# Indoor Localization through Visible Light Characterization using Front-Facing Smartphone Camera


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## ABSTRACT


Research conducted in the field of localization with passive light, or using the intrinsic properties of light to determine a person's location, has seen increased growth in recent years. Specifically, fluorescent lights have been shown to exhibit distinct frequencies which can be recorded, along with their positions, for future lookup and positioning. Developments have been made in utilizing this phenomenon with a smartphone's high-resolution back-facing camera, however the constant flipping between the camera and the screen results in a poor user experience. In this project, we propose an algorithm for extracting and analyzing both loop-shaped and tubular fluorescent lights. Similarly, we contribute an improved method for detecting frequency characteristics of unmodified fluorescent lights using a smartphone's front facing camera, therefore eliminating the need to constantly flip the phone.


## BACKGROUND

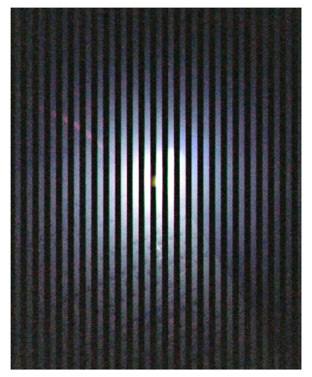
Visible light requires a ***line of sight*** characteristic, which guarantees:

- security [1]
- minimal interference
- unregulated

[2]

***Rolling Shutter Effect:***

- image sensors exposed column by column [3]
- provides longer signal



**Characteristic Frequency:**

- identifiable dominant frequency within fluorescent lights (FL) [4]

[5]

## PROBLEM & OBJECTIVE

**Research problem:**

- Front-facing cameras do not provide picture in RAW format
- Other compressed formats may lose frequency domain information

**Objective:**

To use video on the front-facing camera of commercial off-the-shelf (COTS) smartphones to accurately extract characteristic frequencies of fluorescent lights for localization purposes.

## EXPERIMENTAL SET-UP

Camera placed on a tripod underneath a fluorescent light to collect 1.5 minute long videos.

**Camera Specifications:**

- Open Camera app on Samsung Galaxy S8
- Shutter Speed: 1/14388.7s
- Video Resolution: 2880x2160
- Forced macro mode
- ISO levels 800, 1200 1600, 2400

## METHODOLOGY

Video Capture → Image Processing → Frequency Peak Detection

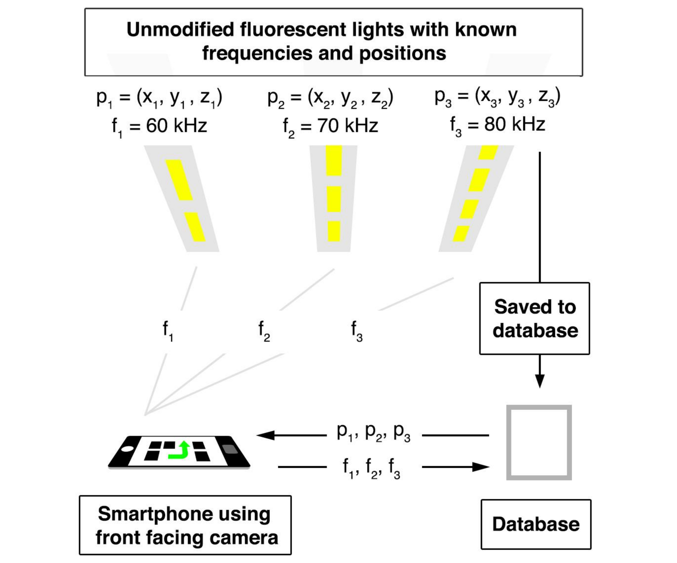



**Figure 1.** Overview of Indoor Localization Scheme

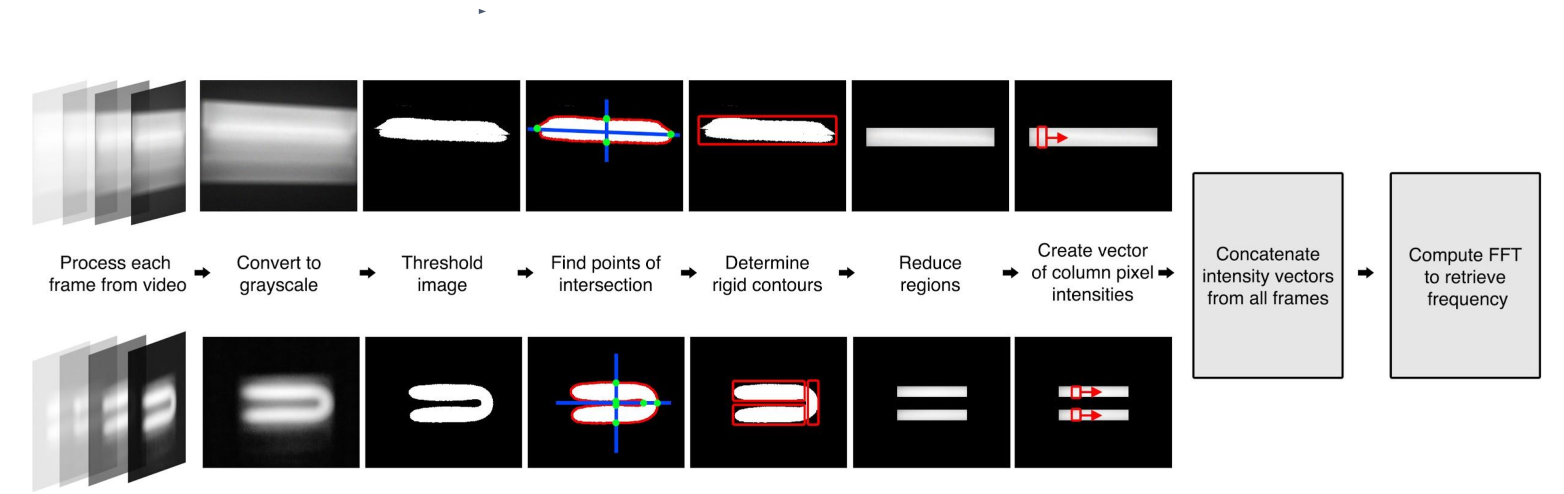



**Figure 2.** Processing of the Video Frames

## RESULTS

Characteristic frequency candidates were identified visually. Peaks seen in multiple other charts were eliminated.

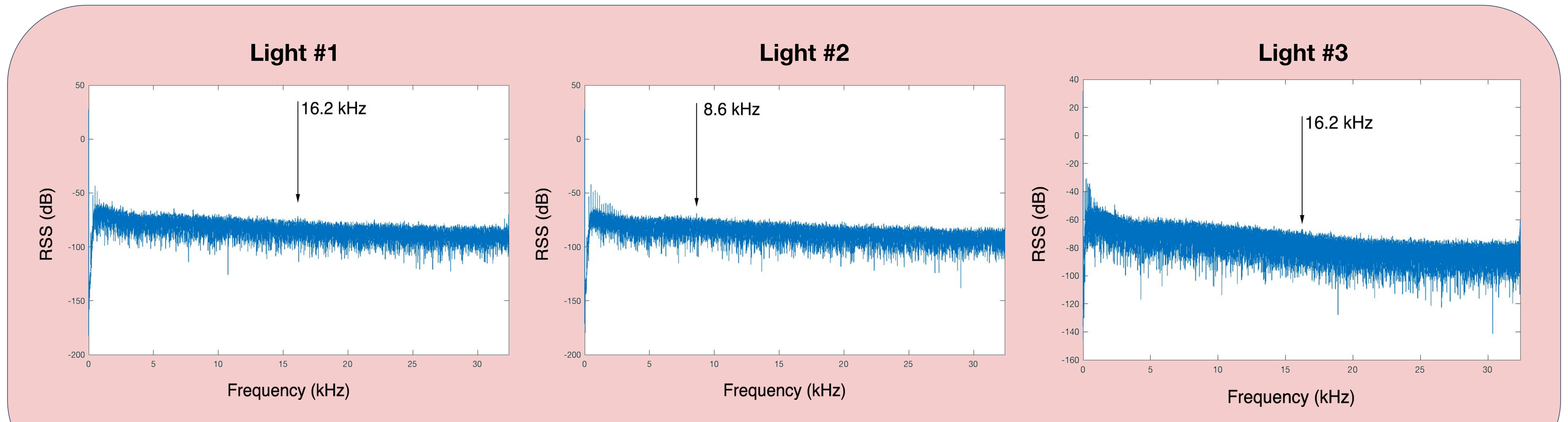



**Figure 3.** Incorrect peaks based off of video

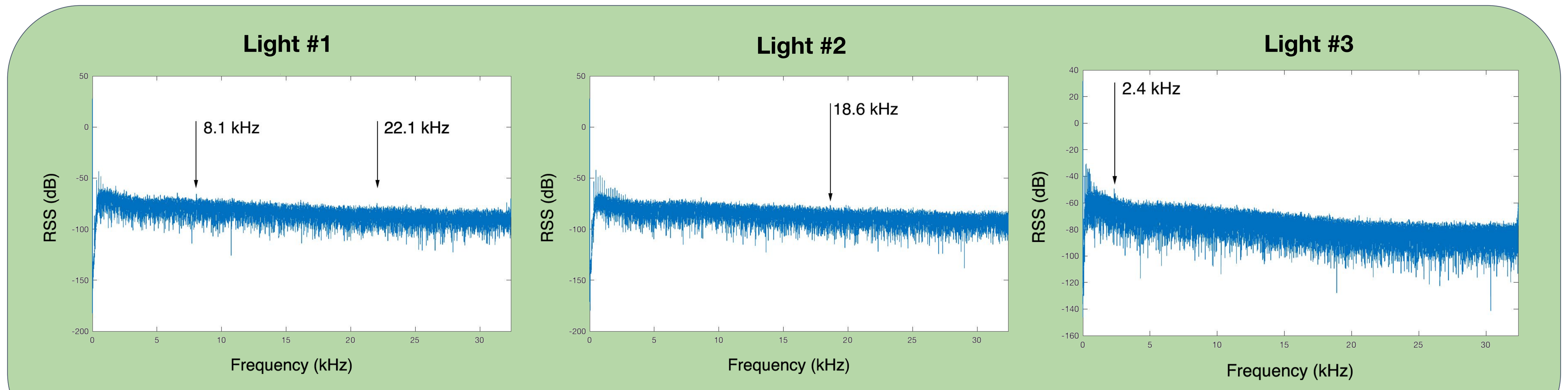



**Figure 4.** Identified unique peaks for lights based off of video for lights #1 - 3, respectively.

## DISCUSSIONS

- Incorrect peaks due to either image processing or mp4 compression
  - Increase camera resolution -> higher sampling rate
  - Ground-truth CF measurement set-up
- ISO can't be too high (results in oversaturated image)
  - Create alternative to Open Camera
    - Shorter shutter speed
    - Higher ISO level
    - More adaptability on various platforms
- JPEG compression only contains incorrect frequencies
  - There are still uniquely identifiable frequencies regardless

## FUTURE WORK

- Investigate other formats (lossless compression)
- Testing effects of ambient light
- Testing various height levels
- Actual implementation with localization system

## CONCLUSIONS

In this work, we explore the feasibility of using a conventional smartphone's front facing camera to distinguish between unmodified fluorescent lights. We captured videos on the front-facing camera and developed an image processing method to extract characteristic frequencies. Our evaluations shows that the front-facing camera is able to detect dominant peaks. Although it can be further improved, our preliminary work shows that the front-facing camera will eliminate the laborious back-and-forth flipping between camera and screen, improving usability.

## REFERENCES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