Indian Institute of Science Education and Research Kolkata

Department of Biological Sciences

Summer Project Report, June-July 2020

Development of low-cost sensor probe for the estuarine systems as an alternative to conventional instruments

Submitted by

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on

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under the supervision of

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Declaration

I declare here that the report included in this project entitled **"Development of low-cost sensor probe for the estuarine systems as an alternative to conventional instruments"** is the summer internship carried out by me in the Department of **Biological Sciences**, Indian Institute of Science Education and Research Kolkata, India from May 18 to July 16, 2020, under the supervision of **Prof./Dr. Punyasloke Bhadury .**

In keeping with the general practice of reporting scientific observations, due acknowledgments have been made wherever the work described is based on the findings of other investigators.

Abhishek	Janjgir-Champa, Chhattisgarh	July-15-2021
Student's e-Signature	Place	Date

CERTIFICATE

It is certified that the summer research work included in the project report entitled **“Development of low-cost sensor probe for the estuarine systems as an alternative to conventional instruments”** has been carried out by **Mr. Abhishek Thawait** under my supervision and guidance. The content of this project report has not been submitted elsewhere for the award of any academic and professional degree.

Signature of Supervisor

July XX , 2021 (Prof./Dr. Punyasloke Bhadury)

IISER Kolkata **Project Supervisor**

List of Abbreviations

CTD	Conductivity, Temperature and Depth
DIY	Do It Yourself
IOT	Internet Of Things
LED	Light Emitting Diode
GPS	Global Positioning System

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“Title of the Project”

Acknowledgments

I would like to express my gratitude to my supervisor Dr. Punyasloke Bhadury for giving me the opportunity to have an internship under him. I'm learning a lot from this opportunity and wish to get mentored ahead in my career.

I would also like to thank my fellow summer researcher colleagues Anushka and Moitrayee, for being involved in fruitful discussions and sharing valuable knowledge.

I sincerely thank IISER Kolkata for allowing me to carry out my summer internship.

Abhishek	Janjgir-Champa, Chhattisgarh	July-15-2021
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“Development of low-cost sensor probe for the estuarine systems as an alternative to conventional instruments”

Introduction

The conventional and modern sophisticated oceanographic instruments have always been super expensive and require careful handling, restricting the collection of data from a large number of sites and making the study difficult which relies on big data recorded over a long period of time to draw out conclusions. Conventional sensor instruments which are robust and extremely precise can cost several thousand dollars per module. The instrument used in oceanographic studies to measure Conductivity Temperature and Depth or CTDs costs starting from approximately $5000 and can reach $25000 or even more (Thaler, Sturdivant, 2013)

These instruments if they stop functioning and need repair then it has to be sent to the manufactures to fix it which could take several weeks or months depending on location and shipping logistics. Thus a need for an easy to repair instrument is felt which has several replaceable components making it easy to sustain for a long time. Also, the instruments are pre-configured by the manufacturer i.e having only certain kinds of sensors available in a module. In some studies, one or two sensors might not be required, which means the researcher is also paying money for the sensor which is not being used in the study. Again the need for an easy to customize sensor is felt.

Aim and Objective

My summer internship this summer is focused on exploring the practicality of using low-cost sensor-based data loggers in estuarine systems like Sundarbans from the components that are available in the electronic hobbyist market at cheap prices, comparing their pros and cons with the existing conventional instruments, making a prototype and testing it in the water bodies.

Discussion

The low-cost sensor and DIY (Do It Yourself) electronics are open source, cheap, and user-friendly. They are easily available in the market and are quite easy to code and configure. These sensors can provide a cheap alternative to the expensive high-end instruments as they are easy to construct, program, and customize according to requirements. The most important quality of the low-cost instrument is that they can provide large spatial resolution in the data measurements because it can be deployed in large numbers on the site giving the researcher much better geo-spatial data over a large area to be analyzed.

I found the Arduino platform to be one of the most simple and handy to work with as it allows flexibility to use as many different sensors and modules as the user wants. Anyone with minimal experience in electronics can work on this platform, the environment for code development is user-friendly and it is based on the C language. Arduino-based electronics are cheap but they are capable of performing intricate codes that mean measured data from the sensors can be processed and analyzed on the microprocessor board itself. When the Internet Of Things or IOT is implemented with the Arduino, it can transmit real-time data across the internet to anywhere around the world. This enhances the capability of Arduino-based instrumentation.

One of the limitations of low-cost sensors is their accuracy in measurements. A temperature sensor would be accurate to +/- 0.1°C in a temperature range of 0°C to 55°C, whereas SBE56 temperature sensor from SeaBird Electronics is accurate up to +/-0.0036°C. They are prone to fluctuations and have to be manipulated in order to filter them from the data. Such sensors with low accuracy cannot be used for studies where high precision measurements are required. They are well suited for studies where drastic changes in physical parameters are expected to observe.

The Arduino microprocessor board can handle many sensors together with other useful modules like communication, storage, drivers, and relays for the mechanical parts, etc. One of the big challenges faced while designing DIY instruments is the fabrication and calibration of sensors. The readings from the sensor might get affected by the material used for waterproofing so they have to be well-calibrated and tested before deploying in the field.

Large conventional instruments are deployed in mooring buoys which adds service, repair, and deployment costs as they are carried and transported by ships and big boats. On the other hand, Arduino-based low-cost instrumentations can be installed in small moorings (fixed or movable). Being smaller in size they can be easily carried and deployed from a small boat. They can be customized to alert researchers for any malfunction if occurred through dedicated LEDs.

Experimental section

In estuaries of Sundarbans, many logistics and technical issues are faced while deploying any scientific instruments in the fields. The region experiences high tide and low tide twice in a 24 hour period and the difference in water level could be in meters. Also, some components like solar panels from the expensive moorings are prone to get stolen from the site by the locals and can even get damaged. It’s also difficult to deploy conventional probes in a large number. So to overcome this, a low-cost Arduino-based sensor probe can be designed at a fraction of the cost of conventional instruments.

I aim to design and develop a fixed point source data logger system having temperature (DS18B20), light intensity (BH1750), and barometric pressure sensor (BMP180) using the Arduino platform. This will be specifically designed for the salty marine environment of estuaries. The data will be stored in the data logger shield of the Arduino containing 16GB of external memory storage enough for recording measurement for months. The recorded data has to be retrieved from the SD card after a certain period of time. The whole instrument will run on a 9V battery pack. One of the objectives is to check the working time of the setup in different conditions before the battery dies and then to minimize the power utilization by making code efficient and reducing the wakeup time of different sensors.

The whole instrument is planned to have three major electronic parts i.e the sensors, microprocessor (Arduino), and the power supply. In further development, a solar panel can also be added if the need to increase the lifetime of the instrument is felt. The structural design will consist of a rod with tripod legs which will be buried in the soil making it stable in strong water currents.

The upper portion will have a watertight box containing the microcontroller and a power source keeping it safe from moisture and water. Above the box, at the top of the electronics box, another rain-protect cover can be attached to it. The solar panel will be installed above the rain cover. This will maximize the amount of sunlight received by the solar panel. Now the most crucial part is the placement of probes which will be dipped inside the water. Estuaries, as said earlier, experience an intense change in water level due to strong tides, making the probes fixed at one place exposed to the air during low tide. This will give undesired data from the probes and there will be no way to know if the probes are in contact with the water. So, to counter this problem a method can be adopted which is attaching the probes to a floater connected to a linear motion sliding bushing (a mechanical structure that can slide on a rod or a rail).
The buoyancy of the floater will make sure that the probe is always dipped in the water. That means during low tide probes will get lowered with the decrease in water level and vice versa with the high tide. This is particularly important if the sensor is pH meter, the electrodes have to be always dipped in the medium where the measurement has to be made.

After the instrument is constructed, the next step is to run all the sensors together on a limited power supply from a 9-volt battery pack for the set measurement frequency of 5 sec, 30sec, 1min, 5min, and 15 mins so on respectively and record the lifetime of the battery.

An important thing to be done in the laboratory is to compare and calibrate with the existing research-grade instrument. A proper analysis has to be done for the used sensors and has to list out any faults or limitations observed while testing out the instrument.

Conclusion

The low-cost instrumentation based on the Arduino platform seems promising, easy to make, requires minimal experience in electronics, provides intense flexibility and customization as per requirement, and can be deployed in large numbers in the field. Based on this report a prototype of the fixed point source data logger is under development.

Future Directions

The prototype has to be tested in the field over and over again with a slight modification each time, alternative structural design has to be tested and different sensors have to be integrated. A maneuverable data logging instrument can be built equipped with the GPS enabled module which can provide large geo-spatial data for the site reducing the need for fixed-point data loggers.

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