JPL Project: Identification of Methane Seeps under Arctic Lakes.

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High Altitude Ballooning Group

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KISS Student Led Project

1 Background

In August of 2011 the high altitude ballooning group at Caltech was approached by Kevin Hand, a JPL scientist who was interested in developing an aerial photography platform which could be used to image lakes in Barrow Alaska, to determine if pictures alone could be used to identify unfrozen areas in arctic lakes. The purpose of this research was to gain insight into the ability of satellites in orbit around Icy Moons like Titan and Europa to identify potentially interesting research sites on the moon by finding active methane lakes. The kinetic motion of the liquid in the lake makes it more difficult to freeze making unfrozen lakes of methane on these moons very attractive targets to study.

The ability to identify these lakes in real time from satellite or aerial photography, could provide future robotic missions with unfrozen lake locations to drop sensors into. On moons such as Titan, the methane lakes are very attractive science targets, as the environment in and around the lakes is potentially supportive of microscopic lifeforms. By building an aerial photography rig for field tests in Alaska, the high altitude ballooning group was helping participate in a feasibility study for future icy world missions.

2 Photography Rig

2.1 Brooxes Kit

There were two separate photography rigs which we tested out in preparation for the field test. The first, was a brooxes kit which was built to allow taking an image from any angle. This kit was designed for use underneath a kite in high winds, however, with slight modifications we felt it would be the perfect platform for taking images underneath a balloon. This kit used a picavet cross for stabilization which kept the pan tilt unit level even while the tether was swinging. Underneath the picavet cross there is a pan tilt unit which allows us to point the camera anywhere between straight down, and level with the horizon in any direction. From a tethered balloon, this gives us the freedom to point the camera at any ground based target. A picture of the rig we started with is shown in figure 1.

Figure 1: Brooxes Kite Aerial Photography Kit

In addition to the pan tilt unit, we hooked server motors up to the unit, and added a video transmitter. For the receiver, we used FatShark goggles so that we could get a real time view of exactly what the camera was pointed at. This way, by looking through the goggles, and using an radio controller to move the servos we could have a real time view of any scene from the balloon, a perfect method for spotting the unfrozen portions of the lakes in Alaska, or any other interesting features we found.

2.2 Stabilization Wing

The second rig which we built was a stabilization system made from a Styrofoam wing. By mounting the camera facing down below the wing, and programming the wing to move it's ailerons in order to remain level even as the wind keeps changing. This way the ground could be mapped out by moving it across the ground. This would also have the advantage of being the first step towards creating a unmanned aerial vehicle capable of mapping out a large area automatically.

While this method provided a stable platform, leading up to the development of an unmanned aerial vehicle, it lost the advantage of being able to point the camera at any angle. While the main goal of mapping out the surface doesn't require the camera to move at any angle, for maping out interesting features in the Alaska field test since there is significantly less mobility of the camera due to restrictions in where the platform can be moved, it would be advantageous to have the ability to point.

3 Aerial Platform

After constructing a general photography platform, we needed some way to lift the camera rig into the air to take photographs. Naturally, the first idea considered was a tethered weather balloon which would build off the knowledge we had gained from our initial high altitude tests to keep the camera aloft for a very long period of time. However, a weather balloon could provide problem in high wind situations, or if it was towed behind a snow mobile to get larger area coverage. The following sections document our initial attempt using a weather balloon, as well as alternative methods.

3.1 Tethered Desert Tests

3.1.1 Balloon Lift Test

The first set of tests to prepare for the Alaska Field test took place in the desert at Soggy Dry Lake. We attached the brooxes kit to the balloon, and allowed i the photography platform to a tethered weather balloon where allowed us to determine the lift capabilities of the balloon. The balloon was capable of lifting both the brooxes case, and the wing without any trouble while held stationary.

3.2 Moving Test

In addition to lifting up the camera, the platform must be capable of being tethered to a snowmobile which can drive it around across the lake in order to get image of a much larger area. In order to test the ability of the balloon to being dragged behind the snowmobile, we held the balloon without the camera platform out a car window, and started to drive slowly picking up speed to see its limit. Unfortunately, due to the large surface area of the balloon the air resistance from being pulled caused the balloon to very quickly sink and start to oscillate violently. While the stabilization system may be able to handle keeping the images still, the camera had it been attached would dropped very close to the ground losing the advantage of having it attached to the balloon in the first place. Figure 2 shows the images from under the balloon while traveling at 5mph.

Figure 2: Image from the camera while attached to the balloon and towed by the car.

3.2.1 Kite Test

In the case of high winds, a kite was brought along in order to acquire lift in high wind conditions. As it was not a windy day when we were out in the desert, the only way to simulate high winds was to hold the kite out of car while driving around. This turned out to be significantly more difficult then expected, due to the difficulty in launching the kite, as well as the direction of the crosswinds. The combination of these factors led to the kite being fairly unstable as well, but leaving us to believe that with constant high winds as were predicted in Alaska, the kite might be the better choice of aerial platform.

4 Alaska Tests

Due to difficulties in getting the wing to work properly, as well as the string of successes we had with the brooxes kite kit we decided to focus on using the brooxes kit.

4.1 Balloon Test

On the first day of tests we decided to attempt a balloon lifted platform which could carry the brooxes kit. Unfortunately the exceedingly high winds made this impossible as not only did the balloon stay nearly parallel with the ground, but it deformed due to the pressure applied to it by the wind. Below figure 3 shows the deformation in the balloon when first launched.

Figure 3: Attempt to launch a weather balloon in the high winds in Barrow, AK

4.2 Kite Flights

Fortunately, the high winds which prevented us from getting a weather balloon up to altitude, provided perfect conditions for launching a kite. Figure 4 shows a picture of the kite tethered to a snowmobile which was later driven around to cover a large section of the lake. The second figure show an image of the kite during flight, with the camera attached taking HD Video of the flight.

Flying the camera underneath the kite proved to be extremely effective, and a combination of pictures and HD video were obtained of many of the lakes surrounding Barrow Alaska.

Figure 4: Snowmobile with kite tethered to it.

Figure 5: Camera hanging below the kite.

5 Results

The trip proved to be exceptionally effective. All of the objectives we set out to prove were feasible were accomplished, with a reliable aerial photography platform developed which could have many more applications than just imaging arctic lakes. Below is one of the images taken on the first day out which fully demonstrated some of the interesting features revealed through aerial photography which couldn't be seen from the ground. The second image is a clip from one of the HD videos taken with a GoPro camera which will be used to test the feasibility of finding the boarders of unfrozen sections of lakes where methane is bubbling up. After traveling to the points identified as unfrozen in this video, it was quite clear that our hypothesis was verified as the methane could be seen clearly as it bubbled to the surface.

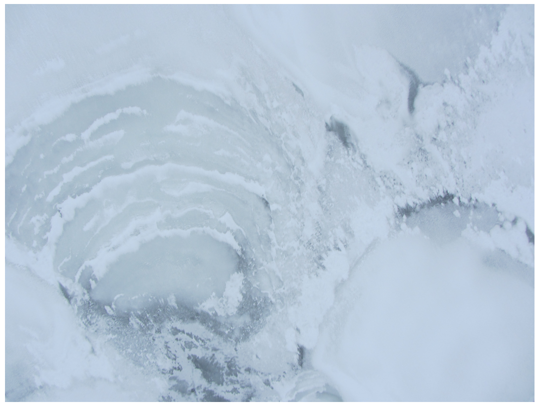

Figure 6: Interesting surface features revealed from the aerial photographs.

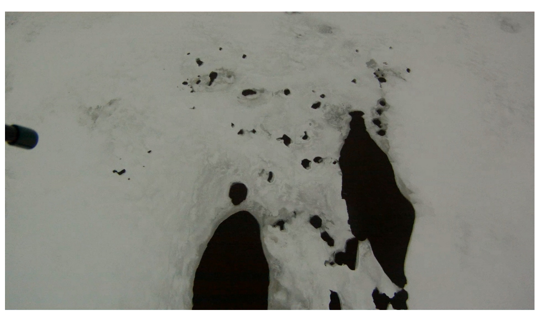

Figure 7: Unfrozen lake pockets due to methane seeps.