Title : ICT-Driven Water Quality Monitoring Systems: Enhancing precision and connectivity in environmental assessment

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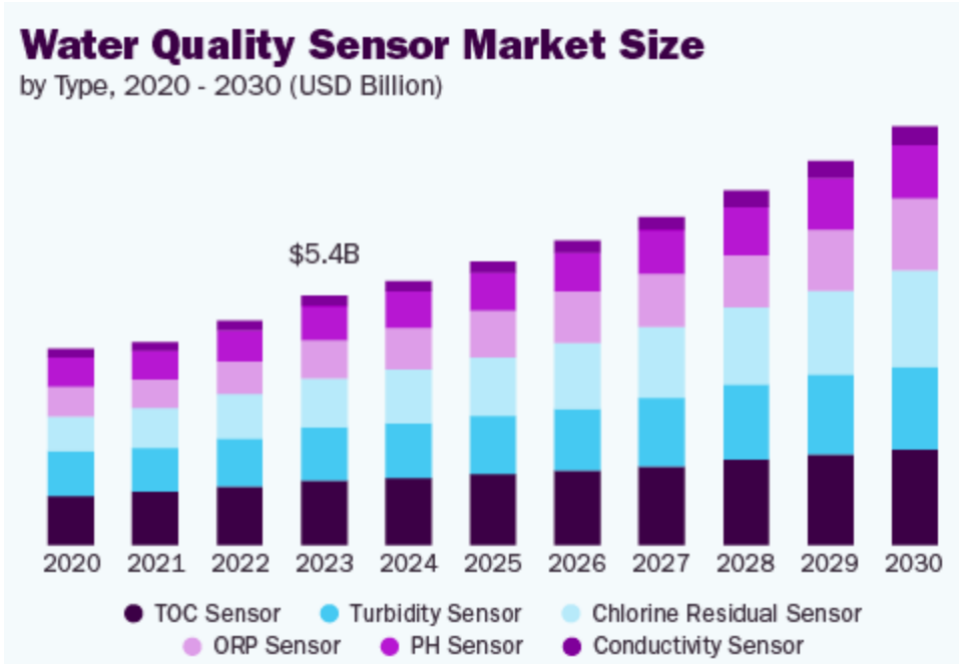
Project Title:

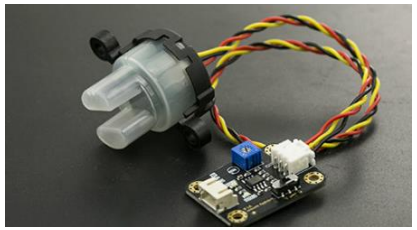
Background :

Water is an essential resource that sustains all forms of life and plays a pivotal role in agriculture, industry, and ecosystem balance. Water quality measurement extracts water quality parameter from the water to determine its water quality. Some example for these water quality parameters are turbidity, pH, total dissolved solid (TDS), dissolved oxygen (DO), electrical conductivity (EC), etc.



(Source: Water Quality Sensor Market Size, Share & Trends Analysis Report By Type https://www.grandviewresearch.com/industry-analysis/water-quality-sensor-market-report)

Water turbidity sensor



IoT Sensor: ~USD 20

Commercial Sensor: ~USD 6k

Project Title:

Problems and challenges :

Challenge 1: Data precision and consistency issue

IoT sensors measurement commonly produce measurement errors, with problems pertaining to measurement linearity, offset, and noise related issues.

Challenge 2: Communication issue

Integration of the IoT system is challenging as IoT devices operate and communicate differently from one another. Device to device communication also face challenges owing to the connectivity problem on site.

Targets:

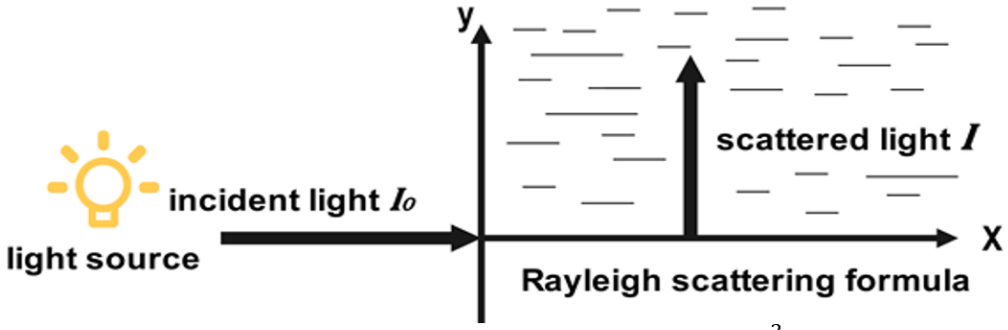
Objective 1: To enhance and improve the precision and performance of the IoT-based sensors through machine learning calibration.

Objective 2: To improve data connectivity in the system in remote area environment incorporating the D2D technology.

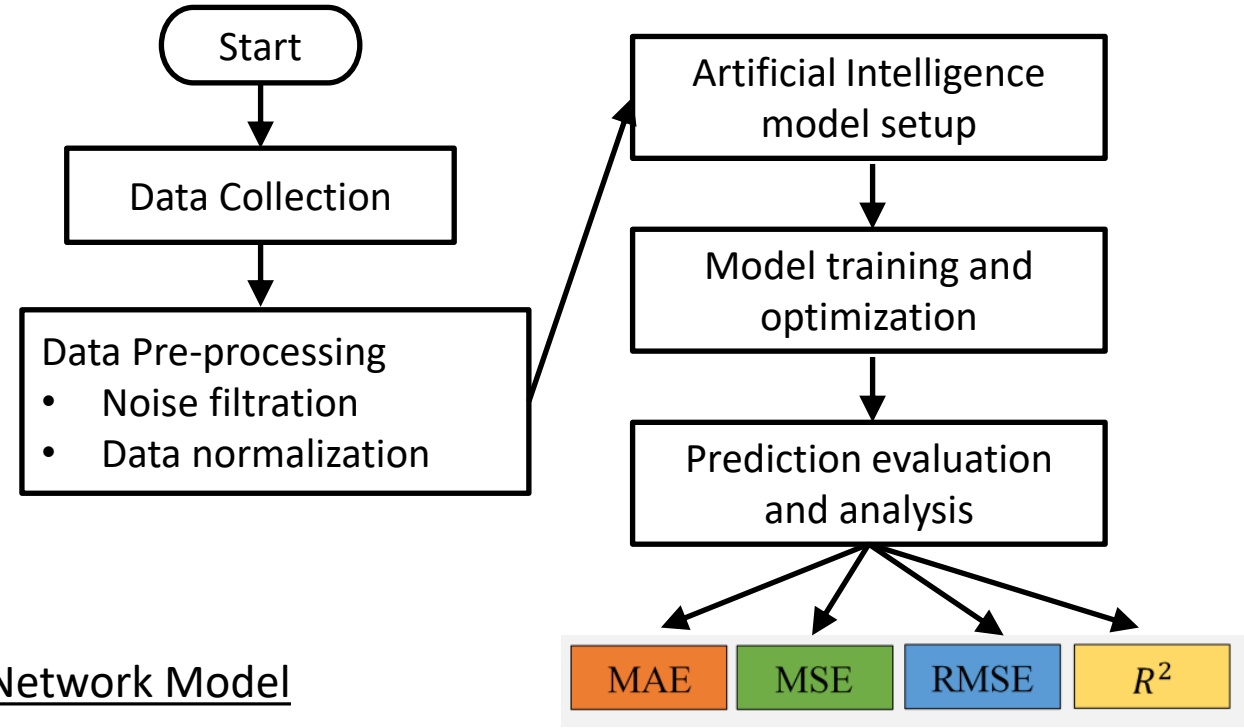
Proposed Method:

Objective 1: To enhance and improve the precision and performance of the IoT-based sensors through machine learning calibration.

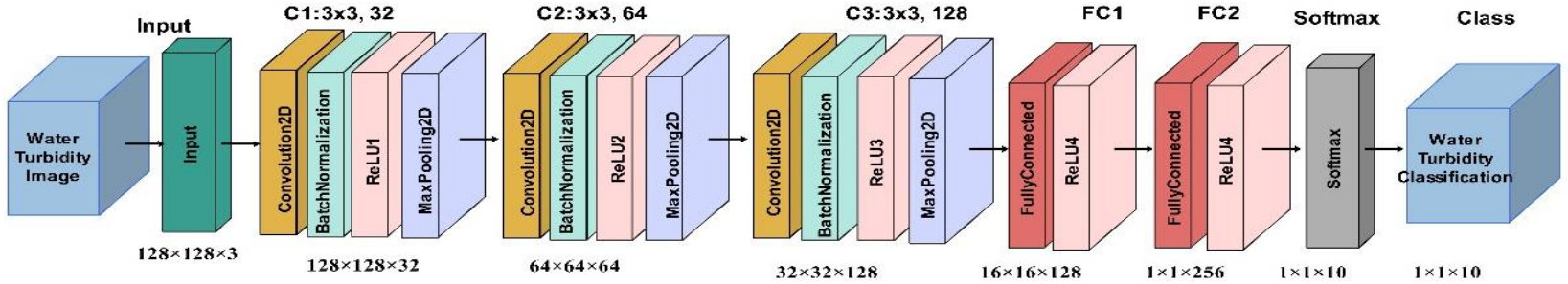
Water turbidity measurement principle



$$I = \frac{9\pi^2}{\lambda^4 r^2}\left(\frac{n_2^2 - n_1^2}{n_2^2 + 2n_1^2}\right)^2 v^2 N I_0 \left(\frac{1+\cos^2\theta}{2}\right)$$



Example: Water Turbidity Convolutional Neural Network Model

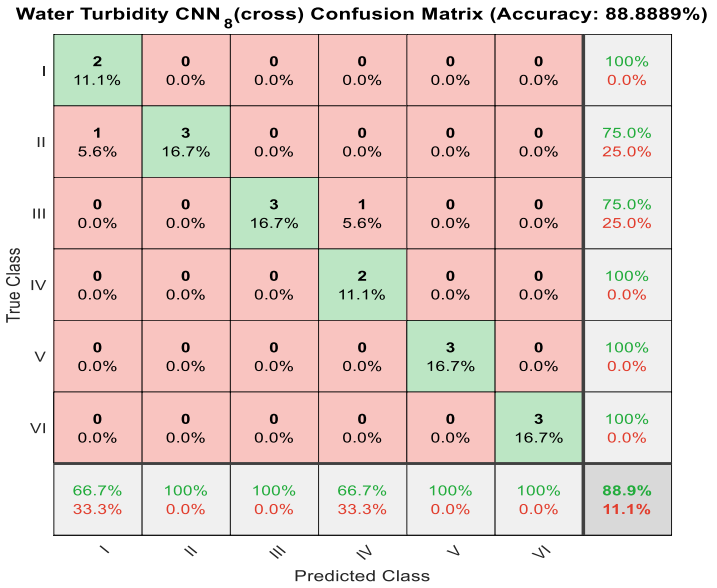


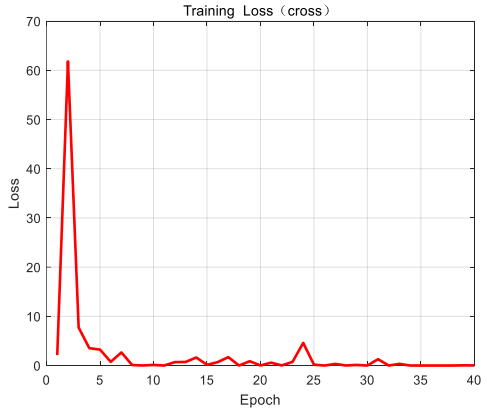
Proposed Method:

Objective 1: To enhance and improve the precision and performance of the IoT-based sensors through machine learning calibration.

Image processing assisted calibration enhancement of water turbidity measurement

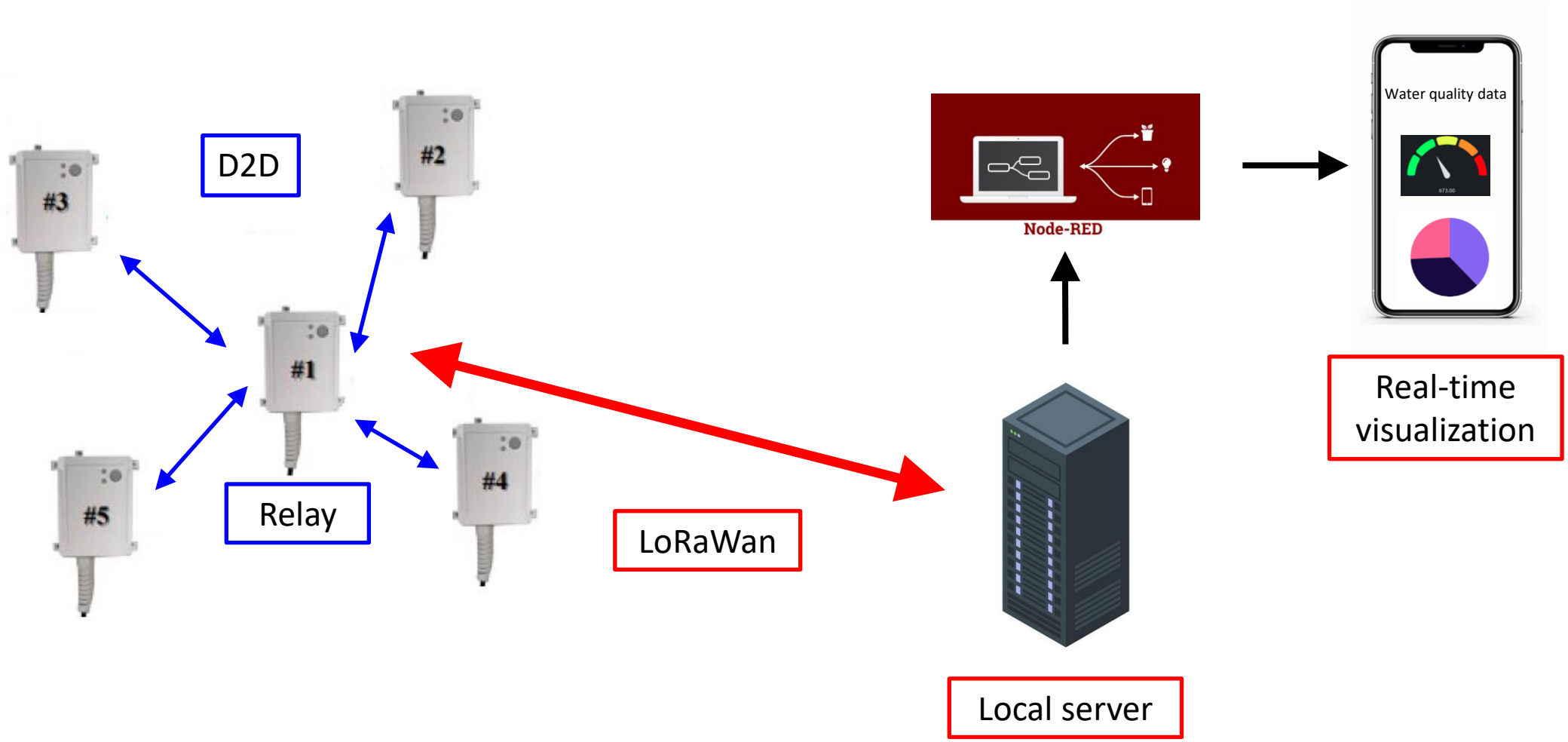
Turbidity Standard (NTU)	White background	Orange background	Blue background	Yellow background	Cross sign background
0 - 100					
100 - 200					
200 - 300					
300 - 400					
400 - 500					
500 - 600					





Proposed Method:

Objective 2: To improve data connectivity in the system in remote area environment incorporating the D2D technology.



Impact: (Max. 3 slides)

Scientific and technological:

IoT and sensors advancement	By integrating IoT technology with water quality monitoring with better accuracy and reliability, the project can stimulate advancements in sensor technology, which permit the wide usage of IoT devices for water quality measurement in applications.
Improved communication IoT network	The employment of D2D technology in water quality measurement system can help to enhance and provide reliable data transfer platform to the local server and for real-time monitoring.
Longitudinal studies and modeling	Collecting continuous data over time provides a foundation for robust longitudinal studies, enabling scientists to model environmental changes, understand seasonal variations, and detect long-term trends in water quality.

Impact: (Max. 3 slides)

Societal Impact:

Sustainable Resource Management	Access to precise data on water quality enables municipalities, industries, and agricultural sectors to make informed decisions, promoting sustainable water resource management that minimizes wastage and pollution.

Collaborative Impact:

Aquaculture industry partners	The IoT system with better water quality measurement shall be beneficial for aquaculture industry partners, i.e., fish breeder, crab breeder, etc. The water quality monitoring is useful to detect poor water quality condition and help to give warning in preventing high mortality during the breeding process.
Environment government agency	Employment of low cost IoT system can help to allow more installation of the water quality monitoring devices in helping to keep the river water quality in line with the standard imposed. This can help government agency in monitoring the water quality of raw water supply.

Output/Outcome: (Max. 2 slides)

Scientific:

New formulation for water quality IoT sensor measurement: New correlation formulation shall be proposed to better predict the water quality measurement in giving more accurate and better precision data. The data attained using the new formulation shall be compared with the data of other conventional measuring device.

AI optimization of water quality measurement: Artificial intelligence models shall be employed to gain insights of the water measurement data. The AI model shall be trained to gain the importance relationship of the resulted data and the expected data.

AI-assisted image processing technique: Apart from measurement from IoT sensor, the measurement of the water quality (i.e., water turbidity) can be enhanced using the image processing based technique. AI models shall be trained using a set of images data in the range of turbidity level.

Enhanced communication network of IoT system: Incorporating the D2D technology, the communication between device to device for the water measurement shall be improved. Http protocol shall be used to transmit the data to the local server and visualized in real-time using the node-red platform.

Output/Outcome:

Collaborative and partnership:

Application of UK Research and Innovation grant: Towards Sustainable and Resilient Aquaculture in Malaysia and Vietnam: A Holistic Approach Incorporating Digital Innovations – AQSURENCE. This project focuses on the application on the usage of ICT in aquaculture industries in Malaysia and Vietnam, pertaining to the mud crab breeding. The improved water quality monitoring system would help to ease the decision making on mud crab breeding and reduce the mortality rate of mud crab.
Involvements of new partners: University of West London (UK), London's Global University (UK), Swansea University (UK), Research Institute for Aquaculture (Vietnam), Universiti Malaysia Terengganu (Malaysia).

Application of Royal Academy of Engineering grant: The application of this grant will focus running program that support technical training for aquaculture workers and other stakeholder in adopting the usage of ICT.
Involvements of new partners: Ton Duc Thang University (TDTU)

Application of Public-Private Research Network 2.0 grant: This project will focus on more precise monitoring, control, and automation of critical parameters that impact fish health and breeding success.
Involvements of new partners: National Yang Ming Chiao Tung University (Taiwan)

Conclusion:

Targets:

- Develop the new AI assisted technique to improve the water quality measurement of IoT sensor.
- Employ the D2D technology to assist the data transmission between IoT devices.

Methods:

- Convolutional neural network model with optimization technique shall be employed to improve the data measurement of water quality IoT device.
- Image processing of turbid water shall be performed with the assistance of AI models to yield measurement of turbidity.
- D2D technique shall be adopted and tested for communication analysis for IoT system.

Scientific and societal impact:

- Enhancement of water quality measurement and wider adoption of IoT system.
- Better environmental monitoring and aquaculture industry usage.