HARMONY: A Smart Aquaponics System integrated with Conversational Interface and Internet of Things

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Abstract. Smart technologies are gradually becoming intrinsic part of our households. In this segment, we have built a prototype on smart aquaponics system that optimises the usage of resources needed to maintain an aquarium while keeping the system self-sustaining. Apart from the Eco-friendly aspect, we provide a smart interface involving a chat interface along with Internet of Things(IoT) necessary to monitor the system remotely. As per experiments so far, we have demonstrated that the fish can co-survive with plants for more than 3 months with minimal human intervention while the system auto cleans the water. The amount of food, light, electricity and human supervision has been minimised using our smart IoT functionalities as well as an interactive interface that can provide assistance for the vitality of fishes and plants remotely.

Keywords: Aquaponics · Chatbot · IoT.

1 Introduction

Smart technologies have enriched our lives and made our day to day activities automated. In this scenario aquaponics is also catching up. The idea in this paper is to make aquaponics a part of IoT and integrate it with a chatbot for remote supervision. The current state-of-the-art is a mobile application to control the behaviour of system remotely located and supervise the processes in a semi-automatic way. We would like to further this approach by introducing language capabilities where-in humans do not need to supervise and smart aquaponics can directly intervene if there are serious anomalies.

In the process of creating this interactive aquaponics system, we also built a chat interface that has the capability to train itself using intents and entities and can provide assistance to a remote supervisor. This system could be easily scaled to large aquaponics systems capable of handling thousands of fishes and plants through the usage of distributed aquaponics system. In such a system the supervisor will have very little interference. Once the system is set he can just give broad statements like *health check*, *sensor check*, *feed fish*, etc.

2 Terms and Definitions

2.1 Aquaponics

Aquaponics is a combination of aquaculture, which is growing fish and other aquatic animals, and hydroponics which is growing plants without soil. Aquaponics uses these two in a symbiotic combination in which plants are fed the aquatic animals' discharge or waste. Aquaponics is a completely natural process that mimics all lakes, ponds, rivers and waterways on Earth. The fish eat the food provided externally and excrete waste, which is converted by beneficial bacteria to nutrients that the plants can use.In return, the vegetables clean the water that goes back to the fish. Along with the fish and their waste, microbes play an important role to the nutrition of the plants.In our experiment we have used Internet of Things for remote controlling of the device through a chat bot ,which will provide a seamless user experience.

2.2 IoT

The Internet of Things (IoT) refers to a system of interrelated, internet-connected objects that are able to collect and transfer data over a wireless network without human intervention. It has applications in various fields which include agriculture, space, healthcare, manufacturing, construction, water, and mining, who are presently transitioning their legacy infrastructure to support IoT.

3 Related Work

The study[1] aimed to develop water quality management systems for catfish ponds by utilizing aquaponics technology and IoT technology, combined with water quality control systems with artificial intelligence fuzzy logic to control temperature and ammonia levels, which are important variables in maintaining water quality.

An Android app, developed using MIT App Inventor, is presented in the study [2] for monitoring and control of the aquaponics system which is commonly used in urban setting. This allows any user to remotely monitor the parameters such as pH, moisture, and temperature level of the water in the aquaponics setup and the specific actions taken by the device in correcting the pH level

Smart Aquaponics - An initiative by several secondary schools, colleges and universities in France, Wallonia and Flanders to train people in the field of Aquaponics in a very interactive way and to contribute to solve the challenges generally faced by those new to the field.

The aim of the project [3] is to monitor and control aquaponics by using Internet of Things (IoT) technology by recording various parameters in real time settings.The use of NodeMcu was to acquire sensors data and deliver them to a web server. The low power consumption of the system had resulted in the possibility of powering it by solar power

4 Model

The model has three components mainly - chatbot, edge AI device[5] and aquaponics system. The remote supervisor sends some request or query to a chatbot. The chatbot converts these requests into action which is then implemented through the edge AI device. The edge AI device executes these action which could be either to read data from the sensor or run some commands like feeding food to the fish using a servo motor operated fish feeder. The whole process is automated i.e the communication between chatbot, edge AI device and aquaponics is completely unsupervised and this system can easily scale to large aquaponics system.

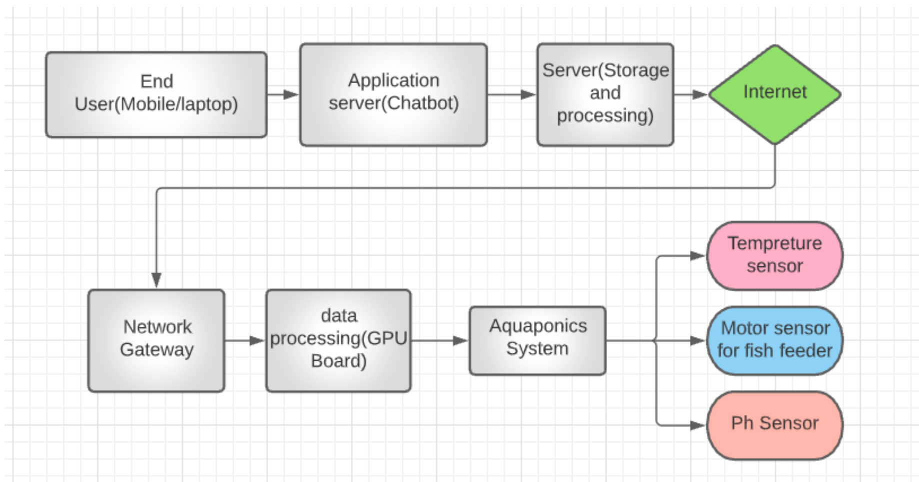

Fig. 1. Diagrammatic representation of model

5 Loss function

In the whole process, we are optimising some variables which we have combined together in the loss function as below. All of these variables have been normalised so that they can be of same unit i.e. a ratio.

$$\begin{array}{ll} \min_{w,m,l,g,p} & W + M + L + \frac{k}{G} + P \\ \text{s.t.} & k_1 \leq pH \leq k_2 \\ & m_1 \leq F_m \leq m_2 \end{array} \tag{1}$$

W is power usage in watts, M is manpower spend on maintenance in hours, L is water consumption per month in litres, G is length of plants in cm per month,

[5] https://lionbridge.ai/articles/what-is-edge-ai-computing/

P is plant mortality rate. The constant k is the ideal max length of plant we can manage. The loss function is constrained by two equation namely - PH of water in aquarium is constrained between k_1 and k_2 and F_m, the fish mobility is between a range of m_1 and m_2.

6 Experiment

A small table top aquaponics setup as shown in Appendix (fig 2) has been created to perform the experiments. The setup consisted of fish tank, grow bed, a fish feeder, LED grow light, a water pump with aerator and various sensors for measuring ambient temperature, humidity, light intensity, fish tank water level, grow bed moisture and water pH level. The sensors are connected to a Arduino Nano device which periodically reads the sensor values and sends those out through USB Com port. A Jetson Nano device acts as the IoT gateway and edge AI device. Computer vision based fish activity detection module detects the fishes in the tank and tracks their activity in real time.

The sensor values and fish activities are send though MQTT protocol. In another remote computer an MQTT client software subscribed to the respective channel gathers the values and stores in a time series database, InfluxDB. Grafana is used to create custom dashboard for visualising real time and historical data points. All the commands for switching on and off pump, light, feeder and scheduling various activities are send through respective MQTT topics. MQTT client running on Jetson Nano listens to the commands and conveys to the Arduino Nano device through USB com port for final execution.

The whole setup has been running for past 4 months without any human intervention. A chatbot interface has been created for humans to communicate with the system.

7 Conclusion & Future Work

Many different adaptations, tests, and experiments have been left for the future due to lack of time.There are some ideas that we would have liked to try during the building phase of the experiment.This paper mainly focused on how to make the aquaponics system more accessible in a friendly way through the use of chat bot. In future work, the following ideas could be implemented:

- The model of the aquaponics system which uses a significant amount of power for maintaining temperature and keeping the fish alive could be provided by a solar powered rechargeable battery instead of traditional power sources, which would further aid this system to become even more sustainable.
- The model could be extended to include intents and entities in different languages thus being accessible to more people and regions in a country like India and worldwide as well.

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