Needs Analysis

Team No. 10

Wakulla Cave LIDAR Mapping System

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3. Abstract

Researchers at the Oceanography department at FSU are seeking help in the development of mapping technology to map out the dry-land portions of the Wakulla Springs Caves. The system must be small enough to fit on a manually controlled vehicle. The goal is to provide a three-dimensional representation of the dry portions of the cave with higher resolution and greater detail than previous efforts in mapping the area. According to our sponsors, if the time restrictions allow, we may move forward in the development of the manually controlled vehicle, which the mapping system will be mounted on.

4. Introduction

The process of mapping the Wakulla Caves is met with many practical challenges. The primary issue of safety in the caves prevents thorough mapping by sending humans into the area. Because of this, our client has requested that we develop mapping technology utilizing LIDAR that is small enough to mount on a manually operated vehicle.

5. Project Definition

A. Background and Literature Review

LIDAR

Figure 1: LIDAR LITE 3, *www.sparkfun.com*

LIDAR is a remote sensing technology often used for geographical mapping and surveying. The word LIDAR is an abbreviation for Light Imaging, Detection, And Ranging. LIDAR technology typically utilizes ultraviolet, visible, and near inferred light imaging in conjunction with GPS. LIDAR sensing methods employ light pulses to measure variable distances and other data along terrestrial surfaces. These systems, commonly mounted on aircrafts are useful in the mapping of broad areas with high accuracy and precision.

LIDAR is widely used in the fields of geodesy, meteorology, geology, atmospheric research, geography, and more. It is often used to create high-resolution maps because of its ability to target a very wide range of materials with very high resolution (typically around 30 cm resolution or better). Two main types of LIDAR systems are topographic, which uses near-infrared laser, and bathymetric, which uses a water-penetrating light to measure underwater areas.

The LIDAR-Lite Rangefinder is a compact and user-configurable optical distance sensor developed by Sparkfun and Garmin. Thanks to its compact size, it is optimized for use on drone and robot applications. It utilizes a 40-meter laser-based optical ranging sensor and boasts a low power consumption of less than 130mA while operating. Because of these features, the LIDAR-Lite is the optimal choice for a portable mapping technology.

Cave Mapping

Caves represent a unique and intriguing challenge for explorers and researchers alike because they are extremely difficult to get to. LANDSAT imagery, topographical mapping, and aerial photography often fail to even identify that a cave is present. As it is, caves provide an unparalleled opportunity for explorers and the scientific community to discover what is hidden in the depths of our planet.

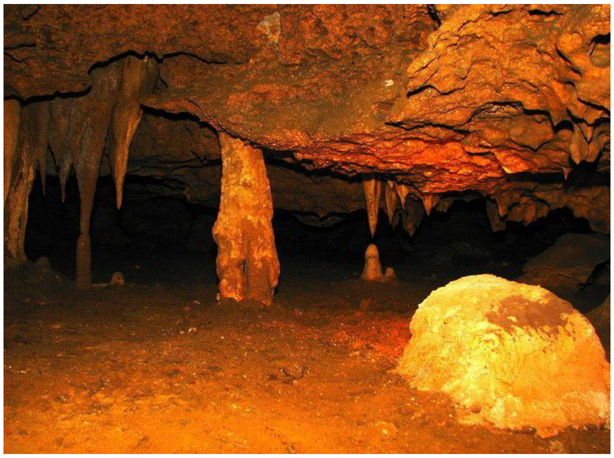

Figure 2: Cave in Florida Caverns State Park, *www.floridastateparks.org*

Cave mapping has traditionally consisted of choosing a centerline in a cave and taking a series of measurements from that centerline to the walls of the cave. The data would then be entered into a computer, which could produce a 2D/3D representation depending on the extent to which the researchers collected measurements. This approach usually requires a team of at least four people, and can take hours, days, or even weeks. In recent years, technology has allowed for quicker, more accurate mapping of caves using LIDAR, but the apparatuses can cost upwards of $50,000.

B. Needs Statement

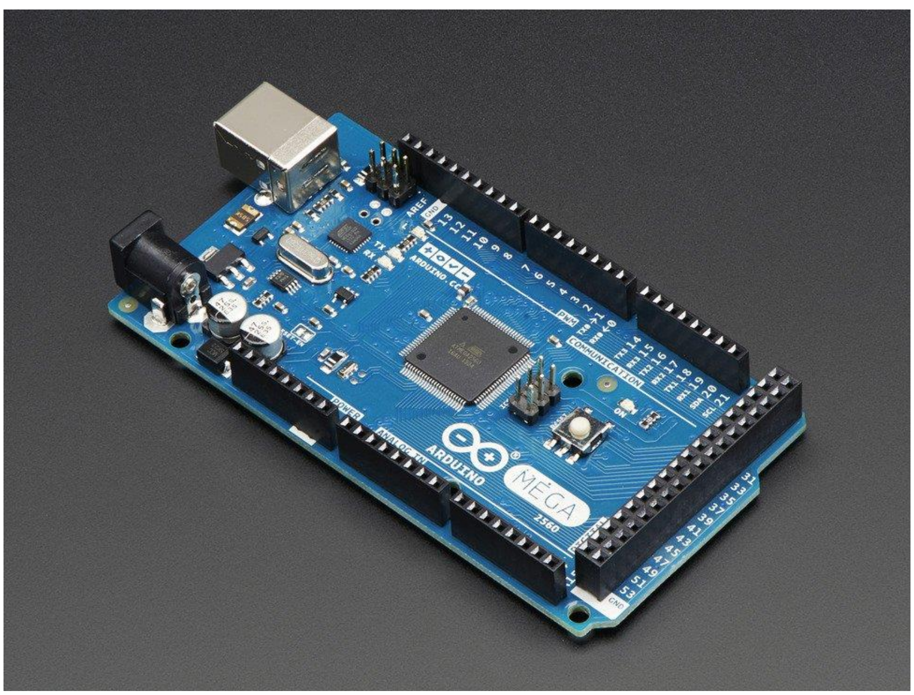

Figure 3: Arduino Mega 2560 R3, *www.arduino.com*

Traditional cave mapping can be costly, limiting participants to professionals. There exist some examples of simple mapping systems online using LIDAR and Arduino programming, but the resolution is low. Our client wants a high resolution system, however our client is requesting a mapping system with much higher resolution and detail than these do-it-yourself approaches considering the extent of the resources that will be provided to us. Furthermore, this system must be small enough to mount on a vehicle, which will be sent into the caves.

Needs and Wants list

- High resolution data encoding software
- Functional and stable mounting system (for mounting onto vehicle)
- Full rotational motion with micro-stepping abilities
- Small size (facilitates portability on a small vehicle)
- Durability (resistant to shock / damage from natural elements)
- Low cost (budget details TBD)

We need a compact, durable, high resolution LIDAR system that can be carried, or mounted, in order to accurately depict the inside walls of any cave system.

	High Resolution	**Portable**	**Low Cost**	**Durable**	**Geometric Mean**	**Normalized Weight**
High Resolution	1.00	2.00	3.00	4.00	1.78	0.30
Portable	0.50	1.00	2.00	3.00	1.59	0.27
Low Cost	0.33	0.50	1.00	2.00	1.39	0.23
Durable	0.25	0.33	0.50	1.00	1.20	0.20

Table 1: Needs Matrix for the LIDARMapping System

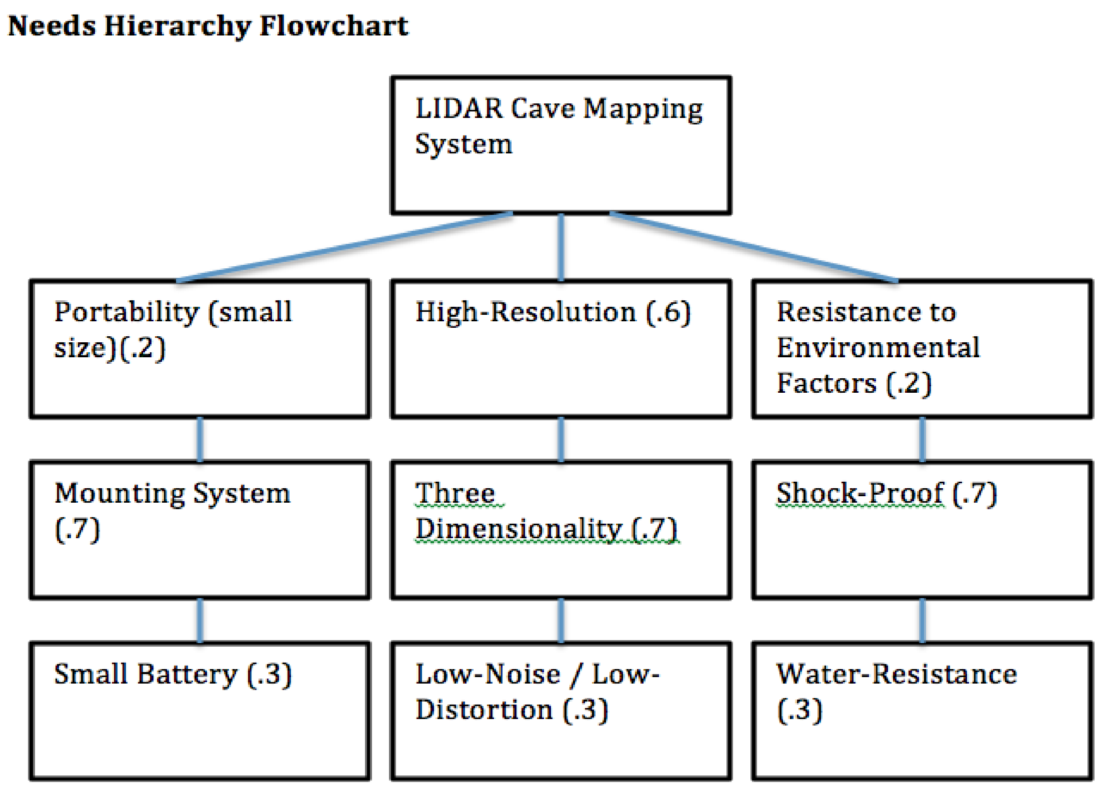

Figure 4: Needs Hierarchy Flowchart for LIDAR Mapping System,

C. Objectives and Goals

The goal of the LIDAR Mapping System is to create a durable, high resolution device that can be easily deployed to map an above ground cavern. The device must be small enough to be carried into a cave and potentially mounted on an autonomous vehicle. The mounting system will be a quick connect/disconnect and will be rigid enough to stabilize the measuring device as it traverses over obstacles. The device will be in an enclosure making it resistant to the rugged and wet environments of caverns.

Once set in position, the device will run autonomously to capture measurements of the targeted area. To acquire reliable data, stepper motors will be used to change the angles of the measuring system in micro steps. Full rotational motion in the x, y and z plane will allow the device to accurately measure a targeted area. The data will be correlated to true north and a high resolution 3D image of the cave will be created.

This device will be made with readily available parts to keep cost low while data encoding will ensure reliability. Inexpensive parts make upgrading or repairing the device much easier. Batteries will be used to provide the system with ample power to perform measurements at multiple target areas. An auto off feature will be added to reserve the batteries in dormant conditions. In case of a system failure, the data will be saved in memory to be exported when the system is retrieved.

D. Constraints

LIDAR device must be fully rotational in x, y, and z plane to map surrounding area up to a 40m range in each direction. It should be able to map up to 5cm in accuracy and convert the data into a 3D image. The total weight should be no more than 3-5lbs. It should be easily portable and small in height, no more than 1.5ft tall. It will need to rest firmly on the ground and have a waterproof case for when not in use.

The device must be operational in dark caves. It should operate with little initial user input, then run autonomously for the duration of the scan. There must be indicator lights to alert user if mapping is finished, running, or fails at any time during the run. The device must have enough battery power for at least one complete scan, preferably two.

The total cost of the finished device should not exceed $500.

6. Conclusion

Cave mapping has been a specialized field utilizing expensive technology only few people can afford to use. The LIDAR Cave Mapping System aims to provide an inexpensive, reliable method for ordinary adventures to map caves. Once set up, the device will require no user input to record data for a target area. Using the data collected, a high resolution 3D image of the cavern will be created. Further development of the LIDAR system will include an autonomous vehicle to transport the device into more dangerous areas.

7. References

[1] S. Kish and B. Broedel, "Introduction to Cave Mapping Design Project," 2016.

[2] S. Kish, "Mapping of the Wakulla Springs Conduit-Cave System Using LIDAR and Inertial Navigation Sensor System– Prototype Modeling,".

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