PROJECT REPORT

On

Smart Hydroponic System

Submitted By

Ms. Yashita Patil **Ms. Shweta Zade**

Mr. Lucky Bhure **Ms. Anushka More**

Mr. Lakshit Chapre

Submitted in partial fulfilment of

"PROJECT–I (PROJCS701)" Course Work of

VII Semester of Bachelor of Technology

Guided By,

Dr. Rashmi Jain

&

Ms. Megha Kalorey

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

S. B. JAIN INSTITUTE OF TECHNOLOGY,MANAGEMENT AND RESEARCH, NAGPUR

(An Autonomous Institute, Affiliated to RTMNU, Nagpur)

2023-2024

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CERTIFICATE

This is to certify that the Project Report titled **"Smart Hydroponics System"** submitted by **Ms. Yashita Patil, Ms. Shweta Zade, Mr. Lucky Bhure, Ms. Anushka More, Mr. Lakshit Chapre** has been accepted under the guidance of **Dr. Rashmi Jain** and **Ms. Megha Kalorey.** This Project work is carried out for the partial fulfillment of "**PROJECT–I (PROJCS701)"** Course Work of VII Semester of Bachelor of Technologyin **Computer Science and Engineering, S. B. Jain Institute of Technology, Management and Research, An Autonomous Institute, Affiliated to RTMNU, Nagpur.**

Ms. Megha Kalorey	**Dr. Rashmi Jain**
Assistant Professor	Assosciate Professor
(Project Co- Guide)	(Project Guide)

Dr. Mrudula Nimbarte	**Dr. S. L. Badjate**
Head of Department	Principal

External Examiner

Mr/Mrs/Ms/Dr.____________________

Designation: ____________________

Institution ____________________

Date: ____________________

DECLARATION

We hereby declare that the Project Report titled **“Smart Hydroponics System”** submitted herein has been carried out by us in the Department of Computer Science & Engineering of S. B. Jain Institute of Technology Management and Research, Nagpur under the guidance of **Dr. Rashmi Jain** and **Ms. Megha Kalorey**. The work is originaland has not been submitted earlier as a whole or in part for the award of any degree/diploma at this or any other Institution / University.

Yashita Patil __________________

Shweta Zade __________________

Lucky Bhure __________________

Anushka More __________________

Lakshit Chapre __________________

Date: - / /

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ABSTRACT

With a rising global population and limited agricultural land, hydroponics has emergedas a sustainable alternative to traditional soil-based farming. This paper introduces an innovative IoT-enabled Smart Hydroponic System (SHS) that employs real-time data monitoring and intelligent control mechanisms to enhance plant growth and resource utilization. The system utilizes a network of sensors to capture crucial environmental parameters such as temperature, humidity, nutrient levels, and pH, providing a comprehensive overview of the hydroponic environment. Its unique feature lies in its adaptability to real-timeenvironmental changes, contributing to the evolution of precision agriculture. This research highlights the transformative potential of IoT in revolutionizing hydroponic farming for futurefood production.

Keywords/Index Terms*— Hydroponics, Sustainable Farming, Internet of Things (IoT), Real-time Data Monitoring, Intelligent Control Mechanisms, Plant Growth Optimization, Resource Utilization, Environmental Parameters, Precision Agriculture.*

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ABBREVIATION

ABBREVIATION	FULL FORM
SHS	Smart Hydroponic System
IoT	Internet of Things
IDE	Integrated Development Environment
TDS	Total Dissolved Solids
pH	Potential of Hydrogen
ppm	Parts per Million

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CHAPTER NO. 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

Chapter 1 delves into the Project Background, tracing hydroponics' evolution and the demand for inventive agricultural solutions. The Problem Statement identifies constraints inconventional farming, prompting the need for smarter systems. The Purpose of the Study is to explore technology's role in enhancing crop yield and sustainability in hydroponics. The Technological Base outlines key technologies for the Smart Hydroponic System.

1.1 PROJECT BACKGROUND

Hydroponics is a way to skip the soil, sub into a different material to support the roots of the plant, and grow crops directly in nutrient-rich water. This Smart Hydroponic System will have sensors, internet, communication, and computer technology. To solve the current deficiency, this system is designed for monitoring and controlling system.

This Smart Hydroponic System will automate crop monitoring during the growth process using a network of sensors and actuators. This system assists in monitoring and commanding numerous real issues in fields such as water PH level, water temperature, and relative humidity.

1.2 PROBLEM STATEMENT

Hydroponics is soil-less agriculture farming, which consumes less water and other resources as compared to traditional soil-based agriculture systems. However, monitoring hydroponics farming is a challenging task due to the simultaneous supervising of numerous parameters, nutrition monitoring, and controlling.

1.3 PURPOSE OF STUDY

The purpose of this smart hydroponic system using IoT project is to revolutionize traditional agricultural practices by leveraging modern technology to enhance the efficiency and sustainability of hydroponic farming. By integrating IoT devices such as sensors and actuators into the hydroponic setup, the project aims to automate and optimize key parameters such as nutrient levels, pH, temperature, humidity, and light intensity. The goal is to enable real-time monitoring and remote control through mobile and web applications, providing farmers with the tools to achieve precision agriculture. Through this innovative approach, the project seeks to improve resource efficiency, increase crop yield, and contribute to a more sustainable and technologically advanced agricultural ecosystem.

Aim

A smart hydroponic system (SHS) with IoT aims to revolutionize hydroponic-based agriculture by integrating sensors and connectivity. It enables remote monitoring and control, resource efficiency, data-driven decision-making, automation, and environment sustainability.

Objectives

- To be able to provide a better temperature for plants to grow in hydroponic farming.
- To Control nutrient parameters in water.
- To Design such an application that gives the user all information regarding temperature, nutrient composition, and recent crop conditions.

1.4 TECHNOLOGICAL BASE

This Project can be implemented by using various technologies like:

- **ARDUINO IDE:**

The Arduino Integrated Development Environment (IDE) is a user-friendly software platform designed for programming Arduino microcontrollers. With a simple interface, it enables both beginners and experienced developers to write, compile, and upload code to Arduino boards effortlessly. Offering a versatile code editor, the IDE supports various programming languages, including C and C++, making it accessible to a wide range of users. It provides a seamless connection between the software and hardware components, allowing programmers to create interactive and innovative projects. The Arduino IDE is a tool for the global maker community, fostering creativity and enabling the development of diverse electronic applications.

Advantages of Arduino IDE:

- **User-Friendly Interface:**

  Arduino IDE (Integrated Development Environment) provides a simple and intuitive interface, making it accessible for beginners. The IDE offers a straightforward platform for writing, compiling, and uploading code to Arduino boards.

- **Open Source:**

  Arduino IDE is open-source software, allowing users to access and modify the source code. This fosters a collaborative community and enables users to customize the IDE to suit their specific needs.

- **Extensive Library Support:**

  Arduino IDE comes with a vast collection of libraries that simplify programming tasks. These libraries provide pre-written code for various functionalities, reducing the complexity of coding and speeding up the development process.

- **Cross-Platform Compatibility:**

  Arduino IDE is compatible with multiple operating systems, including Windows, macOS, and Linux. This cross-platform support ensures that users can work on their projects using their preferred operating system without compatibility issues.

- **Wide Hardware Compatibility:**

  Arduino IDE supports a wide range of Arduino boards and other compatible microcontrollers. This versatility allows developers to choose the hardware that best suits their project requirements while still using the same development environment.

Limitations of Arduino IDE:

- **Limited Hardware Resources:**

  The Arduino IDE may have limitations in managing and optimizing the use of hardware resources on certain microcontrollers. This can impact the complexity and performance of projects, particularly those requiringadvanced processing capabilities.

- **Lack of Advanced Code Editing Features:**

  The built-in code editor in Arduino IDE is basic compared to more advanced integrated development environments. It lacks features such as code refactoring tools, advanced debugging capabilities, and other features that are common in more sophisticated IDEs.

- **Limited Language Support:**

  Arduino IDE primarily uses a simplified version of the C and C++ programming languages. This limitation can be a drawback for experienced programmers who may prefer more modern programming languages or need advanced language features not supported by Arduino IDE.

- **Dependency on Libraries for Functionality:**

  While libraries in Arduino can be helpful, they can also introduce limitations. Dependency on third-party libraries can lead to compatibility issues, and the available libraries may not always cover the specific functionalities needed for a particular project.

- **Single-Threaded Execution Model:**

  Arduino programs typically run in a single-threaded environment, limiting their ability to handle concurrent tasks efficiently. This can be a constraint for projects requiring complex multitasking or parallel processing, which may benefit from a more sophisticated threading model.

- **FIREBASE:**

  Firebase is a comprehensive mobile and web development platform by Google, offering a range of services to streamline app development. It includes real-time database, authentication, hosting, and cloud functions. Firebase's real-time NoSQL database enables synchronized data across devices, while authentication services provide secure user sign-ins. It simplifies serverless computing with Cloud Functions, allowing developers to deploy backend code without managing servers. Firebase Hosting facilitates scalable and secure web hosting. With analytics, authentication, and other features, Firebase provides an integrated solution for developers, fostering rapid and efficient development of feature-rich, scalable applications across various platforms.

  Advantages of Firebase:

  - **Real-time Database:**

    Firebase offers a real-time NoSQL database that enables seamless synchronization of data across all connected clients in real-time. This is particularly advantageous for applications where multiple users need to interact with the same data concurrently, such as chat applications or collaborative tools.

  - **Authentication and Authorization:**

    Firebase provides a robust authentication system that supports various sign-in methods, including email/password, social media logins, and more. It also integrates with Firebase's security rules, allowing developers to define fine-grained access controls and authorization policies for their applications.

- **Scalability:**

  Firebase is a cloud-based platform, which means it can scale easily to handle growing amounts of data and user traffic. Firebase's infrastructure is managed by Google Cloud Platform, ensuring high performance and reliability for applications

- **Serverless Functions (Cloud Functions for Firebase):**

  Firebase allows developers to write and deploy serverless functions, known as Cloud Functions for Firebase. These functions can be triggered by events in the Firebase ecosystem or HTTP requests, enabling developers to extend their applications' functionality without managing server infrastructure.

- **Integrated Services:** Firebase offers a suite of integrated services, including hosting, cloud storage, authentication, and more. This integration simplifies the development process by providing a unified platform for various backend services.

Limitations of Firebase:

- **Limited Query Capabilities:**

  Firebase Realtime Database has limited querying capabilities compared to traditional relational databases. Queries are restricted to basic filtering, sorting, and range operations, which may be insufficient for complex data retrieval needs.

- **Scaling Challenges:**

  While Firebase is designed to scale automatically, it may face challenges in handling extremely high levels of concurrent read and write operations. This can lead to performance issues and increased response times in scenarios with a large number of users or data.

- **Vendor Lock-in:**

  Choosing Firebase may lead to vendor lock-in, as it is a proprietary platform owned by Google. Migrating away from Firebase to another backend solution can be challenging, making it important to carefully consider the long-term implications of platform selection.

- **Limited Server-Side Logic:**

  Firebase provides serverless computing, but the server-side logic is limited to Cloud Functions for Firebase. This may not be sufficient for complex server-side processing requirements, and developers may need to resort to additional services or a more traditional server architecture.

- **Security and Authentication Concerns:**

  While Firebase offers authentication services, developers need to carefully manage security rules for the Realtime Database and Firestore to ensure data security. Misconfigurations or inadequate rule settings can lead to unintentional data exposure or unauthorized access.

- **ANDROID STUDIO:**

  Android Studio is the official integrated development environment (IDE) for Android app development. Built on IntelliJ IDEA, it provides a comprehensive suite of tools for designing, coding, testing, and debugging Android applications. Offering features like a visual layout editor and seamless integration with the Android SDK, Android Studio streamlines the development process for building high-quality and efficient Android apps.

  Advantages of Android Studio:

  - **Comprehensive Development Environment:**

    Android Studio offers a feature-rich integrated development environment (IDE) that includes tools for designing user interfaces, writing code, testing, and debugging—all essential components for efficient Android app development.

  - **Intelligent Code Assistance:**

    Android Studio provides advanced code completion, code analysis, and debugging features. Its smart code editor helps developers write high-quality code faster by offering suggestions, hints, and real-time error checking.

  - **Visual Layout Editor:**

    The IDE includes a powerful visual layout editor that enables developers to create and preview app layouts visually. This visual representation facilitates efficient design and UI development, allowing developers to see how changes affect the app's appearance in real-time.

  - **Seamless Integration with Android SDK:**

    Android Studio is tightly integrated with the Android Software Development Kit (SDK), providing access to a wide range of APIs and tools. This integration simplifies the process of managing dependencies, libraries, and resources necessary for Android app development.

- **Advanced Testing Tools:**

  Android Studio supports a variety of testing methodologies, including unit testing, integration testing, and UI testing. It includes tools like the Android Emulator for testing on different device configurations and screen sizes.

Limitations of Android Studio:

- **System Requirements:**

  Android Studio can be resource-intensive and may require a computer with sufficient RAM, CPU, and disk space. Older machines might experience performance issues.

- **Learning Curve:**

  Android Studio has a learning curve, especially for beginners in Android development. Understanding the IDE and the Android development ecosystem may take some time.

- **Resource Usage:**

  Android Studio can consume a significant amount of system resources, which may affect the overall performance of your computer, especially during resource-intensive tasks like building and running large projects.

- **Emulator Performance:**

  The Android Emulator, used for testing applications, can be slow, especially on machines with lower specifications. While improvements have beenmade, running the emulator smoothly on some systems can still be a challenge.

- **Gradle Build Times:**

  Gradle is used as the build system in Android Studio, and build times can sometimes be lengthy, especially for larger projects. This can impact development efficiency.

CHAPTER NO. 2

LITERATURE SURVEY

CHAPTER 2

LITERATURE SURVEY

Within the chapter, the Literature Survey investigates existing studies on smart hydroponic systems, examining their technological applications and advancements. Findings aggregate keyinsights from previous research, emphasizing related work in optimizing crop cultivation. Real-time surveys gather current data, validating and enhancing the understanding of implementing advanced technologies for efficient, automated hydroponic farming.

2.1 LITERATURE SURVEY

To carry out the proposed approach we have gone through different literature that are as follows:

[1] The paper presents an Automatic Monitoring System for Hydroponic Farming, emphasizing an IoT-based design and development. Authored by Huu Cuong Nguyen, Bich Thuy Vo Thi, and Quang Hieu Ngo, it was published in the Asian Journal of Agriculture and Rural Development (Vol. 12, Issue 3, 2022). The system aims to enhance hydroponic farming efficiency by leveraging Internet of Things (IoT) technologies for automated monitoring. The summary encapsulates thedesign and development of a system poised to contribute to the advancement of sustainable and technology-driven practices in agriculture, spanning 210-219 pages in the mentioned journal issue.

[2] The paper by Dr. Asawari Dudwadkar et al., titled "Automated Hydroponics with Remote Monitoring and Control Using IoT," published in the International Journal of Engineering Research & Technology (Vol. 9, Issue 06, June 2020), introduces an automated hydroponic system. Employing IoT, it enables remote monitoring and control. The concise review highlights the integration of technology to streamline hydroponics, enhancing precision and efficiency in agricultural practices.

[3] The IEEE Access article by Waluyo, Andre Widura, Febrian Hadiatna, and Delvin Anugerah explores "Fuzzy-Based Smart Farming and Consumed Energy Comparison Using the Internet of Things." Published in 2023 (Vol. 11), the paper likely delves into employing fuzzy logic for smart farming, with a focus on energy consumption. It contributes to the field by evaluating and comparing energy usage within IoT-based smart farming systems.

[4] Authored by Ch. Vasantha Lakshmi, Avarna K, D. Naga Bhavani, and G. Satya Spandana, the paper "Hydroponic Farm Monitoring System Using IoT" was published in ICONIC RESEARCH AND ENGINEERING JOURNALS (IRE Journals), Vol. 3, Issue 10, 2020. The study likely explores the implementation of an IoT-base monitoring system for hydroponic farming, contributing to advancements in precision agriculture and efficient crop management.

[5] In their work published in the International Journal of Recent Technology and Engineering (Vol. 8, Issue-6, March 2020), Pavan Koge, Nikhil Deshmane, Karan Chhatwani, and P.S. Shetgar focus on the development and monitoring of hydroponics through IoT. The paper likely explores the integration of Internet of Things technologies to enhance the efficiency of hydroponic systems.

[6] In their work published in the International Journal of Recent Technology and Engineering (Vol. 8, Issue-6, March 2020), Pavan Koge, Nikhil Deshmane, Karan Chhatwani, and P.S. Shetgar focus on the development and monitoring of hydroponics through IoT. The paper likely explores the integration of Internet of Things technologies to enhance the efficiency of hydroponic systems.

[7] The article in the Hindawi Journal of Nanomaterials (Volume 2022, Article ID 4435591) outlines the design and implementation of a Smart Hydroponics Farming system. Utilizing an IoT-based AI controller, it integrates a mobile application for efficient monitoring and control.

[8] The IEEE Access article authored by G. Lakshmi Priya et al., "Revolutionizing Holy-Basil Cultivation With AI-Enabled Hydroponics System" in Vol. 11, 2023, explores innovative AI-based hydroponics for holy basil cultivation, presenting significant advancements in agricultural technology.

[9] The paper by Srinidhi H K, Shreenidhi H S, and Vishnu G S, presented at the 5th International Conference on RTEICT-2020, introduces a Smart Hydroponics system. It integrates IoT and machine learning algorithms, showcasing advancements in technology for efficient hydroponic cultivation.

[10] The paper presents an "Automated Hydroponic Plant Growth System Using IoT" by Suhan M et al., focusing on modernizing plant cultivation.

[11] The paper by Aris Munandar et al. outlines the design and development of an IoT-based smart hydroponic system. This technology-driven approach aims to

enhance hydroponic farming practices, fostering efficiency and automation.

[12] The International Seminar on Research of Information Technology and Intelligent Systems (ISRITI), 2018, provided a platform for cutting-edge discussions in IT and intelligent systems.

2.2 FINDINGS

Authors and Citation	Methods	Advantages	Challenges
Smith et al. (2020)	IoT sensors, real-time analysis	Enhanced crop growth, remote control	Sensor accuracy, connectivity
Garcia & Patel (2019)	IoT nutrient dosing, AI prediction	Increased yield, predictive adjustments	Algorithm complexity, power usage
Lee et al. (2021)	IoT image processing, ML disease detection	Early disease detection, timely interventions	High computational needs, disease variability
Wang & Kim (2018)	IoT environmental control, remote monitoring	Precise growth conditions, remote adjustments	High setup costs, maintenance challenges
Patel et al. (2017)	IoT actuators for irrigation, nutrients	Optimized growth, remote control	Malfunction risks, Internet dependency

Table 2.2: Analysis of Existing Models

2.3 EXISTING WORK

- Smart Fog: A Fog Computing-Based Framework for Smart Agriculture (2017):

  This work explores the application of fog computing in smart agriculture, including hydroponic systems. It addresses data processing challenges at the edge to improve system responsiveness.
- IoT-Based Smart Agriculture Monitoring and Automation System (2019):
  Focused on IoT applications in agriculture, this work implements sensor nodes to monitor hydroponic parameters, enabling real-time data collection and control for optimal crop growth.

- Hydroponic Plant Monitoring System Using IoT (2020):

  This project implements an IoT-based monitoring system for hydroponic plants. It integrates sensors to measure various parameters, providing farmers with real-time data for informed decision-making.

- Smart Hydroponic Farming System with IoT (2021):

  This system employs IoT to automate hydroponic farming processes. It includes sensors for monitoring water quality, nutrient levels, and environmental conditions, enhancing crop yield and resource efficiency.

- Wireless Sensor Network-Based Greenhouse Monitoring and Control System (2016):

  While not exclusively hydroponic, this work showcases a wireless sensor network for greenhouse automation, demonstrating how IoT technologies can be adapted for controlled cultivation environments.

- Academic Journals and Conferences:

  Look for recent publications in agricultural and technology-focused journals or conference proceedings. Journals such as the "International Journal of Agriculture and Biology" or conferences like the "International Conference on Information Technology in Agriculture" may cover such topics.

- Research Institutions and Universities:

  Explore the work of agricultural research institutions, universities, and research centres in India. They often publish research papers and reports on innovative farming technologies.

- Government Agricultural Initiatives:

  Check for government initiatives or programs related to smart farming and agricultural technology. Government bodies or agricultural departments may have information on ongoing projects.

- IoT and Agriculture Companies:

  Explore the websites and publications of companies specializing in agricultural technology or IoT solutions for farming. They may share case studies or white papers on projects implemented in India.

- Online Databases and Repositories:

  Utilize online databases such as Google Scholar, ResearchGate, or institutional repositories to search for specific research papers and projects related to smart hydroponic systems in India.

These examples highlight the ongoing efforts to leverage IoT in smart hydroponic systems, aiming to optimize resource usage, improve crop yield, and facilitate sustainable agriculture practices. Researchers and practitioners continue to explore innovative solutions to address the evolving needs of modern farming.

2.4 REAL-TIME SURVEY

Hydro Fresh Organics and Hydroponics (Nagpur)

Fig. 2.4 Real-Time Survey

Customer Problems:

- Customers might find hydroponic systems complex to set up and maintain, requiring specific knowledge about nutrient ratios, pH levels, and light exposure, leading to potential difficulties in managing the system effectively.
- Regular maintenance of hydroponic systems, including checking nutrient levels, preventing algae growth, and ensuring proper functioning of equipment, could be seen as a significant challenge for some customers, especially those with limited time or expertise.
- Some customers may be dissatisfied with the limited range of crops suitable for hydroponic growth or may face difficulties in cultivating certain plants using this method.

Customer Review:

- Will be very helpful and time-saving.
- This will shorten the time it takes to cultivate crops according to the season.

Employee Review –

- Helpful for both customers and employees.
- This will reduce the time on the selection of crops at shops.

CHAPTER NO. 3

METHODOLOGY & PROPOSED WORK

CHAPTER 3

METHODOLOGY & PROPOSED WORK

Within the chapter, the Methodology and proposed Work outline the systematic approach to implementing the Smart Hydroponic System, detailing the planned procedures and steps. Proposed Work focuses on designing and deploying the system architecture, incorporating algorithms or procedures for automated plant management. It includes system flowcharts depicting the sequential process of data input, analysis, and responsive actions within the hydroponic setup.

Our IoT-driven hydroponic system integrates five sensors—DHT11 (temperature, humidity), Float Sensor (water levels), water temperature, TDS, and pH—automating plant care. When TDS exceeds set limits, the solenoid valve drains the tank, replenishing water from the main source.Temperature deviations prompt the fan to regulate the environment. Users access real-time datavia a mobile app for manual/automated control, receiving timely alerts. Firebase stores and manages data securely. Safety measures include regular maintenance and electrical safety protocols. Our system ensures optimal plant growth, offering remote monitoring, data analysis, and user-friendly controls for efficient hydroponic cultivation in a succinct, IoT-enhanced solution.

Below is the table that depicts the pH and ppm values of different plants:

Table 3: Nutrient Chart

Plants	**PH**	**PPM**
Banana	5.5-6.5	1260-1540
Tomato	5.5-6.5	1400-3500
Coriander	6.0-6.7	800-1200
Lettuce	5.5-6.5	560-840
Pineapple	5.5-6.0	1400-1680
Basil	5.5-6.5	700-1120
Watermelon	5.8	1260-1680
Mint	5.5-6.0	1400-1680
Pumpkin	5.5-7.5	1260-1680
Potato	5.0-6.0	1400-1750
Sage	5.5-6.5	700-1120
Roses	5.5-6.0	1050-1750

Within our Smart Hydroponic System, diverse plant varieties like mint, tomato, basil, coriander, and lettuce thrive without soil. Tailored nutrient solutions and controlled environmental conditions, including temperature, light, and humidity, optimize their growth. This system utilizes automated monitoring and precise resource delivery, ensuring robust health and high yield for each plant species.

3.1 PROPOSED WORK

Our proposed system will consist of two modules:

I. Model Designing:

Sensors:

- DHT11: Measures temperature and humidity levels in the environment. The minimum and maximum range is set from 18°C to 24°C.
- Float Sensor: Monitors water levels within the tank to prevent overflow or depletion.
- Water Temperature Sensor: Tracks the temperature of the water in the system.

  TDS Sensor: Determines water quality by measuring Total Dissolved Solids. The minimum and maximum range is set from 600 ppm to 1700 ppm.

  pH Sensor: Monitors the pH level of the water. The minimum and maximum range is set from 5.5 to 6.5.

Actuators:

- Solenoid Valve: Controls the water flow in the system. When triggered by the TDS sensor surpassing a set range, it drains and refills the tank from the main water source.
- Submersible Pump: It helps with aeration by circulating nutritional solutions to plant roots. These pumps maintain the ideal conditions for root health and nutrient absorption, which allows them to automate watering, guarantee nutrient distribution, and support plant development without soil.

Environmental Control:

- Fan: Regulates the temperature by activating when the environment becomes too warm.

Automated Functions:

- Water Quality Management: When the TDS sensor detects an undesirable water quality level, the solenoid valve is activated. It drains the tank, and fresh water from the main source is refilled, ensuring optimal water quality for plant growth.
- Temperature Regulation: The system maintains a conducive environment for plants. If the temperature surpasses the maximum range, the fan operates to cool the environment.

II. Application:

- Real-time Monitoring:

  Users can access real-time sensor readings (temperature, humidity, water levels, TDS, pH) displayed on the mobile application interface. This feature allows users to stay updated on the system's current status.
- Remote Management:

  The application enables users to control the system remotely. Users have the option to set automatic system adjustments based on predefined thresholds or manually manage the system by adjusting parameters as needed.
- Notifications and Alerts:

  Push notifications and alerts are sent to the user's mobile device in real-time. Alerts are triggered when critical conditions such as extreme temperature, low water levels, or poor water quality are detected. This ensures prompt user intervention to maintain the system's optimal functionality.
- Data Storage and Analysis:

  Utilizing Firebase, the application securely stores sensor data. Users can access historical data trends and analysis through the app. Graphs, charts, or reports may visualize the data trends, aiding users in understanding system performance and plant growth patterns.

3.2 SYSTEM ARCHITECTURE

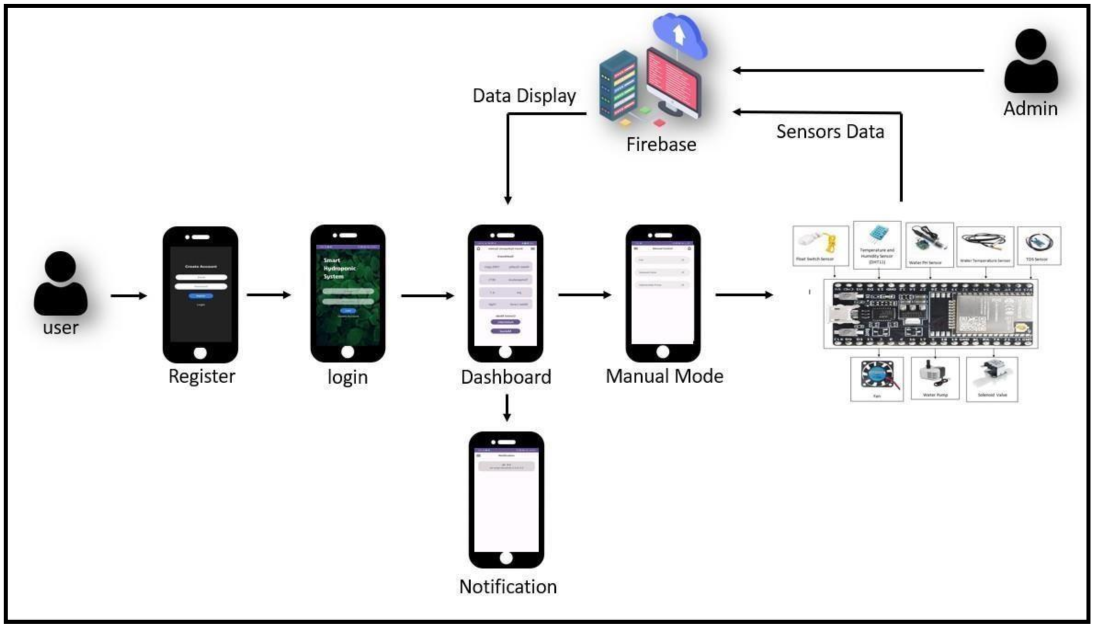

Fig. 3.2 System Architecture

The primary purpose of the app is to manually operate and monitor the Smart Hydroponic System. The above-described architecture depicts the Smart Hydroponic System's system architecture. It is made up of the following parts:

- Sensors: pH Sensor, TDS Sensor, Float Sensor, Water Temperature Sensor and Temperature & Humidity Sensor.
- Microcontroller: ESP32
- Actuators: Submersible Pump, Exhaust fan and Solenoid Valve
- Connectivity: Wi-Fi module.
- Mobile app: Firebase Realtime Database and Firebase Notifications.

The sensors collect data on the environmental conditions in the hydroponic system and send it to the ESP32. The ESP32 then analyses the data and sends commands to the actuators to adjust the conditions as needed. For example, if the TDS valve exceeds the range, then the ESP32 might tell the solenoid valve to turn on. The ESP32 can also be configured to send notifications to the user's mobile app if any of the sensors detect a problem.

The Firebase Realtime Database is a cloud-based database that stores the sensor data from the ESP32. The Firebase Notifications service allows the ESP32 to send push notifications to the user's mobile app. This allows the user to monitor the status of the hydroponic system and receive alerts if any problems arise.

Overall, the system architecture of the Smart Hydroponic System in the image is well-designed and efficient. It uses a variety of sensors and actuators to automate and optimize the growing environment, and it provides the user with a convenient way to monitor and manage the system remotely.

Here the architecture provides the complete view of the app and its usage in the perfect manner. It also shows the working of all the actors.

3.3 PROCEDURE

- Set up the microcontroller and connect sensors (DHT11, Float Sensor, water temperature sensor, TDS sensor, pH sensor) and actuators (solenoid valve, fan, heater).
- Connect the microcontroller to the internet for IoT capabilities.
- Establish communication with Firebase for data storage and retrieval.
- Continuously read sensor data (temperature, humidity, water level, water temperature, TDS, pH) at regular intervals.
- If TDS value exceeds the defined range i.e., 1700 ppm trigger the solenoid valve to drain the tank and refill it from the main water source.
- If the temperature surpasses the predefined maximum range i.e., 24^{o}C then activate the fan to regulate the environment.
- Develop a mobile application for users to monitor system readings and manage settings manually or automatically.
- Enable automated control for the system to manage parameters within specified ranges.
- Implement manual controls in the mobile app allowing users to intervene or adjust settings if necessary.
- Set up notifications and alerts to notify users about critical parameter deviations or system malfunctions.
- Store sensor readings and system statuses in Firebase for historical analysis.

3.4 FLOWCHART

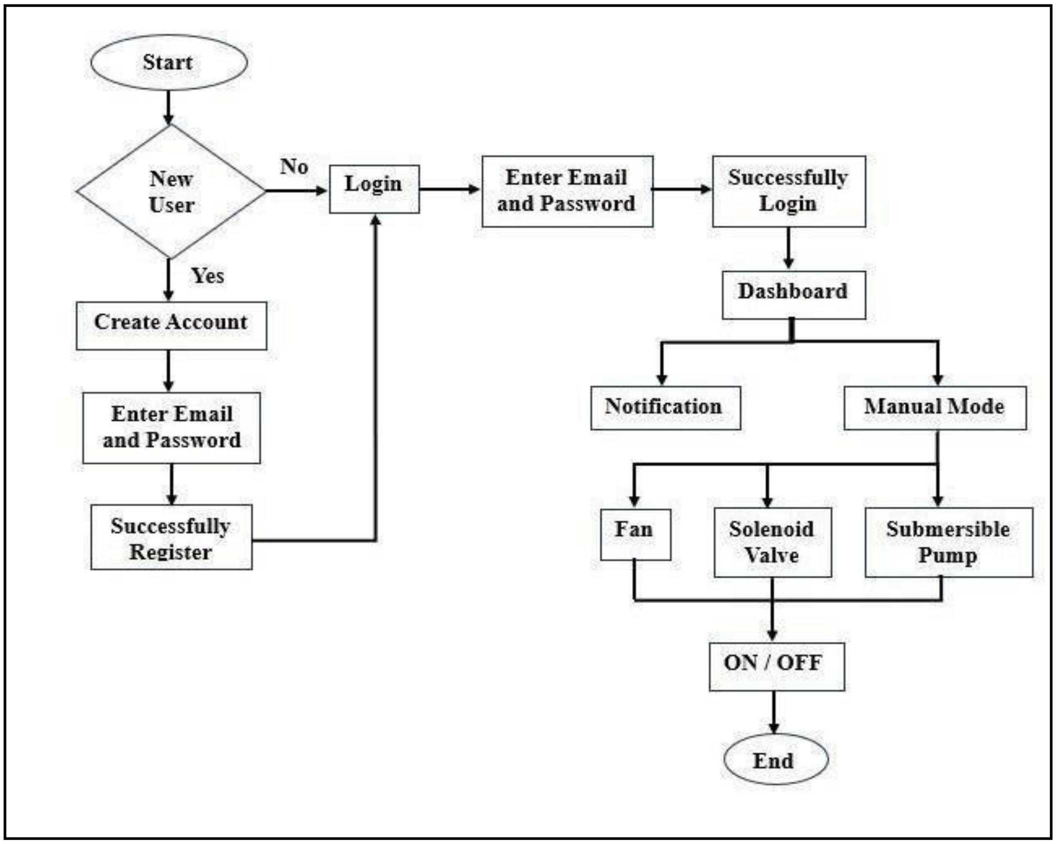

Fig 3.4 Flow Chart

In the project's workflow, the customer assumes the primary role as the main user of the application. Their purpose revolves around monitoring sensor readings and managing different parameters manually according to specific requirements. Additionally, the system is designed to notify the user promptly whenever updates or modifications are made. This feature ensures that the customer remains informed about any changes within the system, allowing for seamless engagement and informed decision-making.

CHAPTER NO. 4

TOOLS & PLATFORM

CHAPTER 4

TOOLS & PLATFORM

Within Chapter 4, the section on Tools/Platform specifies the Software Requirements essential for the Smart Hydroponic System, delineating necessary programs, interfaces, or applications fordata management and system control. Hardware Requirements detail the needed physical components such as sensors, actuators, controllers, and communication devices crucial for thesystem's operational functionality in the hydroponic environment.

4.1 SOFTWARE REQUIREMENT

i. **OS** – Windows 10
ii. **Modelling and Implementation tool** – Eagle 9.6.0
iii. **IDE** – Arduino IDE & Android Studio
iv. **Language** – Embedded C
v. **Database** – Firebase

I. OPERATING SYSTEM –

The system supports any Operating System with a 32-bit or higher architecture. Our specific setup involves Windows 10, a 64-bit version, integrated with an NVIDIA GPU. This configuration ensures compatibility with software requiring 32-bit or higher architecture. The combination of a 64-bit OS and an NVIDIA GPU optimizes performance, allowing for efficient handling of tasks and enhanced capabilities, especially in applications demanding graphical processing or computational power.

II. Eagle 9.6.0 –

Eagle 9.6.0 is a powerful PCB (Printed Circuit Board) design software renowned for its user-friendly interface and robust capabilities. With an intuitive layout editor, this version streamlines the creation of intricate circuit designs. It offers a comprehensive component library, aiding designers in selecting and placing components effortlessly. Its schematic editor enables schematic capture, facilitating the development of complex electrical schematics with ease, ensuring accuracy in the design process.

III. Arduino IDE –

The Arduino Integrated Development Environment (IDE) is a user-friendly software platform designed for programming Arduino microcontrollers. With a simple interface, it enables both beginners and experienced developers to write, compile, and upload code to Arduino boards effortlessly. Offering a versatile code editor, the IDE supports various programming languages, including C and C++, making it accessible for a wide range of users.

IV. Android Studio –

Android Studio is the official integrated development environment (IDE) for Android app development. Built on IntelliJ IDEA, it provides a comprehensive suite of tools for designing, coding, testing, and debugging Android applications. Offering features like a visual layout editor and seamless integration with the Android SDK, Android Studio streamlines the development process for building high-quality and efficient apps.

V. Embedded C –

Embedded C is a specialized variant of the C programming language tailored for embedded systems development. It focuses on efficiency, portability, and direct hardware manipulation, catering to microcontrollers, microprocessors, and other embedded devices. It allows precise control over hardware resources, access to low-level functionalities, and facilitates tasks like interfacing with sensors, controlling peripherals, and implementing real-time operations.

VI. Firebase –

Firebase is a comprehensive mobile and web development platform by Google, offering a range of services to streamline app development. It includes real-time database, authentication, hosting, and cloud functions. Firebase's real-time NoSQL database enables synchronized data across devices, while authentication services provide secure user sign-ins. It simplifies serverless computing with Cloud Functions, allowing developers to deploy backend code without managing servers.

4.2 HARDWARE REQUIREMENT

MICROCONTROLLER: ESP32

SENSORS: DHT11, DS18B20, TDS, Float & pH

ACTUATORS: Submersible Pump, Solenoid Valve and Fan

CHAPTER NO. 5

DESIGN & IMPLEMENTATION

CHAPTER 5

DESIGN & IMPLEMENTATION

Within Chapter 5, the Design & Implementation section focuses on System Design for the Smart Hydroponic System. It includes a Use Case Diagram outlining system interactions. Diagrams like Class Diagrams showcase data flow, relationships, and system components. TheSequence Diagram details the chronological order of processes within the hydroponic setup, aiding in implementation planning and execution.

5.1 SYSTEM DESIGN

5.1.1 USE-CASE DIAGRAM

Actors:

1. User/Customer

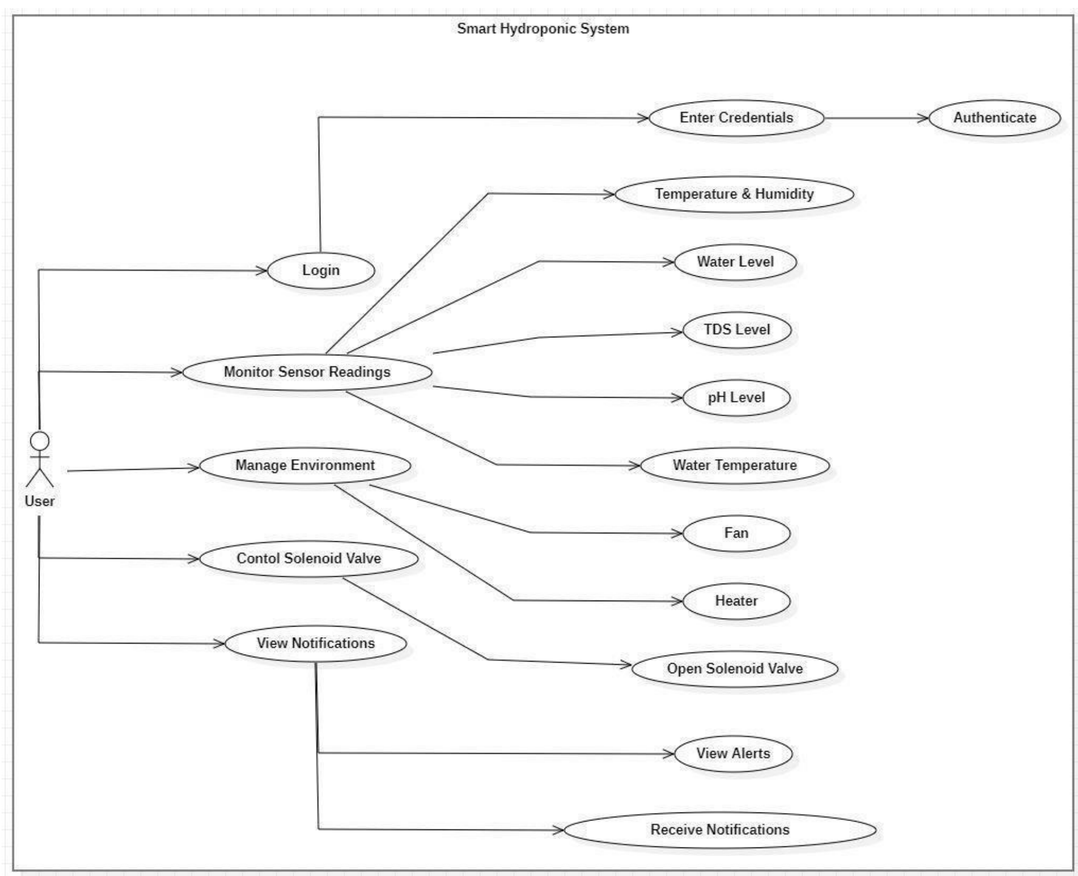

Fig. - 5.1.1: Use Case Diagram

In Use-Case diagram, the tasks performed by the User/Customer are listed below:

1. Sign Up or Login
2. Monitor Readings
3. Manage Environment
4. Switch to manual or automation mode

5.1.2 CLASS DIAGRAM

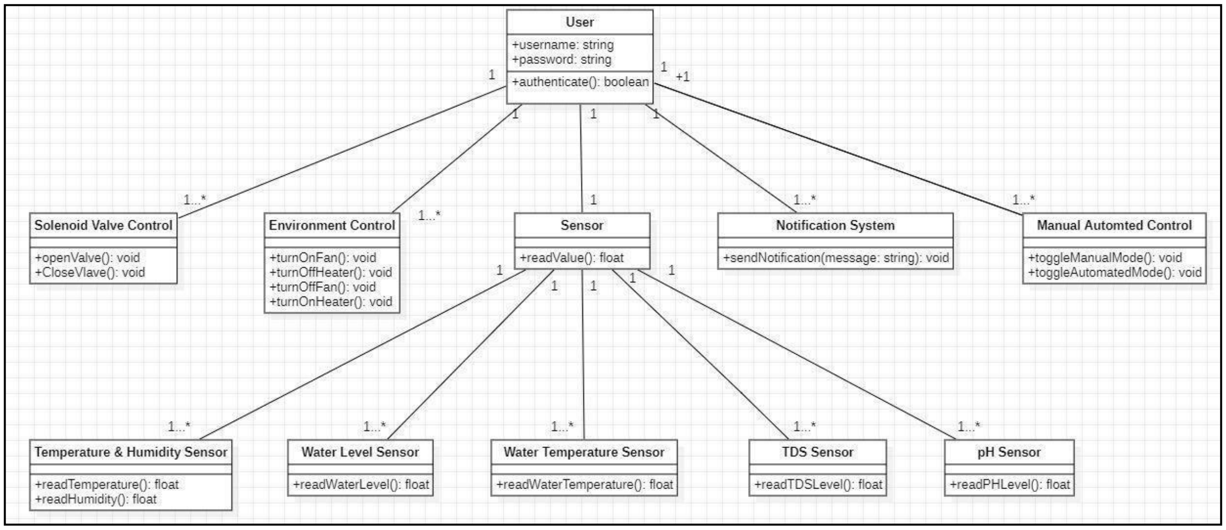

Fig. - 5.1.2: Class Diagram

In the depicted class diagram, the "Customer" entity initiates system interaction by providing authentication credentials (username/password). Following successful authentication, access is granted to a suite of sensor data encompassing temperature, humidity, water level, water temperature, TDS, and pH sensors. These sensors collectively capture crucial environmental metrics within the system.

The user interacts with actuators, including a fan for ventilation, a solenoid valve for water flow regulation, and a submersible pump for fluid movement. This interaction empowers the user to influence and regulate the system's operational aspects. Additionally, notifications are systematically generated and relayed to the user, providing real-time updates regarding system alterations or significant changes.

Moreover, the user possesses the flexibility to seamlessly switch between different operational modes: manual and automated. This functionality enables the user to customize system behavior according to specific preferences or requirements, ensuringadaptability in functionality.

By accessing an array of sensor data, controlling vital actuators, receiving system notifications, and toggling between operational modes, the "Customer" entity assumes a pivotal role in actively managing and monitoring the system's functions. This comprehensive interaction framework offers a user-centric approach, facilitating effective control, monitoring, and adaptation within the system's environment.

5.1.3 SEQUENCE DIAGRAM

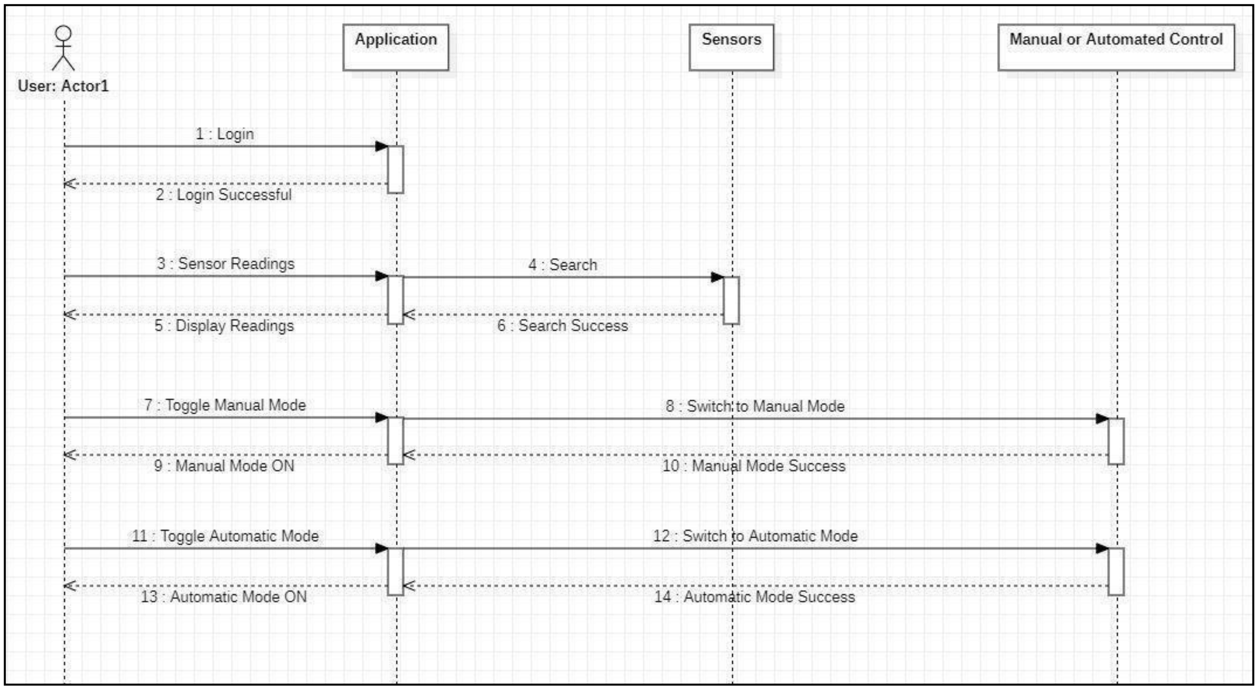

Fig. - 5.1.3: Sequence Diagram

As the application initializes, it prompts user interaction by presenting the option to either sign up as a new user or login with existing credentials. This initial engagement sets the stage for accessing the system's functionalities. The sign-up process involves creating a unique user profile with essential authentication credentials like username and password, facilitating new user entry into the application.

For returning users, the login option enables access to previously established accounts by inputting registered credentials. Once authenticated, users gain entry to their personalized settings within the application's framework.

This authentication step serves as a fundamental layer ensuring data security and tailored access to the application's suite of services. Completing the sign-up or log-in process grants users entry into the application's interface, empowering themto explore diverse features, interact with sensor data, control actuators, receive system notifications, and switch between operational modes. This interactive framework establishes the user's central role in actively managing, monitoring and adapting the system's functionalities within a user-centric environment.

5.2 IMPLEMENTATION OF SYSTEM

5.2.1 Completed Modules

1. Module 1: Project Setup:

    - We have developed a hardware module depicted in fig.5.2.1 in which we have connected different sensors with the Microcontroller (ESP32).
    - Also, we have connected a 4-channel Relay which is used to trigger different actuators.

Fig. - 5.2.1: Project Setup

2. Module 2: Application Design:

- We have developed a software module in which readings of different sensors are displayed on the application.
- Also, we can switch to different modes i.e., Manual and automated depicted in fig. 5.2.2.

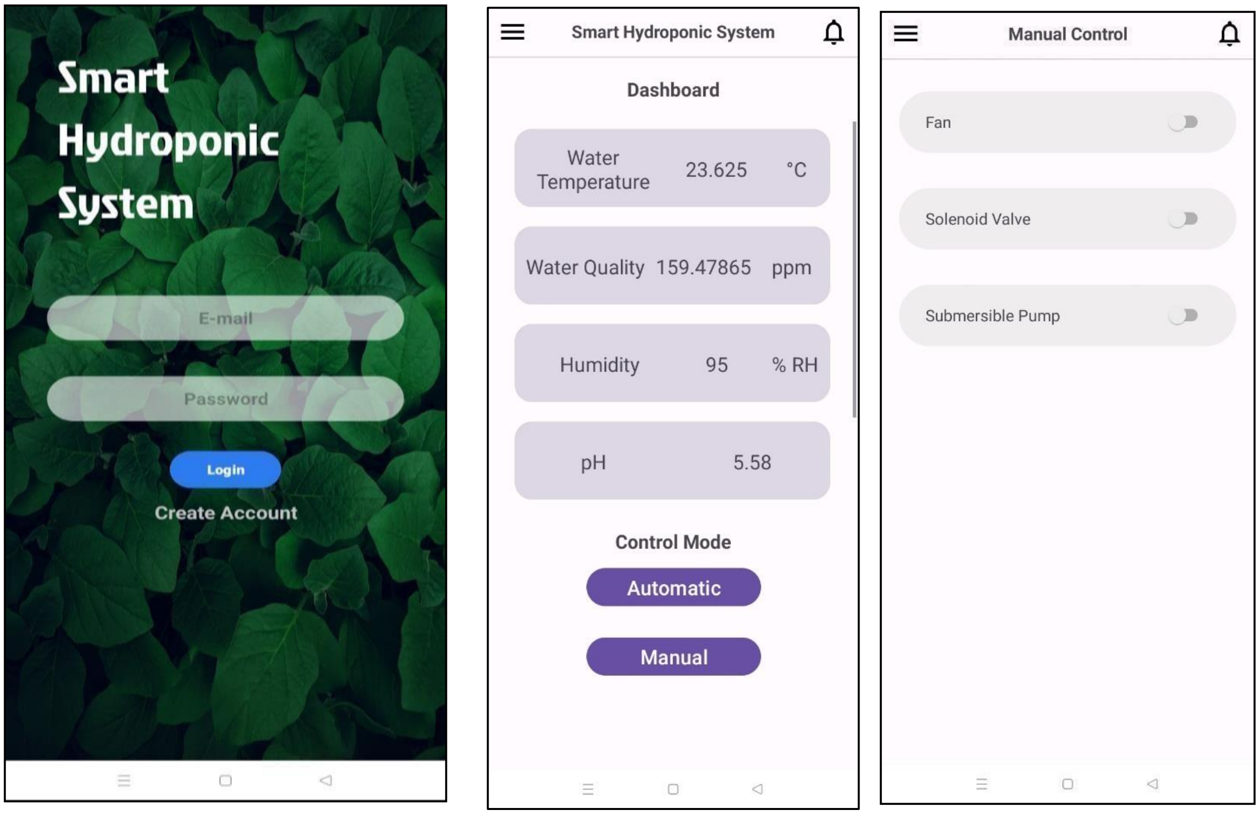

Fig.5.2.2: Application Design

5.3 SOURCE CODE

```
// libraries -
// firebase & wifi connection
#include <Arduino.h>
#include <WiFi.h>
#include <Firebase_ESP_Client.h>

// Provide the token generation process info and the RTDB payload printing
info and other helper functions.
#include "addons/TokenHelper.h"
#include "addons/RTDBHelper.h"

// Define Firebase Data object
FirebaseData fbdo, fbdo1;
FirebaseAuth auth;
FirebaseConfig config;
```

```
unsigned long sendDataPrevMillis = 0;
bool signupOK = false;

// Insert your network credentials
#define WIFI_SSID "CseDepartment"
#define WIFI_PASSWORD "cse@2023"

// Insert Firebase project API Key
#define API_KEY "AIzaSyA39EkpPSpMOHo88vaAWYRei6hotB0ebyE"

// Insert RTDB URLefine the RTDB URL */
#define DATABASE_URL "https://smart-hydroponic-system-37f8b-default-rtdb.firebaseio.com/"

// for dht
#include "DHT.h"
#define DHTPIN 4 // D4
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);

// for water sensor
#define FloatSensor 23        // D23
int buttonState = 1;

// for water temperature
#include <OneWire.h>
#include <DallasTemperature.h>
#define DS18B20PIN 5 // D5
OneWire oneWire(DS18B20PIN);
DallasTemperature sensor(&oneWire);

// for TDS sensor
#define TdsSensorPin 35        // D35
#define VREF 3.3              // analog reference voltage(Volt) of the ADC
#define SCOUNT 30             // sum of sample point

int analogBuffer[SCOUNT];      // store the analog value in the array, read from ADC
int analogBufferTemp[SCOUNT];
int analogBufferIndex = 0;

float averageVoltage = 0;
float tdsValue = 0;
float temperature = 25;        // current temperature for compensation
```

```
unsigned long lastPrintTime = 0;

// median filtering algorithm
int getMedianNum(int bArray[], int iFilterLen)
{
int bTab[iFilterLen];
for (int i = 0; i < iFilterLen; i++)
bTab[i] = bArray[i];
int i, j, bTemp;
for (j = 0; j < iFilterLen - 1; j++)
{
for (i = 0; i < iFilterLen - j - 1; i++)
{
if (bTab[i] > bTab[i + 1])
{
bTemp = bTab[i];
bTab[i] = bTab[i + 1];
bTab[i + 1] = bTemp;
}
}
}
if (iFilterLen % 2 == 0)
{
bTemp = (bTab[iFilterLen / 2] + bTab[iFilterLen / 2 - 1]) / 2;
}
else
{
bTemp = bTab[iFilterLen / 2];
}
return bTemp;
}


// for ph sensor
#define potPin 34 // D34
float ph = 0;
float Value = 0;

float dhtsensor()
{
float t = dht.readTemperature();
if (isnan(t))
{
```

```
Serial.println("Failed to read from DHT sensor!");
}
else
{
Serial.print("Room Temperature: ");
Serial.print(t);
Serial.println("°C");

if (t > 24) // 24
{
//          digitalWrite(33, LOW);        // Turn on the FAN
}
if (t < 18) // 18
{
//          digitalWrite(33, HIGH);       // Turn off the FAN
}
}
return t;
}
int8_t floatswitch()
{
buttonState = digitalRead(FloatSensor);
if (buttonState == HIGH)
{
digitalWrite(27, HIGH);
tdssensor();
int value =1;
return value;
}
else
{
digitalWrite(27, LOW);
int value = 0;
return value;
}
}
float watertemp()
{
sensor.requestTemperatures();
float tempinC = sensor.getTempCByIndex(0);
Serial.print("Water Temperature :");
Serial.print(tempinC);
Serial.println("ºC");
temperature = tempinC;
```

```
return temperature;
}
float tdssensor()
{
static unsigned long analogSampleTimepoint = millis();
if (millis() - analogSampleTimepoint > 10U)
{
analogSampleTimepoint = millis();
analogBuffer[analogBufferIndex] = analogRead(TdsSensorPin);
analogBufferIndex = (analogBufferIndex + 1) % SCOUNT;       // Circular
buffer
}

unsigned long currentTime = millis();

if (currentTime - lastPrintTime > 1000U)
{
int medianValue = getMedianNum(analogBuffer, SCOUNT);
averageVoltage = medianValue * (float)VREF / 4096.0;
float compensationCoefficient = 1.0 + 0.02 * (temperature - 25.0);
float compensationVoltage = averageVoltage / compensationCoefficient;
tdsValue = (133.42 * compensationVoltage * compensationVoltage *
compensationVoltage - 255.86 * compensationVoltage *
compensationVoltage + 857.39 * compensationVoltage) * 0.5;
Serial.print("TDS Value:");
Serial.print(tdsValue);
Serial.println(" ppm");

lastPrintTime = currentTime;
}
if ((tdsValue > 1073)) // 1073

{
//        digitalWrite(25, LOW);
Serial.println("Solenoid valve ON");
}
return tdsValue;
}
float phsensor()
{
Value = analogRead(potPin);
Serial.print("PH value:");
float voltage = Value * (3.3 / 4095.0);
ph = (2.6 * voltage);
```

```
Serial.println(ph);
return ph;
}

void setup()
{
Serial.begin(9600);

//to connect wifi & firebase
WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
Serial.print("Connecting to Wi-Fi");
while (WiFi.status() != WL_CONNECTED)

{
Serial.print(".");
delay(300);
}
Serial.println();
Serial.print("Connected with IP: ");
Serial.println(WiFi.localIP());
Serial.println();

/* Assign the api key (required) */
config.api_key = API_KEY;

/* Assign the RTDB URL (required) */
config.database_url = DATABASE_URL;

/* Sign up */
if (Firebase.signUp(&config, &auth, "luckybhure19@gmail.com",
"9607538821"))

{
Serial.println("ok");
signupOK = true;
}
else
{
Serial.printf("%s\n", config.signer.signupError.message.c_str());
}

/* Assign the callback function for the long running token generation task */
config.token_status_callback = tokenStatusCallback;       // see
addons/TokenHelper.h
```

```
Firebase.begin(&config, &auth);
Firebase.reconnectWiFi(true);

dht.begin();                    // for dht to begin
pinMode(FloatSensor, INPUT_PULLUP); // for float sensor
sensor.begin();                 // for water sensor
pinMode(TdsSensorPin, INPUT);   // for TDS sensor
pinMode(potPin, INPUT);         //for ph sensor

// Relay Pins:
pinMode(27, OUTPUT);   // IN1 for Water Tank Valve
pinMode(26, OUTPUT);   // IN2 for Submersible Pump
pinMode(25, OUTPUT);   // IN3 for Solenoid Valve
pinMode(33, OUTPUT);   // IN4 for Fan

}

void loop()
{
float env_temperature = dhtsensor();   // DHT11 Data
int float_level = floatswitch();       // Float Senser Data
float water_temp = watertemp();        // DS18B20 Data
float water_quality = tdssensor();     // TDS Data
float ph_Value = phsensor();           // pH Sensor Data
//delay(3000);

if (Firebase.ready() && water_quality != 0 && (millis() - sendDataPrevMillis
> 1 || sendDataPrevMillis == 0))
{
// since we want the data to be updated every second
sendDataPrevMillis = millis();

// Environment Temperature From DHT_11 to Firebase
if (Firebase.RTDB.setFloat(&fbdo, "DHT_11/Temperature",
env_temperature))
{
Serial.print("Temperature : ");
Serial.println(env_temperature);
}
else
{
Serial.println(" | Failed to Read from the DHT11 Sensor |");
Serial.println("REASON: " + fbdo.errorReason());
```

```
}

// Water Temperature From DS18B20 to Firebase
if (Firebase.RTDB.setFloat(&fbdo, "Water/Temperature", water_temp))
{
Serial.print(" | Water Temperature : ");
Serial.print(water_temp);
}
else
{
Serial.println(" | Failed to Read from the DS18B20 Sensor |");
Serial.println("REASON: " + fbdo.errorReason());
}

// Water Temperature From Float Sensor to Firebase
if (Firebase.RTDB.setFloat(&fbdo, "Float/Level", float_level))

{
Serial.print(" | Float Level : ");
Serial.print(float_level);
}
else
{
Serial.println(" | Failed to Read from the Float Sensor |");
Serial.println("REASON: " + fbdo.errorReason());
}

// Water Temperature From pH Sensor to Firebase
if (Firebase.RTDB.setFloat(&fbdo, "pH_Sensor/pH_Value", ph_Value))
{
Serial.print(" | pH Value : ");
Serial.print(ph_Value);
}
else
{
Serial.println(" | Failed to Read from the pH Sensor |");
Serial.println("REASON: " + fbdo.errorReason());
}

// Water Temperature From TDS Sensor to Firebase
if (Firebase.RTDB.setFloat(&fbdo, "TDS/Water_Quality", water_quality))
{
Serial.print(" | TDS : ");
Serial.print(water_quality);
```

```
}
else
{
Serial.println(" | Failed to Read from the TDS Sensor |");
Serial.println("REASON: " + fbdo.errorReason());
}

// ON and OFF Fan with Firebase
bool fan;
if (Firebase.RTDB.getBool(&fbdo, "/fanStatus"))
{
fan = fbdo.boolData();
if (fan == false)
{
digitalWrite(33, HIGH);
Serial.print("| Fan is OFF |");
}
else
{
digitalWrite(33, LOW);
Serial.print(" | Fan is ON |");
}
}
else
{
Serial.println(" | Failed to Read from the pH Sensor |");
Serial.println("REASON: " + fbdo.errorReason());
}

// ON and OFF Submersible Pump with Firebase
bool pump;
if (Firebase.RTDB.getBool(&fbdo, "/pumpStatus"))
{
pump = fbdo.boolData();
if (pump == false)
{
digitalWrite(26, HIGH);
Serial.print(" | Sumbersible Pump is OFF |");
}
else
{
digitalWrite(26, LOW);
Serial.print(" | Sumbersible Pump is ON |");
}
```

```
}
else
{
Serial.println(" | Failed to Read from the pH Sensor |");
Serial.println("REASON: " + fbdo.errorReason());
}

// ON and OFF Solenoid Valve with Firebase
bool solenoid;
if (Firebase.RTDB.getBool(&fbdo, "/solenoidStatus"))
{
solenoid = fbdo.boolData();
if (solenoid == false)
{
digitalWrite(25, HIGH);
Serial.print(" | Solenoid Valve is OFF |");
}
else
{
digitalWrite(25, LOW);
Serial.print(" | Solenoid Valve is ON |");
}
}
else{
Serial.println(" | Failed to Read from the pH Sensor |");
Serial.println("REASON: " + fbdo.errorReason());
}
}
}
```

//Home Page XML Code

```
<?xml version="1.0" encoding="utf-8"?>
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:app="http://schemas.android.com/apk/res-auto"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:background="@drawable/main_background"
    tools:context=".MainActivity">

    <TextView
        android:id="@+id/sign_in"
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
```

```
    android:layout_marginStart="50dp"
    android:layout_marginTop="60dp"
    android:layout_marginEnd="50dp"
    android:layout_marginBottom="60dp"
    android:fontFamily="@font/jockey_one"
    android:gravity="start"
    android:text="@string/app_name"
    android:textColor="@color/white"
    android:textSize="50sp" />

<EditText
    android:id="@+id/email"
    android:layout_width="match_parent"
    android:layout_height="50dp"
    android:layout_below="@id/sign_in"
    android:layout_marginStart="40dp"
    android:layout_marginTop="10dp"
    android:layout_marginEnd="40dp"
    android:layout_marginBottom="20dp"
    android:background="@drawable/username_layout"
    android:drawablePadding="20dp"
    android:hint="@string/email"
    android:textAlignment="center"
    android:textStyle="bold"
    android:textColor="#8C232323"
    android:autofillHints="username"/>

<EditText
    android:id="@+id/password"
    android:layout_width="match_parent"
    android:layout_height="50dp"
    android:layout_below="@id/email"
    android:layout_marginStart="40dp"
    android:layout_marginTop="20dp"
    android:layout_marginEnd="40dp"
    android:layout_marginBottom="10dp"
    android:background="@drawable/username_layout"
    android:drawablePadding="10dp"
    android:hint="@string/password"
    android:inputType="textPassword"
    android:padding="10dp"
    android:textAlignment="center"
    android:textColor="#8C232323"
```

```
        android:textStyle="bold"
        android:autofillHints="password"/>

    <com.google.android.material.button.MaterialButton
        android:id="@+id/login_btn"
        android:layout_width="107dp"
        android:layout_height="wrap_content"
        android:layout_below="@id/password"
        android:layout_centerHorizontal="true"
        android:layout_marginStart="20dp"
        android:layout_marginTop="20dp"
        android:layout_marginEnd="20dp"
        android:backgroundTint="@color/blue"
        android:text="@string/login"
        android:textStyle="bold"
        app:toggleCheckedStateOnClick="false" />

    <TextView
        android:id="@+id/create_btn"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_below="@id/login_btn"
        android:layout_centerHorizontal="true"
        android:layout_marginStart="20dp"
        android:layout_marginTop="10dp"
        android:layout_marginEnd="20dp"
        android:layout_marginBottom="20dp"
        android:text="@string/create"
        android:textAlignment="center"
        android:textColor="#C1C1C1"
        android:textSize="20sp"
        android:textStyle="bold" />

</RelativeLayout>
```

CHAPTER NO. 6

RESULTS & DISCUSSION

CHAPTER 6

RESULTS & DISCUSSION

In Chapter 6, the Results & Discussion section presents the outcomes obtained from implementing the Smart Hydroponic System. It details findings concerning crop yield, system efficiency, and sustainability. Discussions critically analyze results, addressing system performance, challenges faced, and potential improvements, offering insights for future enhancements in smart hydroponic technologies.

6.1 RESULTS & DISCUSSION

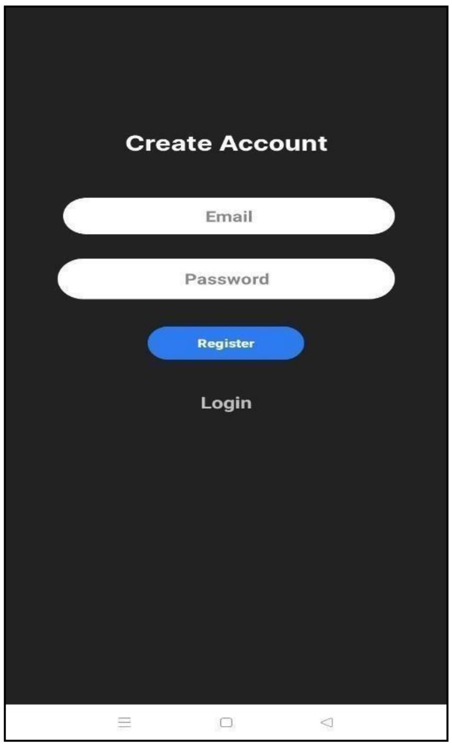

Fig 6.1 Login Screen

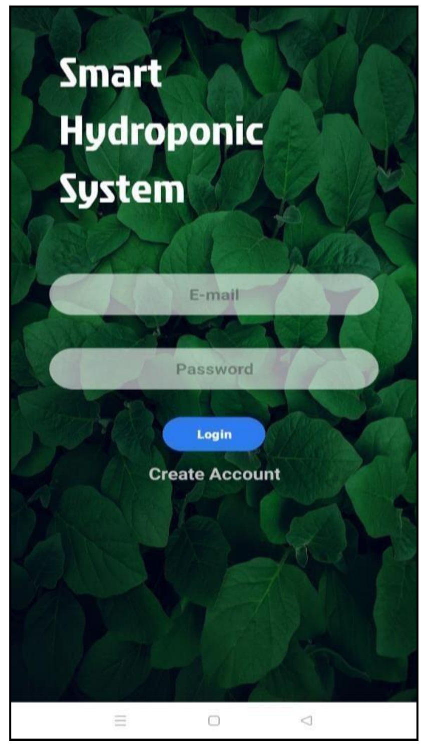

Fig 6.2 Registration Screen

Upon initiating the application, the initial interface, depicted in Fig.6.1 and 6.2, is displayed. At this stage, users are prompted to create an account to access the application's functionalities. However, for existing users, a login option is available to directly access their accounts. This process ensures that new users can swiftly register while established users can conveniently log in, streamlining access to the application's features and facilitating a seamless user experience.

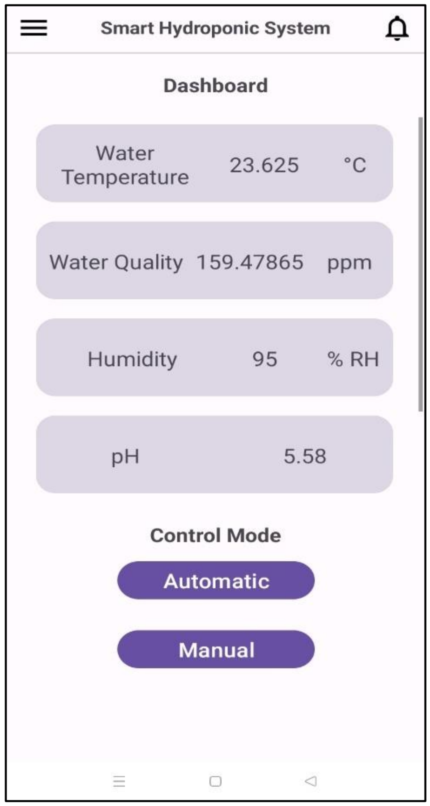

Fig 6.3(a) Dashboard Screen

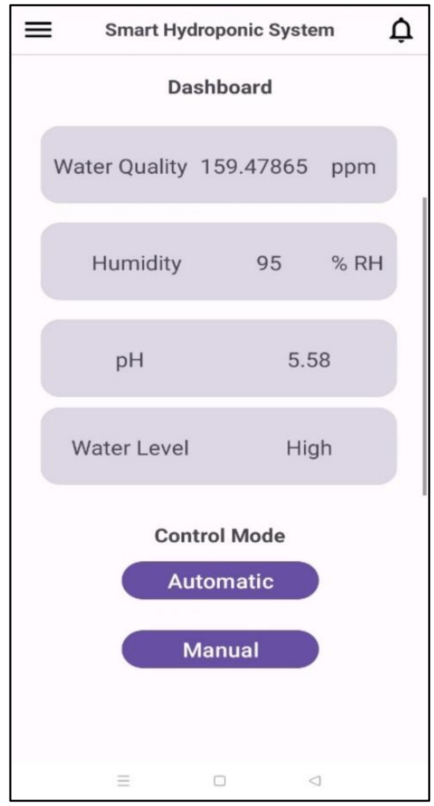

Fig 6.3(b) Dashboard Screen

Once logged in, users are presented with a comprehensive dashboard showcasing readings and values captured by various sensors, illustrated in Fig.6.3. This centralized interface provides real-time data visibility. Additionally, users have access to a control mode allowing them to seamlessly transition between different operational modes—such as automatic and manual settings. This flexibility empowers users to tailor the application's functionality based on their preferences and specific operational requirements, enhancing overall usability and control.

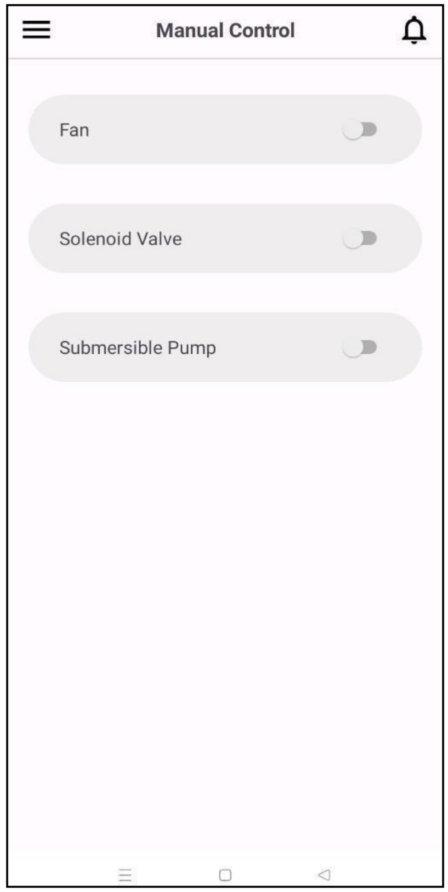

Fig 6.4 Manual Mode Screen

Upon opting for manual control within the system, users gain access to the manual interface as shown in Fig, 6.4, specifically designed for manual mode operation. This screen empowers users to directly oversee and adjust essential parameters like the fan, solenoid valve, and submersible pump. By offering this level of control, individuals can fine-tune these elements according to their preferences or immediate requirements. This capability ensures precise management of system components, fostering a more tailored and hands-on user experience within the application.

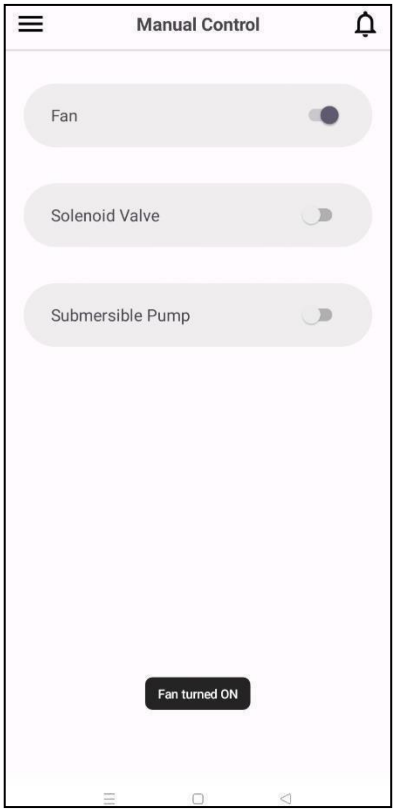

Fig 6.5(a) Fan Turned ON

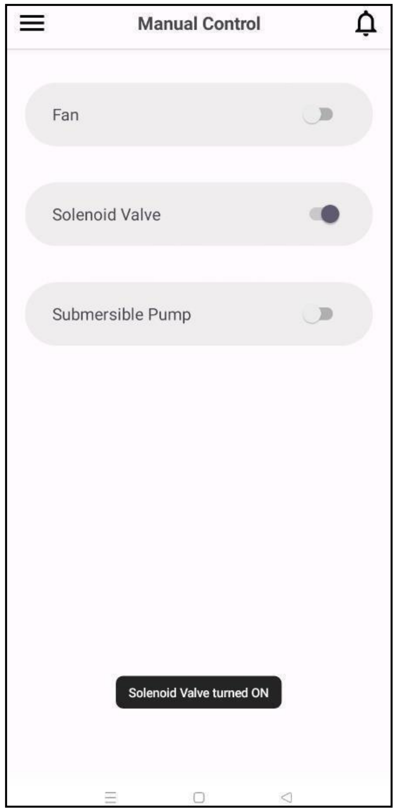

Fig.6.5(b) Solenoid Valve Turned ON

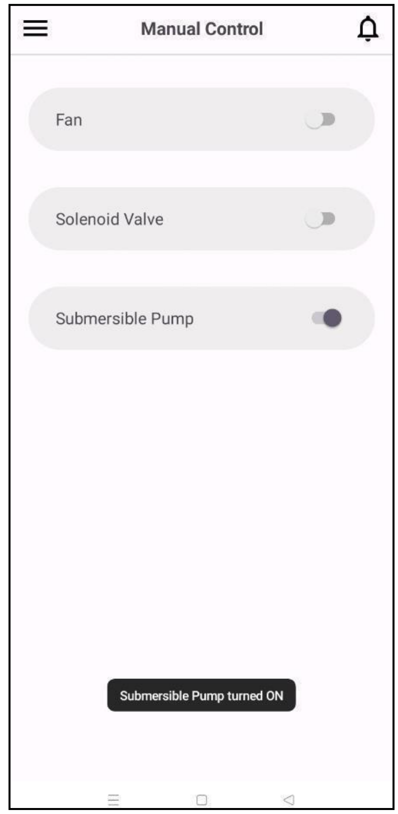

Fig. 6.5(c) Submersible Pump Turned ON

Fig.6.5(a), 6.5(b), and 6.5(c) depict the manual mode within the smart hydroponic system, illustrating control over different actuators based on user requirements. These figures exhibit the activation and deactivation of various components such as fans, solenoid valves, and submersible pumps, showcasing the user's ability to manage and adjust these elements manually within the hydroponic setup for optimized functionality

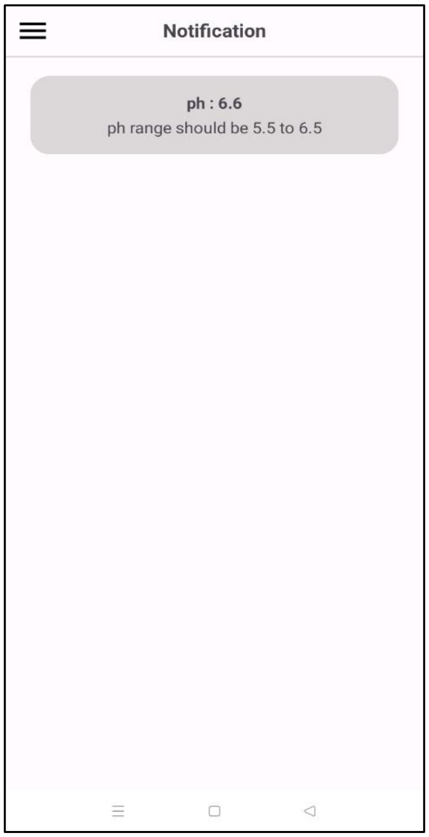

Fig 6.6 Notification Screen

As displayed in Fig.6.6, the notification screen is pivotal for informing users about system alterations or alerts. The screen indicates that the water's pH level has surpassed the accepted range of 5.5 to 6.5. This prompt notification mechanism ensures users are promptly informed of such deviations, enabling timely action or adjustments. This feature emphasizes proactive user engagement, allowing for immediate responses to maintain optimal system conditions within the specified parameters.

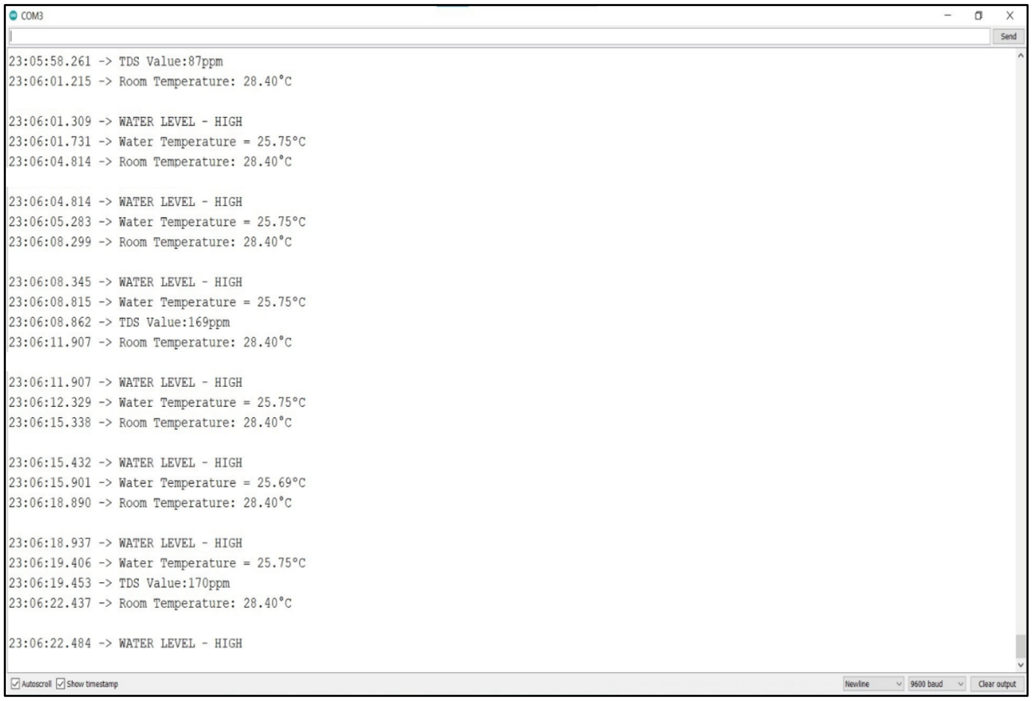

Fig 6.7 Serial Monitoring Result on Arduino IDE

The serial monitor screen showcases readings and values captured by various sensors, illustrated in Fig.6.7. This centralized interface provides real-time data visibility.

CHAPTER NO. 7

ADVANTAGES

&

APPLICATIONS

CHAPTER 7

ADVANTAGES AND APPLICATIONS

Within Chapter 7, the section on Advantages and applications highlights the benefits and practical uses of the Smart Hydroponic System. Advantages delineate increased crop yield, water conservation, and minimized resource usage. Applications explore diverse contexts such as urban farming, controlled environment agriculture, and sustainable food production, showcasing the system's versatility and impact across various settings.

7.1 ADVANTAGES

- **Optimized Growth Conditions:**
  Automated monitoring and control ensure precise management of temperature, water quality, and pH, creating ideal conditions for plant growth.
- **Resource Efficiency:**
  Intelligent use of water and nutrients based on sensor data enhances resource utilization and minimizes waste in the hydroponic setup.
- **Real-time Monitoring:**
  Users can remotely monitor sensor readings via a mobile application, facilitating immediate intervention or adjustments as necessary.
- **Automated System Maintenance:**
  The system autonomously manages water levels using the solenoid valve, maintaining optimal levels without manual intervention.
- **Environmental Control:**
  The fan adjusts the ambient temperature automatically, preventing heat-related stress on plants and ensuring an optimal growth environment.
- **Alerts and Notifications:**
  Immediate alerts and notifications keep users informed about critical system changes or deviations, enabling proactive action.
- **Data-driven Decision Making:**
  Utilization of sensors and Firebase storage enables historical data analysis, facilitating informed decisions for system optimization and plant health.
- **Ease of User Control:**
  Users have the flexibility to switch between automated and manual modes, giving them control over system management as per preferences or specific needs.

- **Enhanced Plant Health:**

  Continuous monitoring and timely corrective actions ensure healthier plants by preventing unfavorable environmental conditions.

- **Efficient Water Management:**

  The incorporation of a float sensor and solenoid valve ensures water conservation by managing water levels and quality, promoting sustainable hydroponic practices.

7.2 APPLICATIONS

- **Urban Agriculture:**

  Enables efficient cultivation of plants in urban environments, utilizing limited space and resources for sustainable food production.

- **Remote Monitoring:**

  Facilitates remote monitoring and management of hydroponic setups, allowing users to oversee operations from anywhere via a mobile application.

- **Resource-Efficient Farming:**

  Optimizes resource usage by precisely managing water, nutrients, and environmental conditions, reducing waste, and maximizing yields.

- **Research and Education:**

  Provides an excellent platform for educational purposes and research in hydroponics, allowing students and researchers to study plant growth and environmental factors.

- **Climate Control in Greenhouses:**

  Enables precise climate control within greenhouse environments, ensuring optimal conditions for plant growth and productivity.

- **Precision Agriculture:**

  Utilizes IoT technology to deliver accurate and real-time data, aiding farmers in making data-driven decisions to improve crop yield and quality.

- **Hydroponic Hobbyists:**

  Offers an accessible and automated solution for hobbyists interested in growing plants hydroponically, fostering an engaging and educational experience.

- **Commercial Farming:**

  Provides a scalable and efficient solution for commercial hydroponic farming, enabling consistent crop production while minimizing resource usage.

- **Environmental Monitoring:**
  Monitors and manages the environmental factors affecting plant growth, contributing to sustainable and environmentally friendly agricultural practices.
- **Smart Home Agriculture:** Integrates hydroponic systems into smart home setups, allowing homeowners to grow fresh produce indoors while utilizing IoT for efficient management.

CHAPTER NO. 8

CONCLUSION & FUTURE SCOPE

CHAPTER 8

CONCLUSION & FUTURE SCOPE

In Chapter 8, the Conclusion sums up the key findings and outcomes of implementing the Smart Hydroponic System, emphasizing its efficacy in enhancing crop yield and sustainability. FutureScope outlines potential advancements like AI integration, robotics, or improved sensor technologies, setting the stage for further innovations and advancements in smart hydroponics,paving the way for more efficient and sustainable agriculture

8.1 CONCLUSION

We have **designed** an embedded system and completed its complete development. Our system empowers users to effortlessly manage and monitor the hydroponic setup, offering real-time data insights, alerts, and notifications. This system also includes the incorporation of sensors, specialized features, or bespoke functionalities, enabling a finely tuned and customized experience for users within the hydroponic environment. We have applied **engineering knowledge** to **analyze** the **societal problem** in traditional farming and hydroponic cultivation and provide a modern engineering solution. Then we designed the application in two modules. We have **investigated** the available applications to find out the new solutions and updates. We have used **modern tools** Arduino IDE and Android Studio for the implementation of the system. During this project tenure, we have applied **professional ethics** and understood the importance of **teamwork** and seminars for **project management**. This solution can be developed at a generalized level for agriculture sectors for **life-long learning**.

8.2 FUTURE SCOPE

- **Enhanced Sensor Capabilities:**
  Integration of more advanced sensors for additional parameters such as dissolved oxygen levels, nutrient concentration, or light intensity to further fine-tune environmental control and plant health monitoring.
- **Machine Learning Integration:**
  Implementing machine learning algorithms to analyze sensor data patterns over time, enabling predictive analytics for optimizing plant growth conditions and automating adjustments based on learned patterns.

- **Remote Control and Automation:**

  Expanding remote control capabilities by incorporating actuators for nutrient dosing, pH adjustments, or lighting control, enabling more comprehensive automation and customization.

- **Mobile Application Upgrades:**

  Upgrading the mobile application interface to provide a more intuitive and interactive user experience, incorporating data visualization, historical analysis, and setting customization for users.

- **Energy Efficiency Measures:**

  Implementing energy-saving technologies such as smart power management systems, utilizing renewable energy sources, or optimizing system components for reduced power consumption.

- **Expansion to Vertical Farming:**

  Adapting the system for vertical farming setups, enabling efficient utilization of space, and scaling the system for increased crop production in limited areas.

- **Integration with AI Assistants:**

  Integration with AI-powered virtual assistants for voice commands, status updates, and personalized suggestions for better system management and user interaction.

- **Collaborative Research and Development:**

  Partnering with agricultural research institutions or universities to explore innovative technologies, methodologies, and scientific advancements in hydroponics for continuous system improvement.

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APPENDIX I

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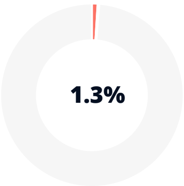

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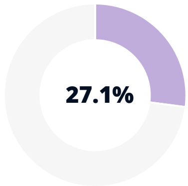

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APPENDIX II

PUBLISHED PAPER

Smart Hydroponic System

Rashmi Jain, Megha Kalorey, Yashita Patil, Shweta Zade, Lucky Bhure, Anushka More, Lakshit Chapre

Dept. of Computer Science & Engineering, S. B. Jain Institute of Technology, Management & Research, Nagpur, Maharashtra, India

Abstract: With a rising global population and limited agricultural land, hydroponics has emerged as a sustainable alternative to traditional soil-based farming. This paper introduces an innovative IoT-enabled Smart Hydroponic System (SHS) that employs real-time data monitoring and intelligent control mechanisms to enhance plant growth and resource utilization. The system utilizes a network of sensors to capture crucial environmental parameters such as temperature, humidity, nutrient levels, and pH, providing a comprehensive overview of the hydroponic environment. Its unique feature lies in its adaptability to real-time environmental changes, contributing to the evolution of precision agriculture. This research highlights the transformative potential of IoT in revolutionizing hydroponic farming for future food production.

Keywords: Hydroponics, Internet of Things (IoT), Precision Agriculture, Sustainable Farming, Real-time Data Monitoring, Intelligent Control Mechanisms, Environmental Parameters, Resource Utilization, Plant Growth Optimization.

1. INTRODUCTION

Hydroponics, a revolutionary approach to farming, uses materials other than soil to support plant roots, allowing crops to grow directly in nutrient-rich water. This is in contrast to traditional soil-based farming. Compared to traditional soil-based agriculture methods, this soil-less farming method provides a sustainable substitute that uses fewer resources, especially water. The issues of pests, crop failure, and climate change are affecting traditional farming [1]. Precision agriculture has a potential future since it is not dependent on the soil, which allows for more control over environmental conditions. The effective management and monitoring of hydroponic systems, however, present substantial difficulties that call for creative solutions for the simultaneous observation of several parameters, dietary advice, and diagnostics for the health of plants.

In response to these challenges, this research introduces a Smart Hydroponic System which primary purpose is to monitor and attempt to control parameters with the aid of actuators built into the system [2]. The intricate demands of hydroponic farming, including maintaining optimal water pH levels, water temperature, and relative humidity, necessitate a comprehensive solution that can adapt to real-time issues in the cultivation environment.

Hydroponically growing plants means taking into account light sources, pH, nutrition, and water management [3].This research delves into the design, implementation, and evaluation of the Smart Hydroponic System, exploring its potential impact on the future of agriculture. The subsequent sections will provide an in-depth analysis of the system's architecture, functionalities, and its ability to address the challenges posed by real-time monitoring and control in hydroponic farming.

Moreover, the Smart Hydroponic System aligns with the evolving landscape of precision agriculture, where advancements in technology play a pivotal role in enhancing crop management practices. By incorporating sensors that provide real-time data on critical environmental factors, the system offers a dynamic approach to agriculture, allowing for immediate responses to changing conditions. A mobile app is utilized to inform users of the hydroponic system's current status over the internet on their phones, and IoT intervention is used for automated monitoring and maintenance and Data is transferred and retrieved to the internet Some tasks are done manually, while others can be controlled via a Smartphone app, such as turning on or off the motor and adjusting the nutrient solution's temperature [4]. This responsiveness not only ensures the optimization of plant growth but also contributes to resource conservation by minimizing unnecessary inputs. The integration of internet connectivity further extends the reach of the system, enabling farmers to remotely monitor and adjust settings, fostering a more flexible and efficient farming paradigm. As we navigate the challenges of feeding a growing global population amidst environmental constraints, the Smart Hydroponic System emerges as a promising solution that amalgamates technology and agriculture, paving the way for sustainable and adaptive farming practices.

The majority of hydroponic practitioners currently employ disparate equipment to assess water temperature and monitor environmental temperature readings. Recognizing this prevalent practice, the focus of this research is to develop an application expressly designed for hydroponic users. The primary objective is to consolidate real-time data, providing users with a streamlined platform to access and visualize essential information pertaining to both water and environmental temperatures. This initiative seeks to streamline the monitoring process, eliminating the need for multiple devices, and enhancing the overall user experience within the hydroponic cultivation domain.

2. LITERATURE SURVEY

This section deals with the detailed analysis of existing methods A hydroponic farming monitoring system for environmental and nutrient solution parameters has been presented by the author. The perception layer, communication layer, and application layer were the three primary levels of the Internet of Things platform on which the system was developed. Sensor data were gathered and sent via ZigBee communication to an IoT gateway. From here, the information was shown to people for in-person viewing before being sent to a web server (cloud platform) for storage and remote viewing via an internet-connected device [1]. With the aid of actuators built into the system, the primary purpose of a hydroponic system is to monitor and attempt to manage parameters. Aside from that, one of the primary goals is remote monitoring and control. There are two subsystems that make up the complete system: the hardware and the software. The system's operations and control are handled by the hardware assembly. This comprises circuitry that has sensors for temperature, humidity, pH, and conductivity plate sensors, among others. These sensors will all be used to assess the water's quality and the conditions in which the plants are housed. In addition to sensors, the circuitry includes actuators such as the Peltier cooling system, air pump, and water pump. The microcontroller is connected to every sensor and actuator [2]. The sensor reading data, which included fuzzy logic programs, fuzzy rules, fuzzy input sets, and output parameters from the board, were sent to the ESP8266 NodeMCU [3]. Sprinklers are used to regulate the temperature and humidity around the plants or Sprinklers are used to dispense water or a pH solution based on humidity levels and The plants' pH tank is filled by the submersible motor .For the plant to be unaffected, the pH of the fertilizer solution should be between 5 and 6.5 [5]. The need to increase production and decrease resource and energy waste to make agriculture more economically accessible drives innovation in IoT-based control systems [6]. Dead roots, wilting seedlings, clogged systems, pest and algae infestations, and nutrient shortages are a few problems with hydroponics [7]. With hydroponics, we can use any combination of nutrients in an indoor farming method that saves water [8]. It gets harder and harder to provide enough food for everyone as the world's population rises and natural resources diminish. The amount of agricultural land decreases in direct proportion to population growth, which means that less food will be produced overall and won't be enough to feed the expanding population [9]. Our future research will involve creating a sophisticated model using the information gathered from this system. By offering some trends or broad predictions based on the data, this model could be used to decide how to operate the actuator or to provide the user with insight [11].

3. METHODOLOGY

The system is equipped with a central microcontroller that orchestrates the monitoring and control of environmental conditions conducive to plant growth. Employing a Digital Humidity and Temperature Sensor (DHT11), the system regulates ambient temperature and humidity.

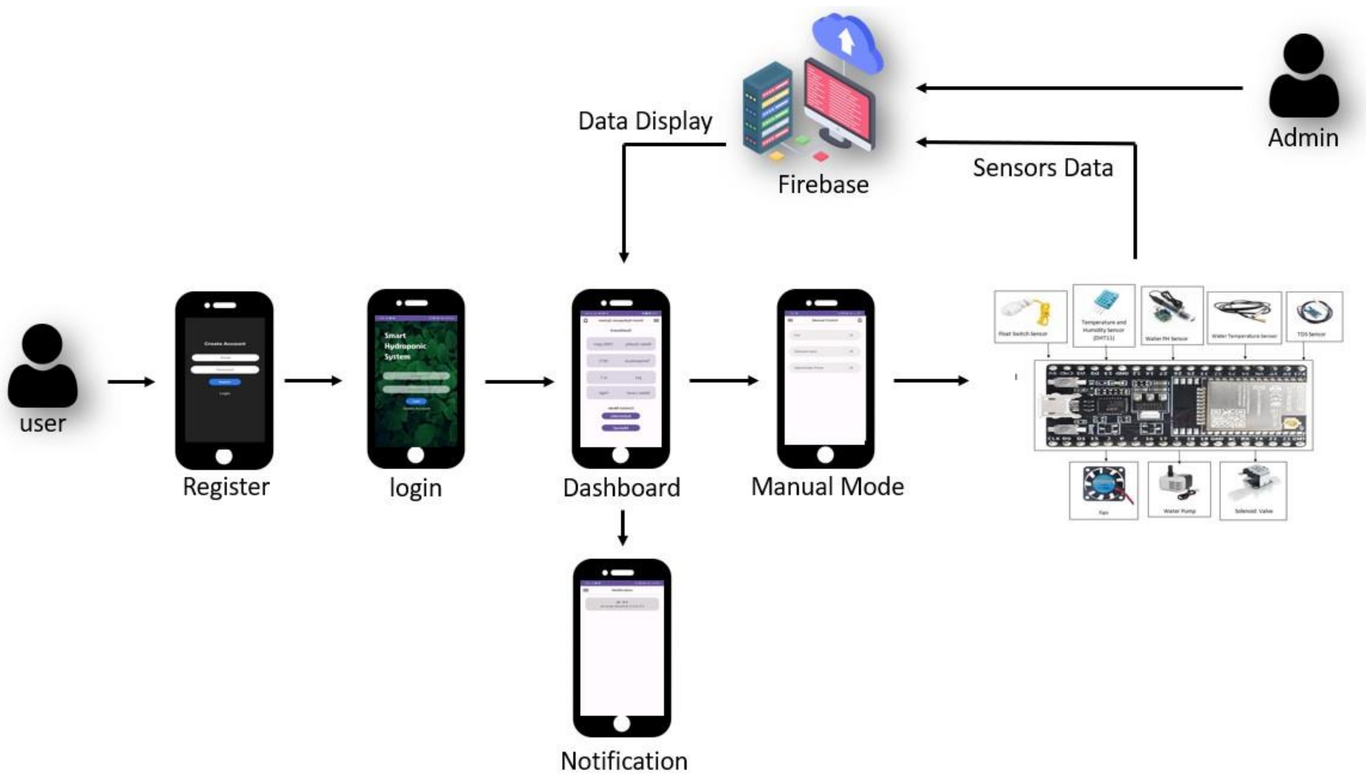

Fig 3.1: System Architecture

The primary purpose of the app is to manually operate and monitor the Smart Hydroponic System. The above-described architecture depicts the Smart Hydroponic System's system architecture. It is made up of the following parts:

- Sensors: pH Sensor, TDS Sensor, Float Sensor, Water Temperature Sensor and Temperature & Humidity Sensor.
- Microcontroller: ESP32
- Actuators: Submersible Pump, Exhaust fan and Solenoid Valve
- Mobile app: Firebase Realtime Database and Firebase Notifications.
- Connectivity: Wi-Fi module.

The sensors collect data on the environmental conditions in the hydroponic system and send it to the ESP32. The ESP32 then analyses the data and sends commands to the actuators to adjust the conditions as needed. For example, if the TDS valve exceeds the range, then the ESP32 might tell the solenoid valve to turn on. The ESP32 can also be configured to send notifications to the user's mobile app if any of the sensors detect a problem.

The Firebase Realtime Database is a cloud-based database that stores the sensor data from the ESP32. The Firebase Notifications service allows the ESP32 to send push notifications to the user's mobile app. This allows the user to monitor the status of the hydroponic system and receive alerts if any problems arise.

Overall, the system architecture of the Smart Hydroponic System in the image is well- designed and efficient. It uses a variety of sensors and actuators to automate and optimize the growing environment, and it provides the user with a convenient way to monitor and manage the system remotely.

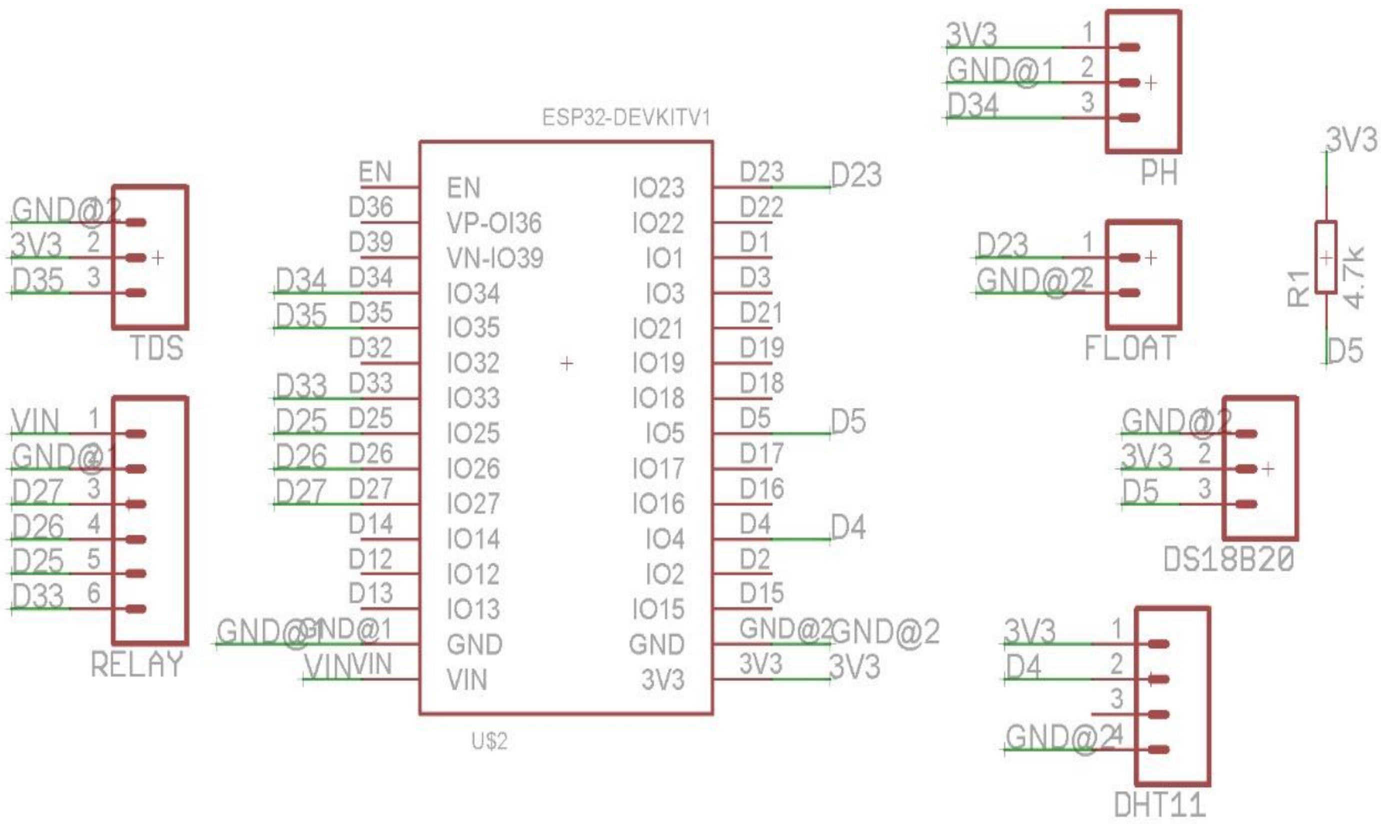

Fig 3.2: Schematic Circuit Diagram

In the above figure [figure 2] the pH sensor is configured with three distinct pins: VCC, Ground, and Data. In adherence to the connectivity protocol, the sensor's VCC and Ground terminals are judiciously linked to the ESP32's 3V3 and GND ports, respectively. Concurrently, the Data pin of the pH sensor is intricately interfaced with the D34 pin of the ESP32 microcontroller.The float sensor exhibits a simplified two-pin configuration, comprising Ground and Data terminals. In accordance with precise connectivity guidelines, the Data pin of the float sensor is meticulously interfaced with the D23 pin

of the ESP32 microcontroller, while the Ground pin of the float sensor is judiciously connected to the GND port of the ESP32.

The DS18B20 water temperature sensor is configured with three essential pins: VCC, Ground, and Data. In adherence to a meticulous connectivity scheme, the Data pin of the DS18B20 is intricately linked to the D5 pin of the ESP32 microcontroller. Additionally, the VCC and Ground terminals of the DS18B20 are judiciously connected to the 3V3 and GND ports of the ESP32, respectively, ensuring a precise and organized electrical interface. Concurrently, a 4.7K resistor has been seamlessly integrated into the circuit. One terminal of the resistor is diligently affixed to the D5 pin, fostering a connection with the DS18B20, while the opposing terminal is astutely coupled to the 3V3 port, serving as a power supply for the resistor in a manner that complements the sensor's operational requirements.

The DHT11 sensor is characterized by a four-pin configuration, comprising VCC, Ground, NC (No Connection), and Data. In adherence to a systematic connectivity protocol, the Data pin of the DHT11 sensor has been meticulously interfaced with the D4 pin of the ESP32 microcontroller. Simultaneously, the VCC and Ground terminals of the DHT11 sensor have been judiciously connected to the 3V3 and GND ports of the ESP32, respectively, establishing a methodical and efficient electrical linkage. It's noteworthy that the NC (No Connection) pin of the DHT11 sensor has been intentionally left unused in the current configuration, as it does not contribute to the specific functionality required for the integration with the ESP32 microcontroller.

The TDS sensor features a three-pin configuration, encompassing VCC, Ground, and Data. In adherence to a methodical connectivity paradigm, the Data pin of the TDS sensor has been meticulously linked to the D35 pin of the ESP32 microcontroller. In parallel, the VCC and Ground terminals of the TDS sensor have been judiciously connected to the 3V3 and GND ports of the ESP32, respectively, establishing a systematic and effective electrical interface.

4-channel relay, equipped with six integral pins, including VCC, Ground, and four Data pins, has been seamlessly integrated into the system. The relay serves as a pivotal component in controlling diverse devices, namely the Fan, Heater, Solenoid Valve, and Submersible Pump. For meticulous orchestration, the Submersible Pump is regulated using D26 pin and Solenoid Valve has been expertly connected to the D25 pin of the relay. The Fan finds controlled operation through the D33 pin, while the main water tank is regulated via the D27 pin of the relay.

4. RESULTS

The optimal pH range for tomato plants is typically maintained within the interval of 5.5 to 6.5. Additionally, the recommended range for parts per million (PPM) concentrations in the growth medium, encompassing essential nutrients, is advised to fall between 1400 and 5500 [10].

Table 1: PH and PPM Range

Plants	PH	PPM
Banana	5.5-6.5	1260-1540
Tomato	5.5-6.5	1400-3500
Coriander	6.0-6.7	800-1200
Lettuce	5.5-6.5	560-840
Pineapple	5.5-6.0	1400-1680
Basil	5.5-6.5	700-1120
Watermelon	5.8	1260-1680
Mint	5.5-6.0	1400-1680
Pumpkin	5.5-7.5	1260-1680
Potato	5.0-6.0	1400-1750
Sage	5.5-6.5	700-1120
Roses	5.5-6.0	1050-1750

Although the sensor circuit can perform extremely accurate measurements, the measurement was impacted by the cable's unstable shape and location in the water [12].The application uses a variety of sensors, such as temperature, humidity, and water temperature sensors, to enable automatic environmental control for hydroponics [13].The system can be operated in two different ways: manually and automatically. In manual mode, the user has the ability to control the system's operations using PC commands or an Android app, whereas in auto mode, the system makes decisions automatically and manages the installed devices [14]. The pH scale, which ranges from 1 to 14, indicates the concentration of hydrogen ions in a solution. pH stands for "power of hydrogen." Generally speaking, an acidic or basic water is determined by its pH value. When the pH is less than 5.5, it is base, when the pH is greater than 6.5, and it is normal when the pH is between 5 and 7[15]. A pH sensor in the pH tank keeps track of the water's pH. The device notifies the user that the pH of the water is out of proper range if the pH is unfavorable [16]. he reservoir's water level is determined using a water level sensor[17].

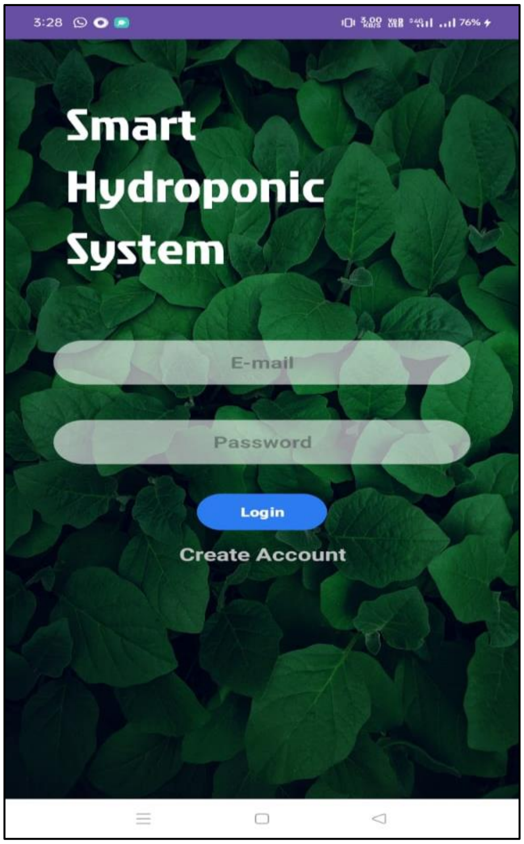

Fig 4.1: Login

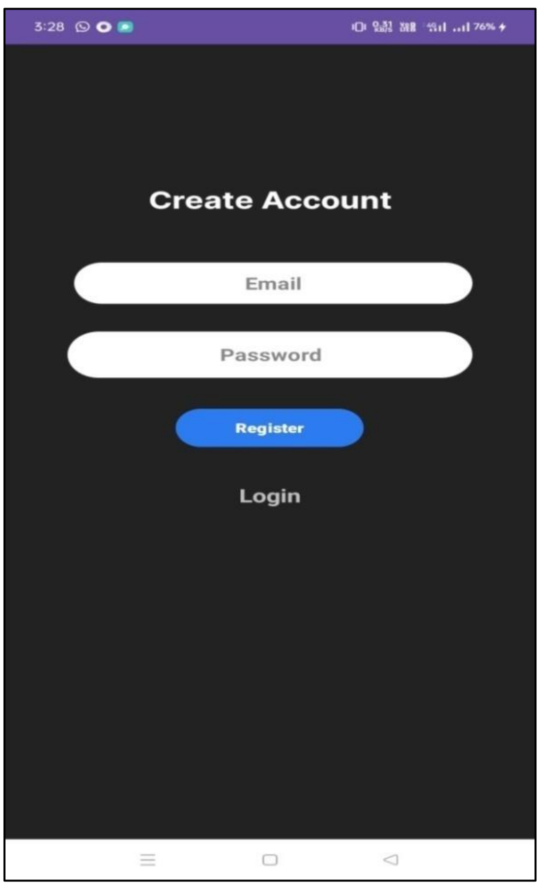

Fig 4.2: Create Account

Upon initiating the application, the initial interface, depicted in figures 4.1 and 4.2, is displayed. At this stage, users are prompted to create an account to access the application's functionalities. However, for existing users, a login option is available to directly access their accounts. This process ensures that new users can swiftly register while established users can conveniently log in, streamlining access to the application's features and facilitating a seamless user experience.

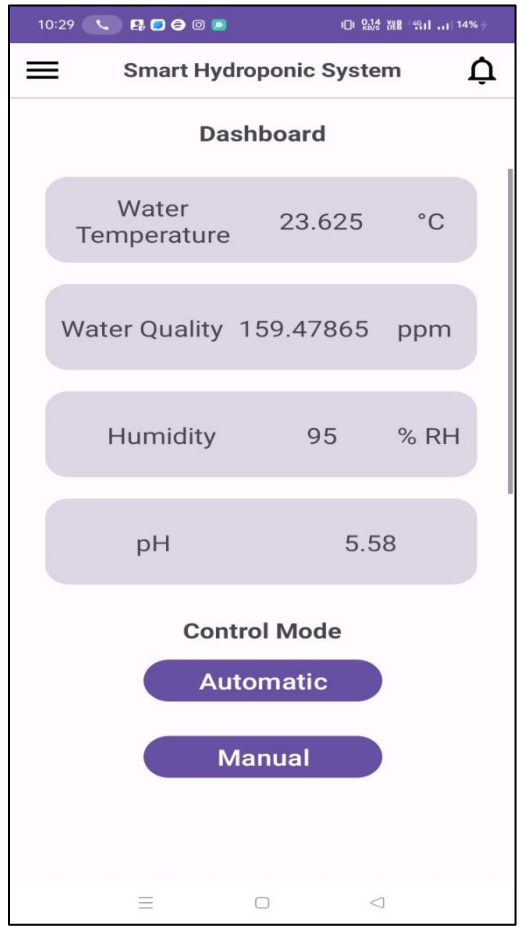

Fig 4.3(a): Dashboard Screen

Fig 4.3(b): Dashboard Screen

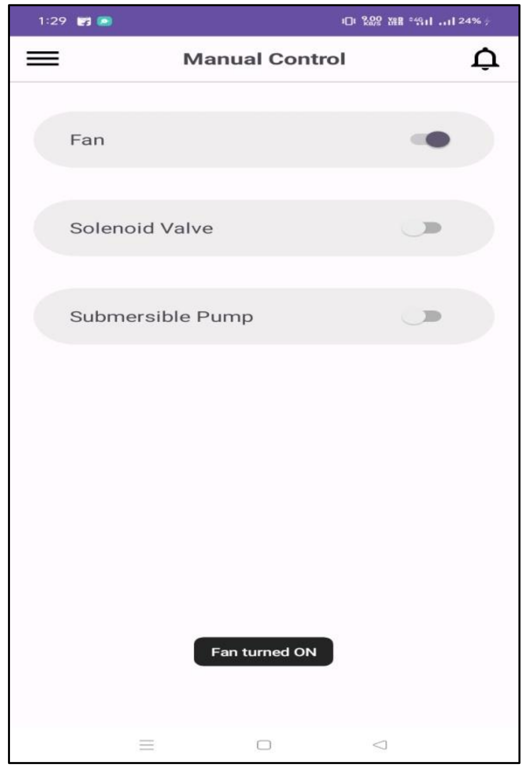

Fig 4.4: Mannual Control

Once logged in, users are presented with a comprehensive dashboard showcasing readings and values captured by various sensors, illustrated in Fig. 4.3(a) and 4.3(b). This centralized interface provides real-time data visibility. Additionally, users have access to a control mode allowing them to seamlessly transition between different operational modes—such as automatic and manual settings. This flexibility empowers users to tailor the application's functionality based on their preferences and specific operational requirements, enhancing overall usability and control.

Upon opting for manual control within the system, users gain access to manual interface as shown in Fig, 6.4, specifically designed for manual mode operation. This screen empowers users to directly oversee and adjust essential parameters like the fan, solenoid valve, and submersible pump. By offering this level of control, individuals can fine-tune these elements according to their preferences or immediate requirements. This capability ensures precise management of system components, fostering a more tailored and hands-on user experience within the application.

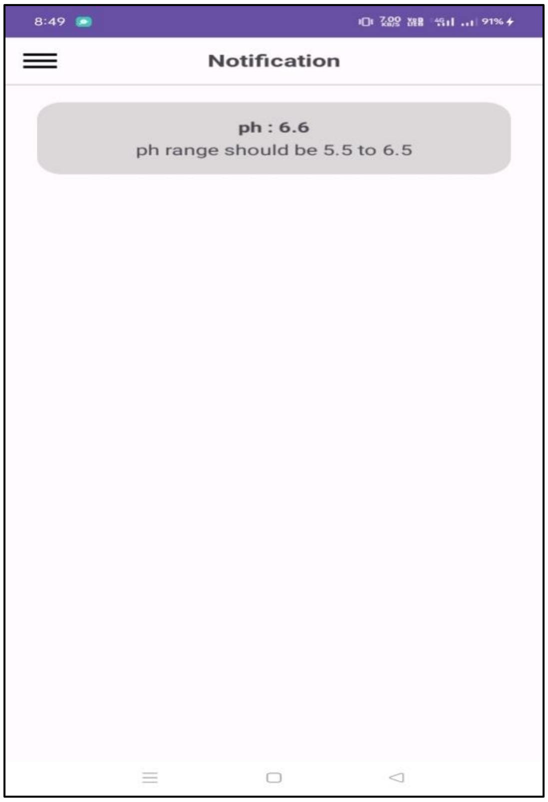

Fig 4.5: Notification Screen

Displayed in Fig. 4.5, the notification screen is pivotal for informing users about system alterations or alerts. In this instance, the screen indicates that the water's pH level has surpassed the accepted range of 5.5 to 6.5. This prompt notification mechanism ensures users are promptly informed of such deviations, enabling timely action or adjustments. This feature emphasizes proactive user engagement, allowing for immediate responses to maintain optimal system conditions within the specified parameters.

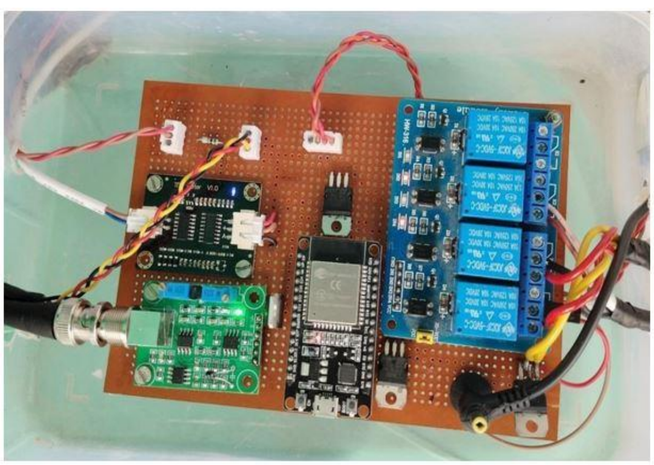

Fig 4.6: Printed Circuit Board

Fig 4.7(a): Project Setup

In the above Fig 4.6 and 4.7(a) we have developed a hardware module in which we have connected different sensors with the Microcontroller (ESP32). • Also, we have connected a 4- channel Relay which is used to trigger different actuators.

Fig 4.7(b): Project Setup

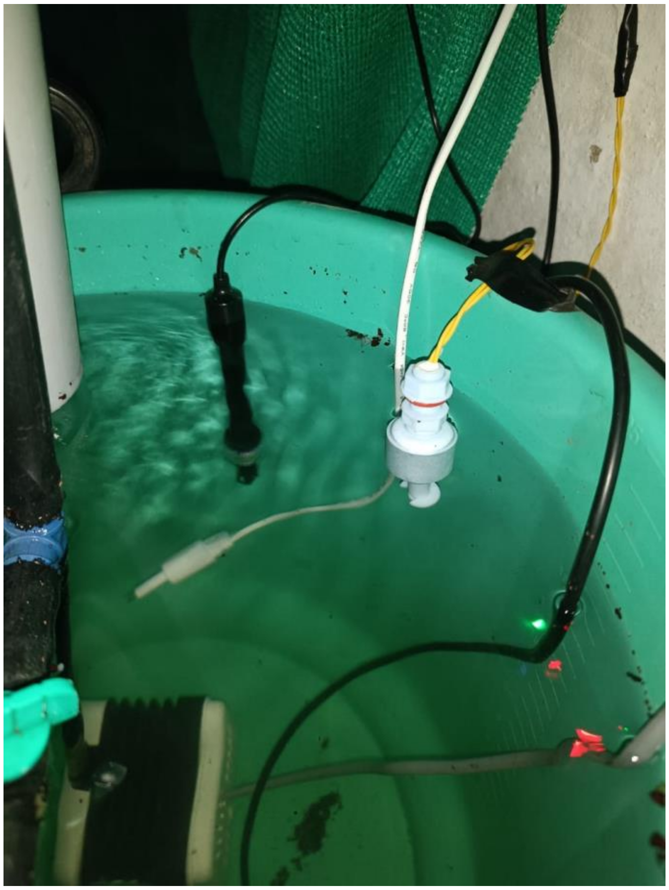

Fig 4.7(C): Project Setup

In above Fig 4.7(b) and 4.7(c) the density of dissolved in water is measured using a sensor called TDS, or total dissolved solid. The purpose of this study is to quantify the dissolved water thickness in the nutrient tank [18]. Immersed in the water are the float sensor, pH sensor, and water temperature sensor, designed to monitor and measure key parameters in a professional and precise manner.

5. DISCUSSION

Hydroponic garden walls, where plants are grown on thin sheets of substrate (like nylon felt) attached to building walls, vertical farms, where hydroponic facilities are densely installed within high-rise buildings, and aquaponics, where fish like tilapia are raised in pools alongside plants (their excretions providing nutrients to the plants) form a symbiotic system are some notable variations of hydroponic systems [19]. The automation of agricultural processes is dependent on remote access to physical objects through the use of sensors, actuators, and software, given the rapid advancement of digitalization [20]. Urban areas are reported to have a shortage of space and farm labor for the production of fodder. Because hydroponic systems require less space, they are suitable for automatic and remote farming. Additionally, a control and monitoring interface is necessary. In order to control and monitor the entire hydroponic system, an automated hydroponic system that can send and receive data through the cloud is needed, and this requires a combination of web and mobile applications [21]. Global policy makers supported the Green Revolution, which aimed to promote sustainable development in the agricultural sector. Modern farming techniques that make use of robotics, AI, big data analysis, and machine learning are essential to the development of Agriculture 4.0, which aims to boost agricultural value creation's productivity and eco-efficiency [22]. In order to make cultivation easier, an automated hydroponics system based on IOT and mobile applications was created. This system has the ability to regulate and control key environmental elements like water, humidity, and temperature [23].

7. FUTURE SCOPE

Based on the type of produce, India's hydroponics market is divided into categories for fruits, vegetables, and flowers. The market value of fruits and vegetables is projected to reach USD 2544.15 thousand in 2018. By 2026, it is anticipated to increase to a peak value of USD XX thousand. For the projected period of 2019–2027, the market growth rate is expected to grow at a CAGR of 13.53%[24]. Future Scope describes prospective developments like robotics, AI integration, or enhanced sensor technologies, laying the groundwork for additional breakthroughs and developments in smart hydroponics and opening the door to more productive and sustainable agriculture.

8. CONCLUSION

We have designed an embedded system and completed its complete development. Our system empowers users to effortlessly manage and monitor the hydroponic setup, offering real-time data insights, alerts, and notifications. This system also includes the incorporation of sensors, specialized features, or bespoke functionalities, enabling a finely-tuned and customized experience for users within the hydroponic environment. We have applied engineering knowledge to analyze the societal problem in traditional farming and hydroponic cultivation and provide a modern engineering solution. Then we have designed the application in two modules. We have investigated the available application to find out the new solutions and updates. We have used modern tool Arduino IDE and Android Studio for the implementation of the system. During this project tenure we have applied professional ethics and understood the importance of team work and seminars for project management. This solution can be developed at generalized level for agriculture sectors for life-long learning. We can conclude that the experiments were successful based on the results that were obtained. It is evident from analyzing the seed germination experiment results that the seeds can develop and germinate properly in pure water. In the same amount of time, the plant grew more quickly in the recipients of the nutrient solution than it did in pure water [25].

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APPENDIX III

PUBLICATION

APPENDIX IV

COPYRIGHT-XIV

FORM XIV
APPLICATION FOR REGISTERATION OF COPYRIGHT
[SEE RULE 70]

To
The Registrar of Copyrights,
Copyright Office,
New Delhi.

Sir,

In Accordance with section 45 of the Copright Act, 1957 (14 of 1957), I hereby apply for registration of copyright and request that
enteries may be made in the Register of Copyrights as in the enclosed Statement of Particulars.

1. [12]I also send herewith duly completed the Statement of further particulars relating to the work.

2. In accordance with rule 70 of the Copyright Rules, 2012, I have sent by prepaid registered post copies of this
letter and of the enclosed Statement to other parties[13] concerned,
as shown below: *

Name of Party	Address of Party	Date of Dispatch
MEGHA KALOREY	S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT & RESEARCH, NAGPUR-441501	06/01/2024
DR. RASHMI JAIN	S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT & RESEARCH, NAGPUR-441501	
YASHITA PATIL	S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT & RESEARCH, NAGPUR-441501	06/01/2024
SHWETA ZADE	S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT & RESEARCH, NAGPUR-441501	
LUCKY BHURE	S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT & RESEARCH, NAGPUR-441501	06/01/2024
ANUSHKA MORE	S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT & RESEARCH, NAGPUR-441501	06/01/2024
LAKSHIT CHAPRE	S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT & RESEARCH, NAGPUR-441501	06/01/2024

3. The prescribed fee has been paid, as per details below:

4. Communications on this subject may be addressed to:

Name * MEGHA KALOREY
Communication Address * S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT
Pincode 441501
Phone 9545595885

5. [14]I hereby declare that to the best of my knowledge and belief, no person, other than to whom a notice has been sent as per paragraph 2 above any claim or interest or dispute to my copyright of this work or its use by me.

6. [15]I hereby verify that the particulars given in this Form and the Statement of Particulars and Statment of Further Particulars are true to the best of my knowledge, belief and information and nothing has been

concealed there from.

7. List of enclosures.

Place:
Date:

12: For Literary, Dramatic, Musical and Artistic works only.
13: See columns 7, 11, 12 and 13 of the Statement of Particulars and the party referred to in column 2(e) of the Statement of Further Particulars.
14: Inserted by G.S.R. 435(E), dated 27th April, 1992.
15: Renumbered by G.S.R. 435(E), dated 27th April, 1992.

APPENDIX V

PPT HANDOUTS

"Smart Hydroponics System"

by

Author Name: Dr. Rashmi Jain, Ms. Megha Kalorey, Yashita Patil, Shweta Zade, Lucky Bhure, Anushka More, Lakshit Chapre

Session: 2023-24(ODD)

Department of Computer Science & Engineering

S. B. JAIN INSTITUTE OF TECHNOLOGY MANAGEMENT AND RESEARCH,NAGPUR

An Autonomous Institute, Affiliated to RTMNU, Nagpur

Contents

Problem Statement

Problem Statement :

Hydroponics is soil-less agriculture farming, which consumes less water and other resources as compared to traditional soil-based agriculture systems. However, monitoring hydroponics farming is a challenging task due to the simultaneous supervising of numerous parameters, nutrition Monitoring, and Controlling.

Introduction

- Hydroponics, a revolutionary approach to farming, uses materials other than soil to support plant roots, allowing crops to grow directly in nutrient-rich water.
- This Smart Hydroponic System will have sensors, internet communication, and computer technology. To solve the current deficiency, this system is designed for monitoring and controlling system.
- This Smart Hydroponic System will automate crop monitoring during the growth process using the network of sensors and actuators.
- This system assists in monitoring and commanding numerous real issues in fields such as water PH level, water temperature, and relative humidity.

Literature Survey

Website / Paper / Article /APP	Reviews / Findings
Automatic monitoring system for hydroponic farming: iot-based design and development (AESS) 2022	This paper presents how the hydroponic will be monitor by user in real time by using various sensors nodes.
Design and Implementation of Smart Hydroponics Farming Using IoT-Based AI Controller with Mobile Application System (Hindawi) 2022	The application is mainly focus on prediction, monitoring and controlling.
Automated Hydroponics with Remote Monitoring and Control Using IoT (International Journal of Engineering Research & Technology) 2020	This review paper basically present Remote monitoring and controlling are as of the main objectives.

Literature Survey

Website / Paper / Article /APP	Reviews / Findings
Revolutionizing Holy-Basil Cultivation With AI-Enabled Hydroponics System (IEEE - 9 August 2023)	This research study focuses on the design and implementation of an IoT-based hydroponic system specifically optimized for the growing of exotic and medicinal plants.
Modular IoT-based Automated Hydroponic System (ICMEAE) ©2021 IEEE	This work proposes the development of an automatic modular and vertical hydroponic system capable to regulate the water flow, the artificial lights, and the pH of the water.
Fuzzy-Based Smart Farming and Consumed Energy Comparison Using the Internet of Things(IEEE - 12 July 2023)	This research investigated hydroponics and electrical energy consumption concerns for prototype design, and analysis with a fuzzy logic framework and the Internet of Things (IoT).

Literature Survey

Website / Paper / Article /APP	Reviews / Findings
3D Printable Hydroponics: A Digital Fabrication Pipeline for Soilless Plant Cultivation(IEEE - April 2, 2019)	The paper conclude with a discussion on how the pipeline may be further extended to realize fabrication of more complex ecological systems.
IoT based Indoor Hydroponics System(©2021 IEEE)	In this paper, considering the yield and the growth of plants, an efficient approach is provided for the accurate growth of plants with less water usage and minimum need for nutrients using IOT-based techniques.
Intelligent Management of Hydroponic Systems Based on IoT for Agrifood Processes(Hindawi Journal of Sensors Volume 2022)	For improvements, we are adding more sensors to have better precision or maintenance of the system like flood sensor, with the objective of making this project a solution for wide variety of situations with different needs.

Aim & Objectives

Aim:

A smart hydroponic system with IoT aims to revolutionize hydroponic-based agriculture by integrating sensors and connectivity. It enables remote monitoring and control, resource efficiency, data-driven decision-making, automation, and environment sustainability.

Objectives:

- To be able to provide a better temperature for plants to grow in hydroponic farming.
- To Control nutrient parameters in water.
- To Design such an application that gives the user all information regarding temperature, nutrient composition, and recent crop conditions.

Proposed Work

Components To Be Used :

- Microcontroller (ESP32)
- Air temperature and humidity sensor (DHT 11): Used to monitor temperature and humidity of a given area.
- Water quality sensor (TDS Sensor): To detect the composition of chemicals and Indicate the quality of water.
- Water temperature sensor (DS18B20): Used to detect water temperature.
- Float Switch Sensor: Detecting the amount of liquid in a tank
- Water PH Sensor: To measure the pH of water
- Fan
- Solenoid valve
- Submersible Pump

Methodology

- Set up the microcontroller and connect sensors (DHT11, Float Sensor, water temperature sensor, TDS sensor, pH sensor) and actuators (solenoid valve, fan).
- Connect the microcontroller to the internet for IoT capabilities.
- Establish communication with Firebase for data storage and retrieval.
- Continuously read sensor data (temperature, humidity, water level, water temperature, TDS, pH) at regular intervals.
- If TDS value exceeds the defined range (600 ppm to 1773 ppm), trigger the solenoid valve to drain the tank and refill it from the main water source.
- If the temperature surpasses the predefined maximum range (18oC to 23oC), activate the fan to regulate the environment.

Methodology

- Develop a mobile application for users to monitor system readings and manage settings manually or automatically.
- Implement manual and automatic controls in the mobile app for controlling the setup.
- Set up notifications and alerts to notify users about critical parameter deviations or system malfunctions.
- Store sensor readings and system statuses in Firebase for historical analysis

System Architecture

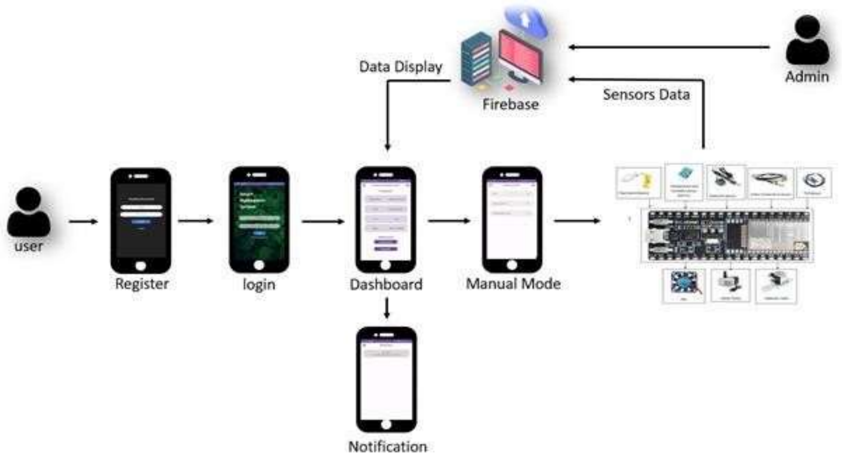

Fig 1: System Architecture of Smart Hydroponic System Using IoT

System Architecture

- The above-described architecture depicts the Smart Hydroponic System's system architecture.
- The sensors collect data on the environmental conditions in the hydroponic system and send it to the ESP32. The ESP32 then analyses the data and sends commands to the actuators to adjust the conditions as needed.
- The ESP32 can also be configured to send notifications to the user's mobile app if any of the sensors detect a problem.
- The Firebase is a cloud-based database that stores the sensor data from the ESP32. The Firebase Notifications service allows the ESP32 to send push notifications to the user's mobile app.
- This allows the user to monitor the status of the hydroponic system and receive alerts if any problems arise.

Circuit Diagram

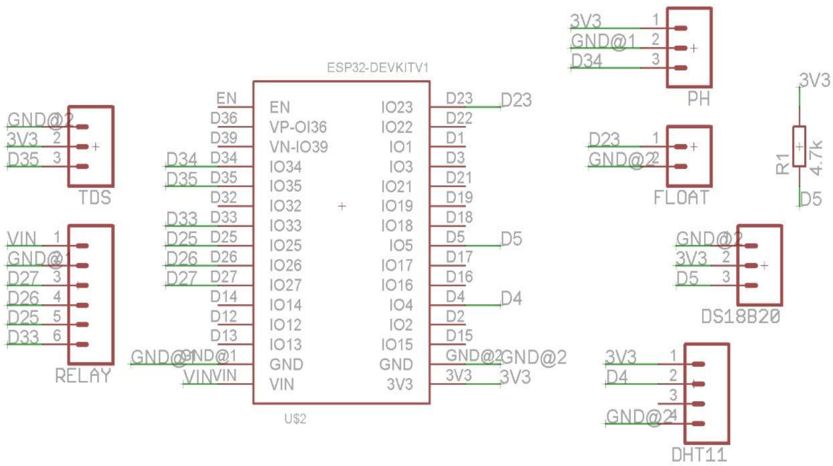

Fig 2: Circuit Diagram of Smart Hydroponic System Using IoT

Circuit Diagram

- This above image explains how pins on the ESP32 module is connected to the pins on the sensors and components.
- The component we have used are TDS, Relay Module, Ph sensor, Float Meter, Humidity and temperature Sensor DHT 11, Water Temperature sensor DS18B20 and ESP32 microcontroller.
- The purpose of these connections is to allow the ESP32 module to communicate with the sensors and components, read their data, and control their actions.

System Design: Flowchart

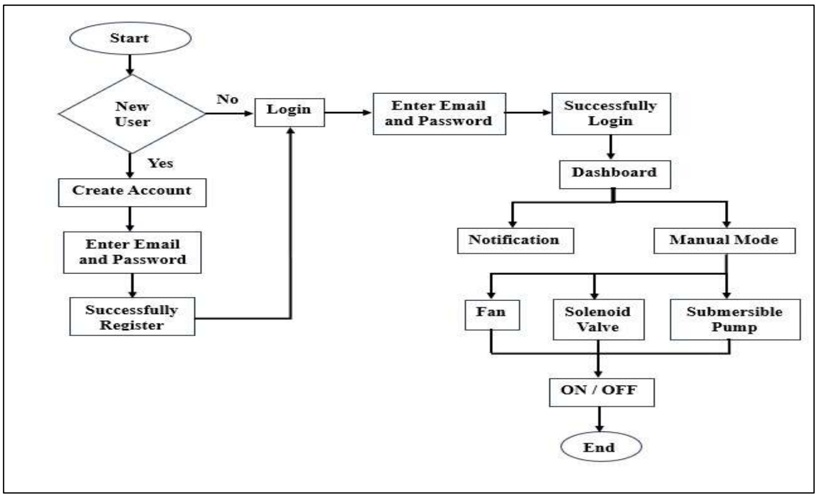

Fig 3: Real Time Data Monitoring Application

System Design: Flowchart

- In the project's workflow, the customer assumes the primary role as the main user of the application.
- Their purpose revolves around monitoring sensor readings and managing different parameters manually according to specific requirements.
- Additionally, the system is designed to notify the user promptly whenever updates or modifications are made.
- This feature ensures that the customer remains informed about any changes within the system, allowing for seamless engagement and informed decision-making.

Module Description

- Registration Page
- Login Page
- Dashboard (Display Sensors Data)
- Manual Control (Actuator Control Unit)
- Notifications /Alerts

Technology

- **Front End:** XML
- **Back End:** Java
- **Library/API/Framework:** Android Studio, Arduino IDE – Code Design
- **Database** – Firebase

Implementation

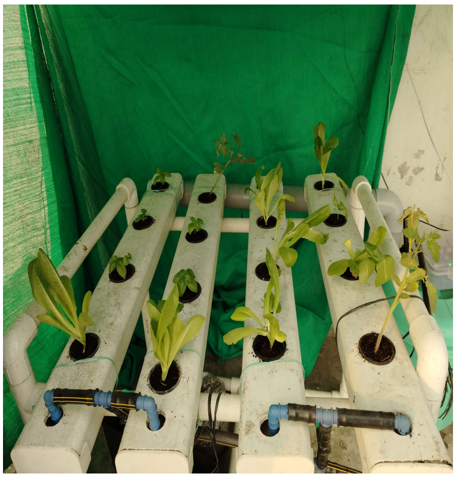

Fig 4.1: Project Setup

Implementation

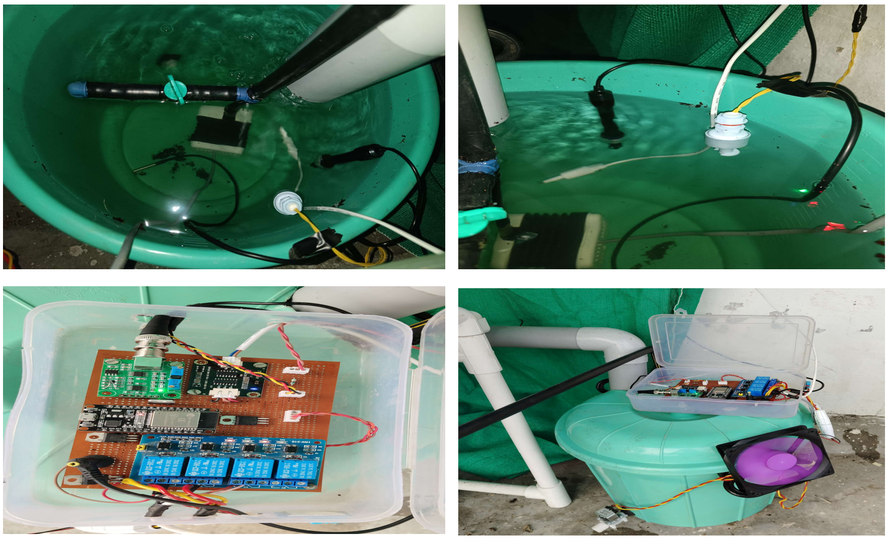

Fig 4.2: Project Setup

Implementation

- We have used a Nutrient film technique (NFT) Setup. In NFT plants are grown in shallow channels or gutters with their roots in a thin film of nutrient-rich water. The water is recirculated continuously, so there is no waste.
- There is also Reservoir tank, Water pump, Tubing, Growing media (for seedlings) and different nutrient solution for the plants.
- We have used coco peat as a growing media to support plants.
- There is space for 16 plants in our setup.
- Green net is used to cover the setup, to limit the amount of sunlight for the crop.

Results & Discussion

Screenshots:

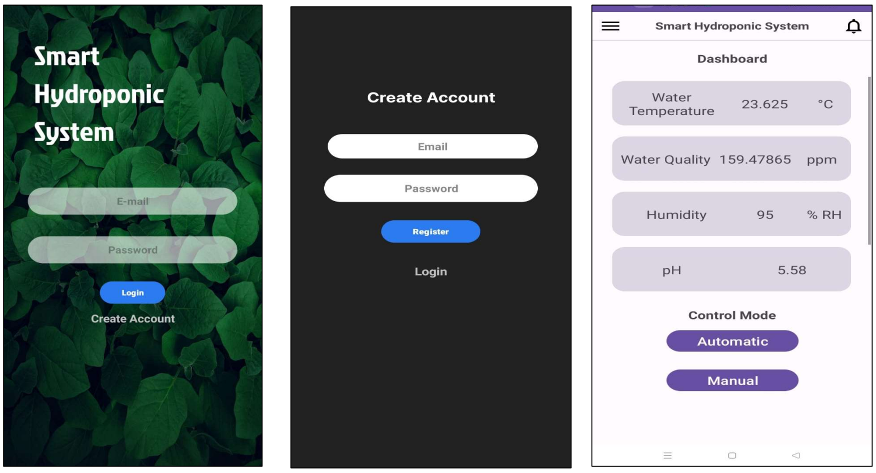

Fig 5.1: Software Application

Results & Discussion

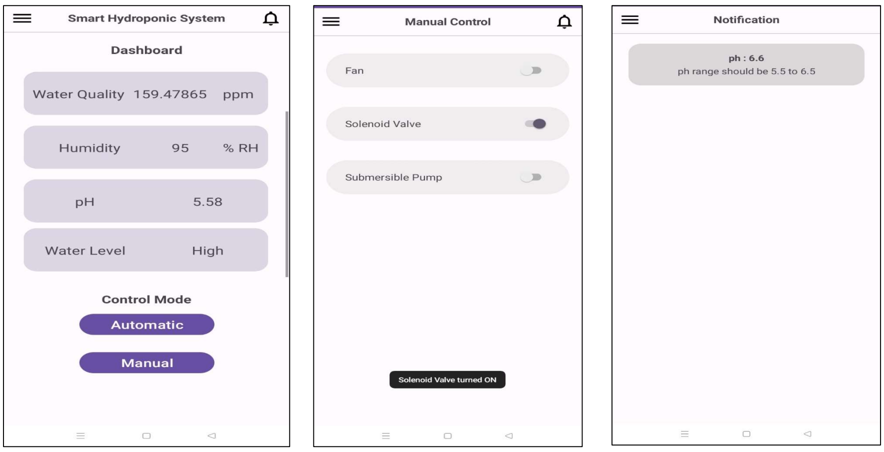

Fig 5.2: Software Application

Results & Discussion

- Upon initiating the application, a registration page is displayed. The users are prompted to create an account to access the application's functionalities.
- For existing users, a login option is available to directly access their accounts. This process ensures that new users can swiftly register while established users can conveniently log in.
- Once logged in, users are presented with a dashboard showcasing readings and values captured by various sensors. This centralized interface provides real-time data visibility.
- Users also have access to a control mode allowing them to seamlessly transition between different operational modes—such as automatic and manual settings.

Results & Discussion

- Upon opting for manual control within the system, users gain access to manual interface, designed for manual mode operation.
- This screen empowers users to directly oversee and adjust essential parameters like the fan, solenoid valve, and submersible pump. By offering this level of control, individuals can fine-tune these elements according to their preferences or requirements.
- The notification screen is pivotal for informing users about system alterations or alerts. This prompt notification mechanism ensures users are promptly informed of deviations, enabling timely action or adjustments.
- This feature emphasizes proactive user engagement, allowing for immediate responses to maintain optimal system conditions within the specified parameters.

Advantages & Applications

Advantages:

- Real-time data analysis and monitoring.
- Based on environmental parameters it will give readings accordingly.(for ex. Monitoring of temperature and humidity).
- Reduces Manual efforts Automation of nutrient delivery, continuous monitoring and adjustment of environmental parameters, efficient resource utilization.
- remote access and control for ease of management, and the potential for increased crop yields and quality through data-driven optimization.
- User can monitor and manage Hydroponic System anytime and anywhere.

Applications:

- Urban farming
- Climate Control in Greenhouses
- Hydroponic Hobbyists

Conclusion

- In conclusion, the integration of IoT into smart hydroponic systems marks a significant leap in agricultural innovation. With data analytics, remote monitoring, AI, and sustainable practices, it revolutionizes cultivation efficiency. Ensures scalability, user-friendly interfaces, and robust security
- One of the key advantages of hydroponic farming is its ability to maximize crop yields in limited spaces. Through vertical farming techniques and optimized resource utilization, hydroponics enables farmers to grow more food per square foot compared to traditional methods.
- This increased productivity not only contributes to food security but also presents economic opportunities for farmers and entrepreneurs.

Future Scope

- Automation and Remote Monitoring
- Improved Crop Yield and Quality
- Resource Efficiency
- Enhanced User Experience
- Integration and Connectivity
- Data-Driven Insights

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APPENDIX VI

USER MANUAL

User Manual

On

"Smart Hydroponic System"

Submitted By

Ms. Yashita Patil

Ms. Shweta Zade

Mr. Lucky Bhure

Ms. Anushka More

Mr. Lakshit Chapre

Under the Guidance of

Dr. Rashmi Jain

&

Ms. Megha Kalorey

Department of Computer Science and Engineering

S. B. Jain Institute of Technology Management and Research Nagpur

(An Autonomous Institute, Affiliated to RTMNU, Nagpur)

2023-2024

1. Overview

With a rising global population and limited agricultural land, hydroponics has emerged as a sustainable alternative to traditional soil-based farming. This paper introduces an innovative IoT-enabled Smart Hydroponic Farming System (SHFS) that employs real-time data monitoring and intelligent control mechanisms to enhance plant growth and resource utilization. The system utilizes a network of sensors to capture crucial environmental parameters such as temperature, humidity, nutrient levels, and pH, providing a comprehensive overview of the hydroponic environment. Its unique feature lies in its adaptability to real-time environmental changes, contributing to the evolution of precision agriculture. This research highlights the transformative potential of IoT in revolutionizing hydroponic farming for future food production.

2. Aim

A smart hydroponic system with IoT aims to revolutionize hydroponic-based agriculture by integrating sensors and connectivity. It enables remote monitoring and control, resource efficiency, data-driven decision-making, automation, and environment sustainability.

3. Objectives

- To be able to provide a better temperature for plants to grow in hydroponic farming.
- To Monitor nutrient parameters in water.
- To Design such an application that gives the user all information regarding temperature, nutrient composition, and recent crop conditions.

4. Proposed Approach

4.1 Registration module:

This will be the registration page for the new user to create a new account by filling in all the details like email, and password to register the user.

4.2 Login module:

The home page of the app Smart Hydroponic System is here the user needs a username and password to log in to the app and in the case of a new user they have a create account option also.

4.3 Dashboard module:

In this module, the user gets the updated values of the parameters like water temperature, temperature and humidity of air, pH of water, water level, and water quality. It also contains a control mode by which the user can control the system in two modes automatic mode and manual mode.

4.4 Manual Mode module:

The module in which the user can manually control the system like the user can on/off the fan, solenoid valve, and submersible pump from anywhere and anytime.

4.5 Notification Module:

In this module, the notification screen is pivotal for informing users about system alterations or alerts. In this instance, the screen indicates that the water's pH level has surpassed the accepted range of 5.5 to 6.5. This prompt notification mechanism ensures users are promptly informed of such deviations, enabling timely action or adjustments. This feature emphasizes proactive user engagement, allowing for immediate responses to maintain optimal system conditions within the specified parameters.

5. Software Requirements

Operating System – Android 9

Modelling and Implementation Tool – Java

IDE – Android Studio

Language – XML,C

6. Hardware Requirements

Microcontroller: ESP32

Sensors**:** DHT11, DS18B20, TDS, Float & pH

Actuators**:** Submersible Pump, Solenoid Valve and Fan

7. Flowchart

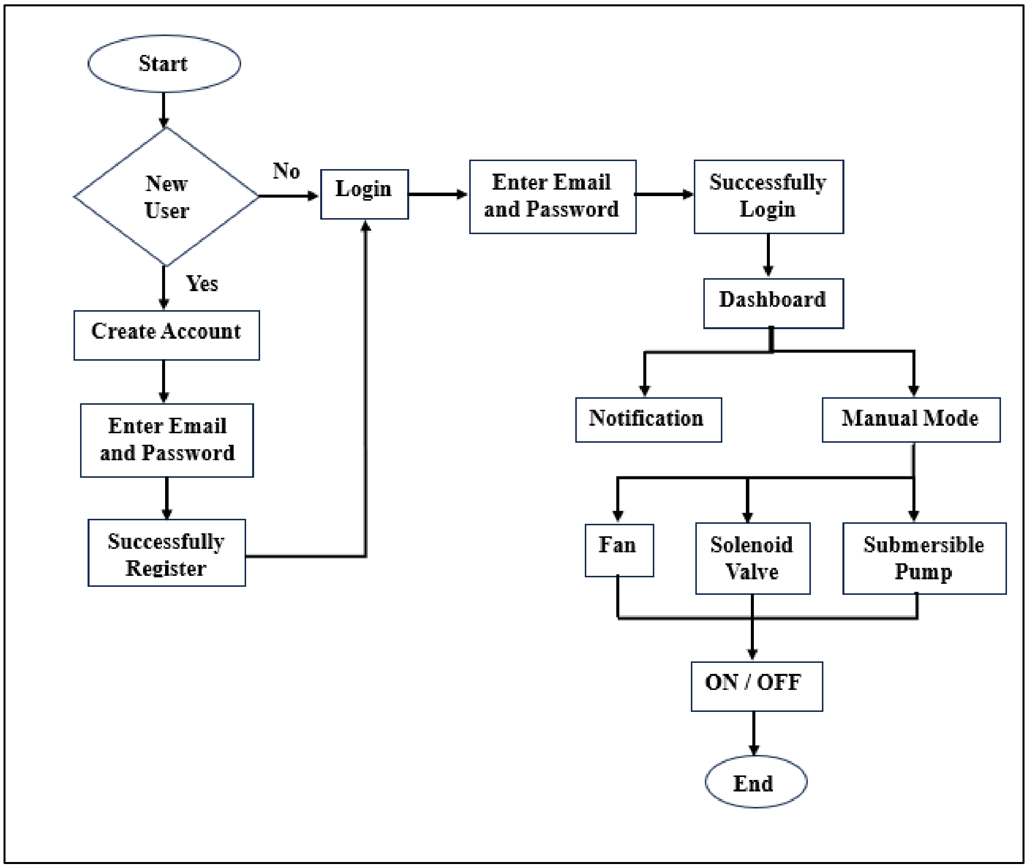


Fig 3.4 Flow Chart

In the project's workflow, the customer assumes the primary role as the main user of the application. Their purpose revolves around monitoring sensor readings and managing different parameters manually according to specific requirements. Additionally, the system is designed to notify the user promptly whenever updates or modifications are made. This feature ensures that the customer remains informed about any changes within the system, allowing for seamless engagement and informed decision-making.

8. Steps to Run the Project

1. **Sign up/ Log in:** The user will start the web application, if the user wants to access, they need to log in through email id and password or if they are a new user, they need to sign up by providing their email id and password. Once the user successfully logs in, they will first get to access the home page.
2. **Dashboard Page:** Once logged in, users are presented with a comprehensive dashboard showcasing readings and values captured by various sensors. This

centralized interface provides real-time data visibility. Additionally, users have access to a control mode allowing them to seamlessly transition between different operational modes such as automatic and manual settings. This flexibility empowers users to tailor the application's functionality based on their preferences and specific operational requirements, enhancing overall usability and control.

3. **Manual Mode:** The module in which the user can manually control the system like the user can on/off the fan, solenoid valve, and submersible pump from anywhere and anytime.
4. **Notification:** The notification screen is pivotal for informing users about system alterations or alerts. The screen indicates that the water's pH level has surpassed the accepted range of 5.5 to 6.5. This prompt notification mechanism ensures users are promptly informed of such deviations, enabling timely action or adjustments. This feature emphasizes proactive user engagement, allowing for immediate responses to maintain optimal system conditions within the specified parameters.

9. Output

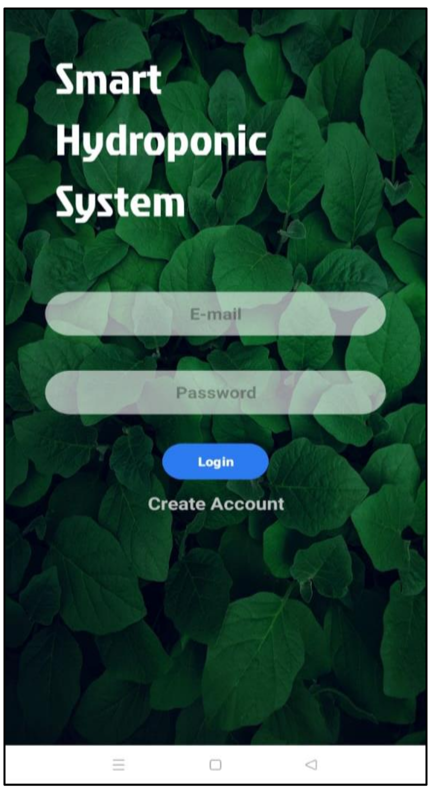


Fig 6.1 Login Screen

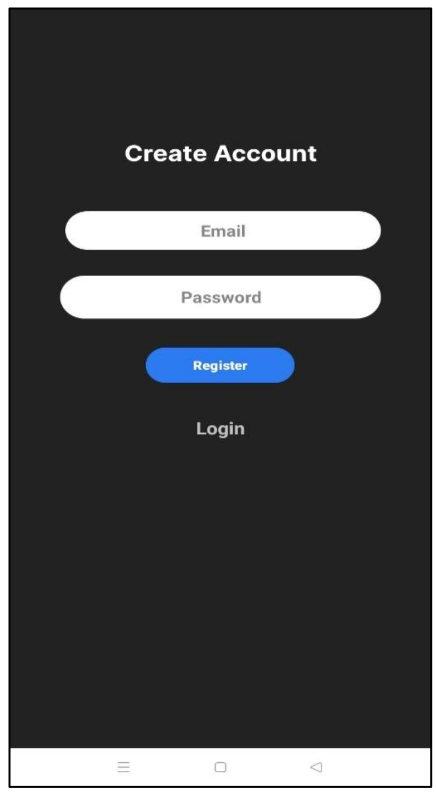


Fig6.2 Registration Screen

Upon initiating the application, the initial interface, depicted in Fig.6.1 and 6.2, is displayed. At this stage, users are prompted to create an account to access the application's functionalities. However, for existing users, a login option is available to directly access their accounts. This process ensures that new users can swiftly register while established users can conveniently log in, streamlining access to the application's features and facilitating a seamless user experience.

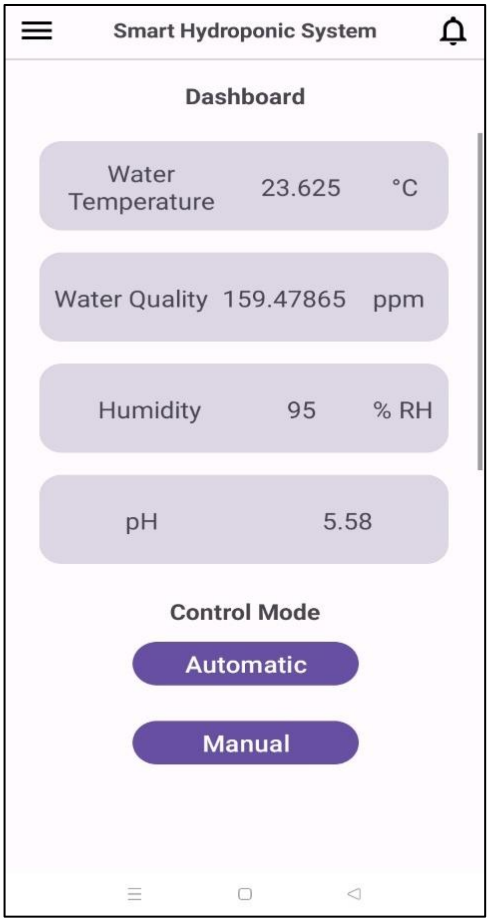


Fig.6.3(a) Dashboard Screen

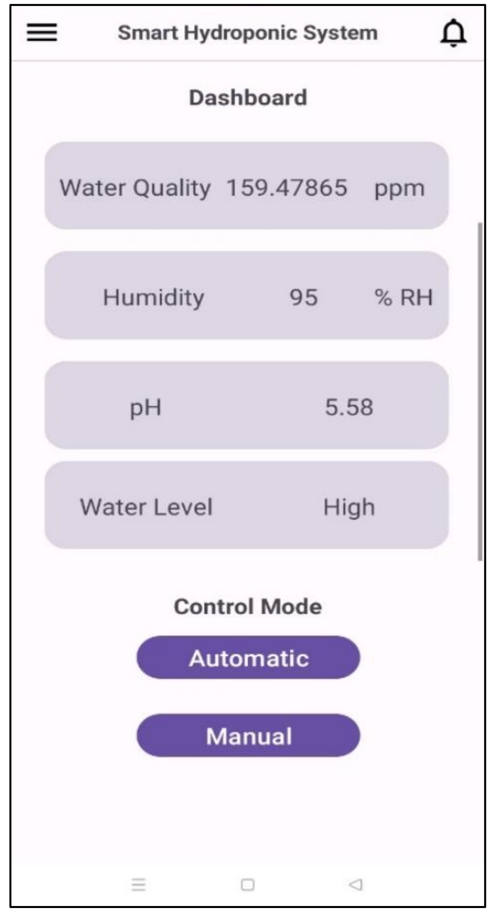


Fig.6.3(b) Dashboard Screen

Once logged in, users are presented with a comprehensive dashboard showcasing readings and values captured by various sensors, illustrated in Fig.6.3. This centralized interface provides real-time data visibility. Additionally, users have access to a control mode allowing them to seamlessly transition between different operational modes such as automatic and manual settings. This flexibility empowers users to tailor the application's functionality based on their preferences and specific operational requirements, enhancing overall usability and control.

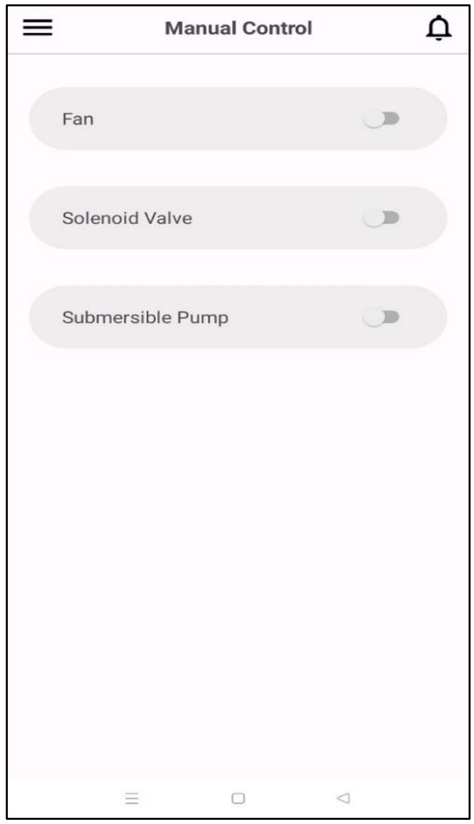
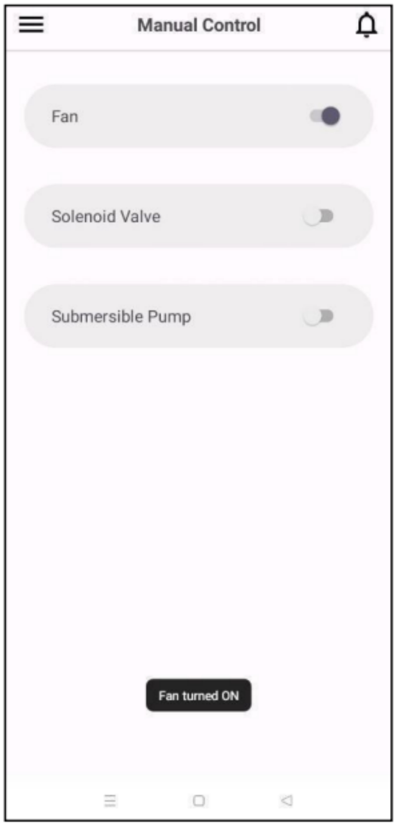
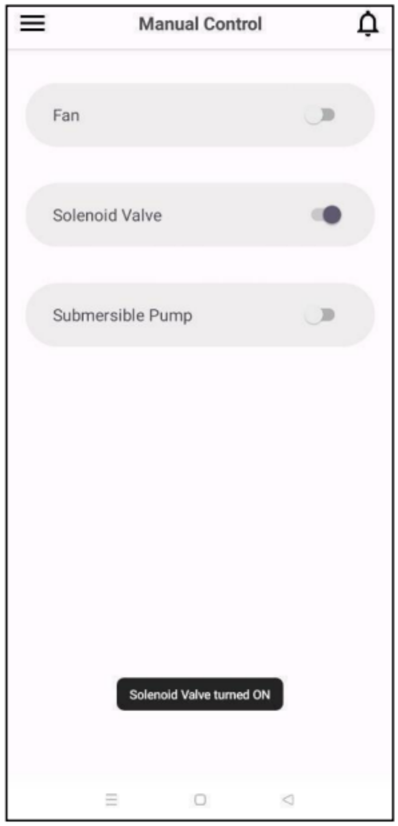


Fig.6.4 Manual Mode Screen

Upon opting for manual control within the system, users gain access to the manual interface as shown in Fig.6.4, specifically designed for manual mode operation. This screen empowers users to directly oversee and adjust essential parameters like the fan, solenoid valve, and submersible pump. By offering this level of control, individuals can fine-tune these elements according to their preferences or immediate requirements. This capability ensures precise management of system components, fostering a more tailored and hands-on user experience within the application.





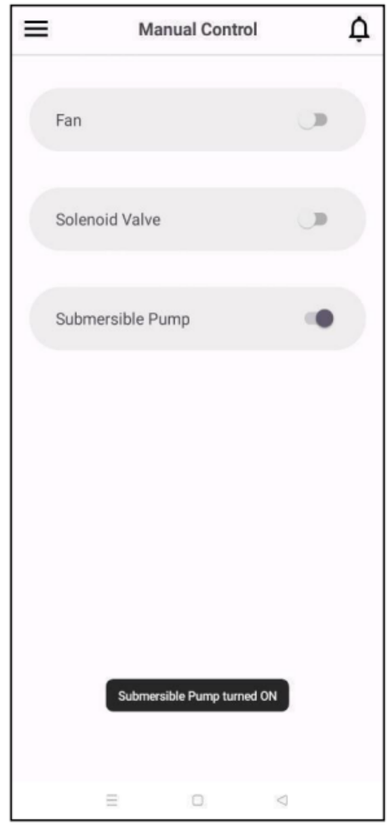


Fig 6.5(a) Fan Turned ON

Fig.6.5(b) Solenoid Valve Turned ON

Fig. 6.5(c)Submersible Pump Turned ON

Fig.6.5(a), 6.5(b), and 6.5(c) depict the manual mode within the smart hydroponic system, illustrating control over different actuators based on user requirements. These figures exhibit the activation and deactivation of various components such as fans, solenoid valves, and submersible pumps, showcasing the user's ability to manage and adjust these elements manually within the hydroponic setup for optimized functionality.

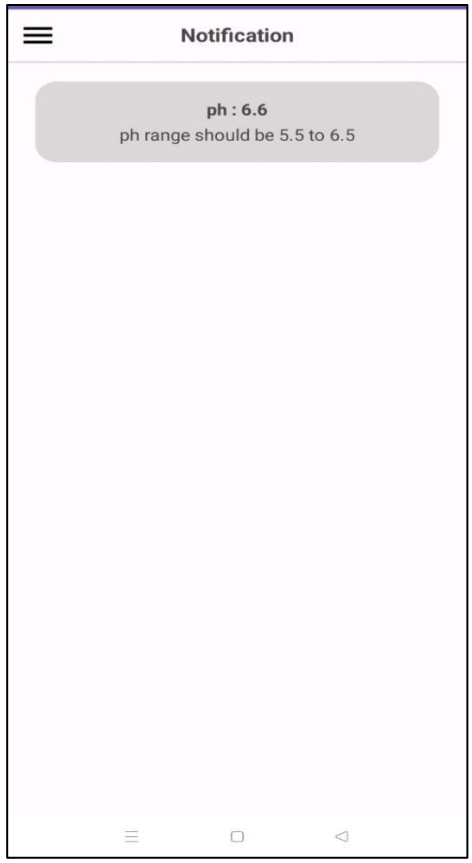


Fig.6.6 Notification Screen

As displayed in Fig.6.6, the notification screen is pivotal for informing users about system alterations or alerts. The screen indicates that the water's pH level has surpassed the accepted range of 5.5 to 6.5. This prompt notification mechanism ensures users are promptly informed of such deviations, enabling timely action or adjustments. This feature emphasizes proactive user engagement, allowing for immediate responses to maintain optimal system conditions within the specified parameters.

10.Project Outcome

CO 1:- Apply: Identify and propose solutions to complex engineering problems of industry and society.

CO 2:-Evaluate: Critically evaluate alternate assumptions, approaches, procedures and tradeoffs to solve engineering problems.

CO 3:-Apply: Apply engineering knowledge for design and development of systems in an ethical and eco-friendly manner as an individual and as a member or leader in diverse team to manage project in multidisciplinary domain.

CO 4:-Analyze: Analyze the system and communicate the inferences with engineers and the community at large in written & oral forms.

CO 5:-Create: Innovate, design & develop systems to address real life problems and engage in life- long learning in continuing professional development.

11.PO and PSO Mapping

CO Code	Program Outcomes (POs)												Program Specific Outcomes (PSOs)	
	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO 12	PSO 1	PSO 2
CO1	3	3	1	1	2	2	1	1				2	3	1
CO2	1	2		3	2	1						2	2	1
CO3	3		3		2	1	1	3	3		3	2	3	2
CO4		2		1						3			1	
CO5		1	3	1	3	1		1		2	2	3	3	3
AVG	2.3	2	2.3	1.5	2.2	1.2	1	1.6	3	2.5	3.5	2.2	2.4	1.7

12. Future Scope

- **Enhanced Sensor Capabilities:**
  Integration of more advanced sensors for additional parameters such as dissolved oxygen levels, nutrient concentration, or light intensity to further fine-tune environmental control and plant health monitoring.
- **Machine Learning Integration:**
  Implementing machine learning algorithms to analyze sensor data patterns over time, enabling predictive analytics for optimizing plant growth conditions and automating adjustments based on learned patterns.

- **Remote Control and Automation:**
  Expanding remote control capabilities by incorporating actuators for nutrient dosing, pH adjustments, or lighting control, enabling more comprehensive automation and customization.
- **Mobile Application Upgrades:**
  Upgrading the mobile application interface to provide a more intuitive and interactive user experience, incorporating data visualization, historical analysis, and setting customization for users.
- **Energy Efficiency Measures:**
  Implementing energy-saving technologies such as smart power management systems, utilizing renewable energy sources, or optimizing system components for reduced power consumption.
- **Expansion to Vertical Farming:**
  Adapting the system for vertical farming setups, enabling efficient utilization of space and scaling the system for increased crop production in limited areas.
- **Integration with AI Assistants:**
  Integration with AI-powered virtual assistants for voice commands, status updates, and personalized suggestions for better system management and user interaction.
- **Collaborative Research and Development:**
  Partnering with agricultural research institutions or universities to explore innovative technologies, methodologies, and scientific advancements in hydroponics for continuous system improvement.

13. Limitations

- Accurate sensor readings.
- An internet connection is required without that you cannot use this application.

14. Achievement Details

- Applied for Copyright