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Scuba Diver Location Tracking System

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ABSTRACT

Global Positioning System (GPS) telemetry technology has been a boon to multiple industries. Oftentimes, the main limitation to widespread application of this technology is the cost, which can dictate the number of industries using GPS technology. Here, we discuss the development of a low-cost, customizable, open-source hardware GPS logger for use in industries where cost is a major limiting factor, like Recreational Scuba Diving. We will be using technology that has been used by wildlife researchers to study animal spatial ecology. The technology will improve the safety of Scuba Diving. These GPS loggers have the potential to facilitate a "connected diving experience" that would be otherwise cost-prohibitive.

Keywords: GPS, Logger, Safety, Scuba Diving, Tracking.

1. INTRODUCTION

WITH the price of commercial GPS loggers for use in outdoor activities relatively high, a number of low-cost alternatives have surfaced. For our purposes, we classify low-cost loggers in two groups: modified and do-it-yourself (DIY). Modified loggers are commercial products that are altered to suit the specific needs of a project, most often increased battery life but, typically, that is the extent of the customization available when modifying a commercial unit. In comparison, DIY loggers are generally built from scratch, allow users a wide variety of customization options, but more importantly, cost less than their commercial counterparts. There has been an increase in the number of DIY projects in the biological sciences due in no small part to the reduced cost and the ability to tailor these devices to the needs of specific projects, for example, constructed GPS loggers to track the movements of wild otters (Lutra lutra) in Portugal. The widespread application of DIY GPS loggers, however, appears to be limited in Recreational scuba diving.

Here we describe a technique for constructing a GPS logger for use in recreational scuba diving. Our GPS loggers are low-cost, simple devices that can easily be modified for use in a wide range of scuba diving applications.

2. HARDWARE IN CONTEXT

The emergence of Global Positioning System (GPS) has revolutionized the way we observe and gather location data. GPS gives users the ability to gather large amounts of data regardless of environmental condition.

While GPS receivers provide numerous benefits, there are many limitations associated with this technology, particularly the cost per unit, which can be higher than $5000, excluding the additional expense of optional network costs for data download. The expense associated with GPS-tracking devices make it unusable in recreational diving as a large amount of units would be needed.

With the price of commercial loggers very high, a number of low-cost options have emerged. For our purposes we have selected a a do-it-yourself (DIY) approach as they are cheaper and generally built from scratch allowing us a wide variety of customization and more importantly cost less than their commercial counterparts.

Our GPS loggers are simple, low-cost devices that can easily be adapted for use in a wide range of studies and animals.

3. HARDWARE DESCRIPTION

For the purpose of recreational scuba diving, we selected light-weight components with a small footprint so that the logger itself would not have any impact on the recreational scuba diver. The logger consists of the following components: GPS Module, Lithium Ion battery, Microcontroller, Transistor and an on/off switch.

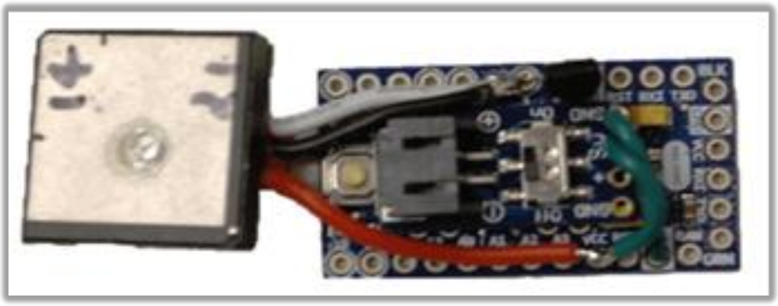

Fig.1. Assembled unit of the logger

Fig.2. Logger encased in heat shrink tubing for use

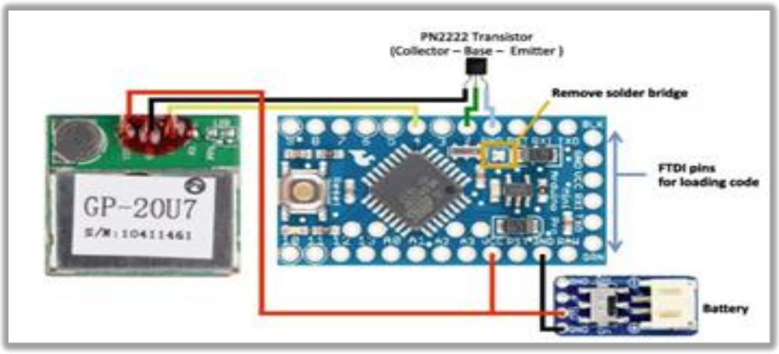

Fig.3. Wiring diagram of the logger

At the core of our GPS Logger is the Atmega328P-AU microcontroller, an integrated circuit with the functionality of a computer. We selected Arduino Pro Mini, a breakout board of the Atmega328P-AU because of the customization options and low over demand.

There are numerous options when purchasing a GPS receiver, but the one we use was selected for its price and the ease with which it can be incorporated into our design.

Many commercial GPS units need to be connected to a battery or a power source to be recharged or the user would have to pay the company who sold the unit to replace the battery. Therefore we went for a rechargeable battery that could easily be replaced in the field. We selected a 400 mAh Lithium Ion option for its cost, size and weight.

To further minimize the footprint and vertical profile of the loggers, we opted to upload/download code and data via an FTDI adapter:

- Low-cost option for GPS tracking (Approx. $60).
- Highly customizable and can be adapted to suit a variety of projects.
- The GPS Logger is easy to build and could be mass-produced quickly.

4. WORKING PRINCIPLE

The principle behind GPS is the measurement of distance (or "range") between the receiver and the satellites. The satellites also tell us exactly where they are in their orbits above the Earth. Four satellites are required to compute the four dimensions of X, Y, Z (position) and Time. GPS receivers are used for navigation, positioning, time dissemination, and other research. One trip around the Earth in space equals one orbit. The GPS satellites each take 12 hours to orbit the Earth. Each satellite is equipped with an accurate clock to let it broadcast signals coupled with a precise time message. The ground unit receives the satellite signal, which travels at the speed of light. Even at this speed, the signal takes a measurable amount of time to reach the receiver. The difference between the time the signal is sent and the time it is received, multiplied by the speed of light, enables the receiver to calculate the distance to the satellite. To measure precise latitude, longitude, and altitude, the receiver measures the time it took for the signals from four separate satellites to get to the receiver.

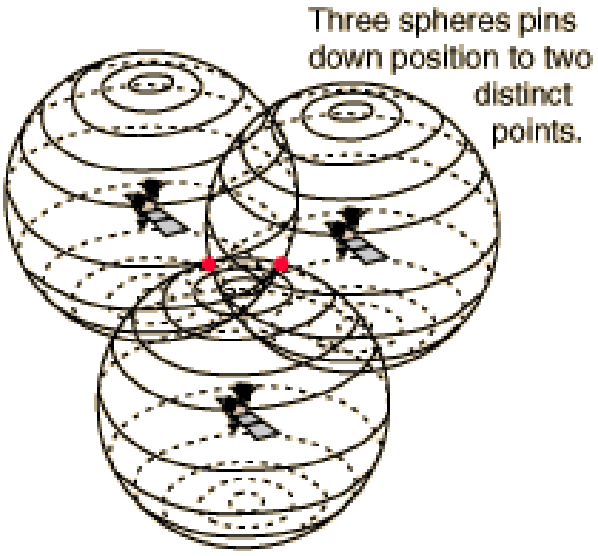

Fig.4. Working of GPS

It works something like this: If we know our exact distance from a satellite in space, we know we are somewhere on the surface of an imaginary sphere with radius equal to the distance to the satellite radius. If we know our exact distance from two satellites, we know that we are located somewhere on the line where the two spheres intersect.

And, if we take a third measurement, there are only two possible points where we could be located. By taking the measurement from the fourth satellite we can exactly point out our location.

5. BUILD INSTRUCTIONS

Building this GPS logger requires very basic electronic skills, the more important being Soldering and wiring/stripping.

The first step is to de-solder the solder bridge on the Pro Mini (Fig 3).

Next, prepare the switch by soldering two lengths of hookup wire (Around 2 cm) to pins "Sw" and "GND".

The next step is to glue the switch onto the Pro Mini such that the battery connector is on the same side as the reset button on the Pro Mini. Once the glue has set, solder the "Sw" and "GND" hookup wires on the switch to the Vcc and Pro Mini, respectively.

The base and emitter pins of the PN2222 transistor are soldered to pins 2 and GND on the Pro mini. The collector pin should be bent toward the reset button on the Pro mini.

Cut off the white JST connector from the GPS receiver, and trim the wires down to the desired length. The length of the GPS receiver leads will depend on the specific package and application used. The Vcc wire (red) connects to the same Vcc pin on the Pro Mini as the Sw pin from the Switch. The GND wire connects to the collector pin of the transistor, and the signal wire (white) connects to pin 4 on the Pro Mini.

6. RESULTS & DISCUSSION

Due to lack of appropriate testing methods and we were unable to personally test the GPS logger on a scuba diver. However a similar build was used and tested by Patrick W. Cain and Matther D. Cross on a Eastern box turtles. During their testing they recorded that the GPS Logger collected more variation than handheld units.

They also noted that accuracy is greatly influenced by environmental variables like cloud cover.

The GPS Loggers performed as expected even in inclement weather.

- Accuracy of the GPS loggers depended on habitat type. The units can occasionally freeze and record the same point repeatedly if satellite reception is poor, but will continue to function normally when signal reception improves. We encourage users to review data prior to analysis to avoid errors in interpretation.

- Using the native memory of the Arduino Pro Mini, TOS loggers can store 83 points when recording latitude, longitude, day, month, hour, and minute.

- Battery life is influenced by number of fix attempts and time spent attempting to obtain a fix.

Based on the above findings the GPS Logger is viable to use in recreational scuba diving.

7. CONCLUSION AND FUTURE SCOPE

The DIY GPS Loggers performed as expected and sometimes performed better than commercially available Handheld GPS. Due to their low cost and footprint they are ideal for use in Scuba Diving. Battery life varies

depending upon configuration of the Logger.
However, one drawback to this system is that the GPS Logger is incapable of transmitting its position live.

We are working on finding a solution to enable the logger to transmits its data to an onshore location without increasing the cost of the GPS Logger

With further advancement in technology and accessibility of said technology at lower prices, the addition of an emergency beacon to the GPS Logger would be very valuable to a scuba diver in case of emergency allowing rescue services to locate the diver easily.

The GPS Logger can also be used in many other applications like vehicle monitoring, fleet management etc., as it can be adapted to suit a wide variety of uses,

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