

In-Cave Data Logger Project
Sponsored by the
Central Connecticut Grotto
of the National Speleological Society

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This project is a work in progress, staffed entirely by unpaid volunteers. Information will be updated when available. To find out more please contact info@ctcavers.org and put “CCG Data Logger” in the subject line. If you don’t receive a reply within a week, please call Norm Berg at 860-621-2080.

Cave Visitation Logging Overview

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Abstract

The Central Connecticut Grotto is developing an in-cave data logging system with the assistance of members of the caving and electronics community. The system will consist of small data logger and the software to configure the logger and to view the data. The logger is designed to be placed in a cave passage to record (time stamp) the presence of any persons in the immediate vicinity. Human presence is assumed by correlating certain environmental conditions, typically light, with the presence of people.

Objective and Assumptions

Objective:

- To log human traffic in caves using a self-contained data logger

Basic Assumptions:

- Each person is using a light to illuminate the cave immediately in front of them.
- A sensor will detect any light in the immediate vicinity of the logger.
- Every person will pass in the vicinity of this sensor at some point during their visit to the cave.

Therefore:

- Light detection by the sensor means a person is in the vicinity of the logger.
- By recording the dates and times when light is detected, we can know when a person is in the cave.
- Charting the light detections will show patterns of visitation.

Contradictions to the Assumptions:

- Detections may be missed. A person's headlamp or flashlight may not be shining on the sensor, or be too weak to be detected. Also a person may travel through the cave but never pass in the vicinity of the sensor, or they may pass by with no light at all.
- The number of light detections cannot reliably be used to determine the number of persons visiting a cave.
- Each sensor has a unique sensitivity to light. Standardized testing and calibration is currently not done.
- It is not possible, at this time, to position a sensor in exactly the same place (with same "view") in the cave as the sensor it replaced.

Outline of Data Logging Procedure

1. Program the logger configuration, such as the current date-time and sampling units.
2. Activate the logger to begin collecting data.
3. Place the logger in the cave.
4. Remove the logger from the cave.
5. Connect the logger to a computer to retrieve the data.
6. Analyze the data and use the analysis to produce reports on cave visitation.

Placement in a Cave

The logger is intended to be placed in a cave where human traffic is likely and the logger can be concealed where it won't be easily disturbed. For ease of describing this project, a logger is assumed to have one light sensor.

Data Retrieval

The time between retrievals is determined by the need to view the information, and the maximum data capacity and battery life of the logger.

Methods to retrieve data from the logger and resume logging:

- Enter the cave, remove the logger from the cave, transfer the data to a laptop, and then put the logger back in the cave.
- Enter the cave with a laptop, remove the logger from the concealed location, transfer the data while in cave, replace logger in concealed location.
- Enter the cave and swap the logger with another. Transfer the data from the removed logger when convenient.
- Depending on the technology supported by the logger, transfer may be done using a removable flash memory card; a non-contact method such as wireless.

Accuracy of Data

Discussion of accuracy of logging methods:

A single logger cannot be expected to produce an accurate 'head count'. However, by strategically employing multiple loggers in one area, it may be possible to obtain an indication of group size and direction of travel. Regardless, any effective logger should produce base-line data by showing the dates and times when groups or individuals are present at a specific point in the cave.

All logging methods are intended to be passive and indirect. Persons in the cave will generally be unaware of the location of the logger, so their behavior should not be affected.

The accuracy of information gathered is determined and affected by:

- The location of the logger in the cave.
- The correlation between the sensed environmental condition and the presence of people. For example, does every person use a light source in the cave?
- The variety of conditions sensed. Sensing light, sound, and motion at a point in the cave should increase the chances of detecting a person than just sensing light.
- The focus of the sensor. For example, sound sensing is generally non-directional and the sensor can be completely hidden. A light or motion sensor requires careful positioning to provide an unobstructed view of passing persons, yet it should also be well camouflaged to avoid detection.
- The sensitivity and calibration of the sensor.
- Environmental factors, such as water levels, may cause visitors to alter the typical path through a cave.

False Negatives and False Positives:

Ideally, every person or group would be logged just once as they pass by a logger. More likely some or many persons will be missed because the logger does not sense them. These are the false negatives. In logger data, is it not unusual to have no events (no light, sound, etc) 98% of the time, which includes false negatives. A person or group may pass by a sensor multiple times and be counted more than once. This would be the false positives.

The logger itself may cause false negatives if the sensor becomes dirty or is pushed out of position, etc. It may also cause false positives if circuit instability causes a spurious signal which is interpreted as a real event.

Logger Hardware and Software

Primary characteristics:

- Be of a size and shape that can be easily concealed ideally smaller than 4 cu in (25 cu cm).
- Be discreet and not produce visible light, sound, or otherwise attract attention.
- Operate in high humidity and in temperatures ranging from 35-90 deg F (so the logger does not fail or lose data while transported).
- Utilize open-source rather than proprietary software to set the logging parameters, and to transfer the data.
- Should be inexpensive to construct. Under \$50 if possible, not including removable memory if used.
- Have an adjustable sensing time interval and/or sense continuously.
- Operate unattended for at least two months.
- Retain data if battery fails during operation.
- Provide data output in CSV or other easily parsed text.
- Have one external sensor and also record data from one internal sensor, such as temperature or battery voltage.

Secondary characteristics:

- Be able to use a variety of external sensors at the same time. For example, to log light and sound events independent of each other using the one logger.
- Utilize removable flash memory cards for data collection so the memory could be swapped out while in the cave without removing and replacing the entire logger or provide a means of non-contact data retrieval (wireless radio, I-R, RFID).

Sensors

Discussion of sensors:

A basic premise of the logger design is that human presence may be assumed by making a correlation between certain environmental conditions and the presence of people. These environmental conditions include light, sound, and motion. The sensors, and related components sense these environmental conditions which are then recorded by a data logger.

A light sensor has been used for initial project development testing. Other sensors and multiple sensors may also be used. For example, one light and one sound sensor, or two light sensors (sensing light from different directions). Additional sensors should increase the overall accuracy of the data. Some sensors can be aimed, which may help determine direction of travel.

Discussion of environmental conditions that can be sensed:

Light:

A light event sensor may be the most practical option, as one could assume that any human exploring a cave will be using a source of light. It would need to sense very low levels of light, approximately 1 lumen or less. It must also detect a range of different light frequencies including candle flames, carbide lights, LED lights, and incandescent bulbs including halogen and xenon. Those persons remaining in one place for extended periods sometimes use candles or glow-stick lights.

Sound:

A sound sensor may offer another option for logging. Of course to be reliable, a sound sensor must accurately differentiate between ambient cave noise and human-produced sounds. An advantage of sensing sound is the sensor can be completely concealed.

Motion:

A motion sensor provides another alternative, although this type of device is generally larger, requires considerably more battery power, and may be more difficult to conceal.

Ambient conditions:

The logger might have the capability to log environmental conditions not associated with visitation, such as temperature, humidity, and air pressure.

Logger and Software Availability and Documentation

It is our goal to provide ready-to-use data loggers and the associated software at a reasonable cost. We intend to utilize common parts and open source software whenever possible. Information on the construction of the logger hardware, the software code, and operating instructions will be made readily available for non-commercial use.

Project Developers

Norman Berg: Project coordinator; Access, Excel, C# programmer

John Froehlich: Hardware developer; C and Assembly programmer

Jansen Cardy: Consultant; Outreach liaison to the caving and cave management community

Project Contacts

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