ELE3305

Design Report

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# Executive Summary

# Application Scenario

Context: Aquaponic systems.

Closed system where fish waste is converted into nitrates that plants use for nourishment. This system requires constant (daily) monitoring to ensure fish and plants are provided with adequate nutrients and not stressed. The delicate balance of water pH, temperature and oxygen levels are vital for a happy ecosystem. Implementing 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 system failure from lack of supervision and maintenance. (Development of an economic smart aquaponic system based on IoT)

Research:

Smart Aquarium using IoT, <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4089695>

* Simple design
* pH
  + 6.5-9
* Temperature
  + Heating bulb
* Fish feeder

Research and design of an intelligent fish tank system, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10159123/>

* Water temp
  + Directly affects fish growth
* pH
* light intensity
  + greater sunlight, faster the evaporation of O2 concentration
* Feeding module
* Sends info to phone
* Has flow charts for reference. Lots of charts for data and testing

IoT-Based Fish Farm Water Quality Monitoring System, <https://www.mdpi.com/1424-8220/22/17/6700>

* Suggested robot for pH to limit exposure and prolong usability
* Water temp
  + 22-28 C
* pH
  + 6.5-8.5
  + CO2 causes higher acidity=lower pH
  + Need to monitor for algae growth
* Dissolved oxygen
  + 5 mg/L
  + DO changes with temperature
* Water pump
  + Maintain water levels in case overflow and fish flow out
* Has flow charts for reference

Development of an economic smart aquaponic system based on IoT, <https://www.sciencedirect.com/science/article/pii/S230718772300202X>

* Water temp
  + 18-32 C. Around 24 C is ideal
  + Use heater, or water pump if >32 C to circulate water and dissipate heat
* pH
  + 6-7
  + Tied to water temp – heating to 24 C helps with lowering pH (converting ammonia to nitrate)
  + Low pH, add more fish food and check temp again
* Dissolved oxygen (DO)
  + 5-8 mg/L
  + Air pump
* Light sensor
  + 380-840 nanometers
  + Lighting unit (for plant growth)
* Water flow
  + Water pump
* Sensors controlled remotely by user via phone or computer

Recent Advances of Smart Systems and Internet of Things (IoT) for Aquaponics Automation: A Comprehensive Overview , <https://www.mdpi.com/2227-9040/10/8/303>

* pH
  + 6.5-8
  + Tailored for the specific fish/plants. Low pH affect plant roots.
* dissolved oxygen (DO) (DFROBOT-SEN0237, Atlas DO probe), CO2
  + >4 mg/L, 340-1300 ppm respectively
  + 5–8 L of air per minute per cubic meter of water
  + DO needed for fish, plant respiration and to combat fungus on roots.
* Water temp
  + 17-34 C
  + Below 17 C affects nitrification process and bacteria production not enough to oxidise ammonia or nitrites. Adequate temp reduces disease risk. High temp affects plants calcium absorption.
* Ammonia (WINSEN-MQ-137), nitrites (Apure-NO2-201 sensor) and nitrates (WINSEN)
  + Near 0 for ammonia, 0.25-1 mg/L nitrite, 50-100 ppm nitrate
  + Ammonia bad for fish. Nitrite causes health problems. Nitrate not very toxic.
* Water level (Omron K8AK-LS1 or some other distance sensor)
* Water Flow through aquaponic system (ETC1:YF-S201)
  + 1-2 L/min
  + Proper flow rate to avoid stressing fish and avoid neglecting plant nutrition
* Alkalinity/water hardness
  + 50-150 mg/L CaCO3, 0.2 ppt CaCO3 salinity.
  + Low hardness causes stress, but high hardness affects pH and therefore fish death and lower plant nutrient intake

“PLC systems are highly flexible when dealing with various combinations of actuators (pumps, fans, ventilation equipment, etc.), sensors, and other devices used in the aquaponics industry.”

Chosen sensors for design:

* Dissolved oxygen
* pH
* water temp

PLC:

* Heating to control temp, thus pH and O2
* Air pump for DO (will help correct pH too if high CO2)

Can be on mains power but solar/battery back up to ensure upkeep in event of power loss.

What to display to user: DO, pH and water temp. Also whether any controls are on/off

Update frequency: hourly

Specifications

Timing needed between actions of PLC to make sure the system is not overcompensated when measurements indicate adjustments need to be made. For example, if the pH is too acidic, filtration or chemicals can be used to correct this, but must be given time to give effect and stabilise.

Overview of Protocols

Data Encoding/Scaling

ICT security risks

Conceptualisation

HMI: This is what the user uses to check the system

References