Enhancing Aquaponic Sustainability through IoT and Predictive AI Technology and Analytics

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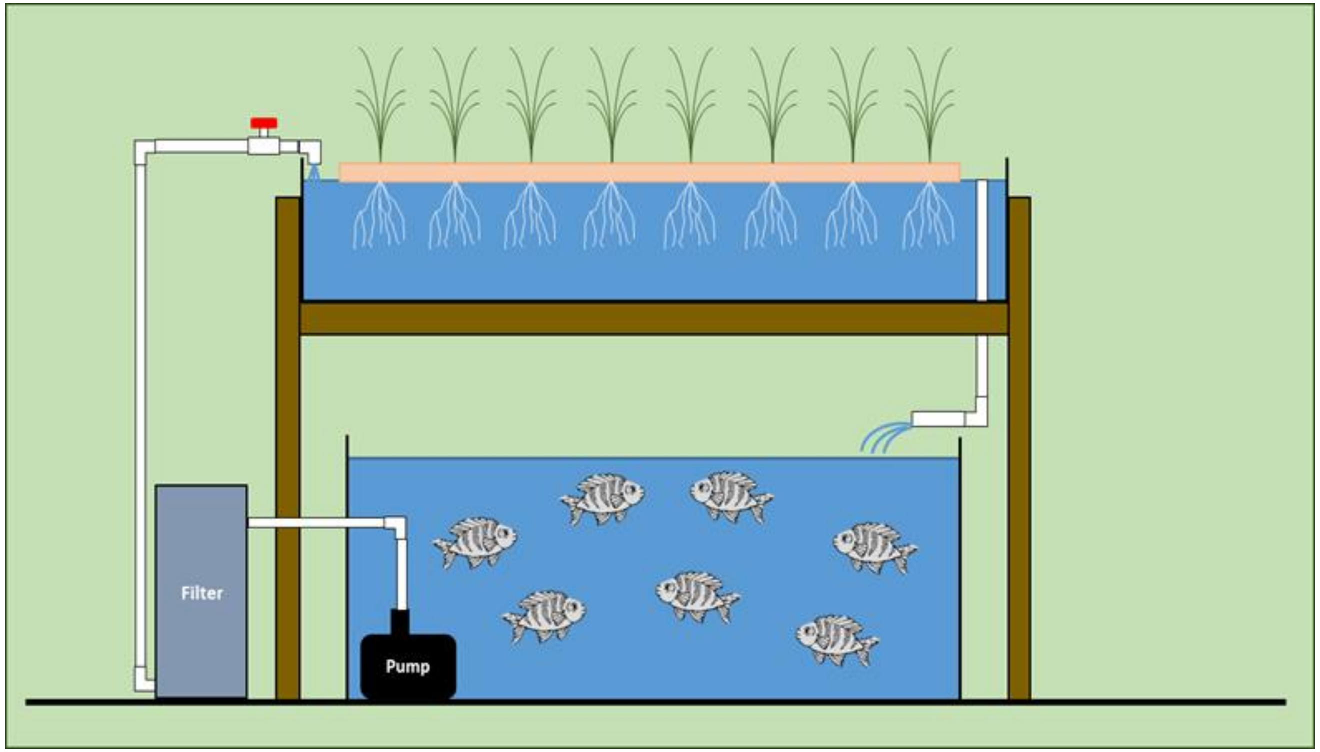
Project Title: Enhancing Aquaponic Sustainability through IoT and Predictive AI Technology and Analytics



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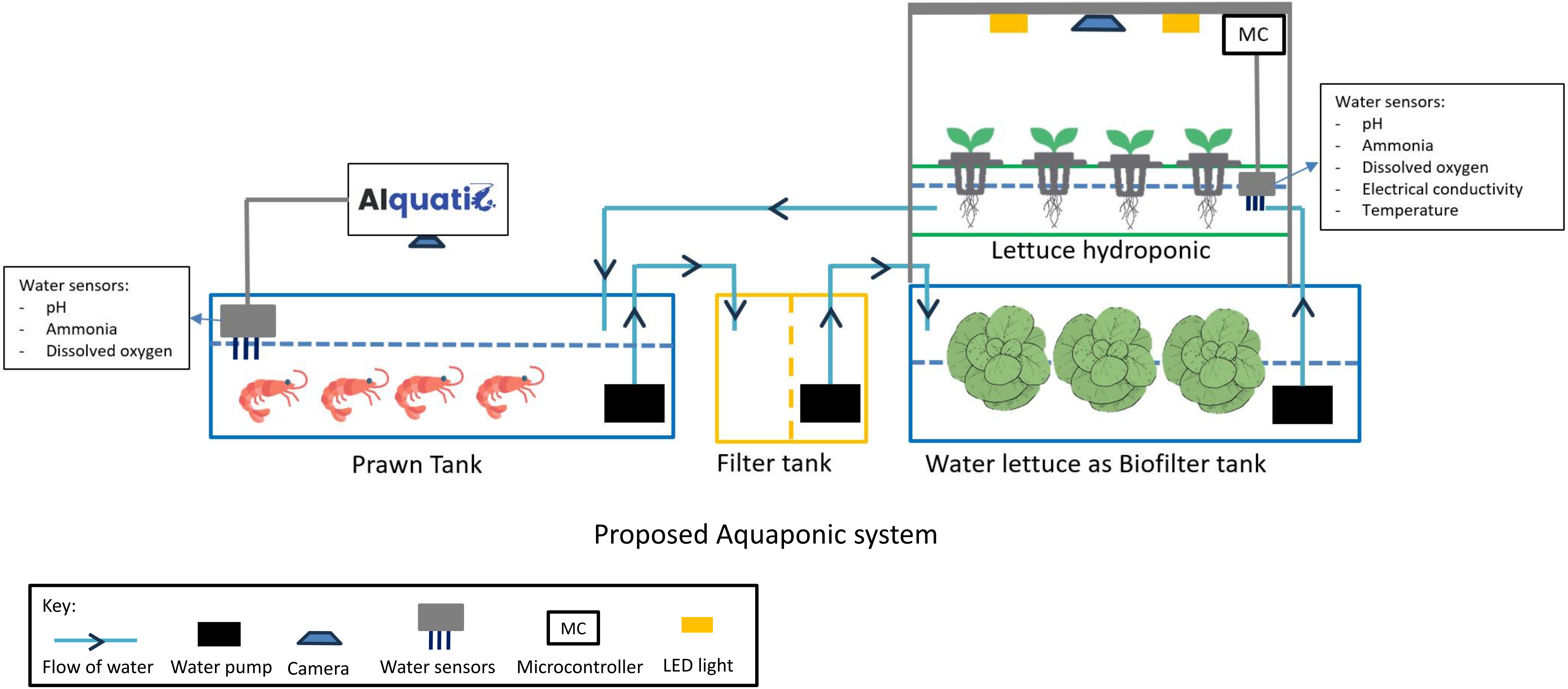
Background of Problem :

- Inefficient water quality management – Traditional method of monitoring is time-consuming
- Lacks capability to predict future water quality conditions and plant growth
- Controlling and Maintaining the water quality suitable for both the plant and prawn can be a challenge

Targets:

- To design and implement a smart aquaponic system that integrates IoT technology for real-time monitoring and control of water parameters
- To assess the effectiveness of water lettuce as a biofilter in maintaining water quality
- To develop a dashboard for visualizing collected data, enabling efficient management of the aquaponic system.
- To analyse the overall sustainability and optimum efficiency of the smart aquaponic system compared to traditional setup

Proposed Method: System Architecture



Proposed Aquaponic system

Proposed Method: System Design

Aquaculture Control Systems:

- AIquatic prawn monitoring system – integrated with water sensors and camera for prawn growth monitoring
- Prawn detection – using YOLOv8 and segmentation (Zariful et al. 2024)

Hydroponic Control System:

- Water Sensors (pH, ammonia, dissolved oxygen, EC, temperature)
- Microcontroller – as the central processing unit, collecting data from sensors and controlling lights and water pump
- Lettuce growth detection – using YOLOv3 (Sasmal et al., 2024), YOLOv8 (Schneider et al. 2024)

AI Based Analysis System:

- Data collection and processing – for data training and preprocessing
- Deploy on various ML algorithms for prawn and plant growth predictions – using Support Vector Regression, Random Forest, KNN (Gour et al. 2020; Gupta et al. 2021; Karuniawati et al., 2021)

Proposed Method: Experimental Approach

Project stages:

1. The development and installation of a comprehensive layout for the aquaponic system.

2. Programming the microcontroller - writing and uploading a program designed to read data from the sensors and control the actuators based on the predefined thresholds water and nutrient parameters

3. IoT integration and the development of a user-friendly dashboard.

4. Data collection and AI model development - Over a 6-month period, we gather data on water quality, nutrient, prawn growth, and plant health.

5. Performance analysis and reporting – Evaluating the effectiveness of the smart aquaponic system in maintaining optimal conditions + comparing its performance to traditional aquaponic setups

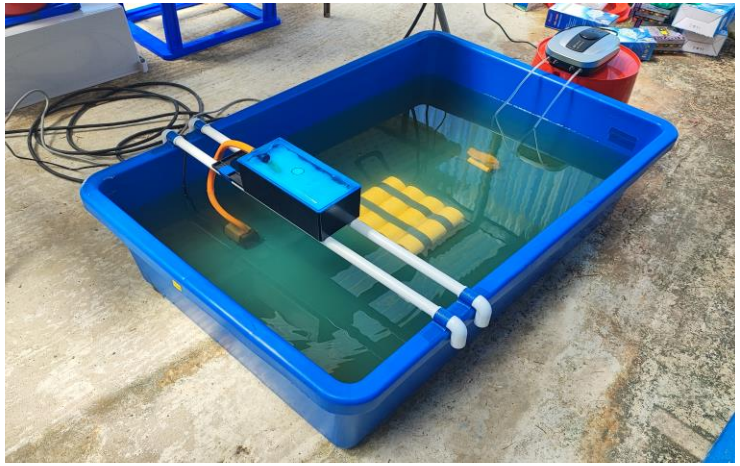
Impact:

- Integration of aquaculture and hydroponics minimise environmental impacts such as nutrient run off and soil erosion
- Integration of AI and IoT technologies improves monitoring and predictive capabilities, helps to enhance system performance and resource management
- Aquaponic contributes to local food security, mitigating reliance on external food sources and encourages farming within urban area

Output/Outcome: Preliminary Result

Comparison between Recirculating Aquaculture System (RAS) and Aquaponics:

RAS system



Day-14

Aquaponic system

Day-14

Day-0

Day-14

Day-28

Output/Outcome: Expected Output

Main **outputs** from this project:

- Fully operational IoT system that continuously monitors water quality parameter
- Predictive analytics models for predicting fish/prawn growth rates and water quality changes and optimal feeding schedules
- Research papers

Main **outcomes** from this project:

- Improved water quality management
- Increased productivity
- Promote sustainable practices by demonstrating how IoT and AI technologies can minimise resource waste, enhance water circularity and reduce environmental impact

Conclusion:

- Enhance aquaponic sustainability through integration of IoT and AI technology
- Implement IoT-enabled system for continuous water monitoring
- Development of predictive models that forecast prawn growth, water quality and best feeding practices for farmers
- Promotion of sustainable aquaculture practices
- Economic benefits