ELE3305

Design Report

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# Executive Summary

Table of Contents

[Executive Summary 2](#_Toc162088283)

[Application Scenario 2](#_Toc162088284)

[Specifications 5](#_Toc162088285)

[Overview of System 5](#_Toc162088286)

[Data Encoding/Scaling 5](#_Toc162088287)

[ICT security risks 6](#_Toc162088288)

[Conceptualisation 6](#_Toc162088289)

[References 6](#_Toc162088290)

# Application Scenario

Aquaponics is defined as a closed system where fish and plants survive and grow together by providing each other with nutrients. In this system, rather than filtering out waste from the tanks, the waste from fish is consumed by bacteria and converted into nitrates which plants use for nourishment [1] [2]. The thriving plants then release oxygen into the water which circulates back to the fish. In this system, the delicate balance of water pH, temperature and oxygen levels are vital for a happy ecosystem [3], and so requires constant monitoring to ensure fish and plants are obtaining adequate nutrients and not stressed out.

Implementing automated monitoring and maintenance to the aquaponics system using Internet of Things (IoT) will take the strain off the owner of the aquaponics system to ensure all these elements are measured and addressed in a timely manner, reducing the risk of plant and fish illness or death caused by lack of supervision [1] [4].

# Specifications

The details of the sensors required to monitor the aquaponics system include the following:

Table 1: Sensor information

|  |  |  |  |
| --- | --- | --- | --- |
| **What is Measured** | **Ideal Range** | **Units** | **Sensor** |
| Dissolved Oxygen (DO) | 5-8 | mg/L | Atlas DO probe |
| pH | 6.5-8 | - | DFROBOT-SKU:SEN0169 |
| Water Temperature | 18-30 | °C | DFROBOT-DS18B20 |

The information obtained from these sensors is sent as a message to an MQTT broker, Mosquitto. The broker then sends the message through the local network to the nodes: Node-Red, OpenPLC and a web-based human machine interface (HMI).

Node-Red is used to implement the IoT network. This creates flows for the decoding and scaling of information.

OpenPLC is used to implement automated control to the aquaponic system. The following table shows how the aquaponics system is controlled. If any values outside of the ideal range mentioned in Table 1 are sent from the sensors, OpenPLC will enable an action to be performed to control the system and maintain balance.

Table 2:

|  |  |  |  |
| --- | --- | --- | --- |
| **Sensor** | **Problem** | **Possible Solutions** | **Required Action** |
| DO | < 5 mg/L | Increase aeration | Turn on air pump |
| Reduce pH | Check pH levels |
| Decrease temperature | Check water temp |
| > 8 mg/L | Decrease aeration | Turn off air pump |
| Increase temperature | Check water temp |
| pH | < 6.5 | Lower water temp | Check water temp |
| > 8 | Raise water temp | Check water temp |
| Water Temp | < 18 °C |  | Turn on heating system |
| > 30 °C |  | Turn on water pump to increase flow |

HMI: This is what the user uses to check the system. What to display to user: DO, pH and water temp. Also whether any controls are on/off

It is considered that the system can be connected to mains power but utilise solar or battery back up to ensure upkeep in event of power loss.

An aquaponics system such as this can be scaled to meet larger demands including farming [2].

# Overview of System

Documentation of the existing system including an overview of the relevant protocols used in the context of the project and an evaluation of why they are appropriate for the application or why other protocols would be more suitable.

# Data Encoding/Scaling

Detail the data encoding and scaling across the various transmission channels in the system.

Scaling for pH: whole range needs to fit into 0-14.

Scaling for water temperature: range needs to fit into -55 to 125 C.

Scaling for DO: range needs to fit into 0-100 mg/L (https://atlas-scientific.com/probes/dissolved-oxygen-probe/)

# ICT security risks

A discussion of potential ICT security risks in the system and potential ways to alleviate those risks.

Potential unauthorized access to HMI.

Access to Node-red and the flows are changed or information obtained.

No issue with confidential information being obtained via the sensors, however login information could be at risk in the local network.

# Conceptualisation

Conceptualisation and documentation of the system and code to achieve the functionality.

This includes the local network configuration. This needs to include details such as the assumptions you have made, function definitions and shortcomings of the implementation and potential improvements. This section should be supported by block diagrams, flow charts etc as appropriate.

# References

[1] M.M.M. Mahmoud, R. Darwish and A.M. Bassiuny, “Development of an economic smart aquaponic system based on IoT,” *J. Eng. Res.*, Aug 2023, doi: https://doi.org/10.1016/j.jer.2023.08.024.

[2] M. F. Taha et al., “Recent Advances of Smart Systems and Internet of Things (IoT) for Aquaponics Automation: A Comprehensive Overview,” *Chemosensors*, vol. 10, no. 8, Aug 2022, doi: https://doi.org/10.3390/chemosensors10080303

[3] S. Fu, W. Xing, J. Wu, J. Chen and S. Liu, “Research and design of an intelligent fish tank system,” *PLoS ONE*, vol. 18, no. 5, May 2023, doi: <https://doi.org/10.1371/journal.pone.0285105>.

[4] F. A. Z. Shaikh and U. Bhaskarwar, “Smart Aquarium using IoT,” *Int. J. Res. Appl. Sci. Eng. Tech. (IJRASET),* vol. 10, no. 3, Mar 2022. [Online]. Available:<https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4089695>

[5] C.-H. Chiung, Y.-C. W, J.-X. Zhang and Y.-H. Chen, “IoT-Based Fish Farm Water Quality Monitoring System,” *Sensors,* vol. 22, no. 17, Sep 2022, doi: https://doi.org/10.3390/s22176700.