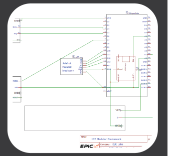
DOXY DISSOLVED OXYGEN MONITORING

WITH NAVID SHAGHAGHI

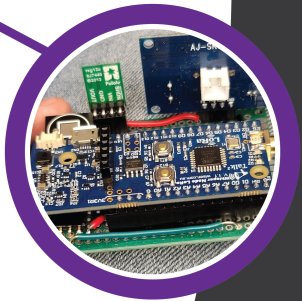


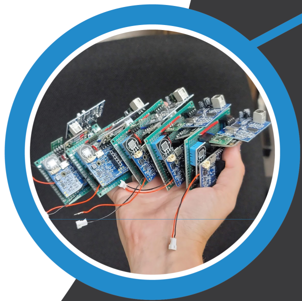
INTRODUCTION

Dissolved oxygen is essential to understanding the health of a body of water. Bodies of water host 80% of the planet's biodiversity and are the largest ecosystems on Earth. If the level of dissolved oxygen becomes either too high or too low, aquatic life can be put under stress. Society is closely tied to the livelihood of aquatic life. Millions of people rely on underwater ecosystems for food, and even more rely on the benefits that healthy bodies of water provide. Typically, dissolved oxygen is measured using expensive tools costing thousands of dollars that have complex and confusing instructions while needing near constant maintenance. DOxy aims to be an alternative that requires little maintenance while being available to everyone at a minimal cost by re-purposing readily available technology such as an infared emitfor dissolved oxygen monitoring.

THE MODULAR IOT PLATFORM

Typically, IoT devices are designed with one purpose in mind, limiting future expandability and requiring major re-designs with every iteration of the product. DOxy was created in tandem with the Modular IoT Platform. While developing DOxy, there was a need to be able to rapidly prototype designs by rearranging and changing key components without damaging any hardware. The result was a modularly designed circuit board that can be used for a multitude of purposes and projects. One benefit of having a modular platform is that the device for sending, receiving, and relaying the data can share a singular PCB, bringing down costs significantly. Moreover, the cost of designing future devices will be drastically reduced due to the ability to add or remove sensors on the platform with relative ease.





NEW SKILLS AND CAREER EXPLORATION

As a team, participating in this research opportunity has opened our eyes to a previously unfamiliar area of computer engineering. Throughout the summer, we collaborated on a wide range of tasks, from soldering and PCB design to programming Arduino code for various applications. While hardware design was not a focus for us before, we found ourselves constantly considering the integration of software and hardware and exploring ways to optimize it.

Working together on designing the Modular IoT Platform and writing the accompanying code allowed us to see the importance of understanding hardware functionality to develop effective programming solutions. Our team now realizes that having a comprehensive understanding of hardware design is crucial to the success of any software project. We are grateful for the opportunity to have gained this new perspective, and we look forward to applying our new knowledge to future projects.

CONCLUSION

DOxy aims to be the solution to a global issue. It's creation spawned a modular IoT Framework that will become present in many of Professor Shaghaghi's other projects. While the development for DOxy isn't complete yet, through testing and using competing devices, it has become apparent to me that there is a strong reason for a device like DOxy to exist. DOxy will give people a way to easily measure the dissolved oxygen in water helping insure the health and wellbeing of millions.

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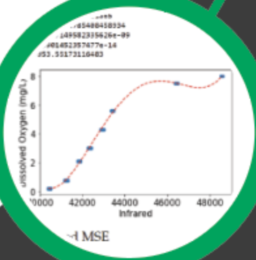
EMBEDDED SOFTWARE

Our software runs on a Talk2 Whispernode microcontroller, a piece of hardware which allows for LoRa communication from a Sensing Unit (SU) to a Bay Station. The SU gathers data samples from its sensor suite, averages them, and uses them to figure out the local concentration of dissolved oxygen (DO) in the water with a conversion equation which we solved for using machine learning. The sensor suite on the SU collects Temperature, Dissolved Oxygen, and Pressure (work in progress) data and relays it through AB: An Energy-Aware Communications Protocol (EACP) for the Internet of Things (IoT)The Bay Station receives the payload (in the packet structure figure above). The data is then organized into a JSON Format, for example:


```
{
  id: '1',
  dox: '22.00',
  temp: ': 24.10',
  batt: '5.00',
  solar: '20.00',
  timestamp: 1676666491
},
```


Finally, the Bay Station will send this JSON in an HTTP request to our web dashboard that displays the data to a user.



FORMULATION

We obtained a calibration curve for dissolved oxygen in water using a dataset of 800 samples, each with 100 readings. We used SKLearn's linear regression and SVM models, with a radial basis function, and 10-fold cross-validation on 70% of the data for training. We also used SciPy's curve_fit library with quadratic, cubic, and quartic equations to get an equation for visualization. SVM outperformed linear regression with MSE of 0.938 vs. 0.226. The quadratic, cubic, and quartic regressions had MSEs and R2 values of 0.156 and 0.979, 0.148 and 0.980, and 0.012 and 0.998, respectively. We chose the cubic regression to avoid overfitting, although the quartic function performed the best.

THE DASHBOARD

The Dashboard is a web application that uses React, a lightweight front-end JavaScript library, to build an interactive user interface. The front-end is served by a server written in Node.js. The server receives updates from a base station at regular intervals, typically every few minutes, and processes these requests. The data from these requests is then stored in a time-series database called Timescale, which is optimized for storing and querying large amounts of time-stamped data. The Timescale database allows for real-time analytics and can be queried to provide up-to-date information on the state of the system. The Dashboard can then display this information allowing users to monitor the system's status.

CASING

The first section holds the sensor, with 3 small screw holes on the bottom to ensure the sensor is firmly secured. The sensor holder is then threaded into the plexiglass lens housing to ensure the sensor is completely parallel to the lens. The lens housing has the lens inserted at the very bottom where the threading ends internally. A gasket is inserted into a rim near the bottom of the lens housing to ensure the sensor assembly is waterproofed.

The final section provides a backdrop for the light from the sensor to reflect off of. This backdrop section is screwed on to the external threading of the lens housing and has large opening along three of its sides in order to ensure air bubbles are not present between the lens and the backdrop.