FLIR Vue Camera Study

December 2017
FlightWave Aerospace Systems

A comparison of two FLIR Vue Cameras

FLIR Vue Pro with a 13mm lens
FLIR Vue Pro R with a 9mm lens

The major difference is that the Pro R version is marketed as a “Radiometric” quality camera, meaning it is supposed to be more accurate in temperature. The results suggest that the Pro R camera reads a more stable temperature over time, and produces a more thermally flat image when observing a thermally flat interior wall. Future work is to examine the behavior of the smaller and lighter FLIR Duo R, and FLIR Boson.

Study 1 - Temperature Stability over Time

Basic Setup

Both cameras were placed on a table in a conference room with the air conditioning turned off, and pointed at a bare wall. The cameras captured images once a second for various stretches of time. The images were processed and the mean of all the pixels was taken to represent the sampled temperature of the image. This temperature is compared over time to assess the stability of the camera.

An important assumption here is that the wall is thermally uniform and does not change temperature over time. The difference in lenses is accounted for in this study by imaging a thermally uniform surface.

There are two major categories of camera configuration that were inspected.

“Scene Presets” - The camera has a few low-level settings for Region of interest, contrast enhancements, and linear mapping.

- Sharpness (DDE) filters fixed pattern noise
- Active Contrast Enhancement (ACE) weights color contrast to hot or cold
- Smart Scene Optimization (SSO) determines what percentage of the scene is given a linear mapping.

Presumably these settings do not affect the Raw data, which is stored in a 14-bit grayscale image.

The scene presets were investigated to see whether the Radiometric camera produced a more thermally flat image, which was an issue observed during the MBAR missions in May 2017.

“Image Type” - The camera can take three types of images, two of which are useful for radiometric studies

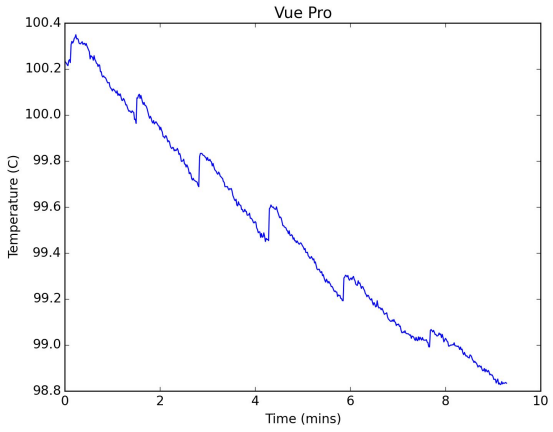
- 8 Bit JPEG - a plain old picture, no extra data on temperature past the colors in the image
- Radiometric JPEG - a jpeg that can be viewed in a normal picture viewer, but in the exif metadata contains the thermal configuration of the camera and the raw data itself.
- 14bit TIFF - a raw 14bit grayscale image with minimal metadata on thermal configuration.

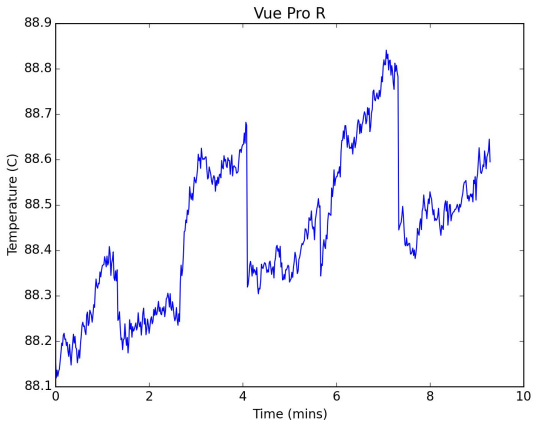
Data Set 1 - 14bit Tiff, Sea or Sky Scene Preset

The cameras took images once a second for approximately 9 minutes. The data below is calculated from the TIFF files but does not include proper calibration data in the image’s metadata to put it in the expected order of magnitude 25degC. As we’ll see in the last data set the Flir Vue Pro R does. We’ll treat this data as representative of trends over time.

As such the data shows that the Vue Pro drifts 1.2degC in 9 minutes without stabilizing. The Vue Pro R data has a range of 0.7degC over 9 minutes, and appears to still be drifting at the end of the experiment.

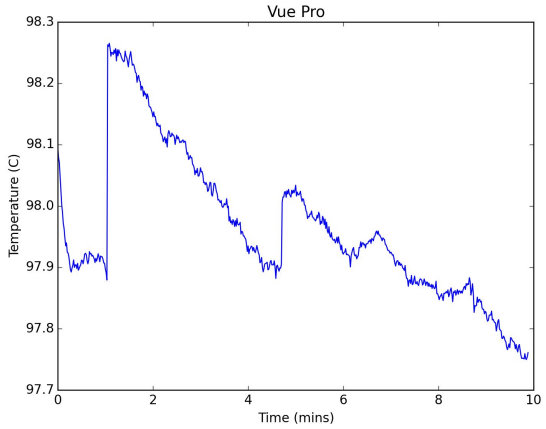
The discontinuities represent a Flat Field Correction (FFC) event.

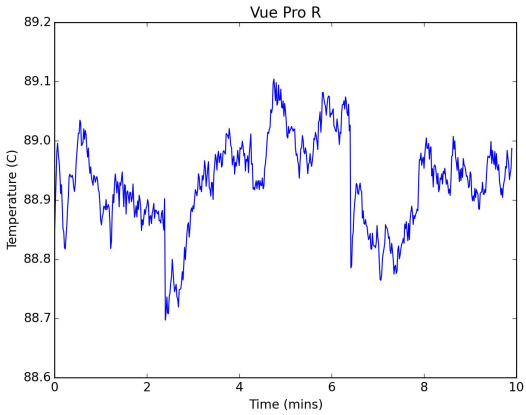




Data Set 2 - 14bit TIFF, Default Scene Preset

This test was run for approximately 10 minutes. By the start of this test, the cameras had been on for approximately 30 minutes, which may account for the smaller variation in these readings. The Vue Pro camera had a range of 0.5degC but seemed to still be drifting. The Vue Pro R had a range of 0.4degC and seemed to be fairly stable. It is not expected that the different scene preset would affect this view of the data since we are averaging each image.

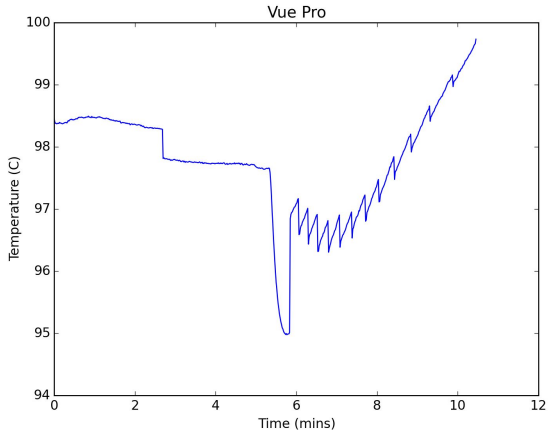


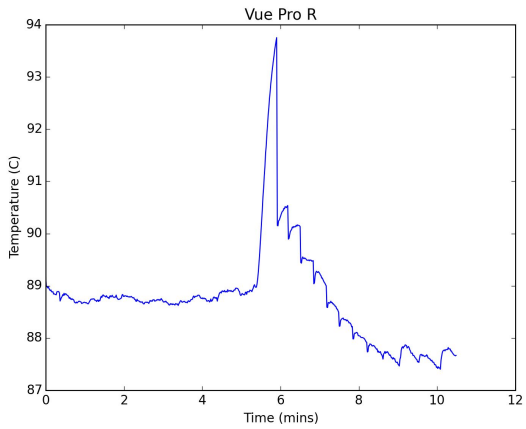


Data Set 3 - 14 bit TIFF, Sea or Sky Preset, Fan at 5mins

In this data set, halfway through the test we turned on a 20inch box fan pointed at the cameras. This is meant to simulate an extreme case in which the camera is flying on the drone without a nose cone. The results show that the cameras have to react to the changing temperature of the camera body.

In the case of the Vue Pro, an initial negative thermal disturbance is recorded, followed by a drifting trend with increasing temperature. In the case of the Vue Pro R, an initial positive thermal disturbance is recorded, followed by a negative drift that appears to have stabilized by the end of the experiment. The reactions of the camera temperatures are likely dependent on the internal workings of the camera so the only major conclusion we can make here is that the cameras do very much depend on the conditions external to the sensor.

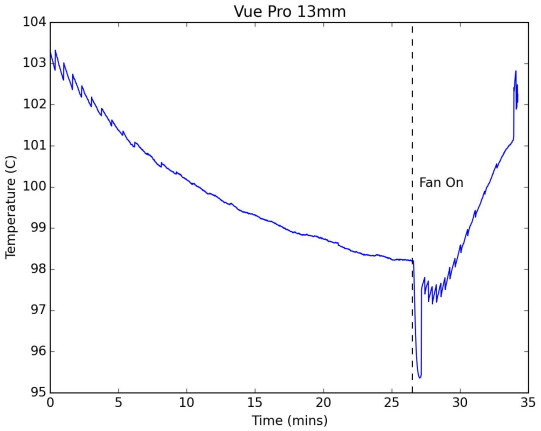


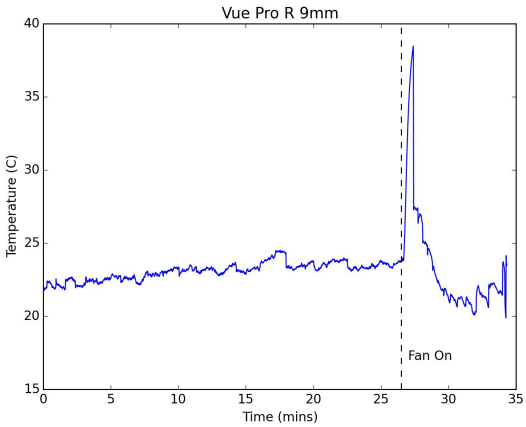


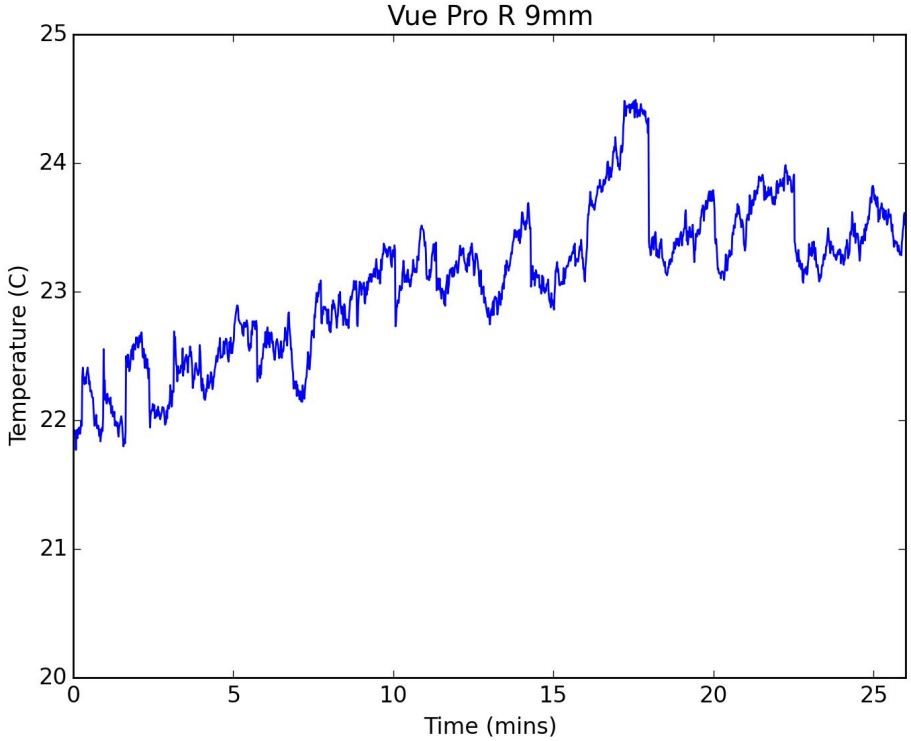
Data Set 3 - Radiometric Jpeg, Sea or Sky Preset, Fan at 27mins

In this data set, the test was much longer, a total of 34 minutes. The fan was turned on much later, 27 minutes into the test. The test starts very shortly after the cameras had been first turned on, after resting at room temperature for 5 hours.

The data shows a longer term temperature settling of the images. For the Vue Pro, it dropped 5degC before settling. For the Vue Pro R, it rose 1.3degC before settling. The reactions of the camera to airflow from the fan are similar to the previous data set.







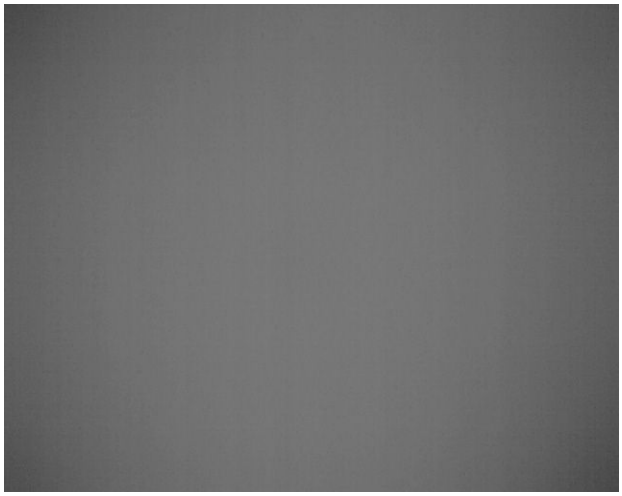
Conclusions for Study 1

- The cameras need to be warmed up to steady state for approximately 30 minutes before they can be trusted with measurement precisions less than +/-0.5deg C. This will have implications on how flight data is interpreted, as once the drone starts flying at fixed wing speeds the steady state temperature will change and the camera will need time to settle again.
- Once settled, The Radiometric camera, Flir Vue Pro R, appears to be more stable over time. Data set 2 shows this most strongly. Data set 3 to some extent also illustrates this because the data during the fan-off part of the testing does not drift very much.
- Since the application of these cameras requires investigating temperature differences as small as 2~4degC over several minutes of flight time, the Vue Pro R in taking Radiometric JPEGs would be a more favorable choice over the Vue Pro. However the stability of the sensor needs to be evaluated on a flying vehicle as the effect of wind was revealed an important factor.

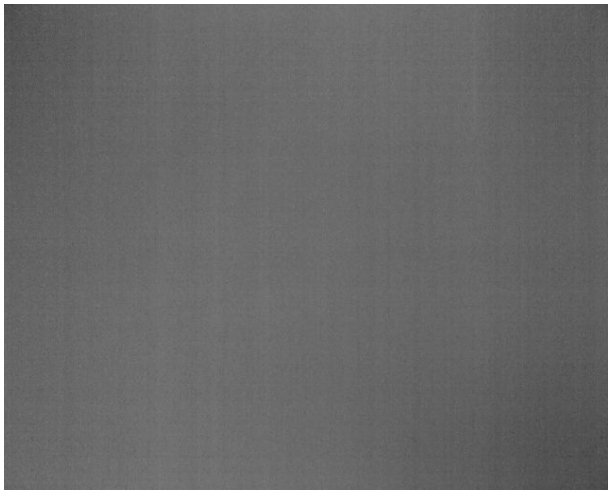
Study 2 - Temperature flatness in Image

Using Data Set 1 and 2 from the previous study, instead of inspecting mean we'll inspect the difference between the max and min of the image. This is treated as an indication for the degree to which the image is flat.

An example of an image of the wall is shown below for each camera. Because the images are grayscale, the absolute values are not particularly useful, however the relative values hint to the behavior that this study is trying to characterize. In the case of the Vue Pro image, the corners of the image are much darker than the center of the image. On the other the contrast of between corners and center is less strong, suggesting the temperatures measured in this image are more uniform.



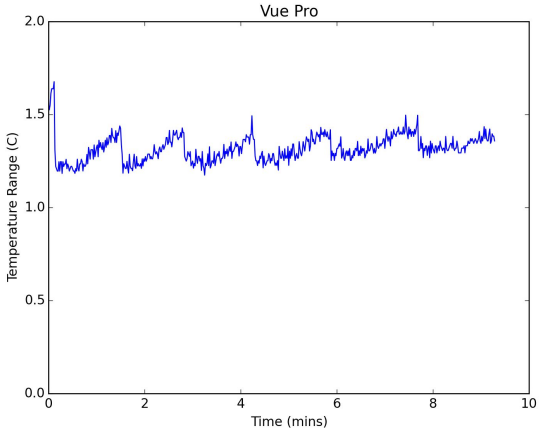
Vue Pro

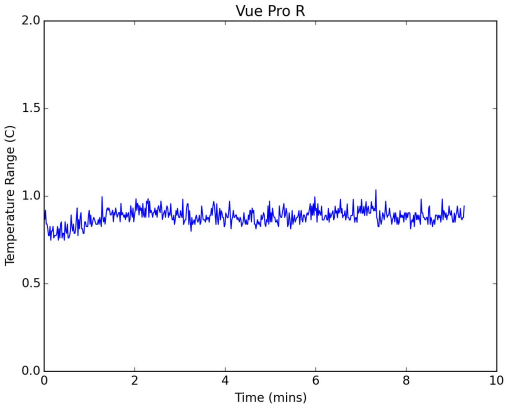


Vue Pro R

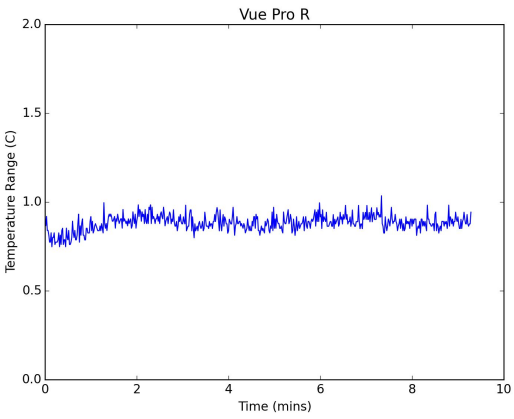
An effect to be aware off is that the Vue Pro R has a wider field of view, with a shorter focal length of 9mm, compared to the 13mm focal length on the Vue Pro. The wide field of view means that there is more of the lens used in the image, and the potential for lens aberrations increases the chance that the image is not flat. However as we will see the Vue Pro R is more flat.

The data below shows the difference between the maximum and minimum temperature for each image collected during Data Set 1 of the previous study. The data shows that the Vue Pro R is more flat, with an average temperature range of 0.8degC on an image of a thermally flat wall, compared to the Vue Pro with an average temperature range of 1.3degC of the same wall at the same time.

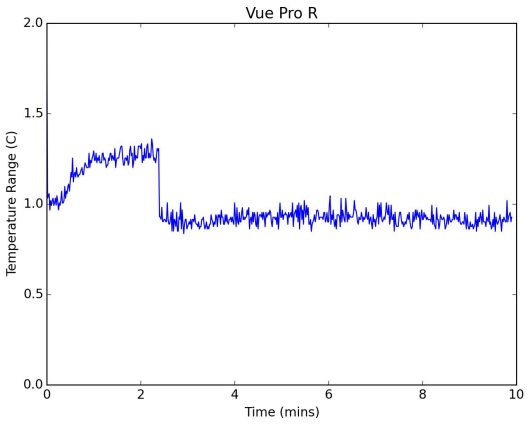




In the case of comparing temperature ranges of these thermal images, it is possible that the Scene Settings would affect the flatness of the images. Specifically the region of interest if constrained could mean that we are looking at a smaller section of the sensor. The data below shows that the temperature range difference for the Vue Pro R did not differ significantly at steady state between the two scene presets.



“Sea and Sky Scene” Preset



“Default” Preset