Advanced Combustion

UCI Samueli School of Engineering

The Background

In 2015, fires caused more than $14.3 billion in property damage. One structure fire was reported every 63 seconds and an injury was reported every 34 minutes.

Floating embers are a main factor for how fires develop and spread, but little is known about their characteristics.

Our Mission

Develop a multicolor pyrometer for analyzing the probability of fire spotting caused by floating embers. We will be using only the visible spectrum of light.

Characterize important aspects of floating embers such as temperature, energy, and the velocity profile.

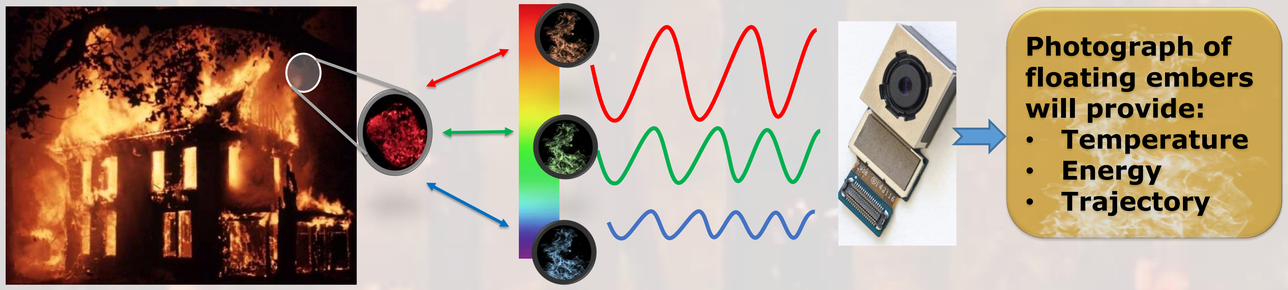
Develop testing procedures and experiments to define the necessary parameters in order to determine the above information

Characterization

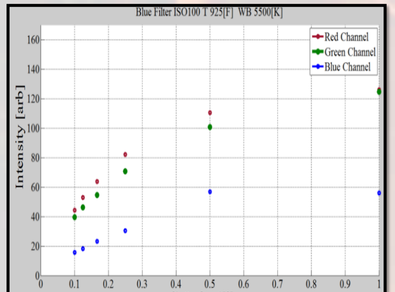
Determining the most sensitive wavelengths allows us to calibrate the final temperature readouts. Our process involves plotting the sensitivity function: $S_i = \frac{X_i}{\Delta t * L(\lambda)}$

X_i = pixel intensity
Δt = camera shutter speed
$L(\lambda)$ = light intensity

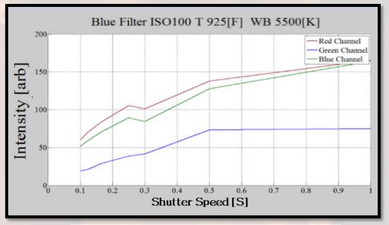
Multicolor Pyrometer using wavelengths from 420nm to 700nm



Photograph of floating embers will provide:
- **Temperature**
- **Energy**
- **Trajectory**

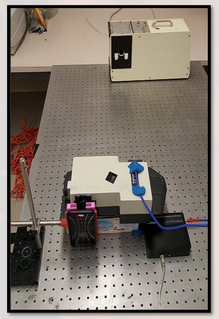


Sensitivity of cellphone camera to change in shutter speed using blue filter.

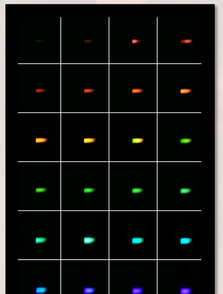


B/G	G/R	B/R
0.457	0.993	0.454
0.575	0.926	0.532
0.494	0.834	0.412
0.432	0.848	0.366
0.411	0.844	0.346
0.360	0.842	0.303

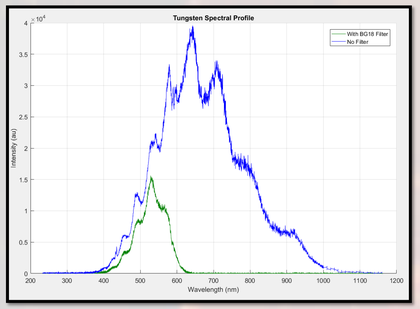
Intensity ratio for ISO 100 and White background. We found multiple linear regions with various slopes.



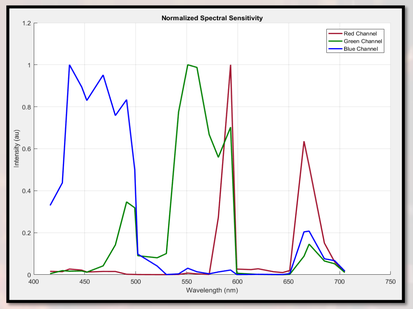
Intensity experiment



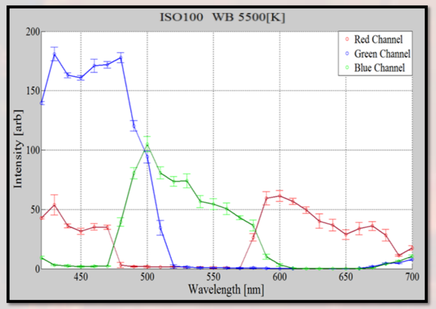
Resultant images from tungsten light through monochromater



Spectral profile of tungsten allows for accurate intensity readings because it is evenly distributed across the spectrum.



Graph of normalized sensitivity to each wavelength. Used to make final temperature analysis



209 images taken at same interval, analyzed through Matlab. Error bars indicate the consistency of camera.

Results

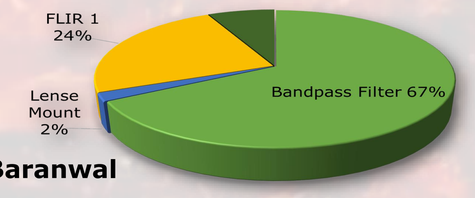
- The additional peak at 630nm was not indicated by Matlab, we will investigate this anomaly.
- We will also investigate why the RGB intensities are mirrored to how they should be in our last graph.
- After re-running the experiment, peak wavelengths continue to agree with previous experiments.

Challenges	Solutions
Abundance of information from experiments. Categorize and determine necessary vs non-necessary data.	Previous research done in this area gave us guidelines as to what data is important, using tools such as Matlab and spectrometers allowed us to extract the important information
Learning the Hardware; spectrometers, monochromaters, thermocouples, and microcontrollers.	Getting accurate data required an exposure time linearization and dark data profiles. We also designed a mobile thermocouple used to take temperature readings anywhere we have our computers.
Small changes in distance and angles of light caused large fluctuations in data	Designed and fabricated special mounts to stabilize the camera system, including the bandpass filter

Goals for Next Quarter

New Experiments	Determine shift in peak wavelengths after scaling the Red intensity down Begin imaging hot coals
Increased Accuracy	Examine discrepancies and errors in the sensitivity of the CFA
Develop New Analysis	Create Matlab code, incorporating key ratio's needed for temperature readout

Total Cost: $975



Advisors: Dr. Dunn-Rankin, Dr. Chien

Team Members: Dorsa Shirazi, Dustin Hall, Jose Hernandez, Kyra Lee, Michael Soliman, Siddharth Baranwal