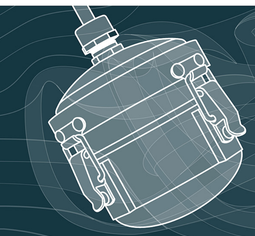
the Cave Pearl Project

A LOW-COST SUBMERSIBLE DATA LOGGER SYSTEM FOR ENVIRONMENTAL MONITORING

Edward K. Mallon: Triple Point Design & Patricia A. Beddows: Earth & Planetary Sciences, Northwestern University

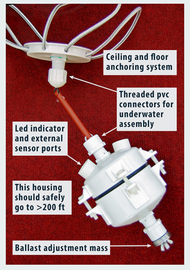


Introduction

The cost of hydrological sensors often limits the number of sites and temporal scope of projects. Here we present the Cave Pearl: a submersible data logger being developed for monitoring projects that require more than one year of continuous operation in or near water. These units are relatively easy to build for $30-$100 using Arduino microcontrollers housed in standard plumbing fittings. Rather than design custom circuit boards from scratch, we have focused on creating a fully functional data acquisition system from a small number of readily available and interchangeable modules.

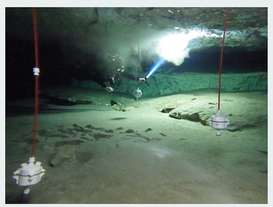
Two example configurations of this logging system are presented here.

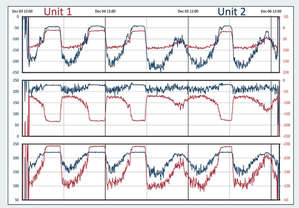
Monitoring Water Flow



Researchers studying water flow in karst systems often find commercial systems sub-optimal. Heavy oceanographic instruments need anchors that can damage the cave environment and require dangerous lift bag deployments. Once deployed, they are often too massive to respond to subtle changes in flow velocity & direction. More sensitive compact acoustic doppler systems are available, but these units can be confused by signal reflections from cave walls and haloclines. To address these concerns we have constructed an easy to deploy device using the principle of the hydrometric pendulum, where drag induced tilt of a freely swinging body allows current speed and direction to be derived. This design is resistant to the bio-fouling which plagues propeller based systems, and exposes no active metal components to the corrosive effects of salt water.

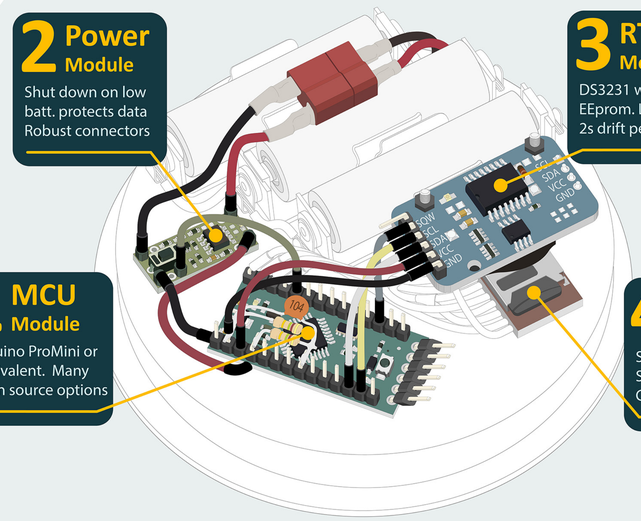
This design has already survived more than five months of salt water submersion at 5m depth in a flooded cave environment, demonstrating excellent low flow sensitivity. Currently deployed units are evaluating different accelerometer and compass modules, and after a final sensor selection is made we will calibrate them to true point velocity. We also have successful deployments of pressure & temperature sensing units and we are working to add full CTD capability in future.





RAW 3-axis Data from one of our earliest deployments with a low bit depth 2g accelerometer, in a system with diurnal tide flows ranging from 0-15 cm/sec. Sensitivity has improved considerably since then!

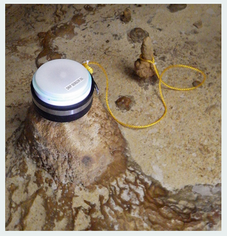
The heart of the system



Component	Cost
Arduino Pro Mini Clone	$4.00
Ds3231 RTC with Eeprom	$2.00
MicroSD card & Adapter	$3.00
Resistors, Wire, Connectors etc.	$2.00
Power Switch & Battery Holders	$10.00
Total	**$21.00**

Drip Sensing

The same logging platform is being used to study vadose hydrology and stalagmite formation, by recording the number of drops of water that impact the housing. An accelerometer on the top surface acts as a tap sensor, triggering an interrupt signal to wake the sleeping logger, which updates a simple counter and then goes back to sleep to conserve power. When the real time clock alarm occurs, the logger writes the time and counter data to eeprom memory. The Arduinio also checks if the eeprom is full, and when necessary transfers the data from the eeprom to the SD card. With bench top tools (and some practice) these units can be assembled in approximately 4 hours. With a suitable funnel to conform drip volume, this configuration could easily serve as a logging rain gauge.



In Summary

The goal of this project is to create a robust platform that is inexpensive enough to bring large monitoring projects within the range of modest research budgets. In addition, exploratory "tattle-tale" deployments of DIY loggers like this is a low risk strategy for identifying locations within complex systems that are worthy of intensive study. However the driving force behind this project is not cost but adaptability. Only interchangeable, nonproprietary components and formats are being used (AA batteries, csv files, SD cards, etc.) Variables such as sample frequency are adjusted directly in the open source driver software and one can easily modify the code to support different analog or digital sensors to address other research questions.

Cave Pearl Project blog
http://edwardmallon.wordpress.com/

With support from
The National Geographic Society / Waitt Grants Program

And from