Rapid Response Low Cost Airborne Digital Imaging System

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Introduction

The acquisition of aerial photography, and conversion to a digital format, has traditionally been a slow and costly process. With the advent of relatively inexpensive digital cameras and computer systems, along with GPS positional information, an opportunity has arisen to reduce the cost and time involved in digital image acquisition.

Overview

Because of a need to monitor short lived events, we designed and built a rapid response, low cost, digital aerial imaging system, and have been flying it for two years. This system, based around a Duncantech MS3100 CIR Multi-Spectral camera, can be deployed in a matter of hours, and enhanced digital photos can be viewed in real time as they are collected or within minutes after landing.

Hardware

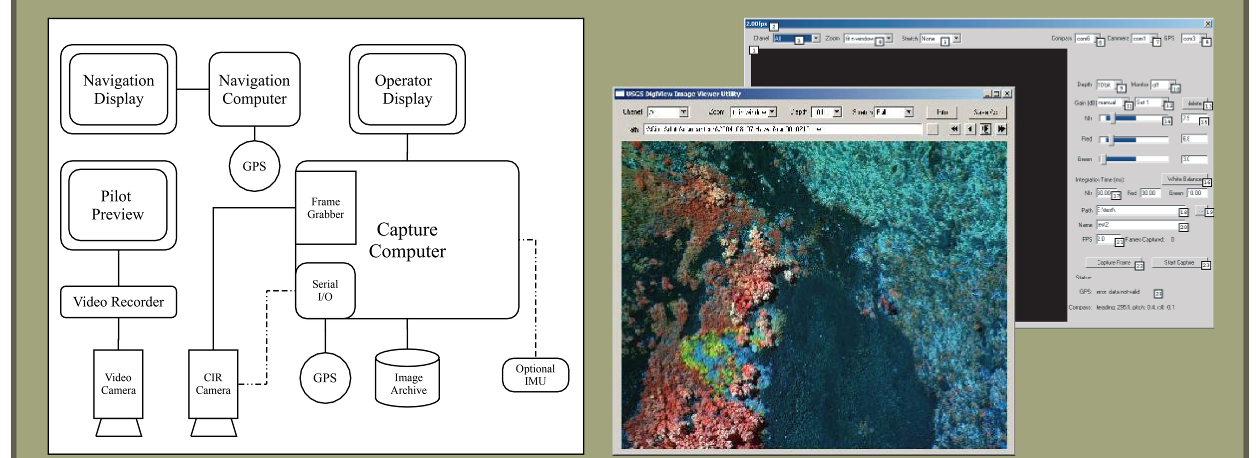
The Duncantech camera used in our system is a 3CCD system with independent gain controls for each CCD which allows the use of different gains for each of the three bands. For example, high gain can be used for one of the bands to optimize clear water penetration while leaving the other two bands at a normal gain settings. The camera has a resolution of 1392x1040 pixels per band, and has a 10-bits per band dynamic brightness range. Two to four images can be captured per second, allowing for flight speeds of 40 to 70 knots. Our typical flight altitude is 150 to 600 meters yielding image resolutions ranging from 0.05 to 0.25 meter/pixels.

An Imagenation PXD1000 frame grabber is used to capture the images from the camera to a computer, and a GPS is used to mark the approximate center point of each photo as it is taken. This is tied together inside a custom touch screen computer we developed for this system. Originally, the system was based around a laptop computer, but the laptop was not durable enough for constant field use. However, it is still be possible to go back to a laptop configuration if needed.

In addition to the camera system we have a GPS navigation system for the pilot to use to make it easier to follow a grid pattern or transect lines. The system also includes a video camera to aid with navigation when following a river, for example, and to serve as a secondary image source.

Camera System

System Overview



The system was assembled for under $20,000 and cost approximately $2,000 to $5,000 per flight for helicopter time and travel, depending on the size of the area and distance from the helicopter's duty station.

Software

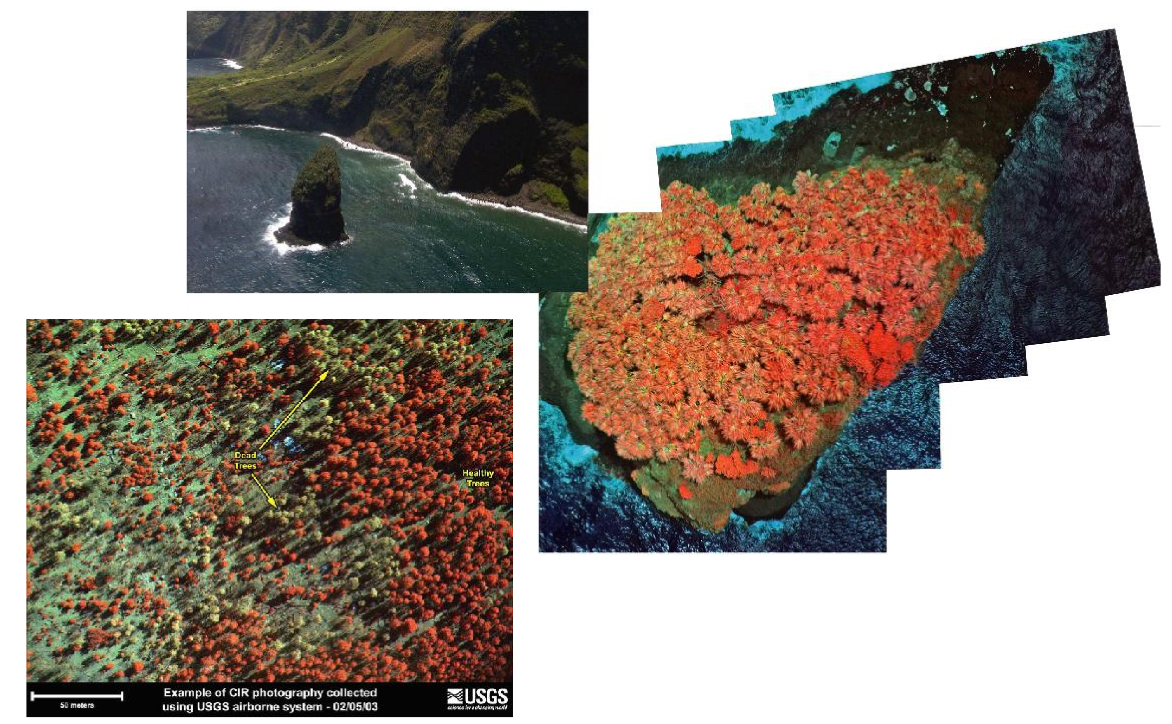
A custom suite of software was developed to control the camera and make post processing of the image data easier. The camera operator has a real-time view of what the camera is seeing during a flight and can control the gains, integration time, and frame rate in flight. In addition, he/she has the opportunity to do some rudimentary image analysis on the images such as histogram generation, contrast stretching and zooming. This gives the operator an opportunity to analyze the images on the spot and make changes as needed to the settings or abort the flight if a problem is encountered that can't be fixed immediately.

For post processing we have several utilities to convert the raw photos into a useful form, as well as applying a uniform contrast stretch across the photos and converting the 10-bit data to 8 or 16-bits, as desired. Also, the GPS data is parsed and an arc file generated with indexes to each photo for access to a desired image.

A typical flight might generate anywhere from 2,000 to 20,000 photos, so, to manage such a high volume of data, a custom viewer was developed. This application makes it possible to play back the flight line at real-time speeds while applying contrast stretching and zoom functions to the images. This allows several hundred photos to be viewed in a matter of minutes.

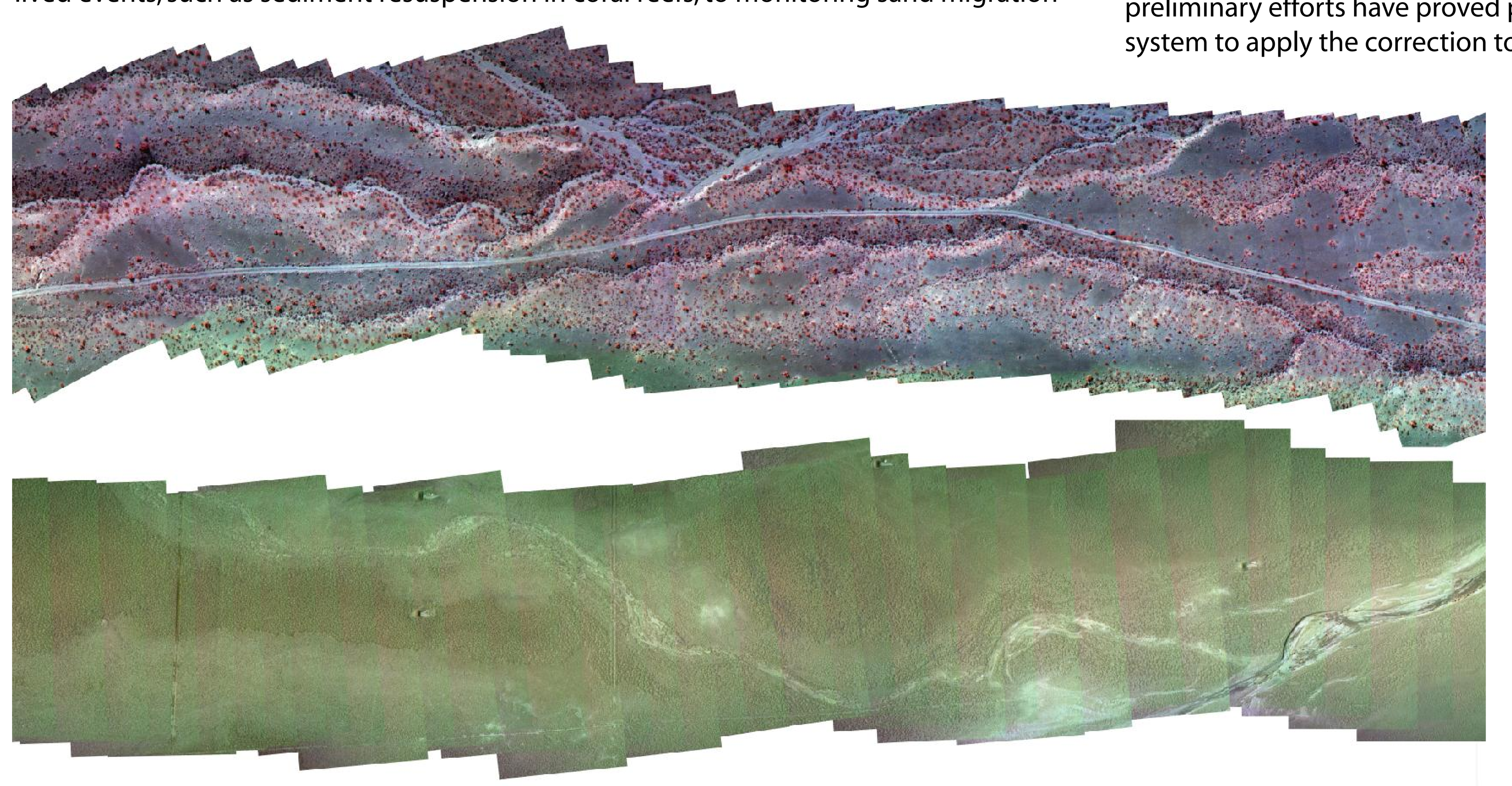
Applications

This system has been used for a wide range of applications.: from monitoring short lived events, such as sediment resuspension in coral reefs, to monitoring sand migration in streams using change detection techniques, to detecting invasive plant species along commercial-wilderness land corridors. This system has proven effective at detecting short lived events or mapping in areas that are difficult for a traditional air survey to image. Such areas might include tropical forests with high altitude cloud coverage or imaging streams inside canyon walls.



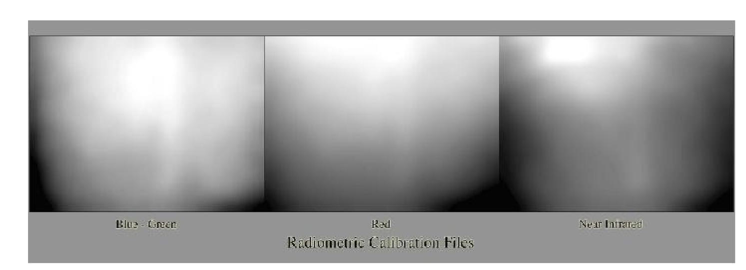
Limitations

The current system is not a direct replacement for traditional aerial photography because the typical footprint is smaller than traditional film photography. Currently, the system does not have an IMU or other spatial reference systems, so our post processing geometry is not ideal. However, it is possible to georectify the images using image-to-image correlation techniques, making this system useful for small survey areas and change detection applications. With newer camera systems having an increased pixels per band on the horizon and the cost of IMU equipment dropping the future of low cost, rapid response digital aerial imaging is promising.



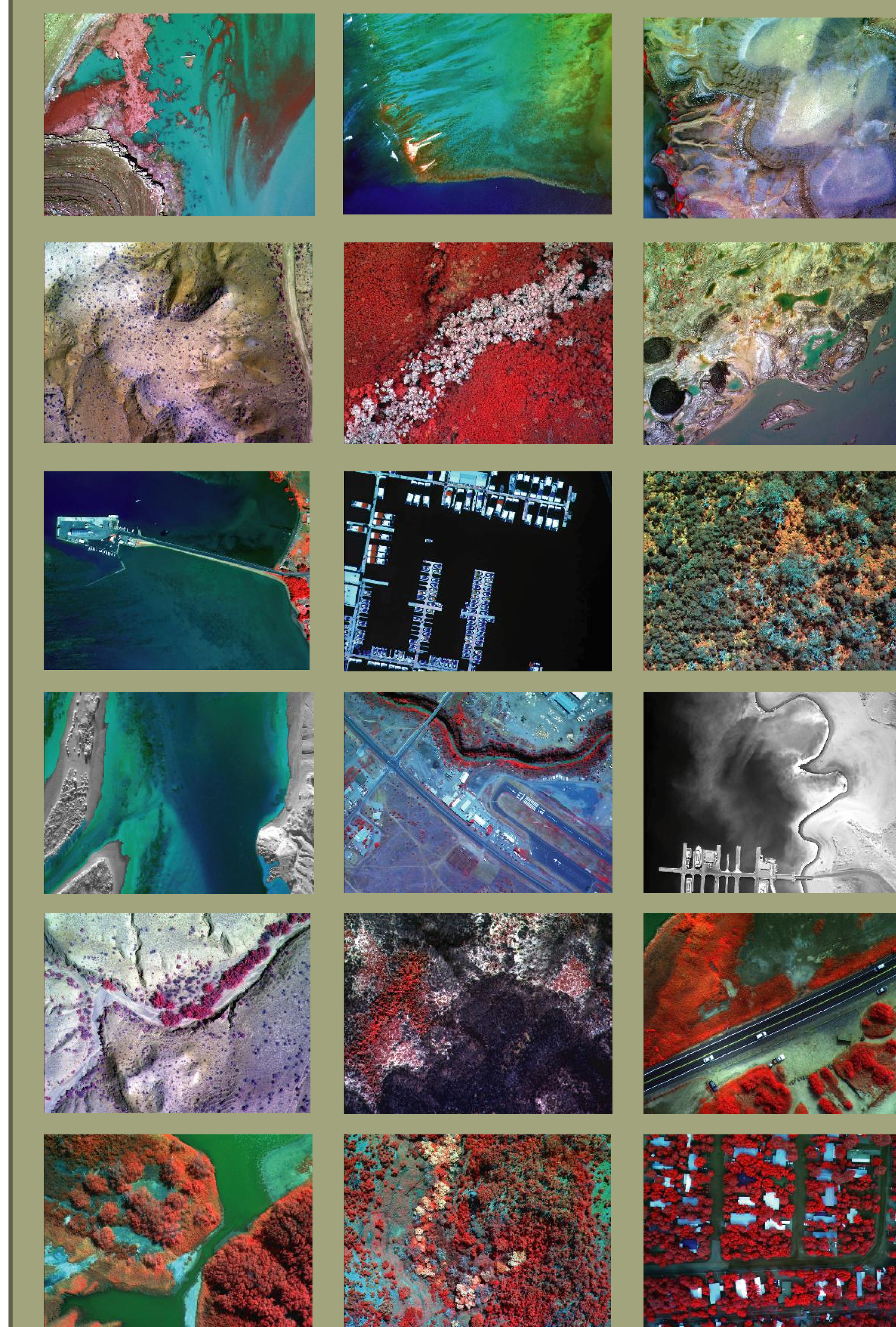
Data

Work continues on using these data sets and maximize the quality of the images. We are experimenting with quickly building mosaics using image-to-image correlation techniques. The camera has a vinetting problem that is noticeable when photographing low contrast areas, such as a desert setting. We are working on generating a radiometric calibration file/image for each band to remove the vinetting. The calibration file/image is produced by photographing a uniform surface in ambient light with no shadows. Our preliminary efforts have proved promising and we are developing a fully automated system to apply the correction to all photographs.



A small subset of the photos collected are presented here. These include samples of stream bed mapping studies, sediment mapping, forest health, and mapping of land slides on cliff faces. One of the bands was selected to optimize water penetration while still remaining useful at monitoring vegetation and other applications.

Sample Images



Summary

A low cost, rapid response imaging system is achievable with today's technologies. Our system has been successfully deployed on thirty flights around the US ranging from marsh lands in Florida, to deserts in Arizona, and rain forests in Hawaii. In every instance, we were able to optimize the camera settings and time of imaging for our project needs with minimal cost and time delays. This combination of hardware and software has allowed us to image remote places quickly and with a high level of quality control on the images.

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