SEARCHING FOR LAVA TUBE CAVES – A RAPID METHOD

CHARLES CHAVDARIAN

3890 Aragon Lane

San Ramon, CA 94583

USA

caver3d@comcast.net

GREGORY CHAVDARIAN

74-5214 Kihawahine Pl

Kailua-Kona, HI 96740

USA

gvchavdarian@gmail.com

Abstract

Searching for lava tube caves by traditional means can involve challenges and limitations such as (a) hiking, which can take a lengthy amount of time, and can, on occasion, be formidable due to the nature of some of the terrain that is encountered, and (b) aerial spotting with either an airplane or helicopter, which can be very costly, and may require prior planning/scheduling. In the case of an airplane, attempts to observe potential caves can be difficult due to the higher elevation of the plane. Use of a helicopter can also be somewhat problematic. Also, with these aerial approaches it would not be possible to truly closely observe, nor enter, a pit or collapse for further assessment.

We offer an alternative to the above approaches with the use of a drone and a mounted high resolution video camera. Such a technique and equipment is also not cost prohibitive, nor requires extensive planning and scheduling. With the available movements of the drone and the mounted camera, essentially all directional axes can be achieved for successful viewing. In this presentation we will demonstrate, with video examples, the rapid use of the drone in a search for lava tube caves on the Big Island. Once collapses/pits or suspected leads have been spotted, actual exploration can commence.

Introduction

Traditional approaches in narrowing the search for caves rely on an understanding of geography and geology, coupled with sound research. This can then be followed by ridgewalking or hiking the terrain to attempt to discover a cave. With limestone-based caves, aerial techniques are also helpful, but may not necessarily discern cave entrances, as such entrances are not always visible from overhead, and can also be obscured by extensive vegetation.

In the case of lava tubes, the nature of the terrain on lava fields can, at times, be very challenging when hiking, and cave entrances/collapses can prove to be very difficult to see at ground level. Aerial techniques for the discovery of new lave tube caves, and the location of existing caves, are possible with the use of aircraft such as airplanes and helicopters. However, these aircraft have their limitations in terms of (1) detailed logistics - the need for advanced

planning, scheduling, location of the aircraft, and the availability of a pilot, and (2) the very significant cost involved for a pilot and aircraft. We offer an alternative to the above approaches with the use of a drone and a mounted high resolution video camera. Such a technique and its equipment is (1) portable, (2) not cost prohibitive, and (3) does not require extensive planning and scheduling. With the available movements of the drone and the mounted camera, essentially all directional axes can be achieved for successful viewing.

To demonstrate the use of a drone for the location, and initial assessment of a lava tube entrance/collapse, we undertook this activity on two different days on the Big Island of Hawaii.

Equipment and Specifications

The equipment and their specifications, used in the drone searches, are described below. It is also important to note that this equipment is portable and can be effectively carried in backpacks into the field.

<u>Equipment</u>

DJI Phantom 2 Quadcopter Drone

Quadcopter Remote Control

GoPro Hero 3+ Camera, with 1080p Video

Tripod Monitor

Key Specifications

The key specifications of the Quadcopter involve (1) a flight time of 12 to 15 minutes with the onboard battery, (2) a top speed of approximately 40 mph (64 kph), (3) a maximum range of at least 2 miles (3.2 km), and (4) a working elevation/altitude near ground level to several hundred feet (or much higher – but not encouraged for reasons due to regulations). When in flight, the quadcopter can be remotely directed to rotate to the left or right, and can move vertically up to higher elevations or down near ground level. The mounted camera can pivot up or down. The quadcopter can easily hover over a specific area of interest. With the available movements of the drone and the mounted camera, essentially all directional axes can be achieved for successful viewing.

<u>Monitor Details</u>

The stationary monitor is mounted on a tripod and remains at the base of operations, while the quadcopter flight is controlled by remote control. During flight, the base monitor's display shows the operator what the quadcoptermounted camera is recording in real-time, and also includes flight data information on (a) distance, (b) elevation, (c) vertical and horizontal speed, (d) the azimuth from the home point (where it first took off), and (e) the battery life of the drone. The monitor is also capable of tracking the GPS location of the quadcopter, but the GPS option was not included with our drone. It should be noted that the drone is controlled remotely by line-of-sight. That is, the drone must be able to communicate with the base operator without obstructions in the field.

Photographs of Equipment



Figure 1: Quadcopter Drone with Mounted GoPro Camera on Platform



Figure 2: Greg Chavdarian with Quadcopter Hand-Held Remote Control and Full Display Monitor on Tripod

Discussion and Results

First Searches and Demonstrations – April 2015

To demonstrate how rapidly a drone can locate a cave, we chose to work in a region known to have a number of caves, or potential caves. In April of 2015 we traveled into the saddle of the Big Island (between Mauna Kea and Mauna Loa) at an elevation of approximately the 8,000 ft (over 2,400 m) and higher. In this region, there are massive lava fields, and a number of known and suspected lava tubes. Having arrived at our base location by vehicle, we quickly set up the equipment near the side of the road. This specific locale was chosen since Crystal Cave is nearby, and had been visited by one of us (C.C.) five years earlier. However, it was not known if there were additional collapses present in this vicinity. The drone was flown in the general direction of Crystal Cave while high definition video was recorded with the onboard camera. The goal was to look for any entrance collapses,

including the entrance to Crystal Cave. With this first flight, the Crystal Cave entrance was quickly located. During the flight, it also became obvious in the video, that Crystal Cave was part of a specific and lengthy lava flow. It is important to note that past (historical) eruptions and flows can be easily differentiated by drones. Unknown to either of us was the possibility of further collapses, which could indicate potentially additional lava tubes within this flow. The drone was therefore flown farther along and above this flow, and we surprisingly found several additional collapses, most in a linear pattern. This could open up the opportunity to explore the collapses beyond Crystal Cave to determine whether there are (a) more lava tubes, and (b) are some or all of these linearly placed entrance collapses part of a larger lava tube. As the drone flew over the collapses, we were able to direct the drone lower and much closer to a specific collapse in order to observe finer details. This first drone flight demonstrated several advantages in the search for caves.

After a successful demonstration with the first drone flight, we then traveled to another locale nearby, where it was known that some modestly deep pits existed that would require a short rappel to explore them. The plan was to find the first pit with the drone, and then demonstrate another advantage of the drone – the ability to remotely direct a camera-mounted drone down into a pit for further exploration/assessment. As part of the 2010 trip to this area by one of us (C.C.), part of our team actually rapelled into the pit closest to the road. (This pit is also noteworthy for the intriguing lava balls lying on the surface nearby.) On this day, we planned to demonstrate an alternative to a rappel. Our second drone flight of the day – from a base location by the road - quickly located this pit. After we hiked to the pit, the drone was then directed down into the pit to demonstrate that video recordings inside a pit could be obtained. The drone was controlled by line-of-sight from an operator standing on the edge of the pit. Due to the angle of the sun, the bottom of the pit was partially shrouded in shadow, but the drone camera did manage to still provide a closer view of a substantial part of the bottom. It should be noted that it is possible to optionally attach an on-board lighting system to the drone for illumination, although we did not have that feature on our specific drone. The demonstration was successful. To show the descent of the drone into the pit and its ascent from a different perspective, we also recorded video with a separate camera held by one of us standing at the lip of the pit. The advantage with the use of this technology is that this technique could assist cavers in determining if there were additional passages in the bottom of a pit, or interesting features, without the necessity of having to rappel into every pit that they encounter. In this fashion, a caver could then make a more informed (and more rapid) decision as to whether or not to physically rappel into a pit for further exploration. As long as line-of-sight is maintained with the operator and the drone, and the pit is wide enough to safely fly the drone, this novel approach will work. We then flew the drone well beyond this first pit in the search for more collapses or pits. One of us (C. C.) was aware of an additional pit beyond the first one (based on the 2010 trip). The drone quickly found this very large and relatively deep pit, while we remained at the base location by the road. The drone hovered over it and took additional video. The drone was then sent even further, and to our pleasant surprise, we discovered a third substantial pit that we were not aware of. Thus, within a matter of minutes, we were able to successfully locate and record three large lava pits. We also demonstrated the ability to lower a drone with camera into a pit to afford additional evaluation of the pit. The video recordings that were obtained are included for presentation at the Symposium.

Second Searches and Demonstrations – October 2015

We returned to another locale off of Saddle Road on the Big Island at an elevation of 5,700 ft (over 1,700 m) under an overcast and somewhat foggy day in October of 2015. This would provide another good test of the drone and camera facing more challenging weather conditions. We parked our vehicle off-road (4WD vehicle) and near the path that would take a hiker to the well-known, undeveloped Emesine Cave, over 2 miles away. Since Emesine Cave was in this area, we wanted to see if the entrance collapses of other caves were also present, and could be spotted in a timely manner. The terrain here was much more rugged than that in the Saddle area during our April 2015 trip. In addition to the tough, undulating lava terrain in this region, there were some areas with partial vegetation, and places with extensive vegetation (even forest-like), which would make hunting for cave entrances more challenging. We knew that our drone would barely have the range (and battery life) to actually reach Emesine Cave and return, so we decided to instead simply search for potential lava tube leads in this general area. We chose to undertake three flights on the same day, one to the east of Emesine, one to the west, and one to the south (and all of them south of Saddle Road). The same base location was used for all three searches. The first flight to the east revealed rugged lava terrain, with some significant vegetation, and variable fog overhead. However, the conditions were still conducive to detecting some leads. The drone and camera finally picked up a potential lead partially obscured in a somewhat forested area. In this case, further exploration would require a hike to the lead to determine the extent of the find, however, the mission was accomplished. The flight to the west was similar in terms of rugged terrain, but very sparse in vegetation, which made it easier to spot possible leads. In this case, an intriguing lead was indeed found. The drone and camera were repositioned above the lead/entrance and re-oriented to provide various views. If this lead was to be further pursued, the next step would likely have involved a hike to this location for further evaluation. The final search was directed to the south, and along the hiking trail to Emesine Cave. However, the drone did not travel as far as Emesine's location due to the range of its battery. This last search traveled over terrain with and without significant vegetation (forest-like areas), but along the Emesine hiking trail. Although no lead was observed during this third and final search, and no large collapses/entrances were observed on this day of overall searching, two potential leads were nonetheless observed and recorded. This aerial search technique again successfully demonstrated the ability to cover extensive swaths of land in an expeditious manner, and discover potential leads. These video recordings are included for presentation at the Symposium.

Conclusion

In this presentation we have successfully demonstrated the use of a remote-controlled quadcopter drone with a high-resolution video camera in the search for lava tube caves/entrances (collapses). The components – drone, camera, monitor, controller, and tripod – can be carried in backpacks into the field. The technique affords rapid and effective searches at a nominal cost, compared to other aerial techniques.

In general, the use of such drones is becoming a world-wide phenomenon. However, to date, this technique has not as yet been in common use, in the caving community, in the search for caves. Because of the nature of the topography on the Big Island of Hawaii, the use of drones is well-suited to the discovery and assessment of possible cave entrances. Once such collapses/pits or suspected leads have been spotted, actual exploration can commence.

In the February 2015 Vulcanospeleology Symposium, we will demonstrate, with video recordings of the two days of exploration, the use of this aerial technique – a drone with a high-resolution video camera - in the search for lava tube caves.