GridInSight: Monitoring Electricity Networks Using Visible Lights

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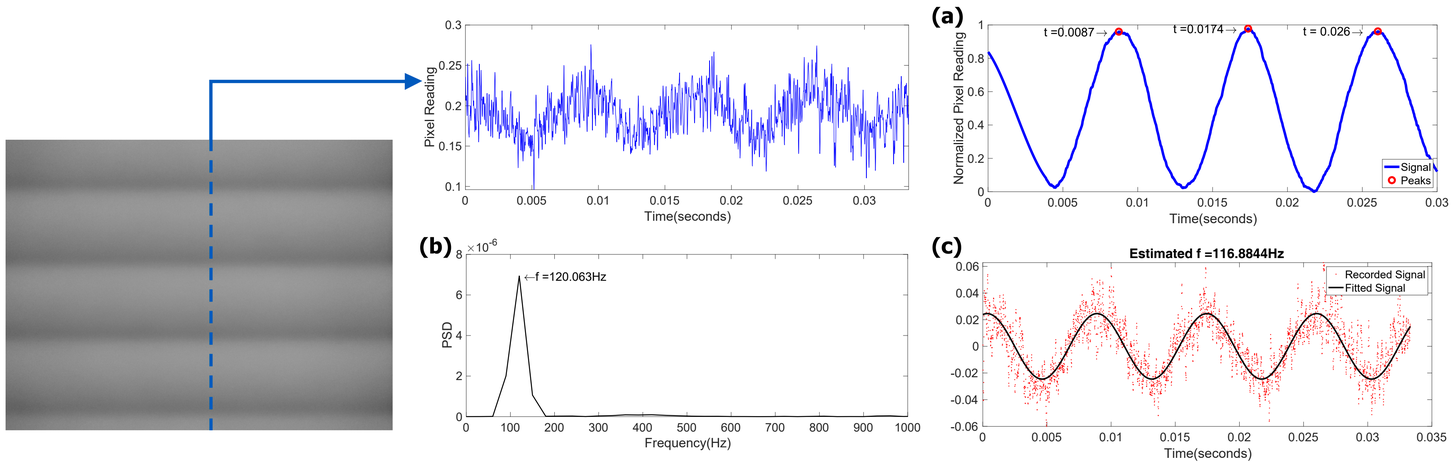
INTRODUCTION

- Cameras may potentially enable widespread power quality data acquisition at low cost.
- We demonstrate the use of off-the-shelf cameras to detect phase, frequency, and voltage of the grid powering artificial lights.
- **Rolling Shutter Sensor:** Inter-row delay provides high temporal sampling.
- **Image Data Acquisition for frequency & phase detection:** Pictures taken of wall illuminated by light sources.

FREQUENCY MONITORING

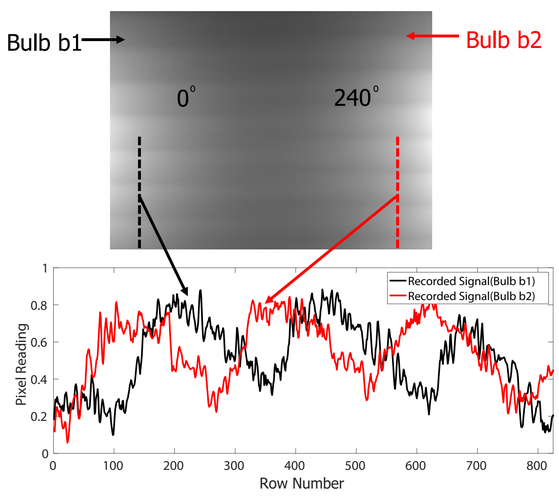
- Frequency measuring techniques-
  (a) Peak finding, (b) Power Spectral Density, (c) Sine-fitting.



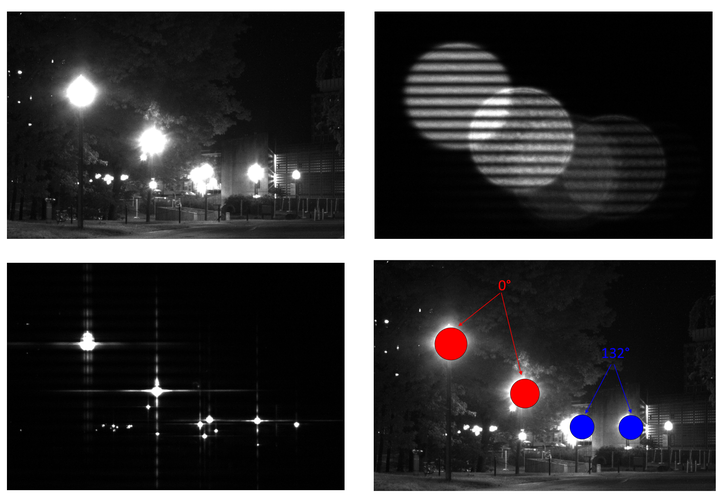
- **Potential Application:** Backup generator detection.

PHASE DETECTION

- Indoor Scenes



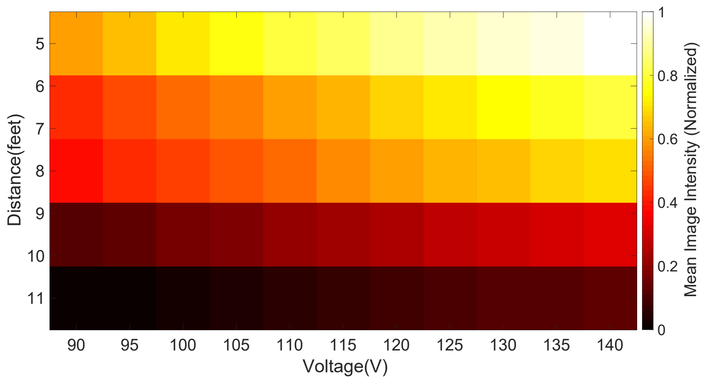
- Outdoor Scenes



- **Potential Applications:**
  Electric-phase mapping, updating old phase maps, backup generator detection, phase balancing studies.

VOLTAGE MONITORING

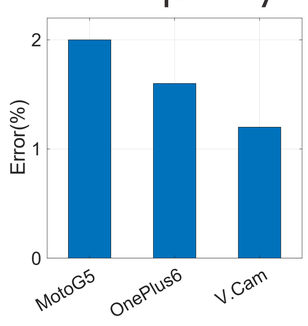
- 150 images per bulb captured at different voltage and distance values.
- Two-level regression model per bulb.
  - Level 1: Eliminates effect of distance on intensity,
  - Level 2: Learns the relation between intensity and voltage.



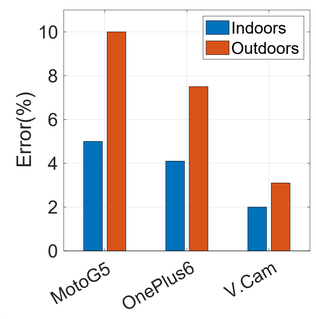
- **Potential Applications:**
  Detecting brownouts & areas with poor power quality, predictive maintainence.

RESULTS

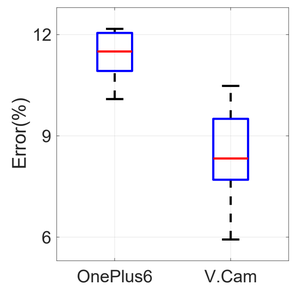
- Frequency



- Phase



- Voltage

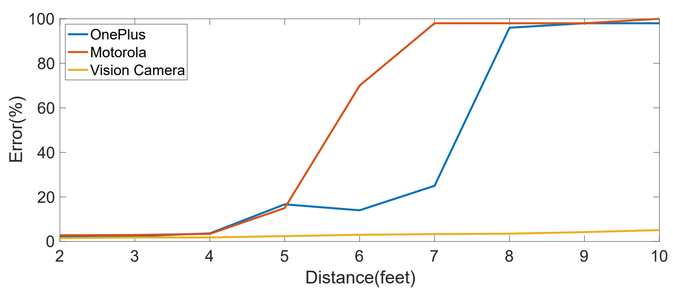


CHALLENGES

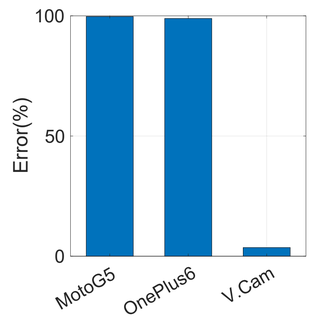
- On-the-fly bulb identification.
- Aging of bulbs might affect voltage measurements.
- Not all LEDs behave as per our model.

LIMITATIONS

- Frequency measurement deterioration with distance.



- Phase measurement deterioration due to poor defocusing.



FUTURE WORK

- Phase & frequency detection for wide-area scenes.
- Conduct more field experiments.
- Localization of light sources on a map.
- Study the effect of a camera post processing software.
- Develop a single universal model for voltage predictions.

KEY REFERENCES

[1] Federica B. Bianco, Steven E. Koonin, Charlie Mydlarz, and Mohit S. Sharma.2016. Hypertemporal Imaging of NYC Grid Dynamics: Short Paper. In Proceedings of the 3rd ACM International Conference on Systems for Energy-Efficient BuiltEnvironments (BuildSys '16).

[2] M. Sheinin, Y. Schechner, and K. Kutulakos. 2017. Computational Imaging on the Electric Grid. In The IEEE Conference on Computer Vision and Pattern Recognition(CVPR).

[3] M. Sheinin, Y. Schechner, and K. Kutulakos. 2018. Rolling shutter imaging on the electric grid. In 2018 IEEE International Conference on Computational Photography(ICCP). IEEE, 1–12