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AUTOMATIC NUTRIENT DELIVERY IOT BASED HYDROPHONIC BY SELF-MONITORING PARAMETER

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ABSTRACT
This paper presents the development of a smart hydroponic system designed specifically for individual households or institutes like hotels, restaurants, hostels, etc. for producing fresh organic vegetables. The aim of developing this system is to get fresh local vegetables rather than buy them from the market. To develop this system Using IoT and sensors with a microcontroller to automate the farming using the Hydroponic technique for smart building agriculture. Parameters like pH, light intensity and humidity, moisture, temperature, and water Tds etc. can be measured with the help of sensors and that data will be sent to the cloud for processing the data If any things are altered like temperature. Ph or other parameters then automatic system will be activated and will manage the parameters by switching the control system.

Keywords:
Future Agriculture, IoT, Hydroponics, Urban Farming, Future Farming

I. Introduction
As per today, [13] world scenario, many people are suffering from many diseases like cancer and others. There are many factors for this suffering. Still, one of the main causes is the food or vegetables that are being consumed or getting from the local market which contains lots of pesticides due to which many people are suffering from diseases. By paying money also people are not getting organic fresh vegetables.[13] Another factor is nowadays the town population is growing rapidly, as demand increases farmers use more fertilizer and more pesticides to grow more vegetables, but also, they don't fulfil the demand requirements. Also, many people in the town area don't get sufficient land to grow vegetables. This paper presents the solution of how every person who has little space in their house also can grow vegetables and get fresh vegetables. Here the solution is developing a such a system which can easily adjust in small spaces, or any corner of the house and that system is a Hydroponic system. But for this system, there is one more problem as in town many people are involved in their business/office purposes so the question is who will control this hydroponic system. Then again, the proper solution is IoT in a hydroponic system. [2] A complete system will be designed in such a way that without the involvement of a person, the system will be controlled automatically by the mobile phone or automatic adjustment system.

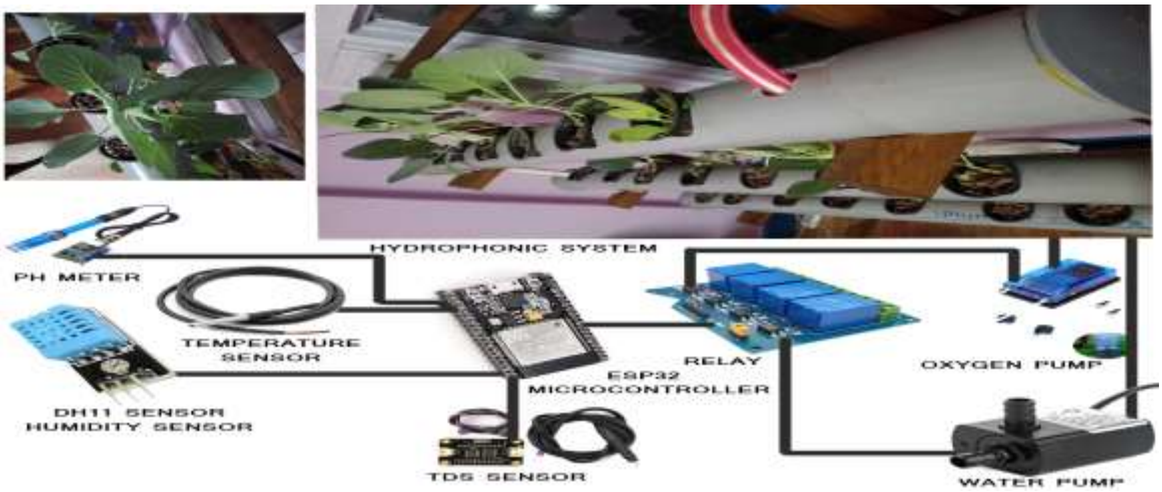

Figure 1: Hydroponic System.

Hydroponic is the technique for growing soilless where macro and all nutrients such as nitrogen, potassium, phosphorus etc. are provided directly to the water solution. This method of growing has various categories such as NFT (Nutrient Film Technique), thin film and flow system. This system / technique doesn't require regular land or using enormous amount of water for cultivation. To develop such system here vertical farming through hydroponic is best which comes under the categories of film and flow system where it is the practice of growing crops in vertically and horizontally stacked layer.in these practices easily can get the crops like herbs, cucumber, tomato, strawberries. and other. This system can be easily adjusted in small spaces where it can get more vegetables. Since day-by-day the fresh vegetable market is growing to fulfill such strong requirement to strengthen the agribusiness market has opened by new effective techniques such as Hydroponics.

Here It is difficult to control the hydroponic system manually because there are several factors that can affect the crops if suddenly changes in parameter like ph. /temperature etc. These parameters to be kept at the required levels are to be done automatic with the use of IoT (Internet of Things), sensors and microcontrollers. Sensors can be used to measure factors that can affect plant growth such as PH level of the nutrient, solutions humidity, temperature, light sensor etc.

Developing a hydroponic system that can produce vegetables for a family. The size of the system will be based on the family's needs, and it will be installed in their house / office / or other suitable space. This system will be connected through IoT, and we will have a central hub to gather data from the hydroponic systems, such as temperature, pH levels, and nutrients, via sensors. This data will also be available on a mobile app provided to the clients.

The app will alert the client if the nutrient levels are low and provide suggestions to add more nutrients. Similarly, if the temperature drops, the app will send an alert with recommendations and support.

The system will also track humidity, light intensity, and water quality. The collected data will help optimize the growing conditions for the plants, ensuring they receive the right amount of nutrients and environmental factors. Clients will be able to monitor the health of their plants in real-time and receive actionable insights to maintain optimal growth conditions. The system will be designed for ease of use, allowing clients to control and manage their hydroponic setup through the mobile app. They can set automated schedules for watering and nutrient delivery, reducing the need for manual intervention. The app will also provide detailed reports on plant growth, helping clients understand how their plants are developing over time. Overall, this IoT-enabled hydroponic system aims to make urban agriculture more accessible and efficient, allowing families to grow fresh, healthy vegetables at home with minimal effort.

II. Literature

[4] Manav Mehra, Sameer Saxena, Suresh Sankaranarayanan, Rijo Jackson Tom, M. Veeramanikandan they concentrated on creating an intelligent IoT-based hydroponics system that uses the latest technologies to control the hydroponic environment completely and more accurately without the need for human intervention. Here, the system recorded parameters like pH, temperature, light intensity, humidity, and level. These are then monitored and evaluated by the results using a Deep Neural Network to forecast the proper course of action for regulating the hydroponic system, which is divided into eight labels.
[2] T C Jermin Jaunita, V. Sarasvathi,M S Harsha , B M Bhavani , T Kavyashree purposed on creation of an indoor farming framework that uses sensors to track the ambient conditions of the plants (DHT11, LDR) and the requirements of the soil. The framework also includes output devices that follow NodeMCU commands, such as an exhaust fan, an inlet fan, and a water pump. To meet the basic demands of plants, the researcher has completed some rudimentary information collection using a few sensors and a few actuators in response to input.
[1] R. Rajkumar and R. Dharmaraj concentrate on implementing the blending of various agricultural kinds. The current method's drawbacks, such as the cultivation of a single crop throughout the system, have been addressed. A methodical strategy has been proposed to control the system's operation. When the plants grown under this approach are compared to those cultivated traditionally, it is discovered that the former develop far more quickly while requiring less nutrients.
[2]. Kuldeep Bhardwaj Komal, "Implementation of Controlled Hydroponics in Urban Infrastructure", goal Controlled hydroponics is a very effective and unique way to achieve both the fundamental goals of achieving food security and environmental protection in urban infrastructure because it allows agriculture to occur even in places where there is no soil, such as waste lands, deserts, polar regions, and constructed areas like houses and apartments. NASA just started using controlled hydroponics on the moon and Mars. Everything points to the controlled hydroponics system as an innovative, intelligent farming method that can preserve humankind's future.
[3] Rajeev Lochan Mishra and Preet Jain, presented the measuring of nutrient solution conductivity was the primary emphasis of this work. The tomato nutrition solution yields result in the mS range. The system's design greatly aids in lowering labor costs and system costs. After measuring the conductivity of a nutritional solution with varying concentrations, the EC initially measured drinking water for reference. The outcomes in both situations are satisfactory. The system is helpful for hydroponic gardening and is small space, cheap cost, low power, and capable of recycling the nutrient solution that the plants have already utilized. To enable widespread use of the system, it must be made more sophisticated, accurate, and economical, which is a challenge that needs to be solved in a future, and hence system become fully automatic by controlling the other parameter such as pH, temperature, light intensity, ambient humidity, oxygen level in water. The designed prototype ensures of high rate of production. This system effectively makes the rural and urban household self-sustained in vegetable consumption.
[7]. Gunaselvi Manohar V. Kamatchi Sundari Antonitta Eileen Pious A. Beno concludes the best conditions for using a hydroponic growing system are those that require careful management of the nutrient medium and the harvesting of undamaged roots for use in other processes. We also show how plant responses to harmful non-essential components and essential nutrients can be induced by varying nutrient concentrations.
[8]. Veena Potdar1, Lavanya Santosh2, Ashwini3, Avinash Manjunath Naik4, Bhavya K R5, Sharath Kumar B S6 conclude that A one-time investment is required to establish the foundation for remote management of the ranch. Automation eliminates the need for ongoing plant monitoring. The greatest method for growing plants without using harsh chemicals that deplete human resources is hydroponic gardening. Additionally, it will be a cutting-edge method of growing healthy, fresh plants without the need for soil. It offers the support required to choose a crop, enabling them to sell products at a fair price.

[13] . Arshpreet a , Annetta P. Reji a , Shilpa Kaushal a* and Shubham research illustrates That complex connection between these two disciplines by closely analyzing the elements of hydroponic techniques and organic concepts. Hydroponic elements—such as materials, fertilizer solutions, and pest and disease control—have been amply shown to be responsive to organic practices. The comparison of organic and inorganic hydroponic systems, which highlights the broader effects of using organic hydroponics, is the review's key point. This study places itself at the forefront of sustainable crop production by outlining the potential benefits of combining hydroponic technology with organic principles. Researchers, experts, and decision-makers were encouraged to look into, create fresh concepts, and further the discussion on organic hydroponics, according to the rates.
[14]. Alexis S. Piscaries, Chelsea Schelly, Laurie Burnham, Joshua M. Pearce. State that In order to meet the world's needs for both food and energy, important land uses must come to complement one another rather than compete with one another. This study represents a proactive endeavor to comprehend agrivoltaics from a solar industry professional's perspective to better appreciate the considerable prospects and development constraints, as social acceptability of renewable energy technologies is crucial to energy transitions.
[15] . Irfan Fajri1 , Mustaqim2 , Rahmad3 present that The system can find out and display data obtained from several sensors that have been installed on hydroponic plants, such as light sensors, Ph sensors, and DTS sensors. . This system can also be used to control or control a four-channel relay that is used to control several actuators installed, such as 1 water pump, and fertilizer pumps, fans, and lights via the website. 3. Even this system has an additional command that is used to control the relay by utilizing the website.

III. Methodology

A. System Design and Architecture

This Hydroponic system is designed to serve small businesses like hostels restaurants and hotels as well as privates' homes. this system is designed to be small and flexible to fit in tight places like rooftops, kitchens and balconies that based on IoT with microcontroller having multiple sensors and cloud connectivity

B. Sensor Integration and Data Acquisition

The system uses several sensors to track important environmental factors, such as:

• pH Sensor: It Determines the nutrient solution's pH level to maintain the acidity or basicity for plant growth.
• Light Intensity Sensor: it tracks light levels to make sure photosynthesis has enough light.
• Humidity Sensor: It Monitors humidity levels to make sure the surroundings are suitable for plant growth.
• Temperature Sensor: This sensor tracks the surrounding air temperature to keep a perfect growing environment.
• Moisture Sensor: This device measures the amount of moisture in the growing media to avoid over- or underwatering.
• Water TDS (Total Dissolved Solids) Sensor: Checks the water's nutrient content to maintain the appropriate feeding for the crops.

These sensors collect data continually, and a microcontroller (ESP32) processes the data give the instruction to the hardware for the adjustment of the values.

C. Cloud Connectivity and Data Processing:

The microcontroller (ESP32) is connected to a cloud server via Wi-Fi, for real-time data upload and monitoring. In Cloud server data will be stored and will process the data on the base of algorithm which enables the remote monitoring and control through the mobile application.

D. Automated Control Systems

The system includes an automated control system for regulating the environment like Nutrient Delivery system which adjusts the nutrients level in the water based on h and Tds reading. Likewise watering system adjust the moisture and adequate hydration based on moisture sensor. And Important is to maintain the temperature of that environment which will be automatic adjust by cooling and heating based on temperature sensor data. The mobile app provides the ability to control manually override the automated system if necessary. Here on the bases of different parameter it will activate the relay and automation

E. Mobile Application Interface

The mobile application serves as the user interface, where user can see the monitoring and control of the hydroponic system. The app gives real time alerts and instance notification for the any issues with historical data. Mobile App also allows the remote control and provides the ability to adjust setting from anywhere.

F. Prototype Development and Testing

A controlled and open environment will be used to design and test prototype of hydroponic to evaluate the usability capacity, dependability and automation to keep up ideal growing for the evaluation. Testing will be on various plant species so that changes to the software and design will be made if any problems found

G. Deployment and Evaluation

After the successful prototype testing, this system will be deployed in the real-world environment like homes and small businesses. The deployment phase will also involve monitoring the system performance over the several months to gather data on its production.

Sensor and Microcontroller working

This system will work based on sensor data and controller to maintain the proper condition of the crops. here key like sensor LM35 for temperature sensor, ph. sensor, humidity sensor, Co2 sensor, TDs sensor, water level sensor, co2 sensor will be used in this sensor. [4] The work of sensor is here lm35 sensor is used for the measurement of the water temperature and DH22 sensor will be used to measurement of environment temperature and humidity. PH sensor is used to measure the ph. of water whether the water is alkaline or basic in nature. A water level sensor measures the water level that is present in the reservoir tank. Likewise, co2 sensor or mq2 sensor used to measure the present of co2 and oxygen level in the environment. Similarly, TDS sensor is used to measure the total particles or electrons present in the water that is measured in ppm which helps to identify the value of solute particles that is present in the water is sufficient for the Growth of vegetable or not. This all sensors will be control by them microcontroller names Esp32 where esp32 send the real time data through the mqtt protocol to the cloud where data processing is happened and again any alter data is happening it send the command from the cloud to esp32 in the form of 0 and 1. Example if the sensor gives the highest value to the cloud, then in cloud data. Then data will be processed and return the command to ESP32 that turn on the motor up to when the temperature value is not normal to the plant. Like this all sensors work with their function that will be defined to the esp32 or cloud.

IV. Future Prospect

Current system focused on monitoring as well as controlling on the basic parameters such as pH, light, humidity, temperature and nutrients level but future development we could expand the system such as Automatic pest control here in this system we will user several organic methods to control the pest. We will also integrate the Artificial intelligence (AI) algorithm to analyses historical data to predict the growth. Also, we will integrate renewable energy sources such as solar panels. Integration with smart city as the cites becomes smarter and more connected this system could include linking with city wide environmental monitoring networks to optimize urban agriculture that contribute to sustained urban development helping cites for reducing carbon and improving food security.

V. Challenges

Initial cost and affordability, primary challenges in implementing a smart hydroponic system are the initial cost of setup as High-quality sensors, microcontrollers IoT Modules and automation system could be expensive. Technical complexity as the integration of IoT sensors and automation requires a level of technical complexity that may be challenges for the users who lacks even for the user-friendly mobile's apps may requires the challenges on troubleshooting issues, and understanding the data provided to addressing these challenges need to provide the ongoing supports or training. Dependency on internet connectivity as for the data transmission remote monitoring and control system depends upon internet so this system may fail but addressing these challenges may require developing the offline functionality for the communication. Environmental factor is also considered as a challenges in this system as this system is influenced by the environment factor such as extreme weather condition, local water quality, power outages, temperature etc. to handle these challenges may require additional sensors, backup power solution colling systems. Energy Consumption, as this system requires 24 hrs. electricity, the energy consumption required to run more sensors, pumps, lighting, microcontroller etc. Required energy these challenges can be solved by reducing the energy consumption features as well as uses of solar power for reduces the power bill.

VI. Automated Nutrient Control System

[17] The system for automated nutrient control system for hydroponic system which contains numerous sensors, data, to control make up an automated system. Data required for this system, nutrients threshold values, and the power system to design an automatic system requires the various sensor and data for the perfect accuracy of system. The system that is utilized by the LM35(linear model) temperature sensors, pH sensor, water level sensor, TDs sensor. Esp32 is used to analyze the gathered sensor data, process it and control the actuators. If Temperature of the environment as well as water sensor the is too high which is detected by the temperature sensor, then cooling fan will be on to maintain the minimum temperature. If humidity is low, the shower will be on by the microcontroller. pH sensor is useful for measuring the acidity or alkalinity of water. Relays are used in this system to control devices like the water motor and cooling fan, Relays are used as a switch to turn on and off the devices that receive Esp32 microcontroller signals. Based on these sensor data microcontrollers give the signal to the relay for turn on and off the data.Fig.1 The algorithm used in the system to define the how system works for balancing the nutrients and Ph value. here we will have the four containers, and each container will be filled with one container with acid, and other container with basic and two other container contains the micro-nutrients and nutrients, respectively. And each container will be fitted with motor pump that motor pump will be fitted with relay and relay relates to esp32, Esp32 process the data given by the sensor like ph. sensor and TDs Sensor based on that sensor value the relay will be on off to balance the ph. and to fulfill the demand of the nutrients required by the plant of the hydroponic.

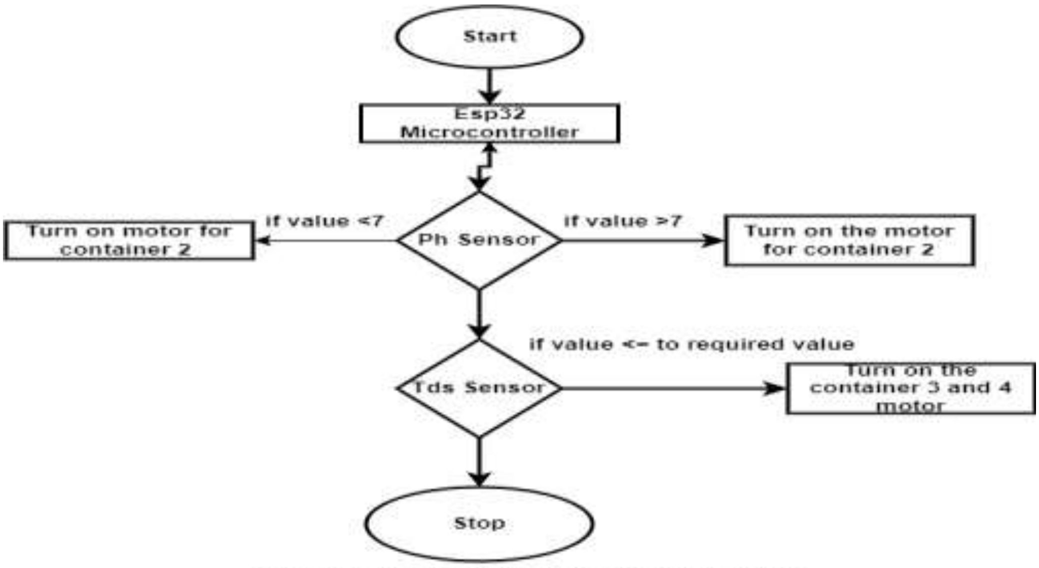

Fig 1: Automated hydroponic nutrient system

Fig : Flowchart of Automatic Nutrients Delivery system .

VII. Parameters Measurement

Parameters	Description
pH: A measure of the acidity or alkalinity of the solution, on a scale of 1 to 14. hydroponically-grown plants prefer a pH of 5.5–6.5. **EC**: A measure of the salts in your system, or the level of nutrients. EC is measured in milli Siemens per centimetre (mS/cm). You should keep EC between 1.2 and 2.0. **Temperature**: The temperature of your plants' root zone. Temperature should be in between 10 deg to 25 deg of the nutrients **Humidity:** Between the range 50% to 70% R.H	Here This is the Average value in which generally system should be adjusted by the sensor or program so that plant can grow well.

VIII. Comparative Study

Nature of System	Parameters Used	Advantages	Drawbacks
A Novel Approach for Smart Hydroponic Farming Using IoT [1].	Internet of Things, Smart Hydroponic Style, Wireless sensor Network	Automation wireless with many feature	-
Implementation of Controlled Hydroponics in Urban Infrastructure.[2]	Agriculture, Hydroponics, Controlled, Encroachment, Urban, Ambitious, Technique, Congested, Environment, Nutrient, Food security	Researched on building 3 step technique to show case how sensors data can be collected, transferred and processed & necessary actions could be taken in NFT based Hydroponics	More number of sensor parameters must investigate with proper data analysis. Tests should be conducted using

		system.	some specific plant only.
Design and Implementation of Automatic Hydroponics System using ARM Processor [3]	pH, Temperature, Liquid level, light intensity	Inside of microcontroller uses Arm processor for the connective and processing	Low consideration of parameters.
IoT based hydroponic system using deep learning networks [4]	application entails the control of sensors for the hydroponic setup for various sensors including temperature, humidity, and ambient lighting. Another advantage of the application is for appropriate planning, timely managing and proper harvesting data recording for the crops. This information recorded from sensors are stored in the Cloud.	developing an intelligent IoT based hydroponics system where intelligence deployed at the edge for controlling hydroponic environment autonomously without the need for human with better accuracy.	Costly, required skilled manpower, highly data need for tanning.
An Automated green house system using agriculture internet of things better crops yield [5]	Light intensity, Water Temperature, EC , pH. Image processing-based algorithm	Development of framework for indoor farming in which plants environmental condition (DHT11, LDR) and Soil requirements are monitored through sensors. The framework also has output devices like Exhaust fan, Inlet fan, water pump which responds as per instructions of Nodemcu	More number of parameters has to investigated with proper data analysis.
Fully Automated Hydroponic System for Indoor Plant Growth [6]	pH, Temperature, Liquid level, light intensity	Renewable energy used	Low consideration of parameters.

Cost Effective Ec And pH Measurement	EC & pH sensors data is collected for Hydroponic plants.	Researched on use of industrial graded EC & pH sensors [DFRobot analog EC and pH meter]] with accurate results and measuring ,recording and analyzing data on Mind Sphere.	The analysis work is not explained.
Different methods of hydroponics like drip system, deep water method etc.	Temperature , Humidity, Water level, pH	Used for places where farming is difficult.	Can be integrated with machine learning.
IoT based automation of Hydroponics with Node MCU [7]	Turbidity, Humidity, Light Water, pH,Flow , Moisture	Can carry out investigations due to stockpiling and saves a lot of water.	
Automatic Hydroponic System integrated to agriculture curriculum [8]	Turbidity, Humidity, Light Water, pH,Flow , Moisture	Fully Automatic agricultural system.	
Automatic monitoring aeroponics irrigation system based on IoT and Raspberry Pi [9]	Humidity , Water,pH, Temperature Light Water, pH,Flow	Conserves energy and water since its fully automatic	Cost of investments

IX. System Architecture

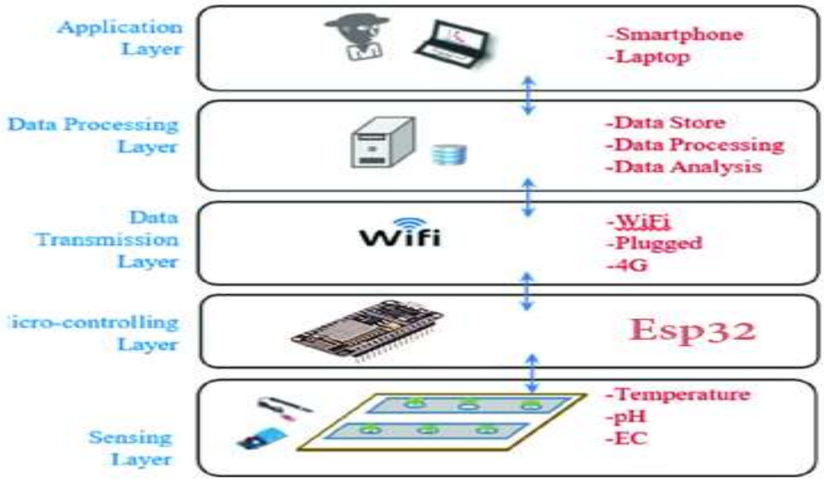

Fig: System Architecture

In the System architecture there are five layers, each layer have their own important, starting from the first layer where there is sensing layer, This layer involves various sensors (e.g., temperature, pH, electrical conductivity (EC), and camera) that collect real-time data from the hydroponic system and from the environment and controlled by the second layer called micro controlling layer it control all the sensor and hardware .micro controlling layer is connected with Data transmission layer which facilitates the transmission of data from the microcontrollers to the processing layer through communication channels such as Wi-Fi, plugged connections, or 4G networks. After when data is transmitted to the server for data storages and data processing into actionable insights .and top layer is application layer which allows users to interact with the system via smartphones or laptops, providing a user interface for monitoring and controlling the hydroponic setup remotely.

System Working process

i. Real-time Monitoring
ii. Continuous data collection from sensors
iii. Data Processing
iv. Analysis of moisture, minerals, pH, and temperature
v. Alert Mechanism
vi. Notifications to users via mobile apps in case of discrepancies
vii. Automated Adjustments
viii. Automatic nutrient and water delivery based on sensor data

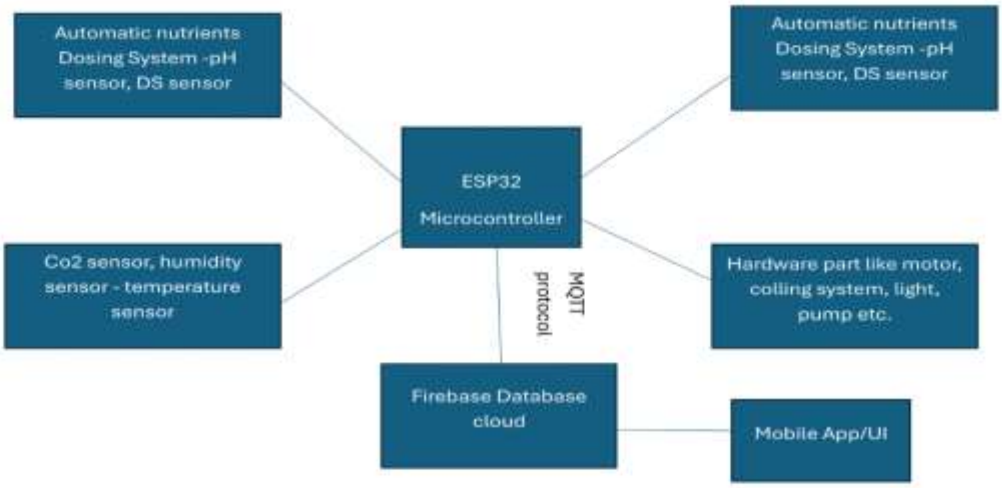

Fig: working framework

X. Conclusion

The system will be designed for ease of use, allowing clients to control and manage their hydroponic setup through the mobile app. They can set automated schedules for watering and nutrient delivery, reducing the need for manual intervention. The app will also provide detailed reports on plant growth, helping clients understand how their plants are developing over time. Overall, this IoT-enabled hydroponic system aims to make urban agriculture more accessible and efficient, allowing families to grow fresh, healthy vegetables at home with minimal effort.

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