Investigating Properties of Commercially Available IR Detector Technology

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Project Overview

- Infrared (IR) detector technology allows us to visualize light emitted at wavelengths beyond that which is typically visible:

$$\lambda = \frac{b}{T}$$

Figure 1. Wien's Law [1]. λ is the wavelength, b is a constant of proportionality, and T the Temperature

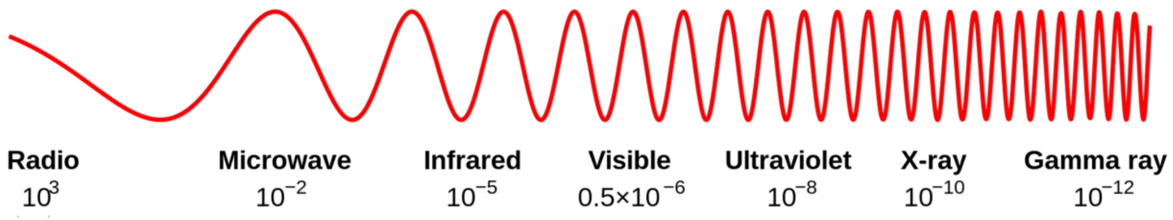

Figure 3. The EM Spectrum, ranging from Radiowaves to Gamma Rays

- Thermal Array relates the energy of incoming photons with the wavelength of the light using Planck's Equation [2]:

$$E = hf = h\frac{c}{\lambda}$$

Figure 2. Planck's Equation. h is Planck's constant, f is the frequency of light – which itself can be described with c, the speed of light, and λ, the wavelength

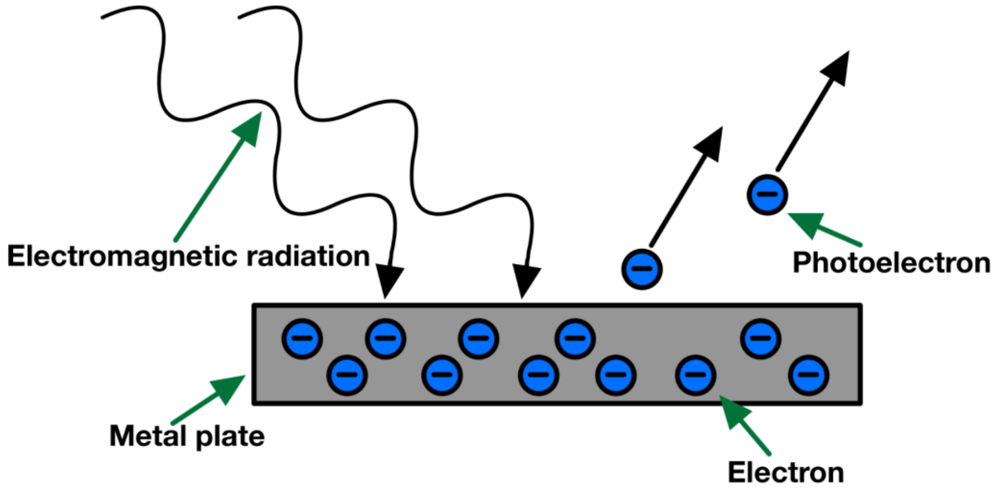

Figure 4. A diagram to showcase the Photoelectric Effect. [3]

Project Goals (Tasks)

- Use a Raspberry Pi 4 and thermal arrays to build an IR camera
- Determine the efficacy of our camera using various data science evaluation techniques

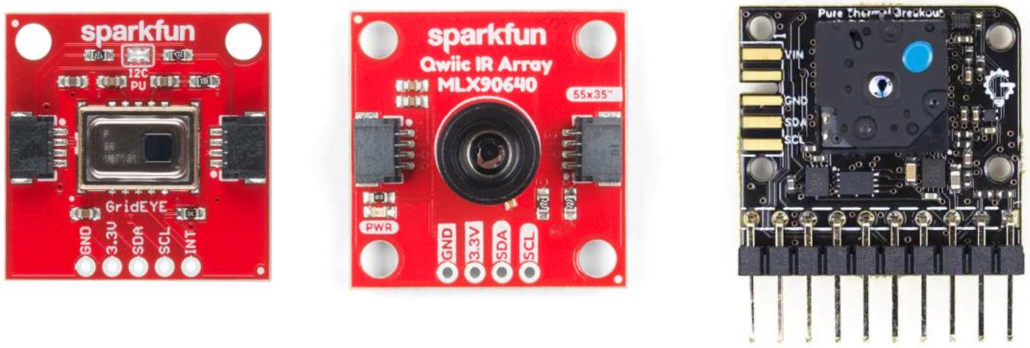

Image 2. All 3 thermal arrays - the Sparkfun AMG8833 (left), Sparkfun MLX90640 (middle), and FLIR Lepton mounted on the FLIR Pure Thermal Breakout (right), in order of increasing quality from left to right.

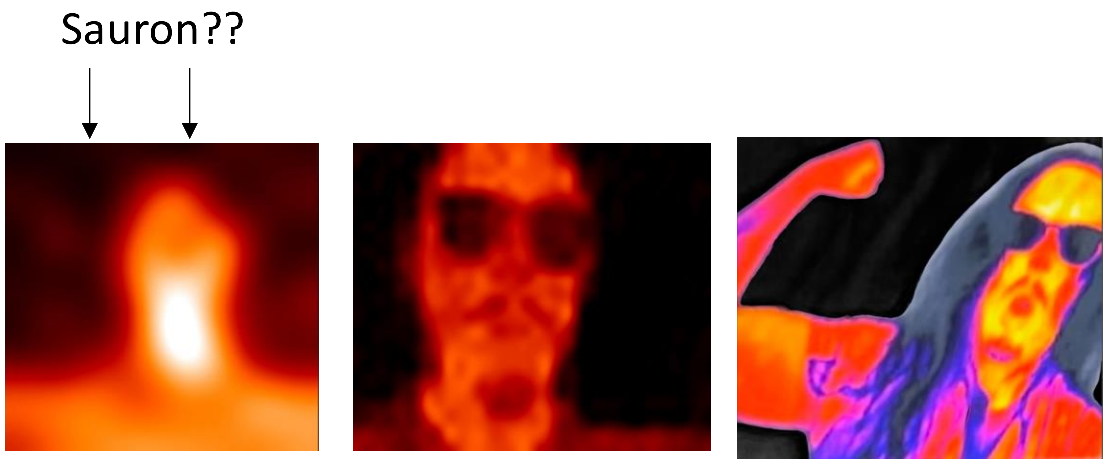

Image 3. Images from all 3 thermal arrays - the Sparkfun AMG8833 (left), Sparkfun MLX90640 (middle), and FLIR Pure Thermal Breakout (right)

Methodology

- The IR camera was built using a raspberry pi, temperature sensor, and 3 thermal arrays of increasing quality
- Software dependencies were installed via the Linux terminal
- As with any software, issues did arise and were handled accordingly. Namely:
  - The Sparkfun AMG8833 had a manufacturing defect (dead cell)
  - The FLIR Lepton did not work as intended with our original model of breakout board.
  - The FLIR Pure Thermal Breakout utilized programs written in C, whereas the other two utilized Python. As a result of this, the display window itself is much less customizable than the other two thermal arrays
- Utilized the “tkinter” Python module to create a Graphical User Interface (GUI)

Results

- Our Infrared Camera works as intended. The aforementioned display error was fixed.
- To combat the dead cell, a custom interpolation scheme was written into the display program. This fixes the error without problem.

Determining the Efficacy of the IR Camera

Methodology

Once the camera was functioning properly, we collected data using the first and simplest thermal array. To do so, we:

- Wrote a program that stores electron excitation count and ambient temperature data in a text file
- Used the data from the text file to plot 2 Histograms, one for individual cells and one for the average of all 64 cells

Results

- The mean and standard deviation of the single-cell histogram is 81.3 electrons/time iteration and 4.23 electrons/time iteration respectively. This is ambient noise
- For the other histogram, these values were 87.8 electrons/time iteration and 12.2 electrons/time iteration. This is intrinsic noise

Future Work

- Uniform Temperature and Extreme Temperature Tests

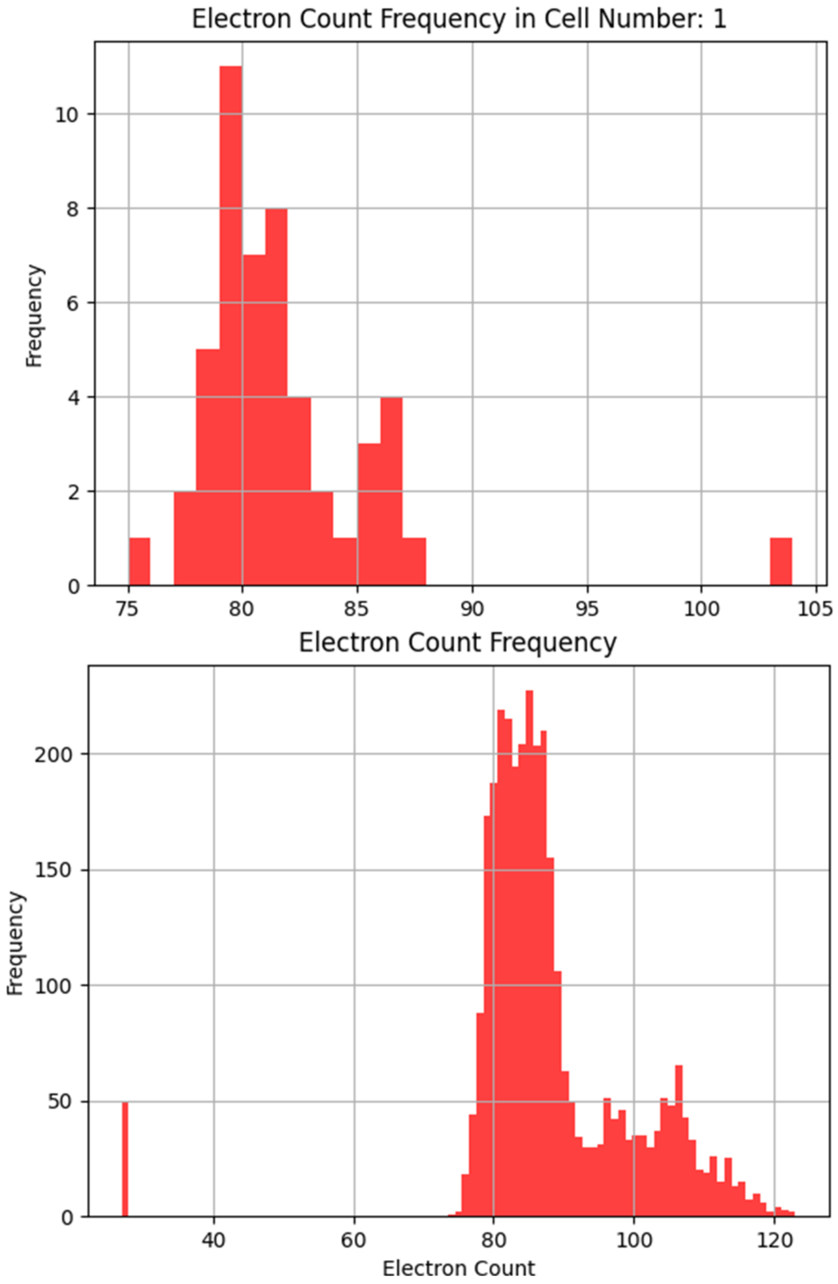

Image 4. Histograms produced from data collected from the AMG 8833. The frequency of detected electron excitations in a particular cell is plotted on the top, while the average of this same data from all cells is displayed on the bottom.

Extra – Fun with the Camera

To show case some interesting phenomena that accompany IR detector technology. Ask yourself these questions:

- If Infrared light's wavelength is smaller than that of visible light, does this mean it can penetrate through materials visible light cannot?
- In a similar vain, should transparent surfaces that allow visible light to pass also allow IR light to pass, or is this also dependent upon wavelength?
- If IR detectors can detect heat, shouldn't this also apply to trace heat left behind?

Methodology

- Stand behind a black trash bag and see if the camera can see through the material
- Point the camera at a pane of glass
- Hold an appendage (a hand should suffice) on a surface, then remove it after some time. Then, point the camera at the location wherein the appendage was placed.

Results

- The individual behind the black trash bag can be seen through the IR camera. This is because at IR wavelengths, the light can pass through the material.
- The scenery behind glass cannot be seen at IR wavelengths. While visible light can pass through glass, IR light cannot.
- The residual heat from a source is still visible to the IR camera.

References

[1] *Wiens Law*. Wiens Law - Energy Education. (n.d.). Retrieved April 17, 2023, from https://energyeducation.ca/encyclopedia/Wiens_Law

[2] Thescienceandmathszone. (2021, March 14). The photoelectric effect, photons and Planck's equation. The Science and Maths Zone.

[3] IBID

Questions?