Fusion of Visual and Near Infrared Images in Embedded Platforms
ECE496 Senior Thesis
Progress Report 1

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1 Overview

The main strides in my senior thesis I am documenting here is the physical system. I have chosen a microcontroller and cameras for the collection and fusion of the images. In order to start experimenting, I decided to purchase the equipment as one of my first steps in this project. I have also devised a plan to capture images of consistent optical deviation.

2 Microcontroller

I have chosen to use a Raspberry Pi 5 for many reasons:

- Raspberry Pi allows me to run a variety of different programming languages. This allows me to develop the overall algorithm in Python, and then adapt the code to lower level languages like C if needed.
- Raspberry Pi 5 has 2 camera inputs that allows for seamless integration.
- Raspberry Pis are widely used and have a lot of documentation and support online.

The Raspberry Pi I chose has 8 Gbs of RAM. I chose a higher RAM amount due to the amount of processing needed to run the image fusion algorithm.

3 Cameras

I chose to use the Raspberry Pi Camera Module 3 and Raspberry Pi Camera Module 3 NoIR. Both of these cameras have a 12 megapixel sensor that captures images at 4608×2592 pixels.

The main difference between these two cameras is that the NoIR camera does not have the Infrared Cut Filter, which eliminates the Near Infrared (NIR) light that the camera captures. We can see in Fig 1 that there is still a very high response in the red sensors within the camera past the visual region or 700 nm. The IR cut Filter drastically lowers the response in all 3 channels past 700 nm, eliminating all NIR influence on the final image. For this reason, I bought the NoIR, to collect the NIR light as well.

Using both of these cameras simultaneously allows us to capture pictures or video within both of these spectrums.

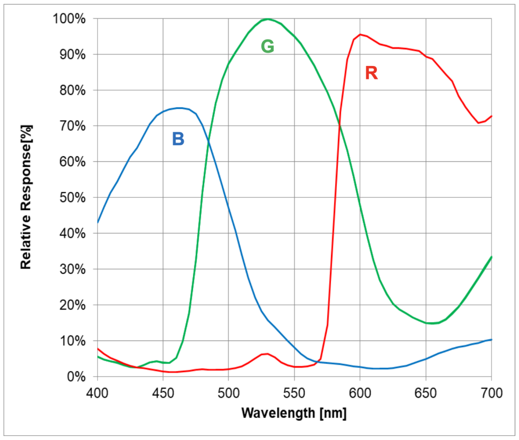

Figure 1: Spectral Sensitivity of Raspberry Pi Camera Module 3 NoIR [1]

If we decide to isolate the NIR light and eliminate the Visable light spectrum (VIS) then we can use a Infrared Long Wave Pass Filter. As we can see in Fig 2, all of the visual spectrum is eliminated with this filter. This allows the NoIR camera to only capture NIR light, which is essentially grayscale.

In Fig 3, we can see a scene captured by the two cameras and with the infrared filter. It is important to note that these images are not optically aligned yet as not all the parts of the setup system have arrived. We can see that the NoIR camera with the Infrared Long Wave Pass Filter does eliminate most visible light.

4 Optical Alignment

A very important aspect for image fusion is having a consistent optical alignment between the two cameras. I will achieve this by attaching the two cameras onto a tripod with a dual camera mount. See Fig 4 for how the tripod will be set up. With this set up, I can properly align the images by shifting the images to have each pixel aligned. This alignment should not change based on the image as then will always be the same distance apart.

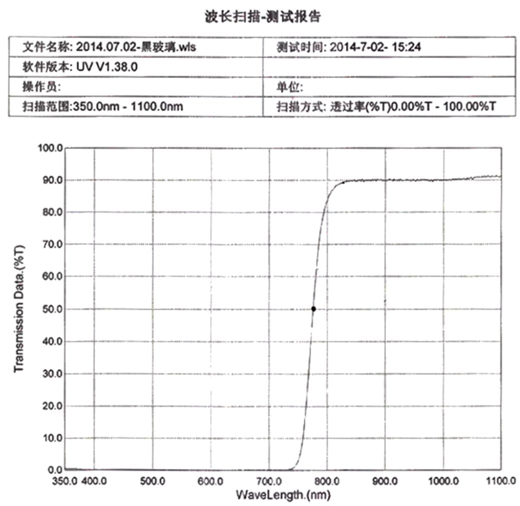

Figure 2: Spectral Sensitivity of Infrared Long Wave Pass Filter [2]

5 Next Steps

After establishing a system to collect VIS and NIR images, I will now attempt to recreate various image fusion methods. I will start with the method described in [3], which uses the wavelet transform for enhancement. During this recreation I will look for any redundancies or improvements within the algorithm. Before porting and optimizing these algorithms in the Raspberry Pi, I will be testing them on my PC using the dataset from [4].

References

[1] Raspberry Pi Foundation, "Raspberry pi camera documentation," 2023, accessed: 2024-9-28. [Online]. Available: https://www.raspberrypi.com/documentation/accessories/camera.html

[2] NEEMOO, "Product listing on aliexpress," 2024, accessed: 2024-10-29. [Online]. Available: https://www.aliexpress.com/item/1005005286063310.html

[3] X. Zhang, T. Sim, and X. Miao, "Enhancing photographs with near infra-red images," in *2008 IEEE conference on computer vision and pattern recognition*. IEEE, 2008, pp. 1–8.

[4] E. IVRL, "RGB-NIR Scene Dataset," https://www.epfl.ch/labs/ivrl/research/downloads/rgb-nir-scene-dataset/, accessed: 2024-10-10.

(a) VIS Image

(b) NoIR Image

(c) NIR Image

Figure 3: Images captured by Raspberry Pi

Figure 4: Tripod Setup for Optical Alignment