In-Cave Data Logger Project (DLP)
Sponsored by the
Central Connecticut Grotto

www.ctcavers.org
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This project is a work in progress, is frequently updated, and done entirely by unpaid volunteers. For more information, updates, and other documents, please contact info@ctcavers.org and put "CCG Data Logger" in the subject line. If you don't get a reply within a week, please call 860-621-2080.

CCG DLP - Overview

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Overview and Design Goals of the In-Cave Data Logger Project

This document was originally published on the CCG website as “Cave Visitation Logger - design request”

1.Objective:
To log caver traffic in caves using a data logger. To do this, we are requesting the assistance of the caving and electronics community to develop a data logger that meets the need described below. We prefer to use readily available parts and open source software. Another solution is to use a commercially available logger and replace the sensor, modify the sensor, or add additional electronics (these assume no stock commercial unit meets our needs). We are open to other methods and other devices that could do the data logging.

2.Contact:
Norman Berg and Jansen Cardy of the Central Connecticut Grotto
Email: info@ctcavers.org (please include "data logger" in the subject line)
Phone: 860-621-2080 (before 9pm eastern time)

3. Summary of the logging method:
Place a data logger in a cave passage to log the presence of people in the vicinity of the logger by saving the date and time. The accuracy of information gathered is mainly determined by the type of sensor, the number of sensors, the sensitivity of the sensor, and the location of the sensor in the cave.

4.Retrieving the data:
The time between retrievals is determined by the need to view the information, and the maximum time is determined by the data logger capacity and battery life. Assuming the data logger does not transmit to a receiver outside the cave, the cave will need to be entered and the data would need to be retrieved from the logger by either 1) Remove the logger from the cave, get the data, then put it back in the cave; 2) Go into the cave with a laptop and get the data while there; 3) Go into the cave, swapping a flash memory card with another; 4) Go into the cave and swap the logger with another.

5. Placement in a cave:
The location of the logger in the cave and type of sensor will affect the accuracy of information gathered. A single sensor cannot generally be expected to produce an accurate ‘head count’. However it is hoped that by strategically employing multiple loggers in one area, this may offer better indications of group numbers and direction of travel. Regardless, any logging should provide base-line data by at least showing the dates and times when groups or individuals are present at a given point in the cave.

6. Sensor types:
Human presence may be detected by using a light-sensor, sound-sensor, motion-sensor, and/or other technology. A data logger may have one or more sensors that save to the same memory, but for ease of discussion in this paper, a logger is assumed to have just one sensor.

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, incandescent bulbs including halogen and xenon, and LED lights. Our observations are that commercial sensors are much more sensitive to incandescent light than to typical white LED light. In early 2008, a rough estimate is that those moving thru a cave use incandescent and LED lights about equally. Those staying in place (breaks, parties) sometimes use a candle or Cyalume (glow-stick) light.

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

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

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7a. The logging device needs to meet these primary characteristics:

- Be of a size and shape that can be easily concealed (ideally under 4 cu-in).
- Not produce visible light, sound, or otherwise attract attention.
- Operate in high humidity and in temperatures ranging from 35-90 deg F.
- Not use proprietary software to program.
- Not be expensive to purchase or to construct or modify. Under $50 is preferred (not including removable memory if used).
- Have an adjustable sensing time interval and/or sense continuously.
- Record thousands of events.
- Operate unattended for at least two months.
- Provide data output in CSV or other easily parsed text.

7b.The logging device should also meet these secondary characteristics:

- Be able to use a variety of sensors at the same time (that is, log light and sound independent of each other and to the same memory).
- Use removable flash memory so the memory could be swapped while in the cave.

8a. The presence or absence of light can be recorded in a number of ways:

- A state recorder at fixed interval: The logger samples the state (on or off) at fixed intervals (such as every 0.5 second) and recorded if the state is different than the prior recorded state. The difference between each set of states (on and off times) can be easily calculated. This method does not record multiple state changes that end on the last recorded state and occur between the sampling interval. In a cave, the sample interval may need to be very frequent so a sweeping light is not missed.
- An event recorder at fixed interval: The logger operates like a state recorder, but only records the light-on event.
- A state recorder with continuous sensing: The logger samples the state (on or off) continuously (limited by the reaction speed of the logger). The state will be recorded when it is different than the prior recorded state. The difference between each set of on and off times can be easily calculated. This method could record hundreds of state changes each minute when it sees a flickering light, or it sees a light that is at the edge of the sensor sensitivity.
- An event recorder with continuous sensing: The logger operates like a state recorder with continuous sensing, but only records the light-on event.

8b. Variations to the above are:

- A recorder with continuous sensing and stretched on-time: The logger operates like either a state or event recorder, but the light-on event is held on for a set period of time, during which state changes are ignored. For an event recorder, this could reduce the number of logged light events caused by a flickering light.
- A recorder at fixed interval and stretched on-time: An additional circuit would hold the light-on event for a period of time greater than the interval state. This could catch any brief light flashes that occur between sensing intervals and hold it "on" until it is recorded at the next fixed interval.

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9. Calibration:
When desired, each logger should respond to the events (light, sound, etc) the same way, such as with the same sensitivity to the same frequencies (there are many other conditions, to be described in future write-ups.

10. Commercial unit overview:
The U9 HOBO light event logger has been used in the past, but current production models are unfortunately not sufficiently sensitive to white LED lights. We have modified one unit by replacing the sensor with a basic photocell, which seems to work adequately, though this is highly dependent on the characteristics of the photocell. Another, though less significant issue, is proprietary software needed to program the unit and to download the data. The following link shows the U9-002 HOBO® Light On/Off Data Logger at the manufacture's website (many other places sell this or an identical device under another brand name) http://www.onsetcomp.com/products/data-loggers/u9-002

11. Links that may provide design ideas, in no particular order:
(note from author: this list was made in early 2008, and needs to be updated and expanded.)
Embedded Systems http://en.wikibooks.org/wiki/Embedded_Systems
One Channel Light On/Off Data Logger http://www.microdaq.com/occ/u9/light.php
OM-53 Light on/off data logger http://www.omega.com/ppt/pptsc.asp?ref=OM-50&Nav=dase01
U9-001 HOBO® State Data Logger http://www.onsetcomp.com/products/data-loggers/u9-001
HOBO U9 State Data Logger http://www.thedataloggershop.com/hobo/u9-loggers/u9-001.php
Choosing Between a State, Event and Pulse Recorder http://www.microdaq.com/support/app_notes/stateeventpulse.php
SD Media Format http://www.maxim-ic.com/appnotes.cfm/appnote_number/3969
Portable Temperature Monitoring http://www.maxim-ic.com/appnotes.cfm/an_pk/1754
Build a Low-Power Data Logger http://www.circuitcellar.com/library/print/hcs-pdf/15-Ciarcia.pdf
Microcontrollers http://www.robotstore.com/store/default.asp?catid=1583
CdS photocell circuit with BASIC Stamp http://www.parallax.com/dl/docs/cols/nv/vol2/col/nv73.pdf
MSP430 Ultra-Low Power Microcontrollers http://focus.ti.com/mcu/docs/mcugettingstarteddetail.tsp?sectionId=97&tabId=1511&familyId=342
AVR series microcontrollers http://www.atmel.com/products/AVR/
Microchip PIC http://en.wikipedia.org/wiki/PIC_microcontroller
HCS08 8-bit microcontroller http://www.freescale.com/webapp/sps/site/overview.jsp?nodeId=01624684491437
List of common microcontrollers http://en.wikipedia.org/wiki/List_of_common_microcontrollers

12. Additional keywords and random thoughts:
photocell, photo-resistor, photo-diode
Embedded System

===== END ====

Terms and Definitions:

Point: The recording of the state of the sensor at a specific time.

State: The value that the sensor senses, either on or off. The logger never records an in-between state.

Event: The duration between two points when the state of the second is different than the state of the first.

Group: One or more events that, for practical purposes, are assumed to be one event and one continuous state and one duration. Like events, the state of groups alternate between on and off.

Minimum Off Time: The upper limit of the duration, in seconds, that an Off event is ignored. A value of 59 seconds means that an off event needs to last more than 59 seconds before it would be counted as a new group, assuming the current group is an On group.

Minimum On Time: The upper limit of the duration, in seconds, that an On event is ignored. A value of 1 seconds means that only on events lasting more than 1 seconds would be counted as a new group, assuming the current group is an Off group.

Frequency of state checks: The time between the checking of states by the logger. With the current Hobo loggers, this value is 1 second which is also the smallest time difference that can be recorded (the resolution). For practical purposes, any change of state between checks is recorded as occurring at the next check. This affects the actual minimum off time and minimum on time. For example, a light goes on at 0 seconds and goes off at 59.1 seconds, would be recorded as On at 0 seconds and On at every sensor check at 1, 2, 3, ... 58, 59 seconds. It goes off between sensor checks, so when checked at 60 seconds, it is off. The time between the state changes is 60-0=60 seconds, which meets the minimum Off time. [need to show this in a graphic]

True data start time: The time just after the logger is placed and when those placing it are out of sensor range for that visit.

True data end time: The time just before the logger is removed and when those removing it have not been in sensor range for that visit.

Day, Date: Usually Day is the day of the week (Mon, Tues) while Date is the combined month/date/year (6/5/2006). Sometimes they are used interchangeably.

UTC (Coordinated Universal Time, Zulu Time):
Conversion chart for United States is at http://hurricanes.noaa.gov/zulu-utc.html
This page provides the UTC time: http://en.wikipedia.org/wiki/Time_zone

Caver: Includes anyone visiting a cave. This is noted because in some caving communities, “spelunker” is used to describe those in a cave to party or vandalize or don’t have the training or gear for a safe trip; while “caver” is everyone else.

Charting: as used here, is interchangeable with charting and with plotting

Graphing: see Charting

Plotting: see Charting

Summary of Objective and Assumptions

Objective:

- To log caver traffic in caves using a data logger

Basic Assumptions:

- Every caver has a light with them that is on which lights up the area around the caver.
- A sensor will detect any light in the vicinity of the sensor.
- Every caver will pass in the vicinity of the sensor at some point during their visit to the cave.

Therefore:

- Light detection by the sensor means a caver is in the vicinity of the sensor.
- By recording the date and time of the light detection, we can know when a caver is in the cave.
- Charting the light detections will show patterns of usage.

Contradictions to the Assumptions:

- There are likely many missed detections and also a caver may never be in the vicinity of the sensor. However there are not likely to be many false positives
- The number of sensor readings cannot determine the number of cavers. When a sensor is monitoring a room, it is very likely that for some cavers, their light will be sensed more than once.
- Sensors currently used vary greatly in sensitivity to light.
- 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.

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Logger process, from start to finish organized by documents:

Note: There is currently no User Interface (friendly program) to do the Access and Excel parts, so some worksheets and tables need to be manually edited and copied, and some routines need to be manually started.

Logger Deployment Worksheet.pdf

- Connect the logger to the computer to configure a data logger (use Logger software)
- Place logger in cave
- Remove logger from cave
- Connect the logger to the computer, run the Logger software and save the data as a CSV file.

Logger Hobo Data To MS Excel to MS Access.pdf
Logger from Hobo and edited A1. csv

- Import Hobo data into Excel, keep the CSV file format.
- Edit Excel CSV file header row
- Edit Excel CSV file to remove unneeded data
- Verify the Excel CSV file start and end states
- Add initial data rows to the Excel CSV file
- Copy the Excel data into Microsoft Access table tData

Logger MS Access Analysis.pdf
Logger Demo A1.mdb

- Run the routines which will analyze data and make the event groups. This is Public Sub StartHere in the module basLogger.
- Run routine to make data table for plotting. This is Public Sub StartHere in the module basLoggerGraphing.

Logger MS Access Reports.pdf
Logger Demo A1.mdb

- Settings and Configuration Summary
- Group Summary
- Point and Event Summary
- Logger Analysis of On Group Data

Logger MS Excel Charting.pdf
Logger Demo A1.xls

- Copy the processed data from MS Access to Excel for charting
- Setup of Chart of Group Data - the X value axis
- Setup of Chart of Group Data - the X Secondary Axis
- Setup of Chart of Group Data - the Y value axis
- Setup of Chart of Point Data - Secondary Axis

Logger process - supporting documents:

Logger User Interface

- Logger User Interface.pdf

Logger Hobo Product Info.pdf

- Typical Hobo file “Details.txt”
- Various Hobo Software screen captures

Logger MS Access Flowchart.pdf