Multispectrally Sharpened Thermal Imaging with a Handheld VIS+LWIR Camera

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1 Introduction

According to Wien's displacement law, objects at room or body temperature emit black body radiation with a peak radiance in the range of 9-10 µm. This range of so-called "thermal radiation" – or long-wave infrared (LWIR) – serves a critical role for defense and security detection, product inspection, and other room temperature imaging purposes [1]. Despite the abundance of infrared light to sense, LWIR cameras are very expensive compared to their visible counterparts, with entry level units ranging from $1000 - $3000 [2].

FLIR Systems produces the Lepton, a compact and significantly more affordable LWIR camera module that is designed to fit inside a smartphone [3]. However, due to its low cost ($259) and small size (10.50 x 12.7 x 7.14 mm), the camera has a limited resolution of only 160 x 120 pixels. Such a low-resolution is not ideal for imaging applications.

The objective of this project is to combine the Lepton LWIR camera with a high-resolution visible light camera and implement a multispectral sharpening algorithm that uses the visible image to improve the resolution of the thermal image. Such a device would serve as an inexpensive thermal camera with reasonable resolutions for standard imaging applications.

2 Related Work

Multispectral imaging over visible and IR bands is already an area with great interest. A significant focus of work in this area is related to hyperspectral object identification [4, 5], pedestrian detection [6], and product inspection [7]. Techniques in these applications range from simply overlapping information from both visible and thermal cameras to create images with more channels of information, to using thermal images to computationally remove backgrounds from visible images in order

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to isolate objects of interest. However, these applications still rely on expensive high-resolution thermal cameras.

There have also been a variety of works that explore multispectral sharpening, using high-resolution images to sharpen low-resolution images at a different wavelength. Examples include the use of black-and-white images to sharpen near-IR images [8], and various approaches to sharpen hyperspectral images with high-resolution multi-spectral images [9, 10].

3 Approach

Our compact system for multispectral sharpening centers around the FLIR Lepton thermal camera, which we will interface with a Raspberry Pi Zero W board. For the visible camera we will use a Raspberry Pi Camera Module V2, which has a resolution of 2464 x 3280 pixels. The two cameras will be mounted adjacent to each other in a 3D printed case that will contain the entire setup. In total, the project is expected to cost $450, about half of which comprises the Lepton. The remaining half comprises the Raspberry Pi, visible camera, and assorted accessories.

Image capture will be synchronized via the Raspberry Pi. Initially the two images will be saved to memory and later offloaded to an external computer for processing. A reach goal for this project will be to add a screen to the system for real-time streaming of the locally sharpened LWIR image.

A very simple method of image sharpening involves highpassing the visible image and overlaying it with the interpolated LWIR image. While computationally inexpensive (and thus implementable on the Raspberry Pi) this will likely not give satisfying results. We will begin by implementing recent results from related work and proceed by tailoring methods that are either high quality or computationally efficient. The final product we will likely balance the quality of the sharpened image with the computational resources available on the Raspberry Pi.

4 Timeline

In total the project is expected to take 4 weeks.

1. Order parts and design a PCB that will break out the surface-mount Lepton socket for connection to the Raspberry Pi. Use a hyperspectral dataset to simulate a multispectral image composed of high resolution RGB channels and a low resolution LWIR channel. Begin writing the image processing pipeline to improve the resolution of the simulated LWIR channel.

2. Assemble cameras and connect them to the Raspberry Pi. Write code to capture and save images from each camera. Design and 3D print the camera body. Continue improving the image processing pipeline with the simulated multispectral image.

3. Switch from simulated images to captured images. First real sharpened images produced. Add a screen to the setup and move image processing onto the Raspberry Pi for real-time streaming of sharpened LWIR images.

4. Continue improving the multispectral sharpening algorithm, exploring and combining various cutting edge techniques as time allows. Write up results.

By the end of Week 4 we expect to produce sharpened LWIR images using the multispectral camera. Should we encounter difficulty in retrieving visible and LWIR images from the camera, we will still be able to demonstrate our image processing pipeline with the simulated multispectral images. We may be limited by the Raspberry Pi's processing power when attempting more computationally expensive algorithms. If this happens we can report a comparison of the quality between efficient, real-time Raspberry Pi algorithms and more sophisticated post-processing performed on a computer.

This project spans EE 367 and EE 368, so we will divide the work commensurately. Evan and Jacob are both enrolled in EE 367, so we will split the building of the camera equally. Jacob is also enrolled in EE 368, so he will be responsible for developing and implementing the sharpening algorithm.

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