from 0 to 180 degrees depending on the duty cycle of the PWM wave given to its signal pin, just like other RC servos.
- Servo motors can provide higher torque than stepper motors, making them suitable for easily lifting the dam gate. It also consumes less power and can rotate continuously to any position within its range.

e) LoRa antenna

- The maximum LoRa range without an antenna is 10 cm. Since our real-world implementation requires long-distance communication, we therefore need antenna to increase the range.
- This antenna has 433 MHz as the center frequency, its peak gain is 3.6dBi and its impedance is 50 ohms which matches our requirements.
- SMA Female pigtail cable: This cable is a connector between the micro-controller and antenna.

4. Methodology

The methodology adopted in the current work is presented in this section. When the system is enabled, an ultrasonic water level sensor (HCSR-04) continuously monitors the water level of glass tank and transmits that information to the Arduino Uno micro-controller unit, where the system continuously analyses the data sent by the sensor.

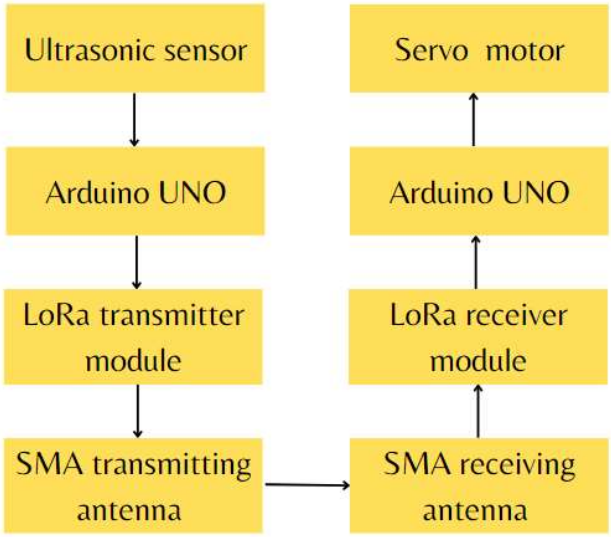


Fig. Block diagram of the system

Based on the code, the system passes the data to a LoRa module which wirelessly transmits the data to the LoRa receiver. The micro-controller unit analyses the data. If the detected water level is higher than the set threshold reference value, the micro-controller will give the signal to the servo motor. The servo motor will rotate according to the predefined set of rules. The configured spread spectrum-based LoRa SX1278 module is run by a set of predefined commands in the Arduino IDE platform to achieve the best possible range for communication purposes on the receiver section. In order to get the best results during flood conditions, the water level is divided into three primary sectors or zones: low level, medium level, and

high level. These pre-set levels of water are programmed into the system and action is taken at each level. If the water level is low, the system performs no action. At this level, if the dam gate is, no further action is taken, but if the dam gates are open, the micro-controller sends a command to close the dam gates. The dam gates will open gradually if the water level is medium. When the water level is high, the motor runs faster
and the gates open more quickly.

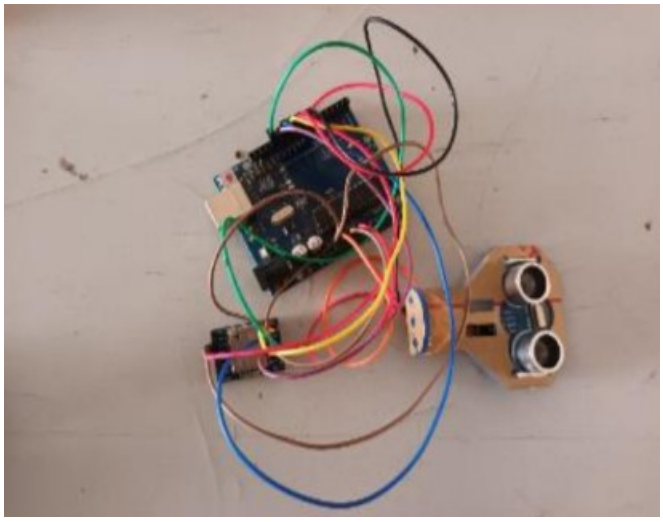


Fig. Transmitter side of system

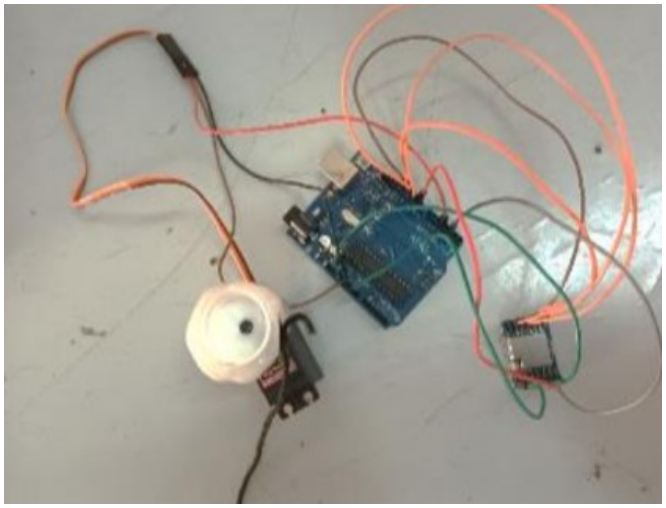


Fig. Receiver side of system

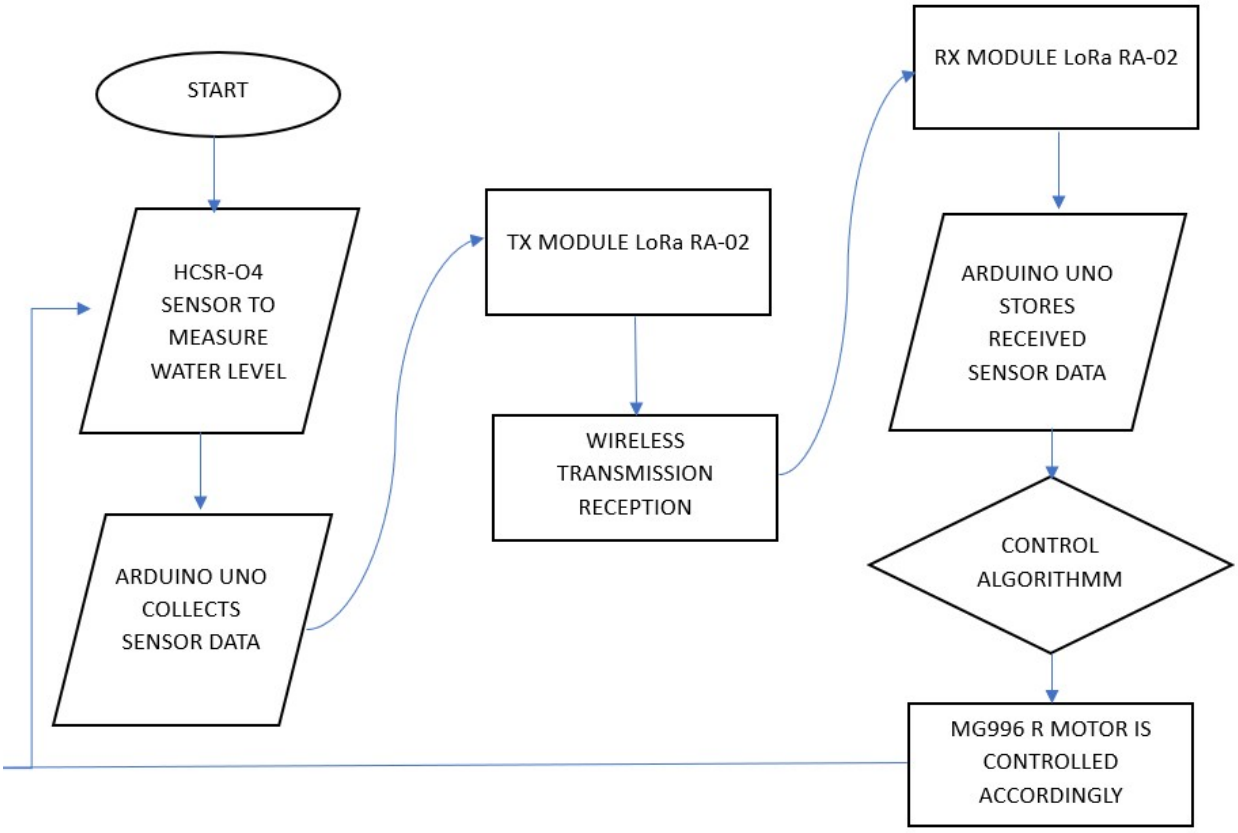


Fig. Flowchart of the system

Fuzzy logic controller: controller with human-like ideas and ambiguous values is fuzzy logic. Instead of employing numerical numbers complicated mathematical equations, it is accomplished by using linguistic variables and rules. Language-related characteristics range from extremely high to high to medium to low. Fuzzification, rule base, interference, and defuzzification processes are all included in the fuzzy logic control technique. Each of these components impacts the overall system behavior and controller performance and plays a significant role in the control process. Fuzzification transforms numerical data into verbal phrases at the input. The necessary data for each component of the fuzzy controller is provided by the rule base. The controller's brain is interference. Fuzzy

values that are not directly used in the control process are obtained at the end of the interference phase. The defuzzification stage yields the numerical value.

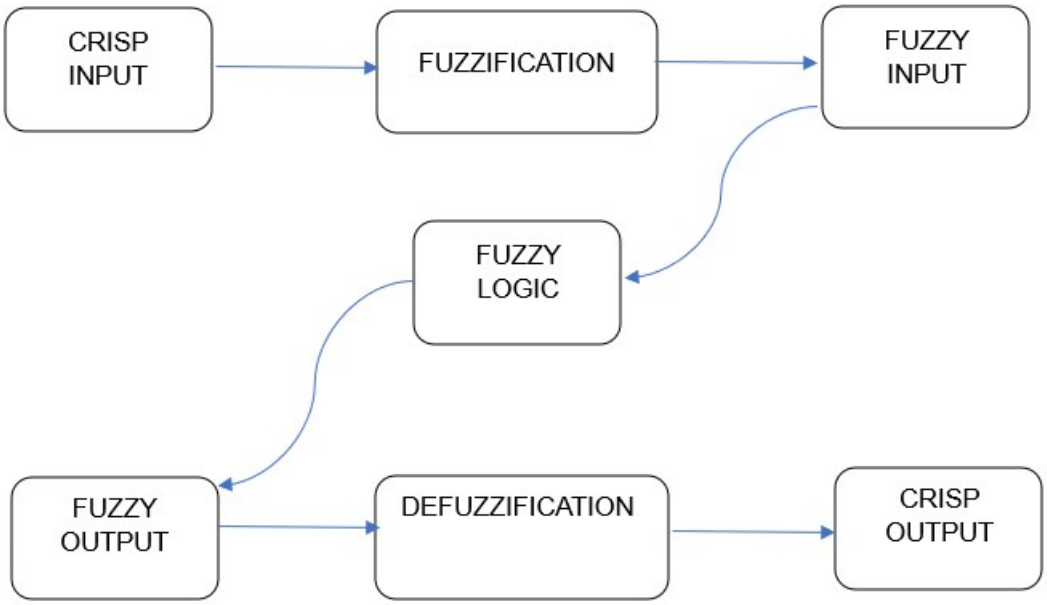


Fig. Fuzzy Logic

5. Detailed Design

a) Mechanical design

A pulley system has been used to operate the automatic opening and closing of gates based on sensor data. We designed a glass tank of dimensions 60x30x30 cm for prototype purpose. The tank was partitioned into two halves , one for the inflow and the other for water outflow. A wooden block with a slit for inserting a metallic gate was used as a partition to show vertical dam gate operation. Below are the components for same.

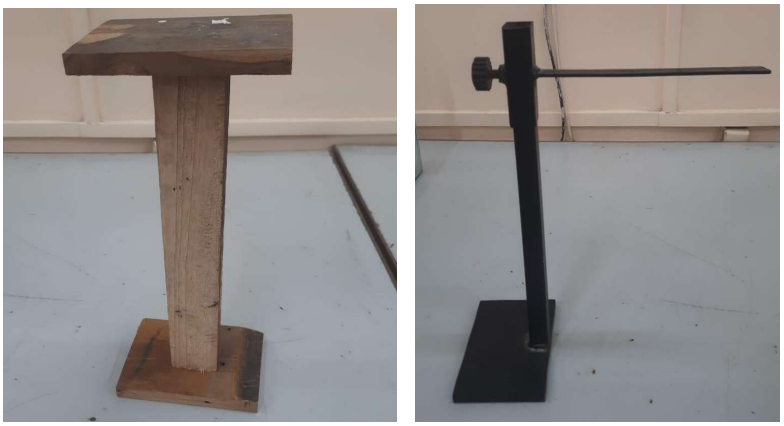


Fig. Stands used in the system for circuit components

Fig. The dam prototype structure

b) Hardware design

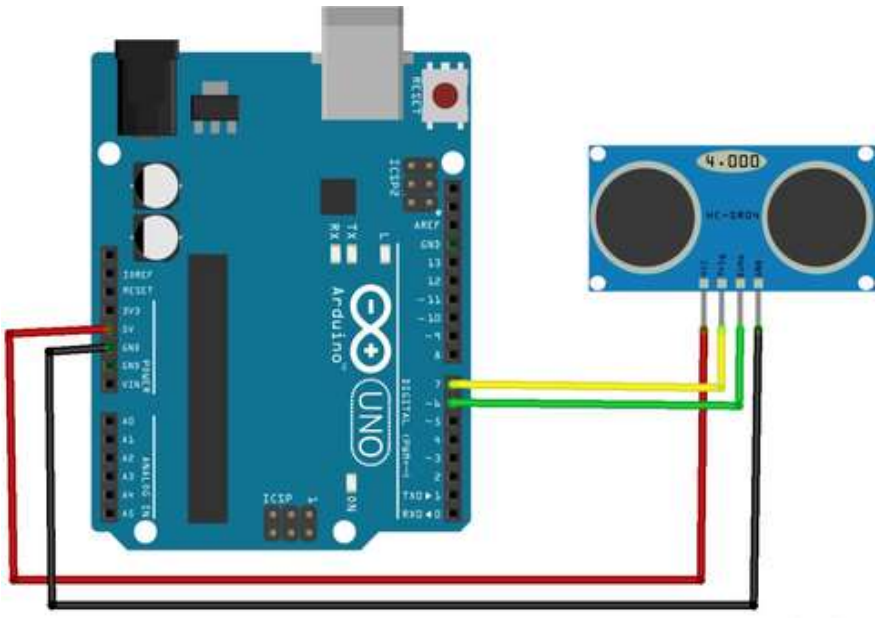


Fig. Arduino UNO connections with HC-SR04

Ultrasonic sensor-

1.Trig: The Trig (Trigger) pin of an ultrasonic sensor is used to initiate ultrasonic sound pulses. The sensor starts an ultrasonic burst by holding this pin HIGH for 10µs.
2.Echo: When an ultrasonic burst is broadcast, the echo pin gets high and stays high until the sensor receives an echo, after which it glows.

Arduino-

1. Digital Pins: The Arduino board's pins 0 to 13 are used as digital inputs or outputs.
2. Serial Pins: Serial pins are also referred to as UART pins. The Arduino

board and other devices can communicate with one another via it. Data is transmitted and received, respectively, using pins numbered 1 and 0 for the transmitter and receiver, respectively.

3.External Interrupt Pins: The Arduino board's pin number 3 is utilized to generate an external interrupt, which is accomplished via pins 2 and 3.

4.PWM Pins: By adjusting the pulse width, this board pin transforms a digital signal into an analogue one. PWM pins are utilized on pins 3,5,6,9,10, and 11.

5.SPI Pins: The Serial Peripheral Interface (SPI) pins are utilized to maintain SPI connection with the aid of the SPI library. SPI pins consist of:

SS: Pin 10 is used as a Slave Select.

MOSI: Pin 11 serves as a Master Out Slave In.

MISO: The Master In Slave Out (MISO) pin is 12.

SCK: Pin 13 is used as a Serial Clock.

6.AREF Pin: This is the Arduino board's analogue reference pin. It serves as a reference voltage source from an external power source.

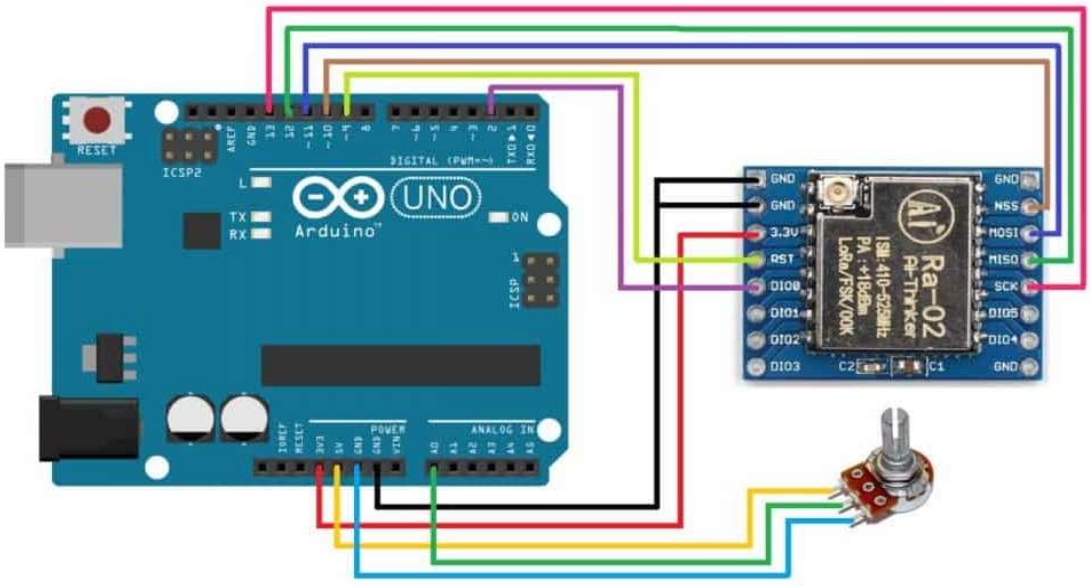


Fig. Arduino UNO connections with LoRa Ra-02

LoRa-

1. Pin 12: SCK pin is used for clock pulse during the SPI communication.
2. Pin 13: MISO pin means Master in and Slave out. Here the master is the controller and the slave is the module. This means that through the MISO pin data will transfer from Module to the Arduino.
3. Pin 14: MOSI pin refers to Master out and Slave in. It receives the data from the Arduino.
4. Pin 15: NSS pin will help to activate slave.

c) Algorithm

We used the data from the LoRa receiver and translated it to integer representation for use in the gate control algorithm. The basic if-else statement and the fuzzy logic control method were the two techniques we employed to regulate the gate's functioning. The specific terms and regulations applied to the project are shown below.

Algorithm: LoRa Transceiver

Input: data to transmit (at the transmitter)
Output: transmitted data (at the receiver)

a. Initialize LoRa transmitter and receiver modules to function at 433MHz;
b. At the transmitter, repeat the following indefinitely:
  i. Wait until new data is available for transmission;
  ii. Allocate and initialize a new LoRa packet;
  iii. Add data to transmit to the packet;
  iv. Transmit the packet;
  v. Free the packet;

c. At the receiver, repeat the following indefinitely:
i. Wait until a packet is received;
ii. Get the size of packet content in bytes;
iii. Allocate enough memory for storing packet content;
iv. Copy packet content into the newly allocated memory;
v. Free the packet;

Algorithm: Gate control

Method_1: if- else statements

Input: Water Level at backwaters
Output: Gate operation

If the Water level < Threshold, then do not operate the motor if gate is already in closed state, if gate is open, close the gate by operating the motor accordingly.
If the Water level >Threshold, then open the motor 360 degrees for the water outflow.

Method_2: Fuzzy Logic Control for Dam Gate Speed

Input: Water Level at backwaters
Output: Speed for gate actuator

1. Designate and define membership functions for plant input
"Water Level" as:
'Low'
'Safe'
'Slightly High'

'High'
'Too High'

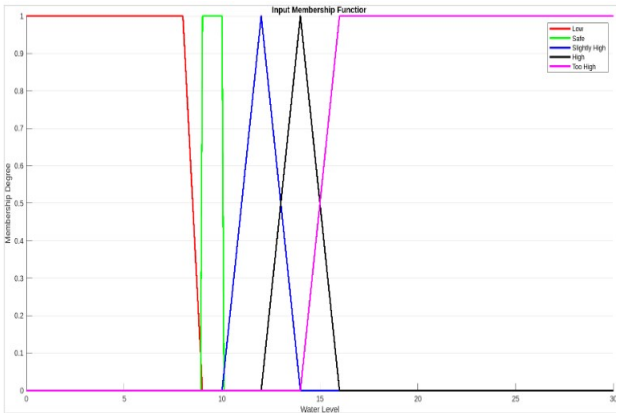


Fig . Membership function plot of water level

2. Designate and define membership functions for plant output "Gate Speed" as:
'Close Fast'
'Zero'
'Open Slow'
'Open'
'Open Fast'

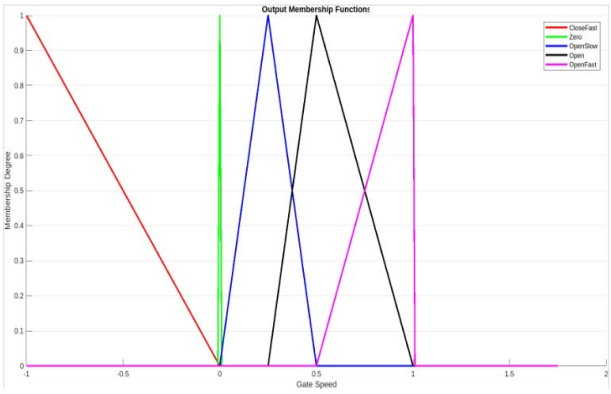


Fig . Membership function plot of gate speed

3. Fuzzy rules:

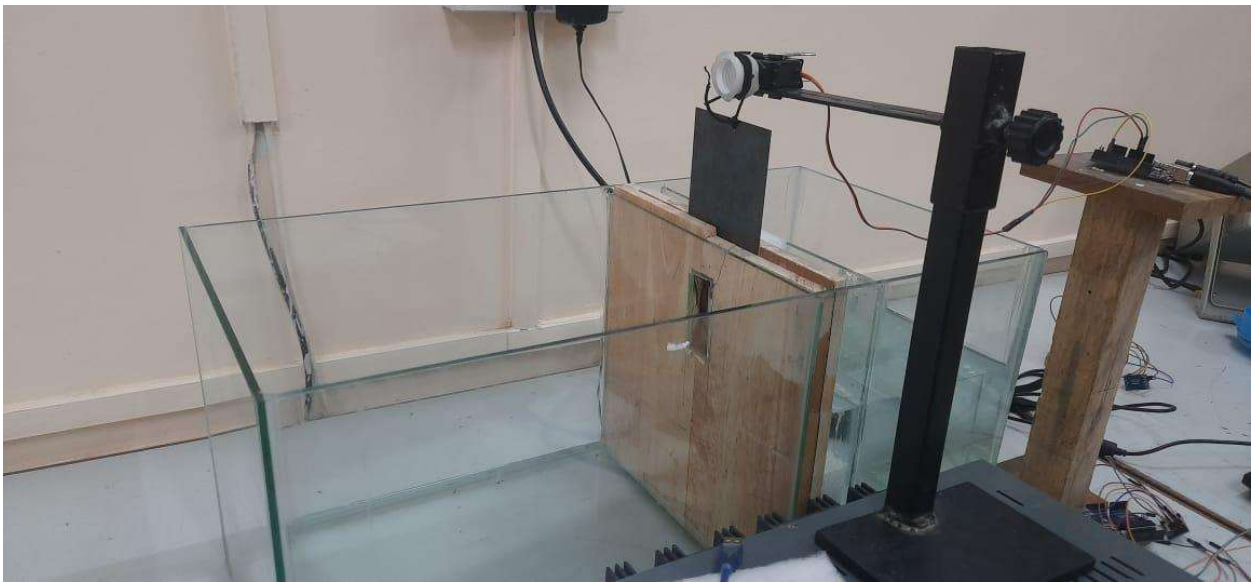
a. IF Water Level = Low THEN Gate Speed < = Close Fast.
b. IF Water Level = Safe THEN Gate Speed <= Zero.
c. IF Water Level = Slightly High THEN Gate Speed<= Open Slow.
d. IF Water Level = High THEN Gate Speed <=Open.
e. IF Water Level = Too High THEN Gate Speed <=Open Fast.

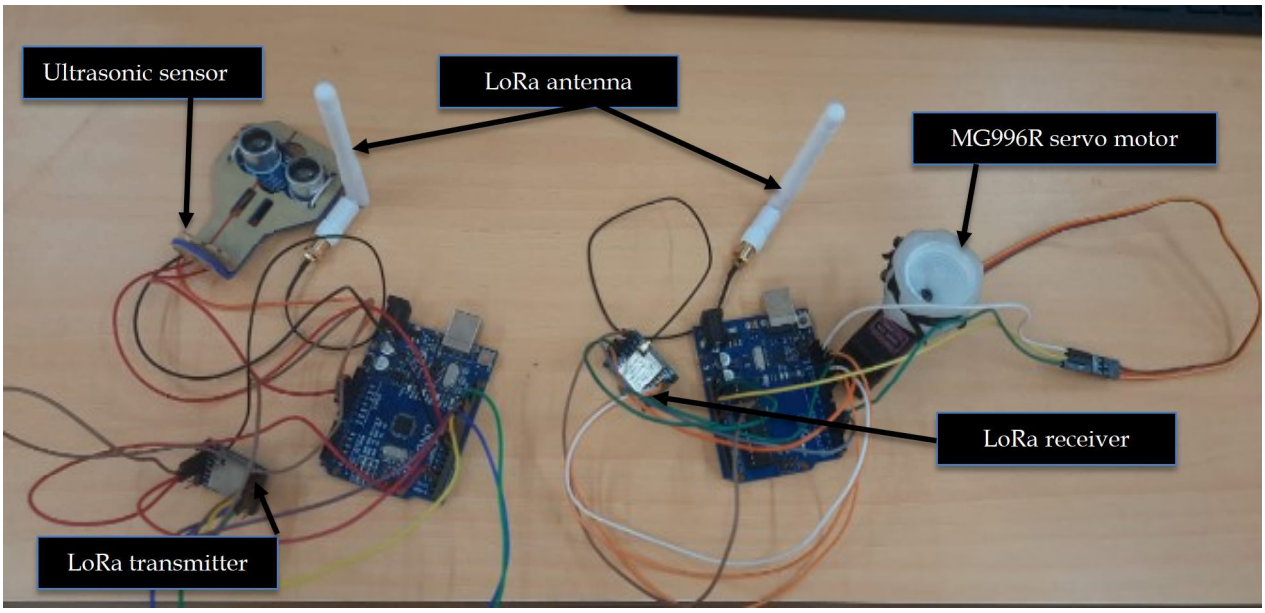
4. Set water level as input to the fuzzy pipeline, Fuzzify using fuzzy rules and store defuzzified value that yields gate speed.

5. Initialize servo controller, interpolate between minimum and maximum pulse widths for servo using stored gate speed value, pulse the servo at calculated durations to control its speed.

The water level has been categorized into 5 different levels: low, safe, slightly high, high, and too high. When the water level qualifies as 'low', i.e., the water level has receded beyond the set point (safe water level), the gate will be closed. When the level qualifies as'safe,' the servo is inactive, and the gate is closed. When it qualifies as 'slightly high', 'high', or 'too high', the servo actuates to open the gate at increasing rates.

Real life view of our setup:





6. Results

To test how effective the system operates, a mini dam prototype was set up. The ultrasonic sensor was calibrated for the mini dam and placed at the top to determine the level of water. The system connections are displayed in figure below.

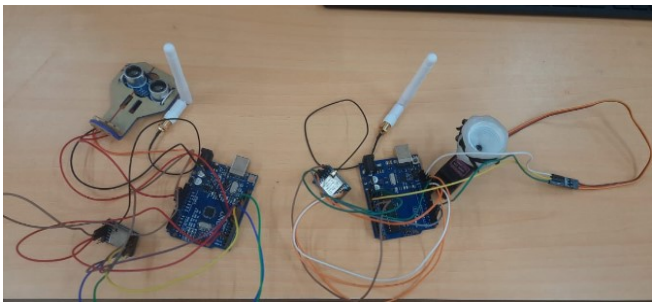


Fig. System connections

A pulley was attached to the servo motor which was used to control the opening and closing of the dam gate. The glass tank was gradually filled with water and the water level sensor output was transmitted and received via LoRa modules as displayed in figure below. The received data was then fed to the micro-controller which controlled the rotation of the servo motor.

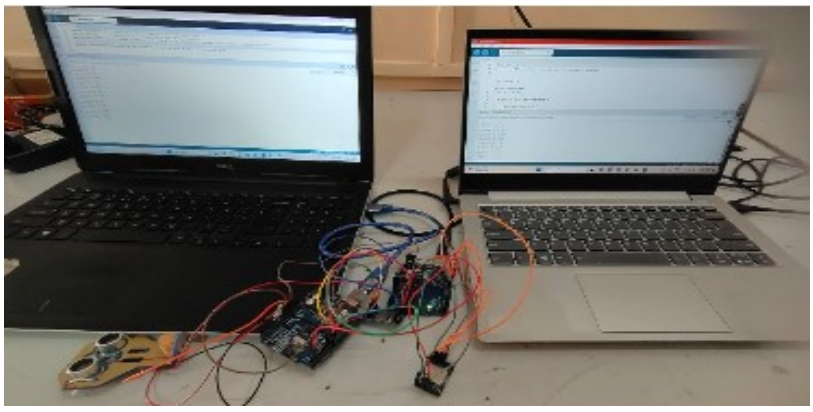


Fig. Entire system operation

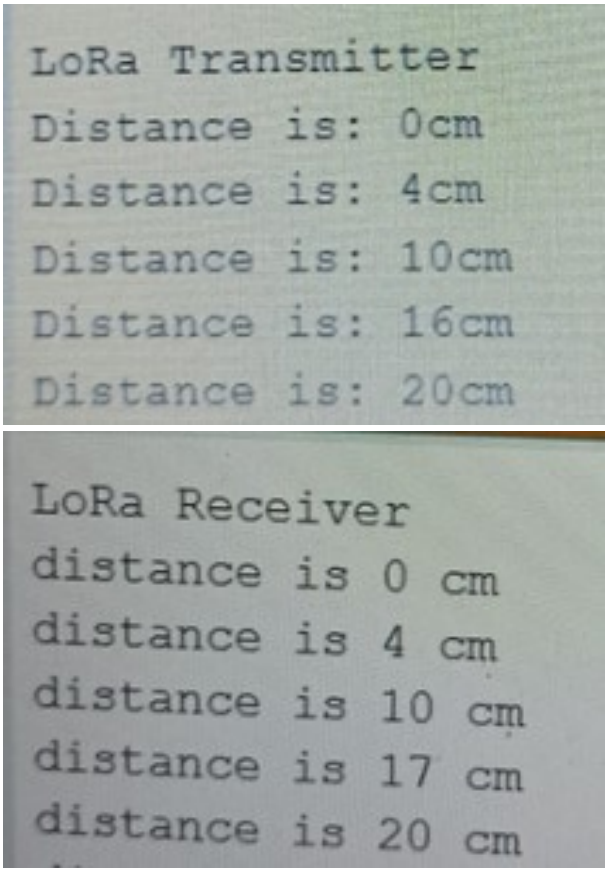


Fig. LoRa transmitted and received data

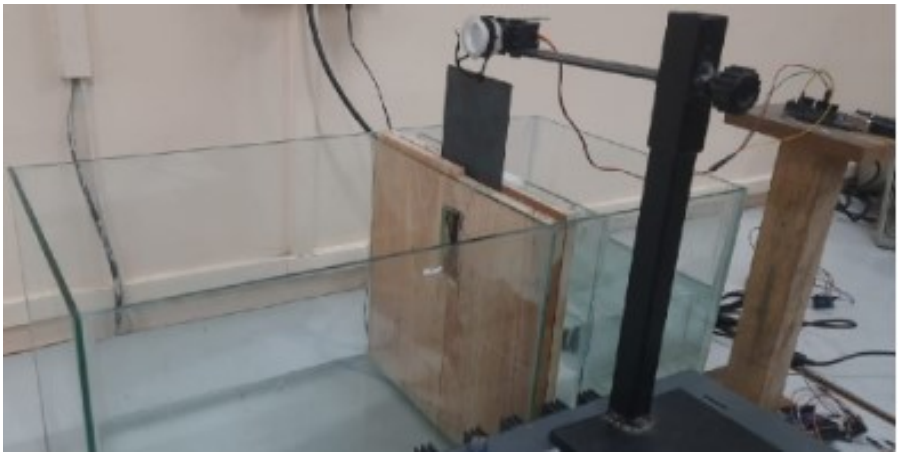


Fig . Gate opening operation

Fig. Water level decreases as the water flows to the opposite side and water flows through the dam gate to the other side

Fig. Dam gate closes according to the water level

7. Conclusion

In this project, a control system for wireless based data transmission system for gate control in Dams has been proposed. A prototype of the same has been fabricated and tested successfully. The LoRa and fuzzy logic was employed for the system. Antenna of 433 MHz as the centre frequency, peak gain of 3.6dBi and its impedance 50 ohms has been used and tested successfully. The present work has been undertaken with single independent parameter to control the gate of the dam. However, this can be extended for multiple parameters for achieving the ultimate objectives of fully automated control of the gate of the dam in future.

8. References

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Appendices

- **Project Expenses (Bill of Materials Table)**

Sr no	Components	Specifications	Quantity	Cost
1	Glass Tank with partition		1	2500
2	Arduino	UNO	2	1000
3	Lora Transceiver module	RA -02	2	1100
4	Antenna	433MHz	2	500
5	Servo Motor	MG996R	1	370
6	Ultrasonic sensor	HCSR-04	1	90
7	Miscellaneous components ,Jumper wires, gate			500

- **Datasheets**

HCSR-04 :https://datasheetspdf.com/pdf/1380136/ETC/HC-SR04/1
Lora:https://cdn-shop.adafruit.com/product-files/3179/sx1276_77_78_79.pdf
Servo Motor MG996R ::https://www.alldatasheet.com/datasheet-pdf/pdf/1131873/ETC2/MG996R.html
Arduino UNO: https://docs.arduino.cc/hardware/mega-2560

- **Workplan**

MONTHS AND WEEKS / TASK OR MODULE	Sign of int. Guide	Sign of coordinator	AUG 18/ 2022 2	Sept 02/ 2022	OCT 10/ 2022	NOV 05/ 2022	NOV 08/ 2022	NOV 20/ 2022	NOV 24/ 2022	NOV 28/ 2022	DEC 01/ 2022	DEC 06/ 2022	JAN 10/ 2023	JAN 25/ 2023	FEB 01/ 2023	FEB 12/ 2023
1. Literature Survey and concept development																
2. Specifications of the entire system																
3. System-level design																
4. Real-life layout of the system																
5. Hardware components selection procurement																
6. Details of design hardwar																

e																
7. Validation of each module's design (hardware & or Software) through Simulation																
8. Seminar Report with Plagiarism Check																
9. Internal Seminar																
10. Hardware setup																
11. Code testing on Raspberry Pi																
12. Integration & Testing of the complete system																

13. Internal Project Demo																
14. project report (with Plagiarism Check)																