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Electrical Engineering Team 8

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Miniaturized Fluorescence Sensor

Abstract

The presence of dangerous phytoplankton in aquatic ecosystems and the inability to efficiently identify these organisms pose risks for the community. The miniaturized fluorescence sensor designed by the team offers a cheap and quick method to identify such phytoplankton.

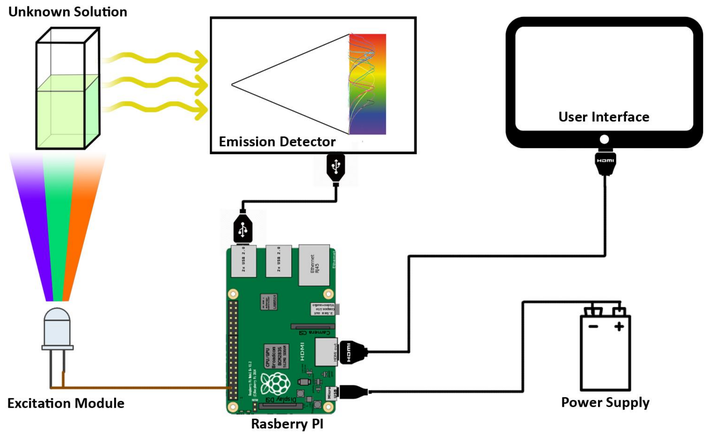
Project Description

The primary objective is to deliver a low-cost autonomous phytoplankton sensor that works by characterizing the organisms based on their fluorescence emission spectrum. The client expressed the need to distinguish between phytoplankton types and determine the concentration level of each. The product is catered towards enabling community science and decreasing communities' reliance on labs.

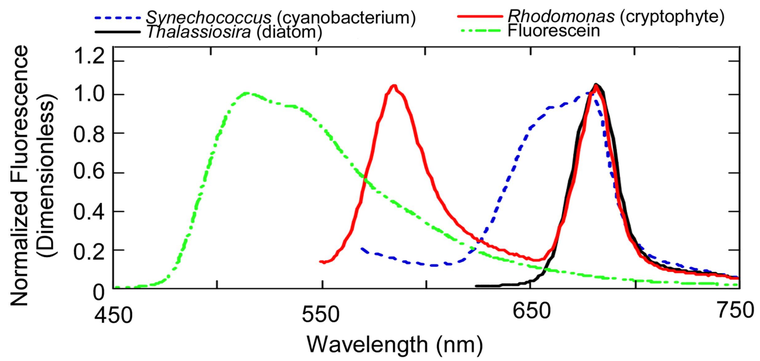
The system design entails shining a desired wavelength of light into an unknown sample and then reading the emitted fluorescence using an emission detector, which will then be run through an algorithm to determine it's content. A user interface will give a range of input options to operators, and then display results simultaneously. The system integration will be handled with a Raspberry Pi microcontroller.

Details of Design

System Architecture:



Fluoresce Spectrum for Plankton:



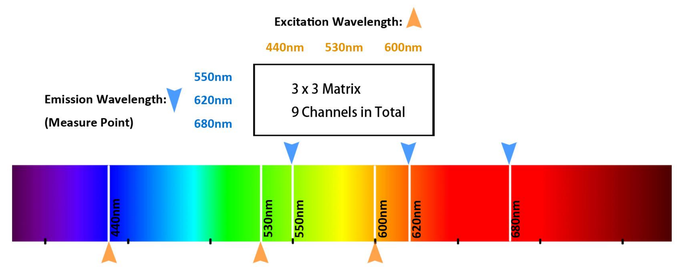
Excitation Module: This module stimulates the sample liquid with light at three chosen excitation wavelengths. One addressable LED light source is preferable in our current approach, and using three single wavelength LEDs or a tunable laser form our alternatives.

Sample Unit: The unknown sample is stored in a cuvette. The cuvette is chosen to have 4 polished surfaces which allows fluorescence measurements from a perpendicular angle. It is made by optical glass to avoid volatile plasticizers and it comes with a lid preventing spilling.

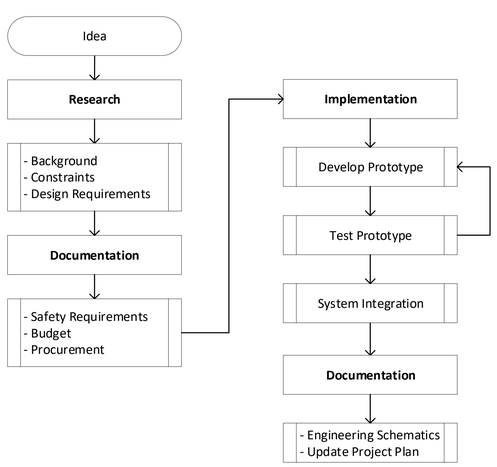
Emission Detection Module: This module measures fluorescence emitted by plankton at three chosen emission wavelengths. A low cost spectrometer is an ideal device for this module. Alternatives include using a prism or optical filter to separate color, and using a photo diode to measure intensity.

Control Module: This microcontroller instructs the light source, acquires and processes data from the detector, and manages the user interface. A Raspberry Pi is chosen due to its low cost and strong compatibility to external modules.

Excitation and Emission Wavelength:



Design Process



Initial Conclusions and Recommendations

To ensure quality, a pre-defined set of verification and quality standards are recommended to define acceptable results. The test process begins with the set up of the initial prototype in the testing environment. The second stage involves testing the prototype to determine if the set requirements are met. The third stage encompasses a feedback loop into the development stage to make improvements. The testing stage is complete when all verifications and quality standards are met.

The current library of phytoplankton may be expanded requiring a larger resolution of and ranges of wavelengths. The recommendation is to optimize the excitation and emission modules for future capability.

The implementation of a more advanced user interface, a wireless communication feature to log output, and an increased water resistance grade, are all recommended features in consideration should the project scope allow.

References

Earp, Alan . (2011). Review of fluorescent standards for calibration of in situ fluorometers: Recommendations applied in coastal and ocean o bserving programs. Optical Society of America, 19(27), 26768-26782.

Gregora, J., Maršálekab, B., & Šípková, H. (2007). Detection and estimation of potentially toxic cyanobacteria in raw water at the drinking water treatment plant by in vivo fluorescence method. In Water Research (Vol. 41, pp. 228-234).

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