FUEGO's First Flight

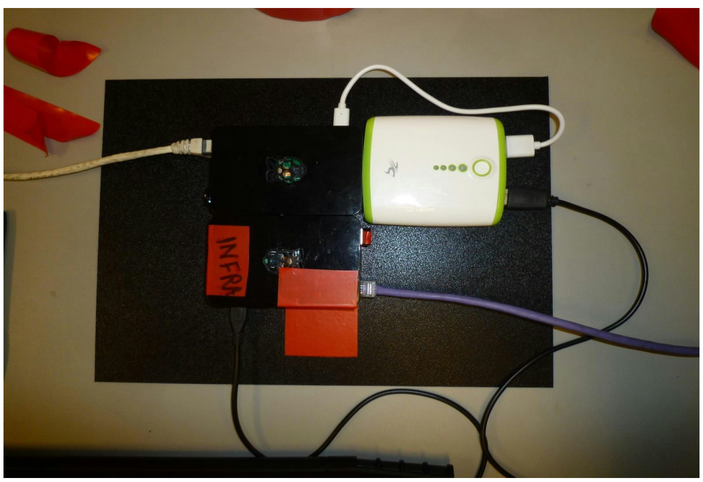
Woodrow Wang, Nicolas Captier, Eugene Tian
FUEGO
12 July 2015

Objective: Obtain pictures of the ground from about 1000 feet at around 85 knots to determine if PiCameras can efficiently detect fires

Equipment and Setup:

- Two Raspberry Pis (one Raspberry Pi labeled "Infra" and a barren Raspberry Pi)
- External power source (Sentey Brio LS-2152)
- Two micro USB power cables to connect the external battery pack and the Raspberry Pi
- Two ethernet cables
- Two laptops.
- An airplane (Cessna 172) and pilot, Robert Zentner

The two Raspberry Pis and an external battery pack were connected on a sturdy, black pliable board. Then, the system was adhesed to the airplane's underside with military grade duct tape. The ethernet cable was fed through the storage door of the airplane and connected to the battery pack. During the flight, the ethernet cables were connected to laptops that were controlling the cameras.

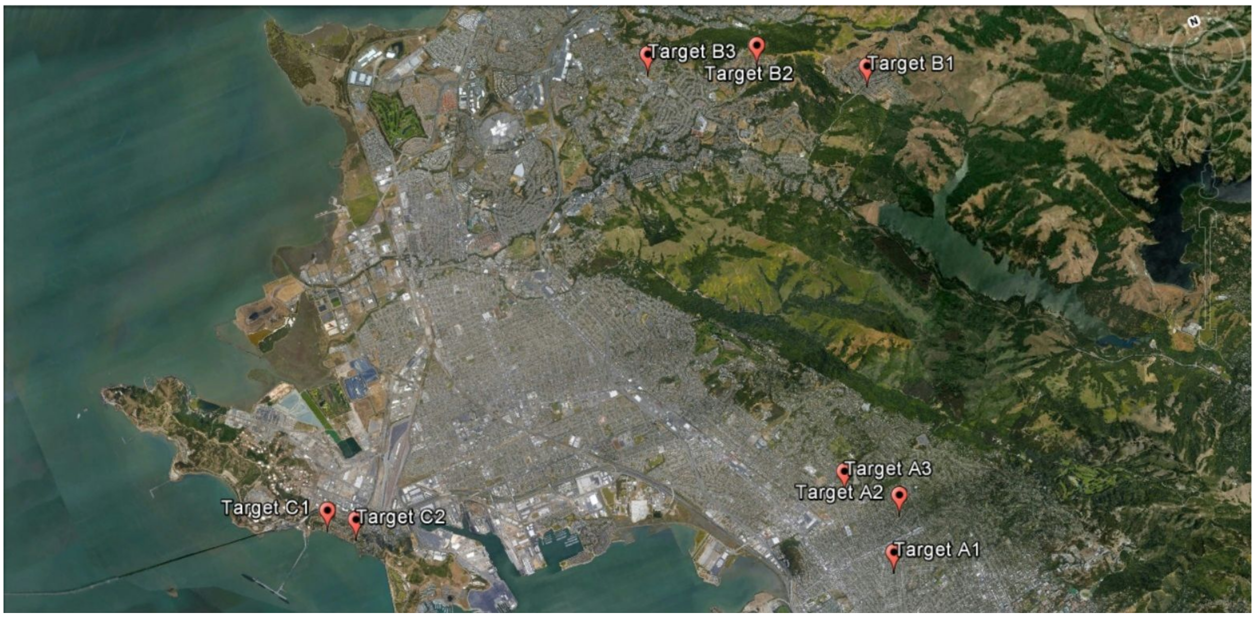


Pictured above is the assembled system of Picameras

Shown above is the Cessna 172 before takeoff

Description of the test:

Before the flight, we asked eight colleagues to set up fires in their grills for us to potentially spot while flying by their houses. After mounting the system of Raspberry PiCameras to the bottom of the plane, we flew for approximately one hour above the east side of the bay, (Berkeley, Oakland, Richmond, El Sobrante, and surrounding areas) attempting to take pictures of the 8 target fires in volunteers' backyards. Each computer was connected to a PiCamera controlled by code written in Python. Unfortunately, just after take-off, the visible light camera lost connection due to a loose ethernet cable. Hence we only took pictures with the camera labeled "Infra," which had a blue filter preventing variegated wavelengths from passing through to the lens, namely green light.



As shown by the picture above, we flew over three clusters of targets in two passes. As we flew over each target area for the first pass, we executed the code and obtained pictures with a 1.5 second delay between pictures at a resolution of 2240 X 1680. During the second pass on the way back to the Oakland Airport, we took pictures with a 1 second delay between pictures at a resolution of 640 X 480. The current code allows for facilitated user manipulation of variables, but in turn increases the amount of human involvement required to operate the cameras.

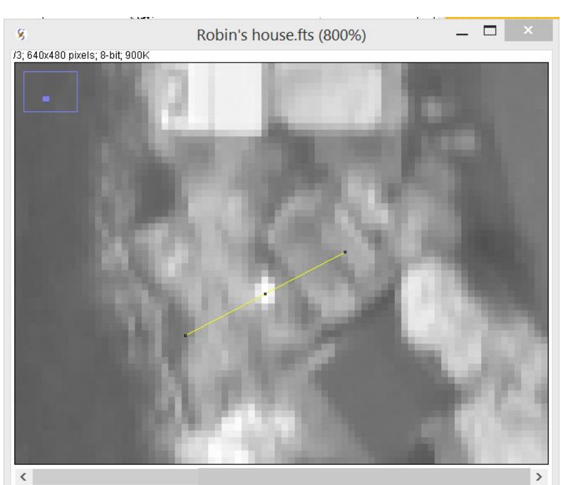
Results:

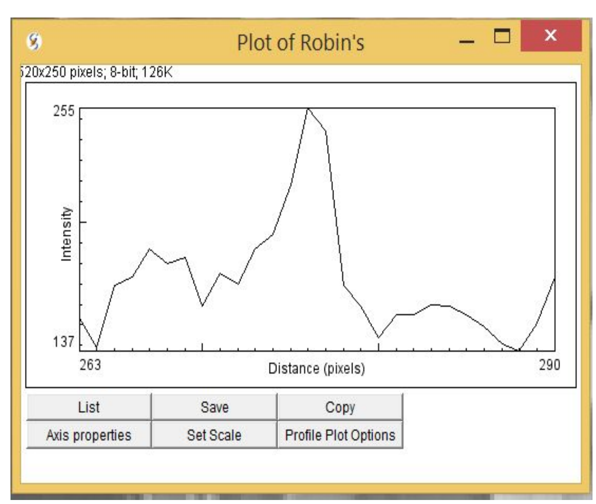
After tracking our flight with Google Earth and inspecting around 500 pictures, we discovered that we successfully acquired pictures of four targets. Robin Lafever's wood fire burning outside was the most notable of the fires. We converted the near-infrared pictures of Robin's house to grayscale pictures in order to run photometric analysis of the pictures using

SalsaJ, an image processing software originally developed to analyze the stars by astrophysicists from the Global Hands On Universe program.

Pictured above is Robin's house in grayscale with the fire at the center of the orange circle

With the validity of the fire confirmed by Lafever himself, we probed the image. Shown below are the data from the plot profile of Robin's fire. A plot profile displays a two dimensional graph of the intensities of pixels along a line drawn on the image. The line drawn through Robin's fire extends from his shed to the Pacific Ocean. The software analyzes each pixel along the line from left to right, obviously showing the intensity of the pixels peaks sharply at the precise location of Robin's fire. Perhaps, in the future, an automated system of plot profiles can be embedded in image processing software to create an efficient method of detecting fires by examining pixel intensities along suspect fire entities.





Conclusion:

With the inaugural flight spotting a lucid fire, the first FUEGO flight ran spectacularly smoothly. Before the test, we feared that pixels would smear heavily and images would be unrecognizable at altitudes near 1000 feet. Thankfully, we obtained clear, crisp images that brighten the imminent implementation of detecting fires with UAV drones. For some reason, the visible light camera disconnected once the Cessna reached an altitude of 800 feet. After further diagnosis, we concluded that the ethernet cable was defective and even the slightest toggling would preclude proper functioning; however, we addressed the issue of the defective ethernet cable by adding a Fast Ethernet Switch to run both PiCameras with one laptop via remote desktop.

Without an exact GPS location linked to our pictures, we had to manually trace our flight with Google Earth. This tedious process reveals the dire need for an efficient georeferencing software. The long process of manually analyzing images provides insight into the mechanics of projected, future image processing software. Ongoing development of software will need to recognize physical features such as landmarks or significant buildings just as humans do when physically processing pictures.

After thorough examination of the photos, previous calculations of pixel size at varying altitudes were confirmed. Furthermore, the pictures were clear and permitted straightforward processing.

Future Developments:

Our system is far from incorrigible. Following the flight, we replaced the original "blue" filter on the Infra PiCamera with a visible light filter that only permits wavelengths above 730 nm, thereby creating a more accurate "Infrared" camera. Although the first flight was largely a success, the system requires critical improvement. We are in the process of developing an efficient, potent software that can analyze pictures and efficiently detect fires. Currently, the software in development scans clusters of pixels for a mean luminosity above a certain preset threshold. Novel parameters can be added to improve the software and narrow down possible fires in pictures. In the near future, a more portable mount may be 3D printed to avoid the arduous dismounting of the system from the plane. With less tape and a cleaner mount, the PiCameras may fly with octocopters and drones in the very near future. FUEGO's first flight and first detected fire mark only the beginning of our ongoing endeavor to prevent fires.