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IOT Project Report

HydroSafe – Water Management System for Irrigation System

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ABSTRACTION

HydroSafe is an IoT-powered water management system. It is an irrigation system that can automatically analyze data. We have designed it to optimize irrigation processes by integrating sensor technology and automation. The system provides farmers with real-time monitoring and control of water resources, ensuring the efficiency of its use and saving time. HydroSafe includes core functionalities such as remote flow control and spill gates control, flow rate measurement and data analytics to improve productivity in the agricultural sector.

The development process focused on creating the UI, integrating Firebase Realtime database for secure authentication and data storage, and addressing challenges such as hardware integration and connectivity issues. Future enhancements include AI based predictive analytics, enhanced security measures, multi-language support and offline functionality to improve accessibility. The project aims to revolutionize water management by providing a scalable, new and user-friendly approach to sustainable irrigation management system.

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1.0 Introduction

1.1 Project overview

HydroSafe is an IOT project developed for water management system efficiency in agriculture for irrigation systems. The system is integrated with sensors such as ultrasonic sensors and water flow sensors. Then the project can easily open spill gates using mobile application. We use automation technologies to specifically optimize water use, minimize wastage of water and ensure efficient irrigation processes. Using advanced IoT capabilities, HydroSafe provides real-time monitoring and control, allowing farmers to make data-driven decisions for sustainable agriculture and they can inform decisions to maximize crop yield and conserve resources. The system enables farmers to remotely control spill gates and use a flow sensor to measure water flow rates and volume of the late or tank ensure optimal water distribution across their fields. And mobile accessibility to provide seamless monitoring and control from any location.

1.2 Objective of the Project

Automation & Remote Access

- Enable farmers to open remotely and close spill gates through a web interface.

User-Friendly Interface

- Created the mobile application provides user can see user friendly interface for users to enhance their interactions.

Accurate Flow Rate Measurement

- This system can use for measuring the flow rate of water entering or leaving the lake/tank in real-time database using IoT sensors such as water flow sensors and ultrasonic sensors.
- The flow rate data can be continuously stored in Firebase database and monitored for decision-making and later analysis about flow rates.

Real-Time Monitoring

- Enable real-time data collection and monitoring of water volume and water flow.

2.0 Problem Statement

There are some problems that we needed to solve in order to create this HydroSafe project. As a solution to them, we created HydroSafe. The problems that we have included are:

There are different changes in the environment according to different weather conditions. Accordingly, if we take the irrigation industry, the spill gates have to be opened as the water level in the tanks rises. Here we have designed it so that we can provide it to the farmers through the spill gates according to the speed of water flowing through the spill gates. This can also minimize water wastage.

Also, the other reason we designed this is that people's time and labor are important to open and close the spill gates of the tank. In that case, it is more practical for us to use a mobile application to save time. This can minimize the impact of floods on people during the rainy season

3.0 Proposed Solution

We have created HydroSafe as a solution to all the above problems. It uses a servo motor as a spill gate and then measures the flowrate using the water flow. This allows us to understand how much water needs to be supplied to the canal and the water level in the tank, which makes farming easier for farmers.

4.0 System Architecture

For the HydroSafe IoT project, we need to use hardware and software. The hardware and software we used are described below.

4.1 Hardware Component

ESP8266 – ESP8266 is a Wi-Fi enabled microcontroller and low-cost component used to wireless data transmission between Firebase and ESP8266. It serves as the CPU (central processing unit) of the HydroSafe IoT Project, gathering sensor data and transmitting it to a real-time firebase database. It allows seamless connectivity for real-time water level and flow monitoring.

Ultrasonic Sensor – Ultrasonic sensor can be used to calculate volume, but it does not measure volume directly. This can measure distance from the sensor to the water surface. The total height is the maximum possible height when the tank/lake is full. This data helps in effectively allows water to flow into canals managing water levels, preventing overflows.

So, First can get water level using below formular

$$\text{Water Level} = \text{Total Tank Height} - \text{Measured Distance}$$

The volume calculated by using the below formula.

$$\text{Volume} = \text{Area of the tank/lake} * \text{Water level}$$

Flow Sensor – Water Flow Sensor can measure the rate of water flow in the pipeline.

Servo Motor – A servo motor is used to control the spill gate mechanism that regulates water release. Based on the water level and flow sensors, the microcontroller adjusts the position of the servo motor to open the spill gate or close the spill gate.

4.2 Software Component

Firebase

- I create Firebase Realtime database in my Firebase default account and I add authentication part using email address and password.

Flutter

- I used flutter web application for the UI design part. I connect flutter app with Firebase Realtime Database.

Arduino IDE

- I used this for a programming part. We used 3 libraries that are

  ESP8266WiFi.h,

  Servo.h,

  ESP8266Firebase.h.

  ESP8266WiFi library used to connect ESP8266 with Wi-Fi. ESP8266Firebase used to connect with firebase. Servo library imports for the get servo motor logic include to code.

5.0 Key Features

1. Real-Time Water Monitoring

Here enables continuous monitoring of water levels of the tank or reservoir and water flow rate in the pipeline, displaying real-time data on a user interface. The system uses sensors such as ultrasonic and water flow sensor to check water usage, offering live insights into water levels and flow.

2. Automated Spill Gate Control

The spill gate mechanism controlled by a servo motor in HydroSafe IoT Project, user can open or close spill gates automatically based on real-time water levels. Here another feature is preventing overflow and optimizing water storage. This automation ensures the efficient use of water resources without manual intervention.

3. Remote Monitoring using Mobile App

The system allows users to control spill gates using a Flutter-based web application. Users can check flow rates, and gate status from anywhere and anytime, providing flexibility and control even when away from the site.

4. Firebase Data Logging

Provide a detailed historical record of spillway operations and water consumption. This data logging feature helps users analyze trends, track events, and make informed decisions for better water management.

5. User Authentication and Account Management

The system includes user authentication features, users can create an account, Sign In and securely access their data such as email and password. This ensures that only authorized users can control the spill gates.

6.0 Development Process

6.1 Core Functionalities

- Remotely control the spill gate

  Allows users to remotely open and close spill gates to regulate the flow of water into their fields.

- Measure the flow rate.

  Water flow sensors are used to monitor water consumption and detect irregularities.

- Data Analytics

  An analysis on the collected real time database data to provide insights for optimizing water distribution and improve the efficiency.

- Real-Time Water Flow Monitoring

  Flow sensors are used to measure and monitor water flow rates in real time. Flow rate data is displayed on a dashboard for users.

6.2 Milestones Achieved

- Project Planning & Research (Completed)

  I conducted a study on IoT-based irrigation systems and researched and founded appropriate sensors and components for the IoT project.

- IoT Connectivity (Completed)

  Developed a web application for sensor readings in Firebase.

- Web Application Development (Completed)

  Designed a user-friendly web dashboard for monitoring flow rate and volume of the tank or lake.

- Hardware & Sensor Integration (Completed)

  Successfully integrated water flow sensor and ultrasonic sensor

- Power Optimization & Energy Management (Completed)

  Integrated adapter to ensure continuous operation.

7.0 System Design

7.1 Web Design

Flutter was used to create the web design UI of the project.

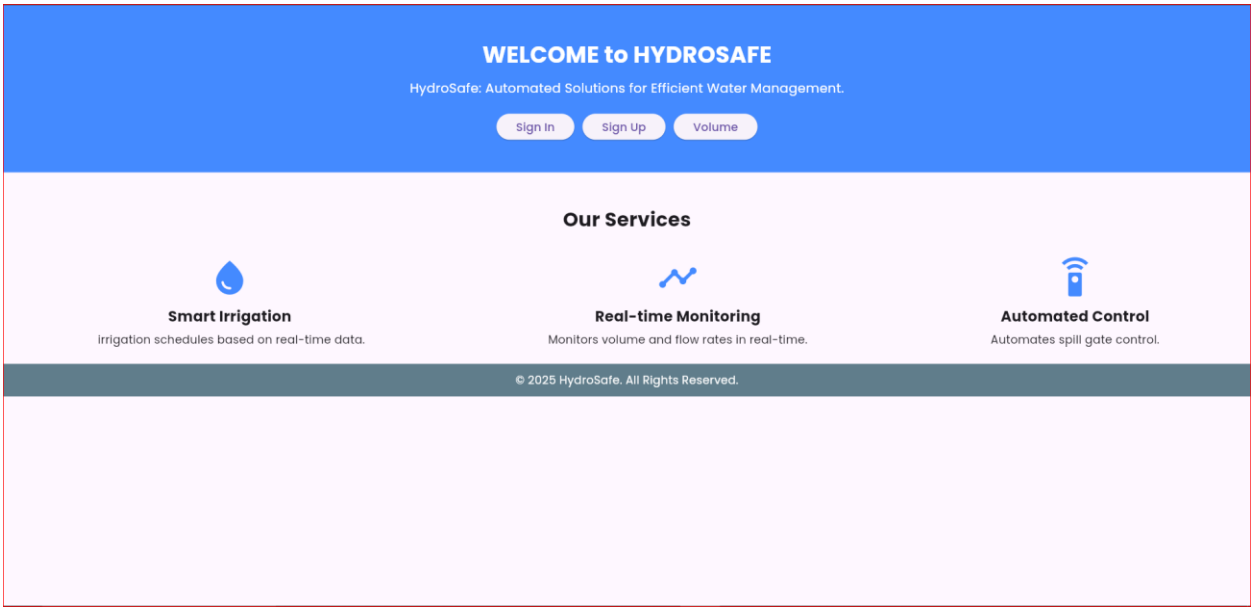

Figure 1 - Home Page

Home page is the first page in my web application. I used flutter and firebase real time database for this and here it has three buttons for go to other pages. Buttons are Sign In, Sign Up and Volume. Users can create an account using Sign Up button and user can log in to account using Sign in button and Volume button goes to volume and water flow page.

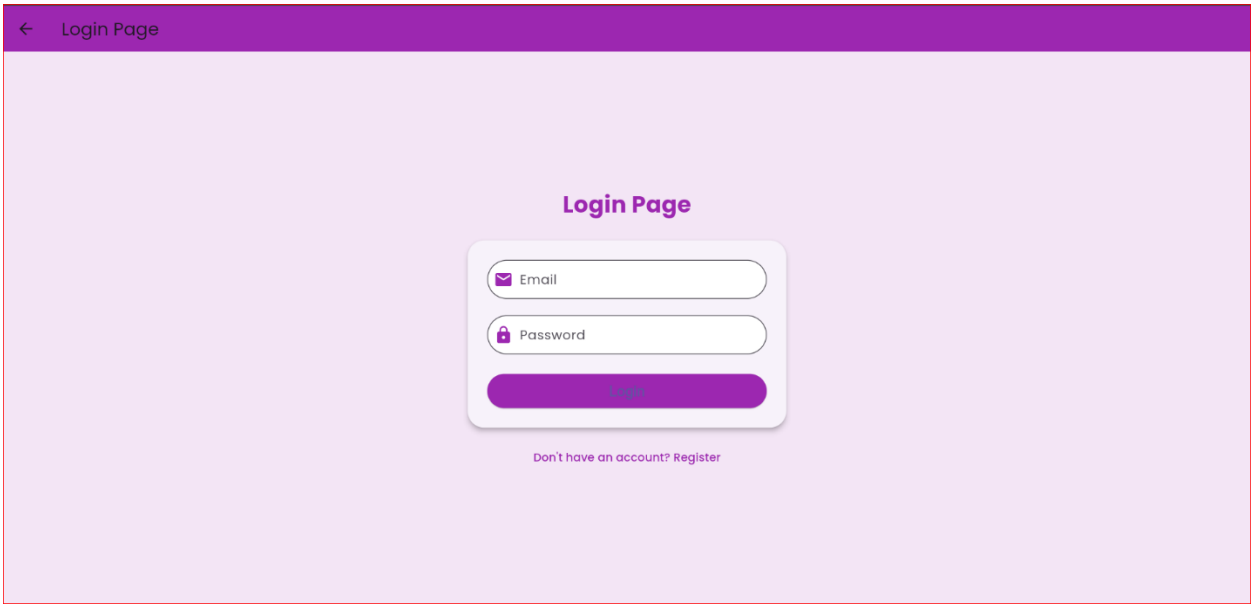

Figure 2 - Sign In Page

Users can login to their account using given email and password. And below the login button has a link to go to register page.

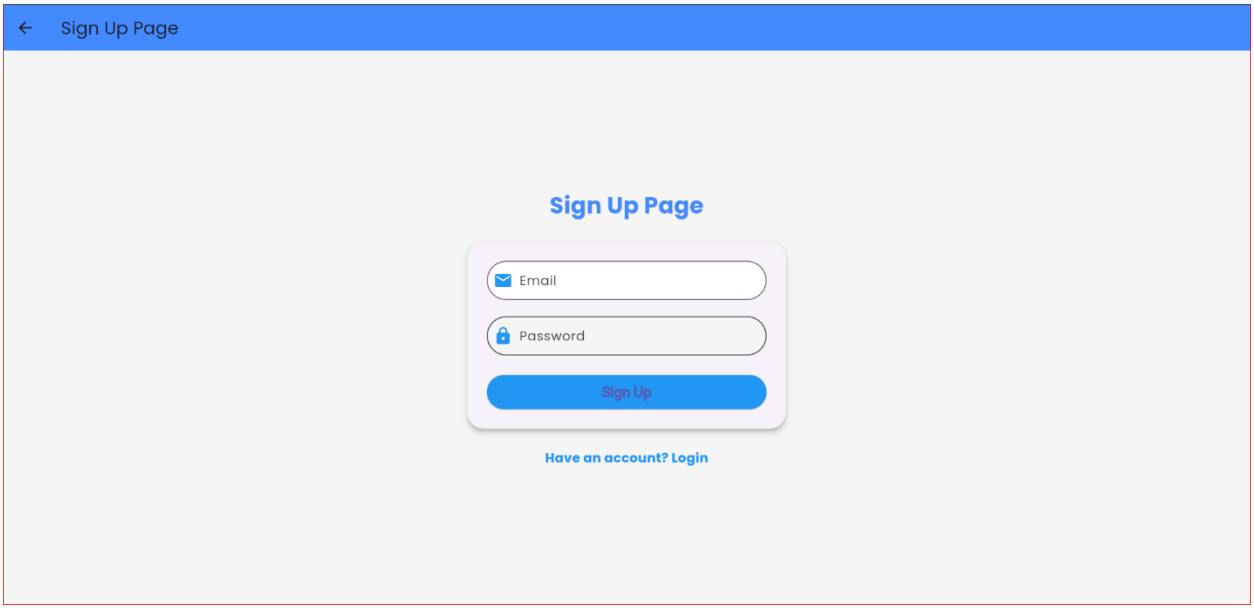

Figure 3 - Sign Up Page

Users can create an account using this page and user have to give email and password.

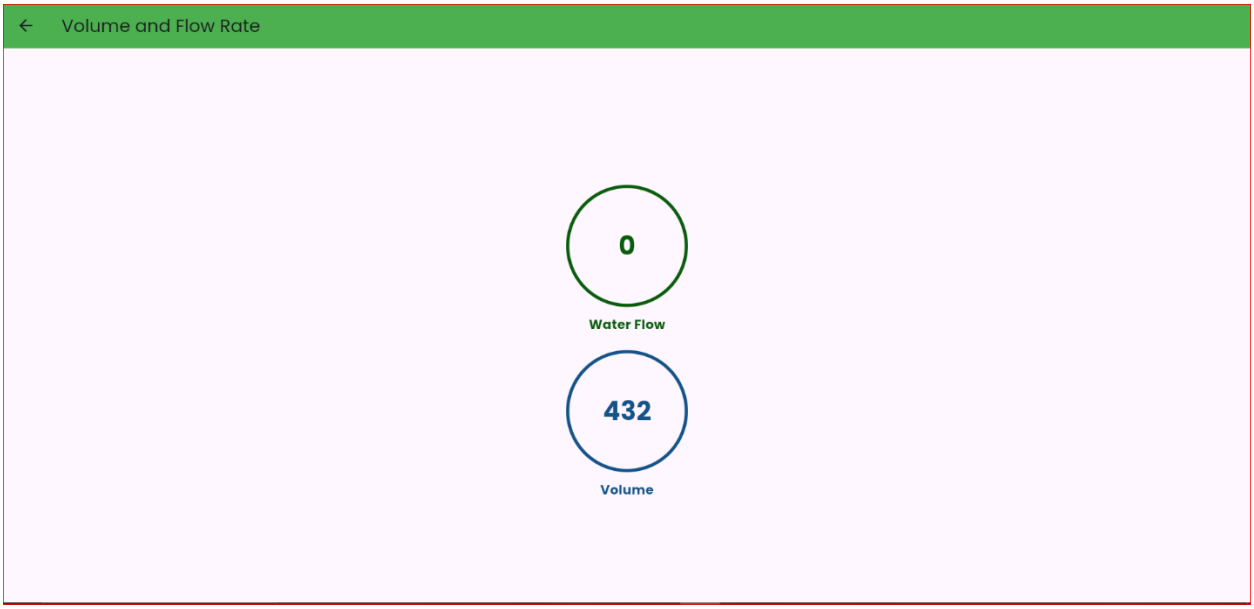

Figure 4 - Volume and Flow Rate Page

Users use this page to check the volume of the tank or reservoir. and can check the water flow rate in the pipelines. Here displays value in real time database in firebase.

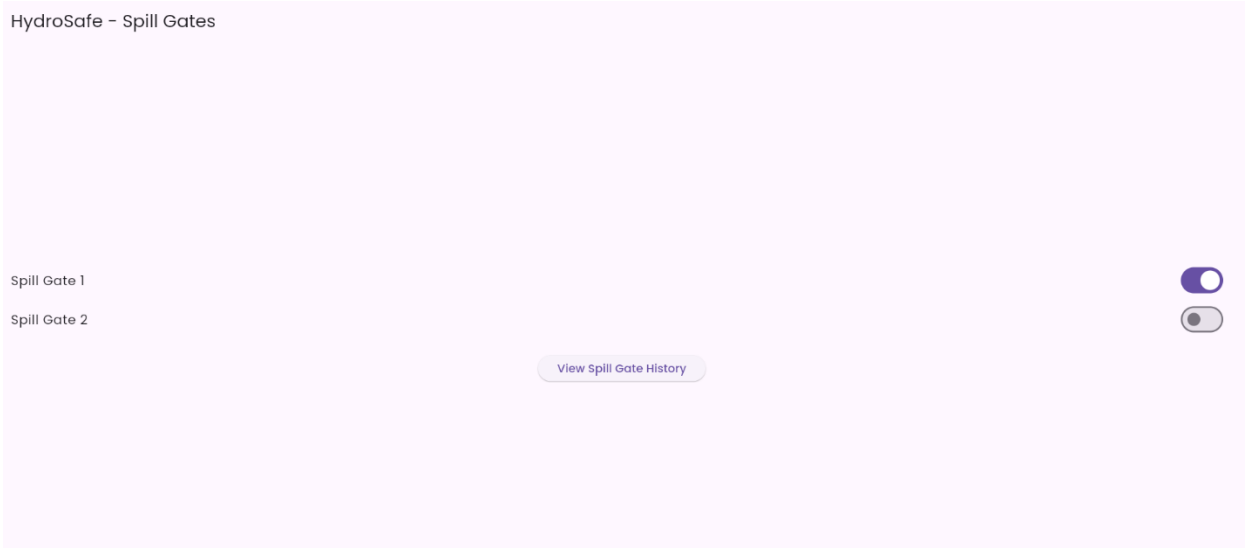

Figure 5 - Spill Gates Page

Here the above page can spill gate on and off. It has a view spill gate history button. So that can go to the history page. Here spill gate of then prototype spill gate can On and If I off the spill gate then servo motor is can off the spill gate.

Figure 6 - History of Spill Gates

Here you can see history of spill gate. If spill gate on or off then can see on/off and date with time.

7.2 Firebase Connect

Firebase has been connected to the web application via a real-time database using the Firebase database package and the Firebase core package. After providing the code to upload that database URL to ESP8266, Firebase has been completely added. We used 3 libraries and they include below image.

```
#include <ESP8266WiFi.h>
#include <Servo.h>
#include "ESP8266Firebase.h"


#define WIFI_SSID "c_w"
#define WIFI_PASSWORD "12345678"


#define FIREBASE_URL "https://hydrosafe-d564c-default-rtdb.firebaseio.com/"

Firebase firebase(FIREBASE_URL);
Servo servo;
```

Figure 7 - Developed code

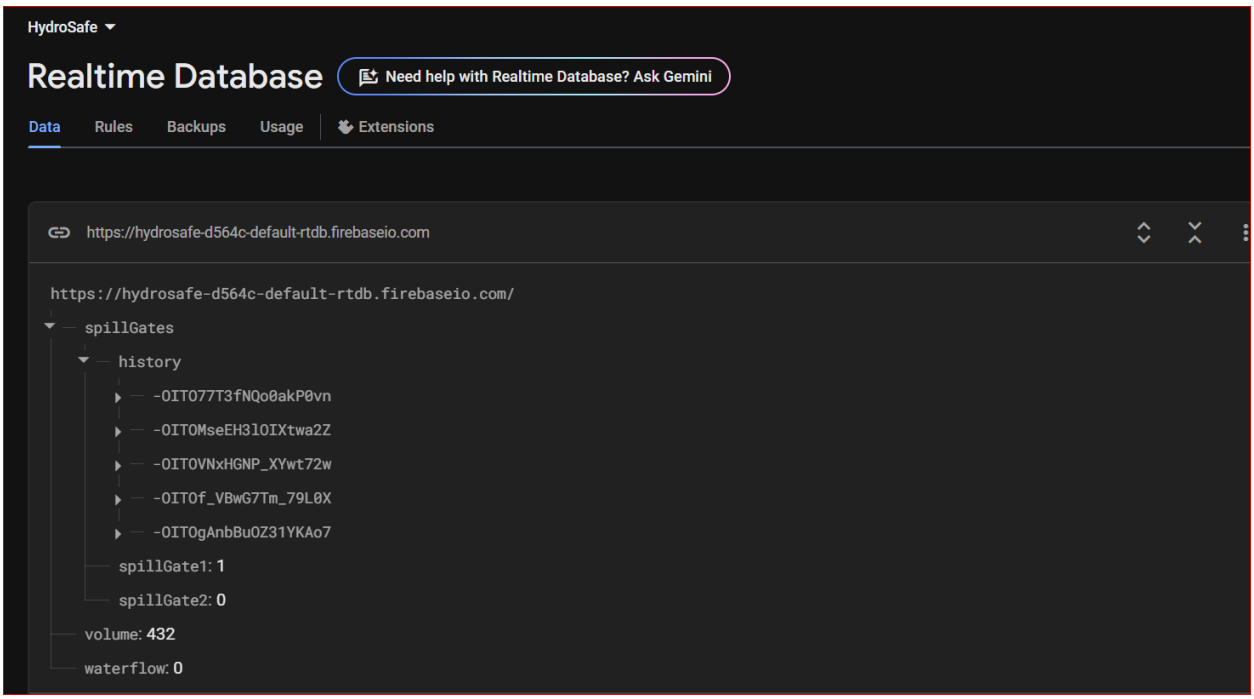

Figure 8 - Firebase Realtime Database

This can be seen on firebase history. Here display spill gate 1 represents spill gate on and 0 represent off.

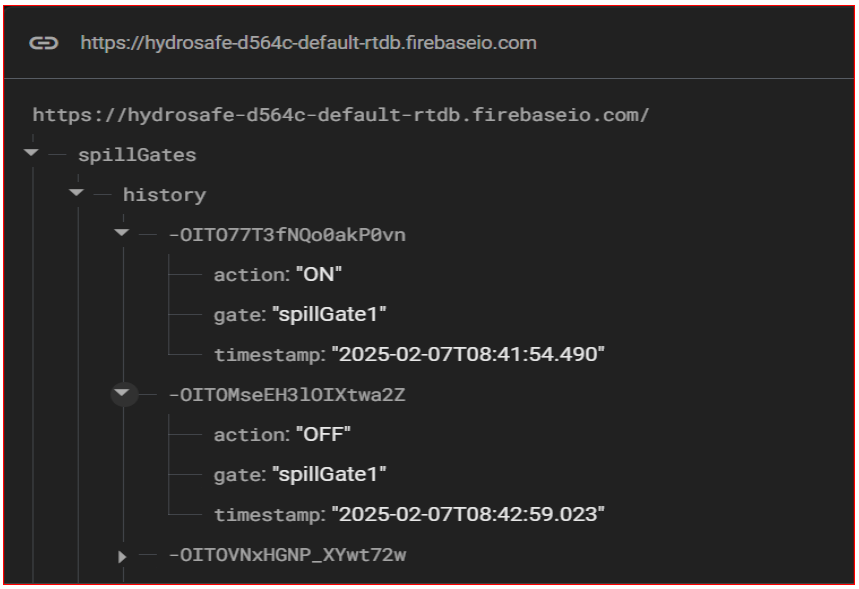

Figure 9 - Firebase Spill Gate History

Here can see Spill gate ON or OFF and date with time.

7.3 Prototype

This prototype can check volume using ultrasonic sensors and water flow rate using water flow sensor.

Figure 10 - Prototype

8.0 Challenges and Solutions

8.1 Challenges

I faced the following challenges while creating this IOT project.

- Connecting to Firebase

  Establish a trusted connection between the web application and the Firebase database for real time data synchronization.

- Finding components to use

  After choosing the topic for this project, we needed to find the components related to the project through research papers.

- Power Management

  Most of the time, the power provided by the USB was not enough, so sometimes the project did not work.

- Displaying the flow rate

  The real time database does not display decimal numbers.

- Hardware Integration and Connecting IoT Sensors

  Handling compatibility issues between sensor's output and the mobile app's output.

- Components are not working.

  Jumper wires bought are sometimes new and don't work. Sometimes, even if we think there is a problem with the project or code, one mistake in one of our jumper wires can cause the entire project to fail.

- Display Volume

  If I do not add water to tank, that time display volume is negative number.

8.2 Solutions

Below are the solutions to the above challenges I faced while creating this IOT project.

- Solution for firebase connection

  Enable Firebase authentication for secure login and Firebase Fire store for real-time data storage. Then create a new firebase project and sync the web with Firebase using the Firebase SDK

- Solution for finding components

  At that time, we got the component list through Google School website and discussed it with the lecturer and gained new knowledge about it.

- Solution for power management

  At that time, we used an adapter to generate power.

- Solution for flow rate display

  Since the real time database does not display decimal numbers, a multiplication was added to the code that connects it to the ESP8266.

- Solution for Hardware Integration and Connecting IoT Sensors

  Use ESP8266 to act as an intermediary between sensors and web application and to use a fast network connection.

- Solution for the Jump wire not working.

  Check all purchased jump wires first.

- Solution for the display volume

  I add code part using IF Statement If have negative number get 0. And we added water then display positive number of volume.

9.0 Budget

Components	Prices
Ultrasonic	Rs. 400/=
Water flow sensor	Rs. 1950/=
Servo motor	Rs. 300/=
Jumper wire * 2	Rs. 600/=
Pipes	Rs.250/=
ESP8266	Rs. 1000/=
Total	**Rs. 4500/=**

10.0 Gantt Chart

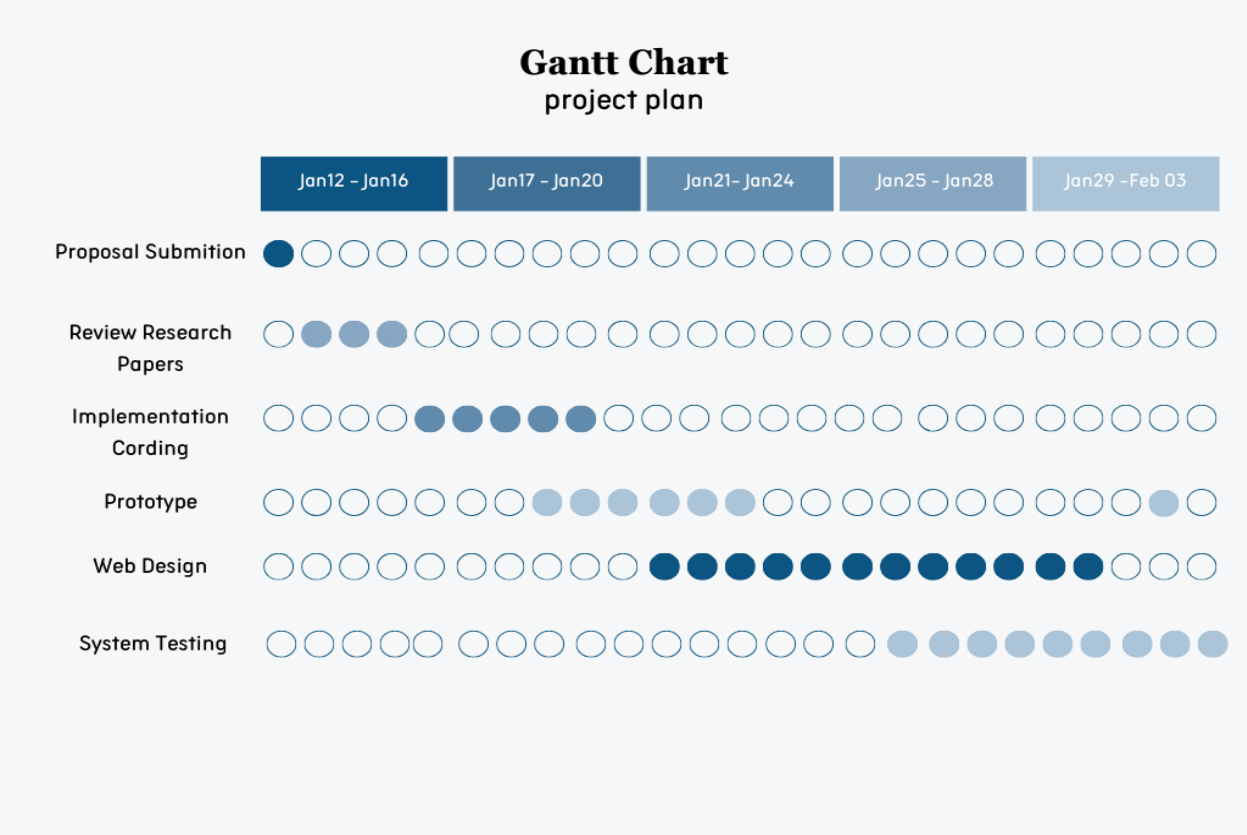

Figure 11 - Gantt Chart

11.0 Discussion

This HydroSafe Project is my university IoT Project, and it is an irrigation system using IoT. So, I created this project. For HydroSafe we must use software and hardware. So, I bought some products, and I had some hardware products. So First I create ultrasonic sensors working part. This project is also important for water conservation.

First we created the prototype by connecting the ultrasound and water flow. Then we did the implementation part in Arduino IDE and Flutter Web application. There are three people in our team and as Lecher said, we had to make the prototype for all three of us, but we had to make the Firebase and mobile applications separately.

All three of us had to create a mobile application, I used Flutter and Firebase for that. But due to a bug in my laptop, I couldn't create the mobile application. But I created a web application for it. For that, I added three buttons to the dashboard: sign in, sign up, and volume, and any user can sign in after creating an account. Sign in user can open spill gates and view their history. Also, any user who visits this web application can monitor the volume and water flow rate without having to create an account.

The next step is to create the Arduino IDE code for the implementation part. For this, we created three libraries, which are mentioned above. Here we need to upload the code to the ESP8266 via a USB cable. We connected the ESP8266 to the breadboard and connected the sensors to the breadboard via jumper wires. Here, we bought all the sensors to create this prototype and also got some things from our home.

I had to create Firebase Realtime database then we have to add authentication part. First, I created a real time database in my Firebase default account. Then I connected it to my flutter web application. Then when I started debugging the web application the details entered in firebase were automatically added. Then I set it up to provide its email password for the verification part.

12.0 Future Enhancements

- Mobile and Hosted Web App

  Develop a dedicated mobile app with a fully hosted web app that allows users to seamlessly monitor and control the system.

  Ensure a responsive and user-friendly user interface for an improved user experience across multiple devices.

- AI-powered insights with Gemini AI

  Integrate AI like Google's Gemini to analyze historical water usage patterns or provide predictive insights.

  AI can suggest optimal water management strategies based on past trends and environmental factors.

- Water Flow Volume History

  Store historical water flow and volume data in the data warehouse and allow users to check their water consumption.

  Display graphical insights and trend analysis for efficient water usage planning.

- Water Level Visualization

  Introduce a real-time visual representation of water levels using dynamic charts and graphical indicators.

  Provide alerts when water reaches critical levels to prevent overflows or shortages.

- User Account Management in the Mobile App

  Enable users to view and manage their account details, including their past activities such as opening and closing sluice gates, access logs, and system usage history.

  Implement role-based access control for different user types such as administrators, regular users, etc.

- Weather API Integration

  Include a weather API to display real-time weather conditions and forecasts within the app.

- Cloud-based Data Management

  We can enhance the system with cloud storage, real-time access to water level and usage data.

- Smart Notifications and Alerts

  We can enable notifications to notify users via email or phone number about significant changes in water levels, weather conditions, and unusual water flow rates.

13.0 Conclusion

This IoT project was created for a irrigation management system. Here you can calculate the volume of the tank or reservoir. Another thing is this project can calculate the water flow rate in the pipelines. This smart irrigation system designed IoT technologies with real-time monitoring and automation, contributing greatly to water conservation and increasing agriculture efficiency. Water flow, and ultrasonic distance-measuring sensors are applied so that irrigation takes place only when needed, which will avoid the conditions of overwatering or flooding. This system can store and monitor irrigation measurements anywhere, anytime, with its Firebase real-time database, which enables farmers to access volume and water flow information in real time with ease. Moreover, the ESP8266 microcontroller provides an implementing way of radio communication using Wi-Fi between sensors and the firebase at lower cost and more reliable means. This project will show how smart systems work in the optimization of resources, reducing water waste.

14.0 References

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