Additional File 5: Performance

Equipment

Before deployment, we were concerned that overheating could be a major problem because the cameras generated substantial amounts of heat. In the office the camera internal temperatures during steady operation were 38-41 °C, with the camera outside of any enclosure. Enclosing the camera in a sealed, waterproof box, and heated by the sun, could potentially raise the temperatures past 51 °C, which is the temperature at which the M7500 automatically shuts off to avoid damage. The aluminum mounting plates were meant to mitigate this heating by providing a heat sink and an improved route for conducting heat to the outside of the box. Having deployed the cameras for over a year now, we have not had any problems with overheating. In one case, the thermal camera on the rim of Puʻu ʻŌʻō was operating without interruption when the lava lake rose to just six meters below the rim where the camera was situated, and the front of the camera box was too hot to touch (the camera was removed at this point, and lava eventually overtopped the rim in this location).

The enclosures have worked flawlessly over the past year, enduring many days of rain and thick gas. Periodic inspections of the enclosures have shown they have successfully sealed out rain and gas. The Halemaʻumaʻu Crater thermal camera faces particularly high gas concentrations, as it is positioned immediately downwind of the vent. The only potential problem we have observed is deep rust on the stainless steel brackets on the tripod legs, which may eventually lead to the tripod coming apart.

The cameras have stopped working on several occasions, and nearly all of these instances were due to power problems. In one such case, the thermal camera on Puʻu ʻŌʻō was situated downwind of the vent in very thick fume. After several weeks, the camera acquisition stopped due to power loss. Presumably, this was due to thick fume blocking sunlight and preventing adequate charging of the solar panels. Once the camera was moved across the crater, out of the fume, the power problem did not reappear.

High frame rate acquisition

As described above with Script H1, the Mikrospec software occasionally loses the camera connection and abruptly exits. Our Matlab script (Script H1) detects this and restarts the program, but brief (2-3 minute) data gaps are nonetheless present. We still do not understand the cause of this problem, but have observed that it depends on computer, and possibly operating system. We have had the program run with almost no connection losses on some computers, and then with almost hourly losses on others. Thus, it is advantageous to test out performance on different operating systems and computers when setting this scheme up.

The Matlab scripts described above are all run by Windows Scheduler. We found that using Windows Server 2008, however, Windows Scheduler would sometimes not run Script H1 correctly (the Matlab script would run but it could not restart Mikrospec). It is still not clear why this happened, but it appeared that it was a permissions issue not being transferred through.

Rather than hunt down the source of the problem, we decided it was easier to use a third party scheduler program (System Scheduler).

The high frame rate acquisition is bandwidth heavy, and may not be suitable for all networks. The Mikrospec program maintains an open connection with the camera, effectively downloading the preview image every second or so. Bandwidth for the HTcam using this acquisition approach averaged 12 Mbit/s but could be up to 15 Mbit/s.

<u>Low frame rate acquisition</u>

Like the high rate acquisition above, we also had troublesome computer issues with the low rate acquisition. Our Visual BASIC script (Script L1b) would successfully acquire images from the camera when run on some machines, but not others. We were able to exclude any network related issues, and it appeared to be dependent upon operating system. Once we found a computer that successfully ran the scripts, we did not encounter any serious problems with the acquisition. Failed acquisitions have been rare, and overall the low-rate acquisition has been very robust.

We discovered that the acquisitions periodically fail for no apparent reason, and this is due to a camera, not a network, issue. The camera remains ping-able but will not allow image acquisition. This problem usually appeared after 1-1.5 weeks of continuous acquisition, suggesting it may be memory related. To solve this, we periodically (once a week) perform a pre-emptive power cycle to restart the camera, using Script L6 to reset the power relay device.

The current version of the low-rate acquisition scheme does not appear to be able to pull images with a frequency higher than once per minute. This is because a whole acquisition cycle (pinging the camera, opening connection, acquiring image, closing connection) takes about 40 seconds. Higher rate acquisitions would need to use the high rate acquisition scheme described above.

A primary benefit of the low-rate acquisition is that it is bandwidth-friendly. Bandwidth for the PTcam, which was acquiring an image every two minutes using this approach, averaged 41 kbit/s. Note this is 0.3% of the bandwidth of the high-rate acquisition.