Internet of Things based Smart Aquaponics Plant Monitoring System

RAGINI SHARMA[1], ADITYA KHANDARE[2], INTHIYAZ KHAN[3], CHANDANI MOURYA[4]
[1] *Professor, Department of Information Technology, Saraswati College of Engineering, Kharghar*
[2, 3, 4] *Student, Department of Information Technology, Saraswati College of Engineering, Kharghar*

Abstract*— A vast fraction of the population of India considers agriculture as their primary occupation. Producing the maximum amount of crops is an important thing in our country. For crop growth, it is essential to measure the level of nutrients present in the soil mixture. The proposed system of IoT-enabled soil testing is based on measuring and observing soil parameters. This system lessens the chances of soil degradation and helps to maintain crop's health. Different sensors such as pH and soil moisture are used in this system for monitoring temperature, humidity, soil moisture, and soil pH along with color sensors for NPK nutrients of the soil mix. The data sensed by these sensors is stored in the cloud and analyzed based on which suggestions for the growth of the suitable crop are made. A digital system is also created which gives information about the fertilizer(s) required for their crops. The purpose of this project is to make a steadfast system through creating an aquaponics system using the concept of internet of things. By creating an automated aquaponic system with the use of interface sensors with the Arduino, we can monitor the fish feed intervals, supply of water to plants at periodic intervals.

Indexed Terms*— Crops, IoT, Sensor, Aquaponics, Reading.

I. INTRODUCTION

Aquaponics is a system that is a combination of aquaculture (breeding, raising, and harvesting fish, shellfish, and aquatic plants) & hydroponics (a part of hydroculture that revolves around the cultivation of plants, usually crops, without the soil, making use of nutrient solution in an aqueous solvent) in one aquaponic system. The aquaponic model should consist of water filtration systems, water storage tanks, fish tanks, sensors for regulating various parameters, and an adequate piping system to facilitate the transfer of water from one section to the another.

It uses Fish's which contains nitrogen and minerals to provide important nutrients for the growth of the plants and in return, the plants will absorb the minerals, nutrients & nitrogen and purify the water, and give it back to the fishes.

The nutrients will further aid the water purification process, since this liquid will be fed into the plants section of the aquaponic model. We have installed filtration tanks in other parts of the system too to make sure water is constantly filtered.

The ultimate goal of this project is to make an steadfast system by creating an aquaponics system using the concept of IoT (Internet of Things). By creating an automatic system of aquaponics with the use of interface sensors with the Arduino board & Raspberry pi, it is possible to monitor fishes and supply of water to the plants at regular timed intervals.

II. LITERATURE SURVEY

[1] This task incorporates numerous highlights like temperature detection. And also controlling utilizing a heat source and cooling fan. Along with that the discovery of pH in water utilizing a pH sensor. And a siphon for cleaning and also re-coursing the water. The proposed system initially differentiates the parameters of water by making use of multiple sensors. We were utilizing a PIC 16F877A microcontroller. Where the information will be contrasted and an ideal scope of the particular parameters. At that point, if the features are lower or upper than the ideal range then required tasks will be done in a similar manner. Another approach called the Internet of Things (IoT) jumps over any barrier between the physical world and the computerized world. In this aquaponics observing framework, with the utilization of IoT, the webserver persistently shows the estimations of the parameters and data.

[2] Traditional farming and fishkeeping have enabled human populations to produce foods, but as communities grow though, less and less agricultural and farmland is available. Also, due to change in climate, producing crops continuously is a difficult thing to do. Aquaponics addresses these concerns. Aquaponics is the mix of aquaculture along with hydroponics in a single system. The purpose of this study is to create an automatic aquaponics system using Nile Tilapia, Romaine Lettuce with access and control of pH level and temperature using the concept of IoT. Intel Edison is used as the microprocessor which continuously sends information about the aquaponics' status and adjusts them if the parameters fall below their optimal levels. The whole system can be checked with the use of an Internet Protocol camera.

Weekly comparison of the growth of the plant and fish in automated aquaponics, and traditional fish keeping and hydroponics are done and growth in the automated aquaponics is significantly greater than its traditional alternative.

[3] Aquaponics is a technique which mixes aquaculture along with hydroponics, growing fish and plants each in a single system. It uses fish excreta to give important nutrients to plants, hence, in exchange, the plants will purify the water and give it back to the fishes. The scope of this paper is to make an steadfast system by creating an aquaponics environment by using the concept of IoT . By creating an automatic environment of aquaponics with the use of sensors interfaced with the Arduino, it is necessary to make an automatic fish feeder and supply of water to the plants at regular intervals. Present system combines these technologies and must overcome fundamental issues like cost of plants, food's quality, and growth being limited. In this paper, we have intended to create a kit that has all the features we have told above, and is useful to give the vegetation for the house.

[4] The ideated smart, sustainable house aquaponic environment has lots of sensors, actuator, and a microcontroller with stable internet connection to monitor and limit, to keep track of tank water and air quality. Growth of fish, plants is made sure by sending a warning beforehand to a person in the erratic conditions by phone notification in a feature-rich internet of the things mobile application.

[5] In this paper, we have projected aquaponics in a new light that would require only very minimal manual intervention and yield great results with the help of technology. Here they have made use of wireless sensors to identify and monitor the parts of the ecosystem that would require manual intervention, automate the process thereby resulting in a sustainable system.
Using various techniques and to propose a novel automated aquaponics system with all

[6] An agricultural irrigation technological development that is worth saying is the aquaponic process that is their ideation in this report. With ample amount of light and temperature along with humidity changes of the plant, it will be well suited to be put into indoor areas. Agricultural concept ideation with aquaponics is using the knowledge of the IoT since the data from sensors and limit actuator readings can be seen by softwares installed on phones from remote areas with just an active Internet. Agricultural concept ideation with inhouse aquaponic irrigation technology gives an option for someone who has no area for farming but still conducts business transactions which can give the farmer a source of livelihood. The irrigation processes applied to aquaponics are very averse from traditional farming processes. Hence, using this concept of the Internet of Things has more pros as opposed to traditional farming.

[7] The goal of this research paper is to show how we can build an steadfast Internet of Things model in aquaponics to make an autonomous and independent system with the use of an Wireless Sensor Network. The standard of WSN which is called 6LoWPAN is preferred in this model that helps us to make an all round aquaponic model which is systematic in nature.

[8] Goal of this paper is to understand the existing aquaponics systems implementing the necessary requirements and very less human intervention with the system. The technique for this project used is IoT which has automated fish feeding at regular intervals of time, automated water supply to the plants is done by using GSM.

III. PROBLEM STATEMENT

Nowadays multiple factors go into growing agriculture successfully. But alas, there were too many issues are there which affect the growth of the crops like soil erosion, droughts, limited land, etc., resulting in famine, reduced ability of the soil to store water and nutrients, loss of newly planted crops, etc., And because of that farming has become a tough task for farmers in India, who form 60% of the total population suffers a lot due to this. To overcome the drawback modern farming methods like organic farming and vertical farming were used but they were not able to keep the sustainable agenda. The methods need a constant amount of resources which can lead to the depletion of natural minerals.

IV. DETAIL OF HARDWARE AND SOFTWARE

Hardware Requirements –

- Raspberry Pi:

The Raspberry Pi is a very cheap computer that runs Linux, but it also provides a set of GPIO (general purpose input/output) pins, allowing you to control electronic components for physical computing and explore the Internet of Things (IoT).

- Arduino Nano:

The Arduino Nano is a tiny, breadboard compatible board based on the ATmega328P made public in 2008. It gives the same connections and specifications as the Arduino Uno type in a much tinier form.

- Ph sensor:

Helps to measure the acidity or alkalinity of the water with a value between 0-14.

- DHT11 sensor for temperature & humidity:

The DHT11 sensor is used to determine the surrounding temperature and humidity.

- Water level sensor:

Water Level sensors are used to detect the level of the water.

- Water pumps:

Water pumps are mainly used to transfer the water from lower levels to higher levels in a water tank.

- White LED Light:

LED lights are very efficient and capable of producing the type of light needed by plants.

- Fan:

The fan is used to remove the moisture and hot air from the room.

V. BLOCK DIAGRAM

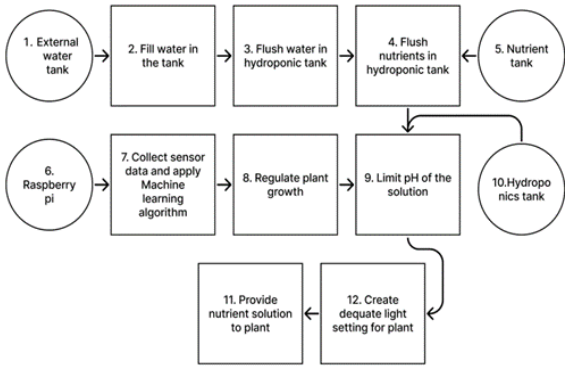

Fig 1. A structural flow of the system

1. The aquaponic system needs to be provided with an external water source in order to perform its core tasks.
2. This water source will be stored in the water storage tank which has a series of connections with other storage tanks.
3. This water from the storage tank is transferred to the hydroponic tank.
4. This hydroponic tank is provided with some essential nutrients.
5. These nutrients are supplied by the nutrient tank which consists of minerals and carbohydrates for the plants.
6. In order to regulate and monitor the sensor connections, and raspberry pi is connected to the sensors and the serial monitor.
7. All the core monitoring factors such as temperature, pH etc are taken and an ML algorithm is performed, which is not detailed in this research paper.
8. The actions for the tanks are then regulated manually or automatically based on the readings.

9. First of those is pH regulation, since this water will be sent to plants, it has to have ~7 pH value.
10. The contents to this pH regulation are provided by another hydroponics tank which consists of nutrients which can change the value to safety.
11. This nutrient and pH regulated solution is provided to the plant.
12. The plants also need good lighting which can be regulated by the white spectrum LED lights.
13. As seen in the above descriptions of the images, there are various components which have been attached to the system. These circuits and structures have been modeled in such a way that it provides the system with best ergonomics.

VI. WORKING

Aquaponics is a process that mixes aquaculture, hydroponics which help in growing fishes along with plants together in a single model. It makes use of fish excreta to give important nutrients to plants which in exchange, will purify the water and give it back to the fishes. The aim of this research paper is to make an steadfast system by creating an aquaponics model using IoT. By creating an automatic model with the use of interface sensors with the Arduino board and raspberry pi, it can be made sure to make the fish feeder and supply of water to the plants at the periodic intervals of time automatic. Traditional systems that mix these processes should solve key problems like costing of plants, and food quality. In this paper, we plan to design a model that has all of these mentioned features, those are helpful to give the basic inhouse vegetation for the house.

The different components in it are:
Biofilter tank: It receives the water from the fish tank, which is now toxic with fish excreta. This tank will clear the waste and extract the ammonia which will be used to nutrify the plants. Storage tank: Before releasing the water from the biofilter tank, and into the plant system, we need to regulate the pH values, since high or low levels which aren't in the range of 5.5 to 7.5 will need to be controlled. Once the liquid is in that range, we can proceed to slowly share it with the plants. PVC pipes: These plastic pipes will be used to transfer all the water from one tank to the other, and from the plant system to the plant watering system.

Arduino: All the data coming from the respective sensors are in analog signals. But for sending this data and processing it, we will need to convert it to digital using serial communication.

Raspberry pi: This device is used to take i/p, give o/p, process and convert the data coming from the sensors and store it. This raspberry pi is connected to all the sensors which help in streamlining the whole process.
LED: These lights are used to check the feedback coming from each sensor, in case of issues they can be resolved easily.

Plants: We will need to check which plants are suitable to grow under indoor conditions, i.e., the plants which don't need many conditions to be grown easily. We are using Stevia and Indian ginseng here.

VII. RESULTS

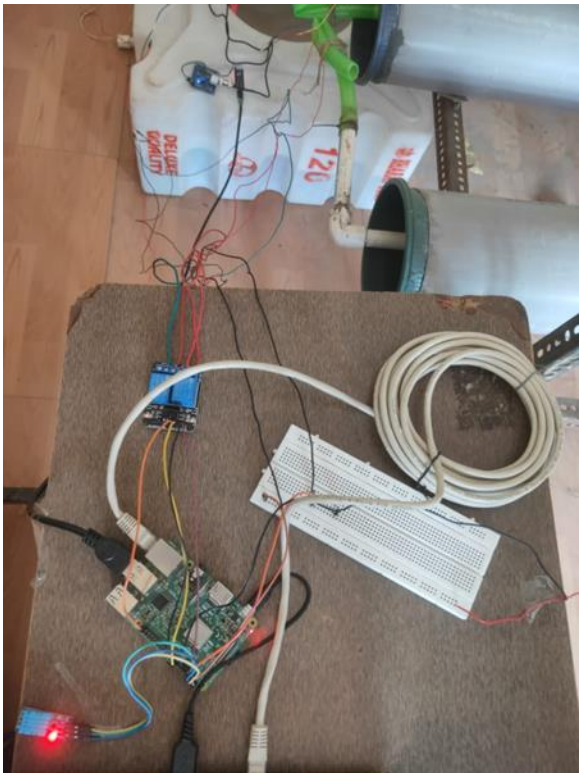

Fig 2. Sensor hardware setup and wirings

Many components such as Arduino, raspberry pi module, breadboard, wirings, etc can be seen here in this physical setting.

Aquaponics

pH Value	Temperature	Humidity	Water Level
35	41	7.08	100%
34	41	7.07	100%
35	41	7.10	100%
35	40	7.09	100%
35	40	7.09	100%
35	40	7.08	100%
35	40	7.09	100%
35	40	7.07	100%
36	41	7.08	100%
36	41	7.06	100%
35	40	7.10	100%
35	40	7.09	100%
36	42	7.07	100%
36	41	7.06	100%
35	40	7.09	100%
36	42	7.07	100%
35	41	7.07	100%
36	41	7.08	100%
36	41	7.06	100%
36	41	7.06	100%
36	41	7.07	100%
36	41	7.07	100%
36	41	7.12	100%
36	233	7.08	100%
36	41	7.06	100%
36	41	7.11	100%
36	41	7.07	100%
36	41	7.08	100%
36	41	7.06	100%
36	41	7.07	100%
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35	41	7.06	100%
35	41	7.06	100%
35	41	7.06	100%
35	41	7.06	100%
35	41	7.06	100%
35	42	7.10	100%
35	42	7.07	100%
35	42	7.06	100%
35	42	7.07	100%

Fig 3. Sensor data collected on computer

The data which is generated by the pH sensors, temperature, humidity sensors, water level sensors are given to the system for inspection, regulation.

Fig 4. Aquaponic structural design

The seen structure is the actual 7 foot Aquaponic model consisting of plants, tanks, lighting, fishes and sensor connections.

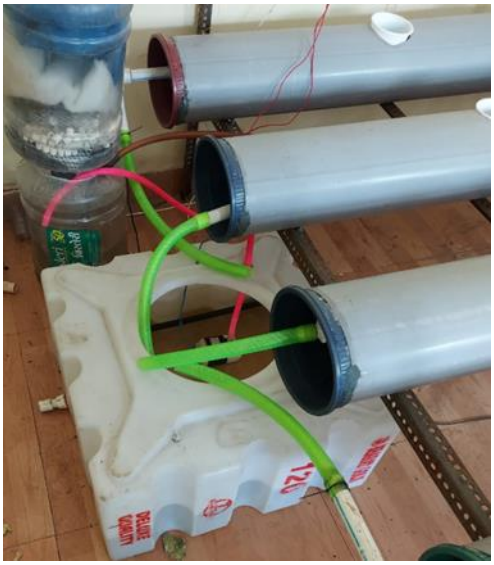

Fig 5. Filtration system in the tank

The Biofilter tank helps in purifying the water which is to be fed to the fish. With that is the actual fish tank with excreta.

Fig 6. Plant germination at early stage

The plants Stevia and Ashwagantha were used here, which can be seen in their germination stage, which is essential for their growth in the long run.

VIII. CONCLUSION

There are many different ways to fix the issue of food security, but certainly, aquaponics is the most environmentally friendly and efficient way of farming and conserving water, that could easily ensure the needs of all people and suit all climates around the world. This aquaponic model is not only sustainable, but can also be used to perform rain water harvesting on rainy days. This rain water collected can be recycled, purified and used for continuous usage in the whole aquaponic system As we see the above execution of our project, we are almost checked every possible design for the aquaponics model and selected the best one, calculated the necessary amount of components required for making the project and finalized the components, finalized the plants so we can make our project fully automatic and can increase the productivity and growth of plants and fishes.

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