Low Cost Spectrometry

3D Printed, Raspberry-Pi Based, and Simple to Operate

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Abstract

Optical Spectrometry is a valuable technique in a scientist's toolkit which allows them to determine a light source's composition or a material's absorption of light based on its emission spectrum. An optical spectrometer measures the wavelength and frequency of light in the visible spectrum. Presently, access to the tools necessary to accurately conduct optical spectrometry is constricted by either the financial burden and technical skill required to obtain and use sophisticated spectrometers or the imprecision of rudimentary models. This project has combined the cost-efficiency of 3D printing and the straightforward use of a Raspberry Pi microcontroller to develop a spectrometer that alleviates many of the difficulties of optical spectrometry, having the best attributes of each; cost effective, versatile, and accurate. This will allow any scientist or teacher to quickly start implementing spectral analysis.

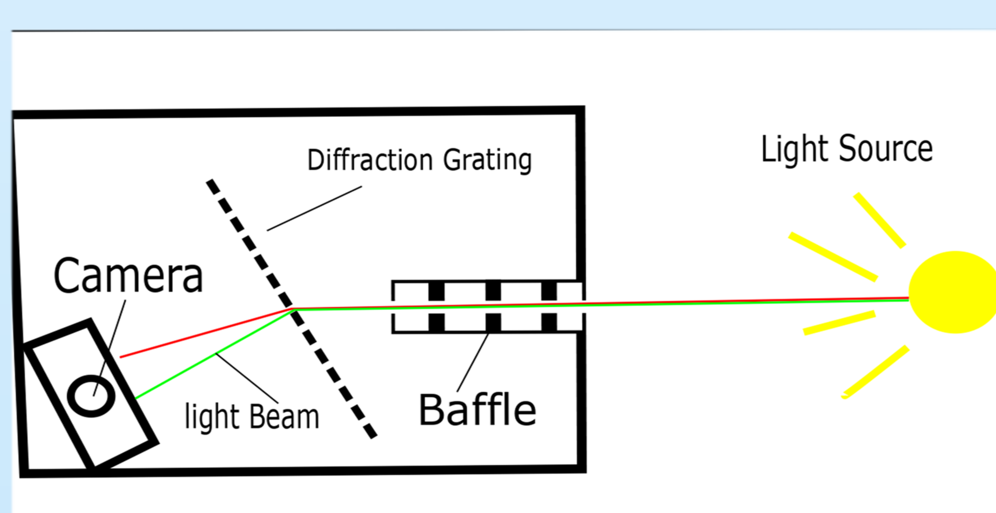
Methods

A Raspberry-Pi is easily transformed into an optical spectrometer. First, attach a camera and mount it inside the housing. Next, run a simple script that deciphers the image to create graphs and a CSV file for further data analysis.
Any stationary surface works to anchor the camera and housing to the light source as it diffracts through the grating for consistent results.

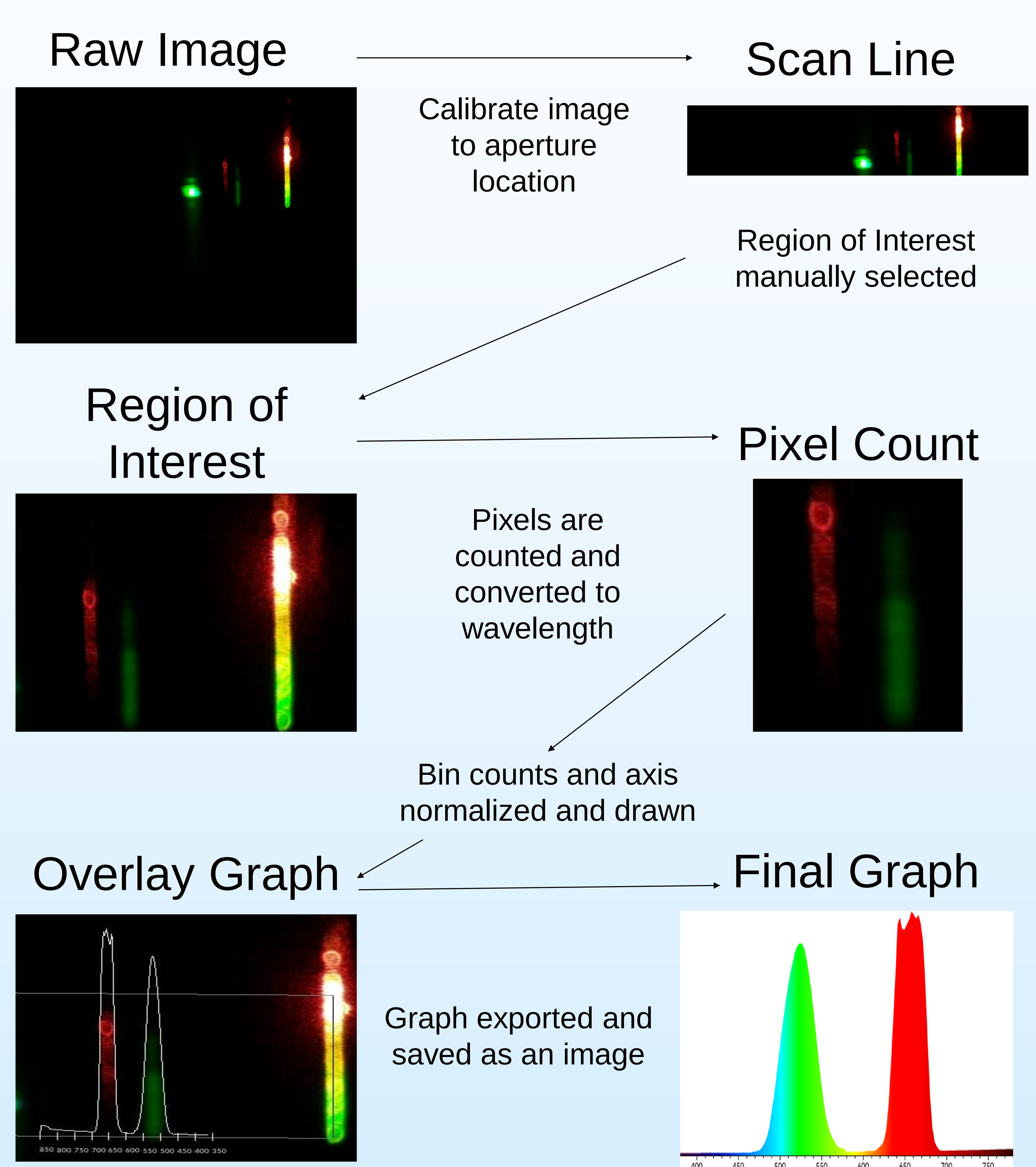
The cost for the Raspberry-Pi with camera, PLA printing material, and all the hardware is approximately $80. In comparison a spectrometer from Ocean Optics can start at $1100.

Setup

A light source is shown through a small slit on the front of the housing. The light travels through a baffle structure which collimates the beam and reduces stray light from entering. Once through the baffle it is redirected through a typical diffraction grating towards the camera.

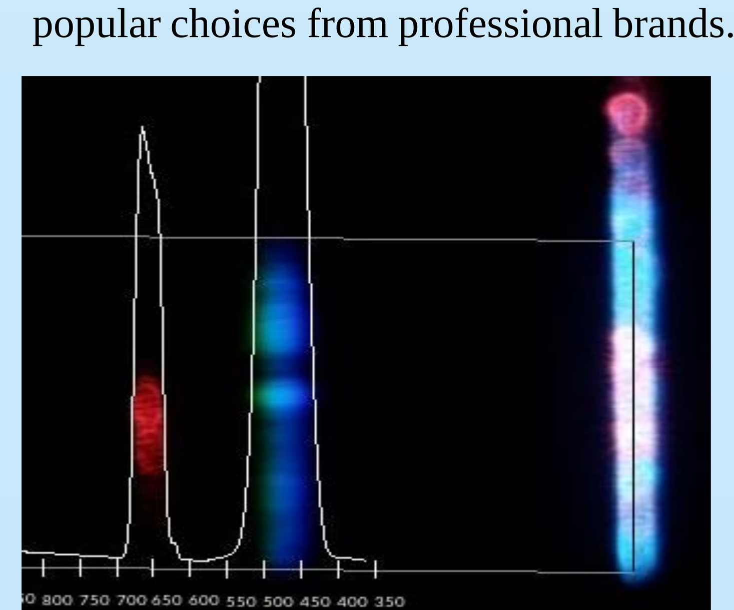


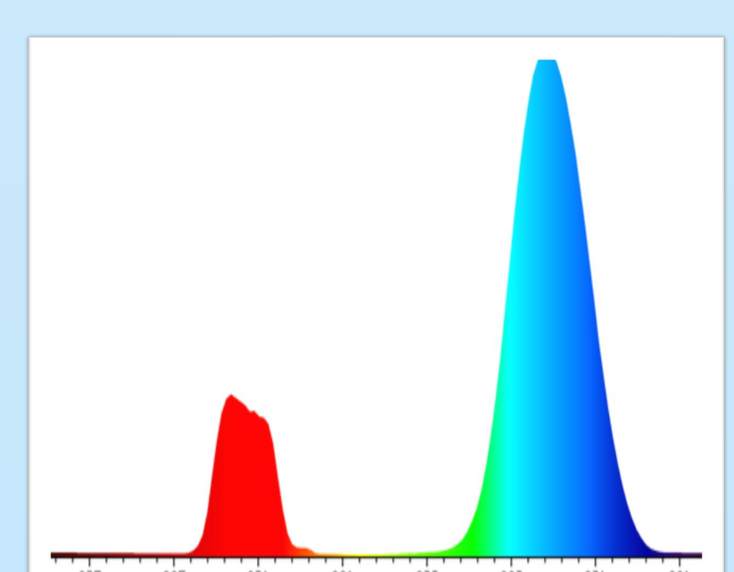
Program Flow Chart



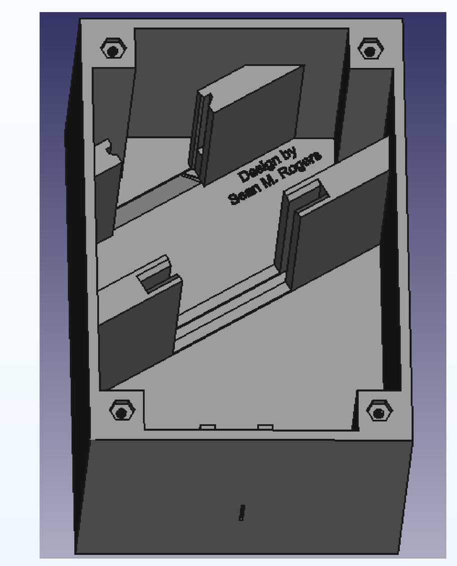
Results

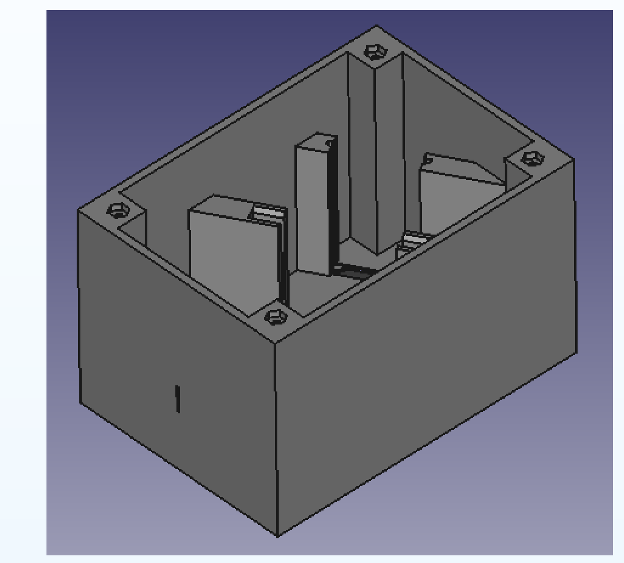
The spectrometer worked and could be calibrated with multiple light sources. Below are the calibrated images for a 650 nm laser and 470 nm blue LED light source and corresponding graphic generated from the same image. Focusing issues continue to skew clear data making it's accuracy appreciably low for now. The versatility of the device has not yet been properly tested however it's modular design provides potential in the future. Finally, the cost of the entire project was under $100. Even if additions are made, it is far more inexpensive that many of the popular choices from professional brands.





Future Work





- Program & Hardware
  - Improve focus on the camera and optimize program to more precisely interpret the data. This will increase the devices accuracy.
- Housing and Modules
  - Expanding the variety of modules will increase the devices versatility and perhaps lead to some more way to improve accuracy.
- Diffraction Grating
  - Preliminary steps towards 3D printing a diffraction grating by heating and stretching PETG has potential to further increase accuracy as well as lower overall cost.

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