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Survey on Aqua Robotics Urban Farm System

***Vinutha Raju*[1], *S. Yashaswini*[2], *K. Panimozhi*[3]**

[1]Department of Computer Science and Engineering, B M S College of Engineering, Karnataka, India
[2]Department of Computer Science and Engineering, B M S College of Engineering, Karnataka, India
[3]Department of Computer Sciences and Engineering, B M S College of Engineering, Karnataka, India

Corresponding Author: vinu.raju.in@gmail.com, Ph.no.: +91 89047 70901

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Abstract— Aqua Robotics Urban Farm System is an energy efficiency and cost effective way to grow plants, vegetables or flowers using natural process without soil and external nutrients. Aquaponics system is developed by fish and plants in a cyclic system. There are six goals to achieve, our first goal is to automate fish feeder this is possible with the help of a sensor called servo motor. Second goal is to supply excretion of fish to the plants through regular water supply. And this water contains all necessary nutrients that plant can need. Third goal is to use led grow lights instead of sunlight because this an indoor plant farming. Forth goal is to replace the dirty water in aquariums every three months automatically based on PH value. Fifth goal is to upload the sensed data to the Blynk cloud, an IOT analytics platform service that enables us to connect devices whether they are powered by Blynk modules or by other modules. By cloud information we are able to analyze data which in-tern helps in maintenance of an aqua system and also growth of fish and plants. And retrieve those data using telegram bot as a front UI. Sixth goal is to maintain the temperature of water in the aquarium. Our responsibility in this project is achieving all these six goals.

Keywords— *aquaponics, hydroponics, IOT, blynk cloud, zoho analytics, robotics urban farm system [RUFS].*

I. Introduction

The objective of an aquaponics system is to make the plants grow in a natural way to produce food for humans. Aquaculture and hydroponics combined together forms an aquaponics system. It is a robotic urban farm in which the work of a person is done automatically or controlled by a computer. For this automation to happen IOT is best platform to implement.

The excretion of fishes is used as a nutrients for plants and hence there is no need to add external fertilizers. The plants are grown without the help of soil. Thus there is no need of soil. This aqua RUFS is an indoor as well as outdoor system. Instead of sunlight we can use led grow lights for indoor plants. Photosynthesis is also possible with led grow lights. The water transferred to plants are again transferred back to aquarium tank and this is possible by supplying water automatically and filtering. We are also using sump tank i.e. backend water tank, which is used to replace the dirty water in the aquarium every three months. This automation is possible by using IOT components and data analyzed in cloud. The main goal is to analyze the water levels, plant growth, progress of the system, percentage change in the total measurements. So overall process is automate the things that results in self-farming system.

II. Related Work

Wanda Vernandhes, N.S Salahuddin, A. Kowanda and Sri Poernomo Sari [1] proposed that their project is based on aquaponics agriculture technique. They tells that for indoor aquaponics system light, modifications of temperature and humidity in plant is well suited. They also tells that their project used Internet Of Things (iot) technology so that the sensed information from sensors are accessed through smartphones using internet connection and the iot concept has more advantages when compared to traditional farming

Sazali Mahmud, Shuhaizar Daud, Muhamad Asmi Romli, Phak Len Eh Kan and Zahari Awang Ahmad [2] described that their project shows how to control and regulate water in grow bed of an aquaponics with help of fog server. The layer between device and cloud is a fog server. It gathers real time data, they also insist that modern agriculture need to include real time data assessment device. They have implemented by using fog server and in cloud only selected data are uploaded and other remains in fog server itself.

Fareed Ismail and Jasson Gryzagoridis [3] proposed that their project is based in modular solar powered aquaponics system that used photovalvic for the generation of electronic and solar thermal energy to heat the environment of aquaculture unit.

K S Aishwarya, M Harish, S Prathibhashree and K Panimozhi [4] proposed that their system uses Internet of Things (iot) technology, with the help of sensor and arduino board they have automated fish feeder and water is supplied automatically to the plants. As a result by creating an automated aquaponics system. Their purpose was to develop a tool that includes automated aquaponics system that had automated features.

Sandhya Baskaran, N. Hari Kumar, Sanjana Hariraj, and Vaishali Krishnan [5] describes that their purpose was to show and build an iot application for aquaponics system that it is on self-regulating system using wireless sensor network. For wireless sensor networks they have used 6lowpan to build a network infrastructure. An end to end system is proposed in their paper which includes WSN by enabling connected aquaponics.

Adrian K. Pasha, Cecep Hidayat, Edi Mulyana, Muhammad Ali Ramdhani, M. Adhipradana and , Opik T. Kurahman [6] insist that monitoring of water temperature and pH value in aquaponics system is the main purpose of this paper. To do this they have used web socket framework to make system running in real time and data is collected by two arduino devices. For web servers and gateway raspberry pi is used to access web interface.

Megumi U. Leatherbury [7] tells that she, her clients and Japanese company helped her in implementing the VEGILAB plant. She also tells that VEGILAB is nothing but an indoor system in which vegetables are grown using led lights. And her project is an integration of aquaponics system and VEGILAB in which it can be used at home and industries as well.

M.N. Mamatha and S.N. Namratha [8] states that the growth of fishes and plants depends on light, temperature and fish wastes. For the plant growth all the required nutrients should be fed to the fishes so that those nutrients should be absorbed by the plants. Automatic fish feeder was their main technique and water is purified by removing waste products and unwanted materials, they have used filter system. Arduino board that receives sensed information and actuators reacts based on those received information.

Armand Shahbazian, Shiny Abraham, Phillip Thompson, Kevin Dao, and Han Tran [9] states that aquaponics is a combination of hydroponics and aquaculture. The demand to develop monitoring water quality techniques is created when the bond between bacteria, fish and plants. They also tell that the work is focused on Internet of Things (iot), sensor and real time systems that are indicated on a graphical user interface (gui). To visualize and analyse data they have used Thingspeak.

Ralf Biernatzki and Rolf Meinecke [10] Proposed that their paper focused on concepts on closed greenhouse with thermal energy system. Their main aim was to develop a prototype aqua system at coal mine so that they can use mine water for heating aquaponics system. By doing this they can improve energy balance.

N. S. M. Fadhil, M. F. Saaid, M. Z. H. Noor and M. S. A. Megat Ali [11] states that the growth of fishes and plants depends on light, temperature and fish wastes. For the plant growth all the required nutrients should be fed to the fishes so that those nutrients should be absorbed by the plants. Automatic fish feeder was their main technique and water is purified by removing waste products and unwanted materials, they have used filter system. Arduino board that receives sensed information and actuators reacts based on those received information.

Cesar Mendoza, Analene Montesines Nagayo, Rodrigo S. Jamisola, Raad K. S. Al Izki, and Eugene Vega, [12] states that their paper focuses on creating solar powered automated aquaponics system. Its main purpose is to achieve four goals. First goal was circulation of water to aquarium tank by beds. Second is to control and monitor aqua system using sensors, actuators with the help of arduino board. Third goal was to convert solar energy system. Fourth goal was cooling and heating of air and water that helps to grow plants and fishes.

M. Manju, V. Karthik, S. Hariharan and B. Sreekar [13] proposed that their system consisted of continuous monitoring of water quality using sensor. The information sensed by sensors are accessed and for continuous monitoring purpose iot technology is used. And that helps in reducing human intervention that results in system efficiency. Thus iot has more advantages than traditional farming.

P. C. A De Silva and P. C. P De Silva [14] had introduced soil less food production system, their main objective was to create and design a coordinated system in which data are collected and control water quality. They have introduced big data analysis and for water quality control they have used controllers of fuzzy logic.

P.J. Mahesh, Minhas Naheem, Razak Mubafar, S Shyba and Sunitha Beevi [15] states that their main was to genetically enable to farmers the modified crops to excellent yield through biotechnology. They stated that that was the reliable way for organic farming and also makes new breakthrough.
J. F. Garcia-Rejo, M. I. Nieto-Ramirez, M. V. Oviedo Olvera, M. M. Tovar-Ramirez and A. A. Feregrino Perez [16] describes that their objective was to use salicylic acid application to differentiate compounds of phenolic, flavonoids and antioxidant activity. They compared with fertilizers and aquaculture residuals in two times every 14 days. The results showed 0.5 SA increased when plants were grown using fertilizers. With 1.0 SA Flavonoids was increased in plants. Thus plants grown using aquaculture had less SA, so plants grown in aquaponics system was the best.

Harry Goldstein [17] proposed that using aquaponics which combines aquaculture and hydroponics. They stated that indoor fields of greens will feed thousands of fishes and plants will be fertilized by the excretion of fish wastes so nothing goes wastes.

III. PROPOSED SYSTEM

To propose an analytical and robotic based aquaponics system that includes all the required demands and with less intervention of human, Internet of Things Technology is used as the key technology. By using this technology the implementation of regularly feeding of food for the fishes and automatically water is supplied to the plants. We also use grow lights to enable plant growth and a backend tank or sump tank, the water in aquarium is exchanged by new water pumped in from the back-end tank every 3 months. The main task is analysing the following: 1. Measurements made on water level, 2. Change in plant length 3. Photographs taken during the experiment to monitor the progress of the cultures 4. Percentage change in the total measurements from the start to the end of the experiment

In proposed aqua RUFS we are having 5 modules, following are: 1) Automatic fish food feeder 2) Automatic water supply 3) usage of grow lights 4) Collecting cloud information 5) to replace the dirty water in aquariums every 3 months automatically.

A. Automatic fish food feeder

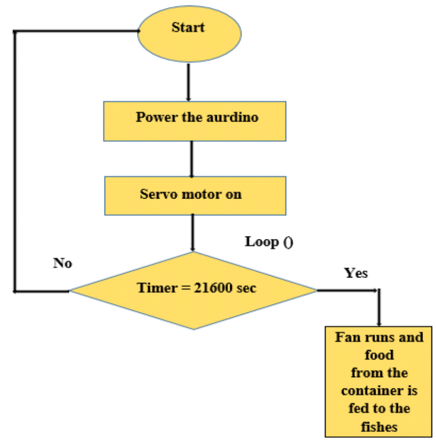


Figure 1: Automated Fish Feeder

The above depicts the figure depicts the flow chart of automatic food fish feeder. The basic necessity of living beings is food, so it is needed by fishes for its growth and development. The automatic feeing is done with the help of arduino board and a servo motor that is connected. When the arduino is powered servo motor gets started, when the defined timer is alarmed the fan of the servo motor runs and hence food is fed to the fishes from the holder.

B. Automatic water supply

Several series of measurements are taken from PH sensor. If the value is greater than 7 that is acidic the water is supplied to the plants for their growth. As we are using coir instead soil, the moisture should be present in the coir if not water is pumped until the coir absorbs nutrients from water and this should be present for at least one week. The amount of water transferred to plants can be stored in cloud database and also we can re-pump the water back to the aquarium.

C. Usage of grow lights

As we are growing plants in indoor as well as outdoor, the plants need sunlight in the cases. For indoor aqua we are using led grow lights to make photosynthesis happen.

D. Cloud storage

Blynk cloud is an IOT platform that is used to retrieve information and store that to the cloud and hence results in developing IOT applications.

Figure 2: Wi-Fi module

Wi-Fi module is used to send the data to the cloud. The Wi-Fi module had Micro Controller Unit that is connected Wi-Fi and TCP/IP connections are established

E. Replacing dirty water in the aquarium

The fifth module is to replace the water in aquariums. There are three reasons to pump water to the aquarium from back end tank. If the water is dirty, temperature of the water too high and if the water level is too low.

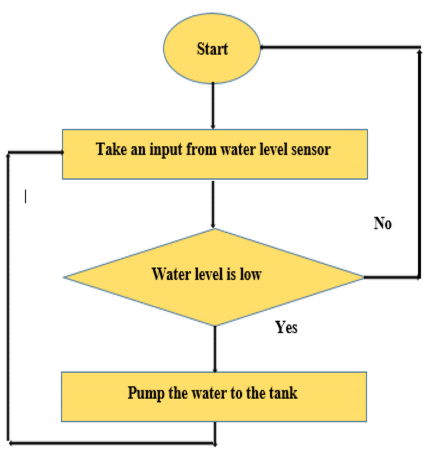


Figure 3: Automatic water level controller

IV. WORKING OF SESNORS

A. *DS18B20 temperature sensor* - is small waterproof sensor. It is built in 12bit ADC, doesn't require additional components such as wires and it communicates through one wire bus.

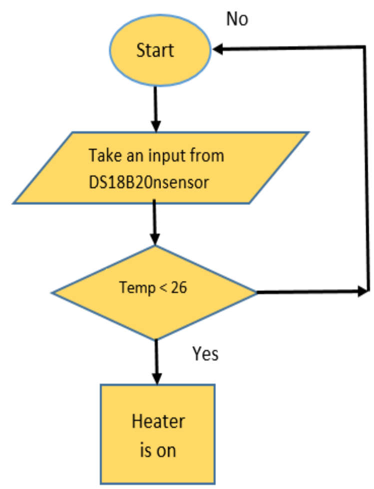


Figure 4: Temperature control flowchart.

B. PH sensor- it is used to obtain pH value in water accurately and also it connects to the internet

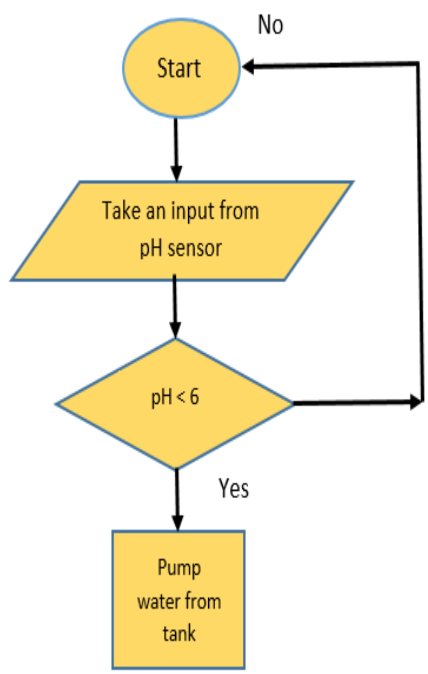


Figure 5: PH value control flowchart.

C. *Water level sensor* – is used to check the level of water in the tank.

D. *Temperature sensor (dht11)* – a temperature and humidity sensor. It used to measure moisture and warmth in the air respectively.

V. PROPOSED SYSTEM DESIGN ARCHITECTURE

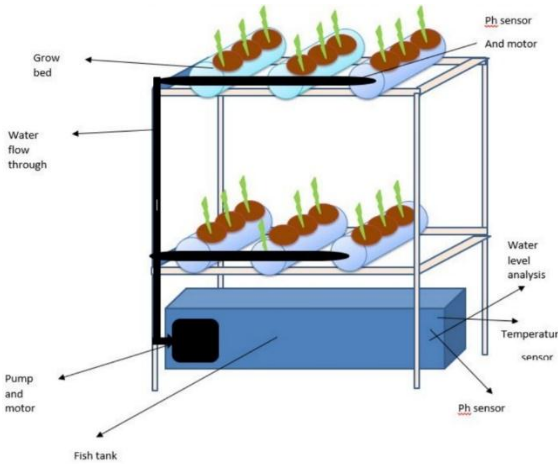


Figure 6: Aquaponics proposed design

VI. PARAMETERS CONSIDERED FOR HEALTHY AQUAPONICS

A. *Water quality parameters*

- For the plants and fishes to grow bore well water is used.
- To measure the quality of the water we consider dissolved oxygen, pH value, ammonium contents.
- Ammonia has two forms namely unionized (NH3) and ionized (NH4). Unionized is more toxic to fishes.
- Nitrite (NO2) and nitrate (NO3) are the two elements of ammonia produced by the excretion of fishes. Nitrite is toxic and nitrate is not toxic.
- The sum of nitrogen from NH3 or NH4+ is called total ammonium nitrogen (TAN). It should be below 3 mg/L
- PH is measure of hydrogen power content in the water. It ranges from 0-14 and 7 is neutral, the value below 7 is base and above 7 is acidic.
- For the growth of plans pH value should be less.
- For warm water fishes such as gold fish should have 5ppm and cold water fishes such as small shark should have 6.5 ppm.
- If ammonia is high plants will not grow. When there is less fishes and more water ammonia content will be more.
- If nitrate is higher than 150ppm then we can plant more plants.
- If pH value is less than 6.4 calcium and potassium is added to bring back to 7.0.
- For fishes the pH value should range from 5.0 – 10.0 and plants should have less than 6.5, hence plants, fishes and bacteria should have a range of 6.8 to 7.0.

B. *Water temperature parameters*

- Warm water fishes should have 65 degree to 85 degree Fahrenheit and cold water fishes should have 55 degree to 65 degree Fahrenheit.
- Plants grow if the temperature ranges from 70 degree to 75 degree Fahrenheit.

C. *Quality parameters for both water and plants*

Table 1. Quality Parameters

Sl. No	Parameters	Values	Analysis
1.	Temperature	65 – 85 F	daily
2.	PH value	6 - 7	daily
3.	Total ammonium nitrogen	< 1ppm	weekly
4.	NO2	< 1ppm	weekly
5.	NO3	5 – 150 ppm	weekly
6.	DO	5ppm	Daily

D. *Fish food analysis* - depicts how much protein contained in the fish food and how much quantity is to be fed to the fishes

Table 2. Fish Food Analysis

Sl. no.	Proximity analysis	
1.	Crude protein	Minimum 32%
2.	Crude fat	Minimum 4%
3.	Crude fibre	Maximum 5%
4.	Moisture	Maximum 10%

Table 3. Fish Food Analysis

Day	Quantity	
	Morning	Evening
1	5-10gm	5-10gm
2	5-10gm	5-10gm

E. Water Level Analysis – the below table show how much gallons of water is absorbed by the plants after one week

Table 4. Water Level Analysis

Total volume of tank	Water in aquarium	Water absorbed by the plants
5.96 gallons / 22.55 litres	1.98 gallons / 7.49 litres	0.28 gallons / 1.05 litres

VII. RESULTS AND DISCUSSION

A. Cost analysis- the table shown below shows the overall cost of the project.

Table 5. Cost analysis

Components used	Number of Pieces	Price
Arduino Board	2	400
Bread board	1	70
Jump wires	3	200
Motor	1	1100
PH sensor	2	3600
Resistor	3	30
Servo motor	1	115
Temperature sensor DS1820	1	125
Water Level Sensor BC548C	1	20
Water test	3	800
ESP8266 Node MCU	1	310
Labour cost + Model Design		Gross : 14,770

B. Plant diseases – the table shows the diseases that causes damage to the plants and also its precautions to prevent them. Leaves turning yellow and leaf miners are the two problems that was encountered during the project development.

Table 6. Plant Diseases

Problem on leaves	Cause	Cure
1. leaves turn yellow	1. Under-watering 2. Over-watering 3. Nitrogen deficiencies 4. A lack of sunlight on the bottom leaves	1. Check for moisture stress 2. Providing lights 3. Protect from cold drafts 4. Providing nutrients
2. leaf miners	The larva of an insect, a miner that lives in and eats the tissue of leaf plants.	1. Use of pesticides 2. conventional insecticides

C. Test analysis - The fresh water, water after one week and water after two weeks are tested and the results are given in the below table 7. The conclusion drwan here is that the value of nitrate is low, so if we add or if we grow more fishes we can increase the nitrate value which increases plants gowth.

Table 7. Test Analysis

Sl. no	Parameters	Units	Fresh water	After 1 week	After 2 weeks
1.	pH value	-	6.69	7.70	7.30
2.	Hardness (CaCo3)	Mg/L	230.0	310	280.0
3.	Calcium (Ca)	Mg/L	56.0	80.0	72.1
4.	Nitrate (No3)	Mg/L	2.1	3.4	3.0
5.	Potassium (K)	Mg/L	<1.0	1.0	1.0

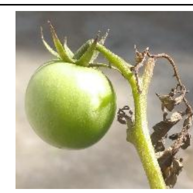
D. Average height of tomato leaves – for the project analysis and development the tomato plant is taken for analysis. The difference between tomato leaves grown using aquaponics method are given in the table.

Table 8. Average Height of Tomato Leaves

Tomato leaves	Number of days after planting	Leaf size / plant size
	5 days	1 cm / 1cm
	66 days	2 – 3 cm / 7 cm
	88 days	3 - 4 cm / 15 cm
	97 days	5-6.5 cm / 32 cm
	98 days	5-6.5 cm / 32 cm

E. *Traditional Farming versus Aquaponics*- the difference in plant growth in traditional farming and aquaponics system is given. So here we can analyse that plants grows healthy, fastly using aquaponics method than traditional farming.

Table 9. Traditional Farming versus Aquaponics

Number of days after planting	Without soil (aquaponics)	With soil (traditional farming)
103 days		
107 days		

VIII. Screenshots

Cloud storage analysis – the sensed values are sent over to the cloud and analysed is done using blynk application. Here is the screenshots of data collected for three months. It collects and displays live data and if the water level is high there is an option to switch off the pump.

Figure 7: Live temperature and pH values

Figure 7.1: Live temperature and pH values

IX. CONCLUSION

By considering the collected cloud data we saw the growth and progression of plants compared to the traditional farming. The pant produced in this aqua system had better nutrients and stronger than plants grown in traditional farming.

As our project is based in robotics urban farm system, it reduces manual work, increases efficiency and gives accurate results as we are using IOT devices to sense the things

Plants Uses fish waste as nutrients and because of this plants turned out to be an organic plant, where as in traditional farming plants do not get this type of nutrients.

When we compare the results of both aquaponics and traditional farming. The plants grown in aquaponics has more height and strong stem so this is due to the nutrients that are available. The main issue that we face in traditional farming is growing of unwanted plants that is weeds. But here they won't allow weeds to grow

As we are using cloud storage it is easy to analyse data. Considering overall requirements our aqua RUFS has several advantages like it reduces labour cost, it uses less water than traditional farming, soil is not required, fish waste is the only nutrients the plants are getting and all this work are done automatic this avoiding intervention and satisfy user needs

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Authors Profile

Prof. K.Panimozhi has over 14 years of teaching and 6 years of research expereince.She holds B.E in Computer Science and Engineering from Madras University and obtained M.E in Computer Science and Engineering from UVCE, Bangalore University in the years 2003 and 2009, respectively. She is currently pursuing her reseacrch on Quality of service frame work for WSN at Visvesvaraya Technological University. Her research interests are mainly focused on Quality of service for low powered networks with varied data types. Her interest includes designing IoT based application for societal needs. She has published 5 papers in various reputed journals.

Vinutha Raju studying in Computer Science and Engineering department from BMS College of Engineering. She will be graduating this year. She has done projects on c, c++, java, R, iot, cloud, big data, web.

Yashaswini S studying in Computer Science and Engineering department from BMS College of Engineering. She will be graduating this year. She has done projects on c, c++, java, R, iot, cloud, big data, web.

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