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EVALUATING ELECTROLUMINESCENCE IMAGING AND IMAGE PROCESSING AS A QUANTITATIVE SOLAR CELL CHARACTERIZATION METHOD

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ABSTRACT

Mitigating dust accumulation on the surface of solar arrays is crucial for maintaining maximum power output. We propose investigating electroluminescence imaging paired with image processing as a means of evaluating various dust mitigation techniques. Image processing was able to clearly differentiate between pristine and dusted solar cells. Paired with traditional analysis techniques, this method proves to be a quick and powerful characterization tool.

INTRODUCTION

Preventing lunar dust accretion on the surface of an array is key to achieving maximum power output during lunar surface missions

Electroluminescence (EL) imaging paired with image processing can generate histogram plots of pixel brightness. Lunar dust is much smaller than a pixel (≤ 20µm vs ~25mm), so pixels with dust present will emit dimmer light instead of being fully blacked out.

Plot comparison before/after lunar simulant deposition can inform on the efficiency of a mitigation technique.

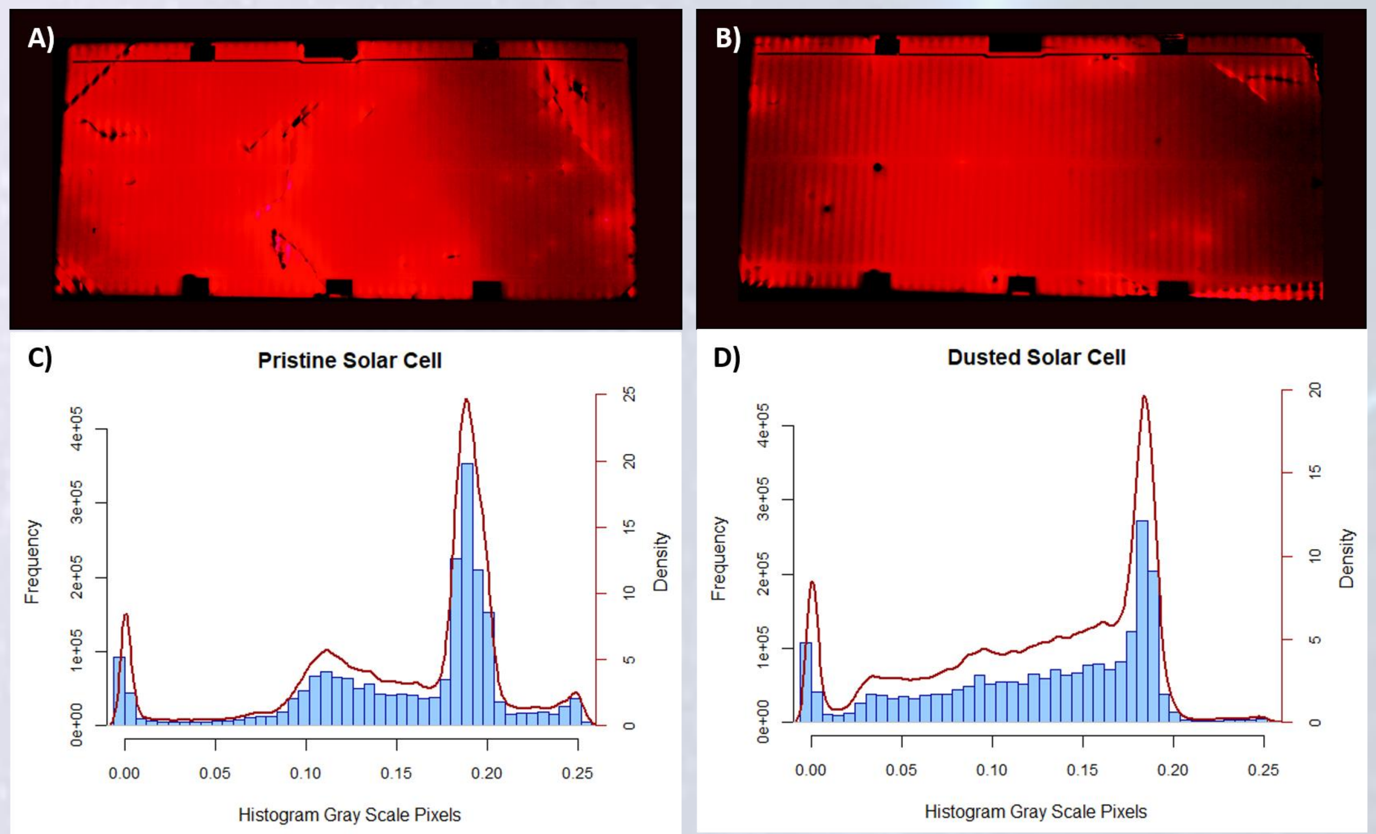
EXPERIMENT

Raspberry Pi with camera connect via ribbon cable

Initial testing focused on validating that the image processing script is sensitive enough to reliably detect dust on the surface.

Solar cells from a previous Martian dust experiment were biased and photographed using a Raspberry Pi camera module run in fully manual mode.

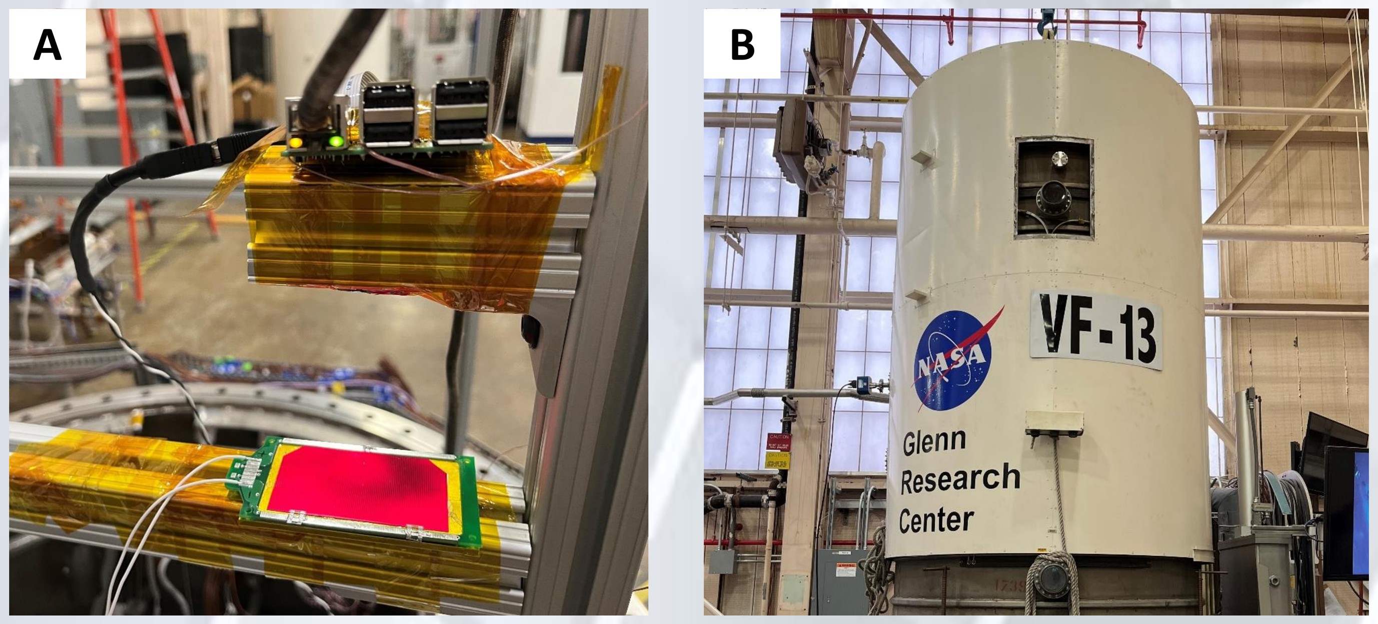
Grayscale photographs are run through an image processing script in RStudio. The brightness of each pixel is evaluated and plotted with the overall density of each bin.



A luminescing pristine (A) and dusted (B) solar cell and their resulting histograms (C, D) of image brightness.

- Cells exhibit regions of fully dark (bin = 0.00) electrode and fully bright (bin = ~0.19) emitting regions.
- The dusted solar cell has significantly more bins in the 0.001 - 0.10 range, indicating dimmer, dust covered pixels.
- The pristine solar cell shows a higher density of pixels in the fully bright region (25 vs 20).

Method repeatability was investigated by taking images across three trials with full system restarts in between. There were fluctuations in exact bin height, but the shape and peak size of the histogram remained uniform.



***A**: Mounted Solar cell and Raspberry Pi*
***B**: "Dirty" vacuum chamber used for simulant testing*

The Raspberry Pi functionality and EL imaging technique was tested by taking images at multiple points in vacuum pump down process.

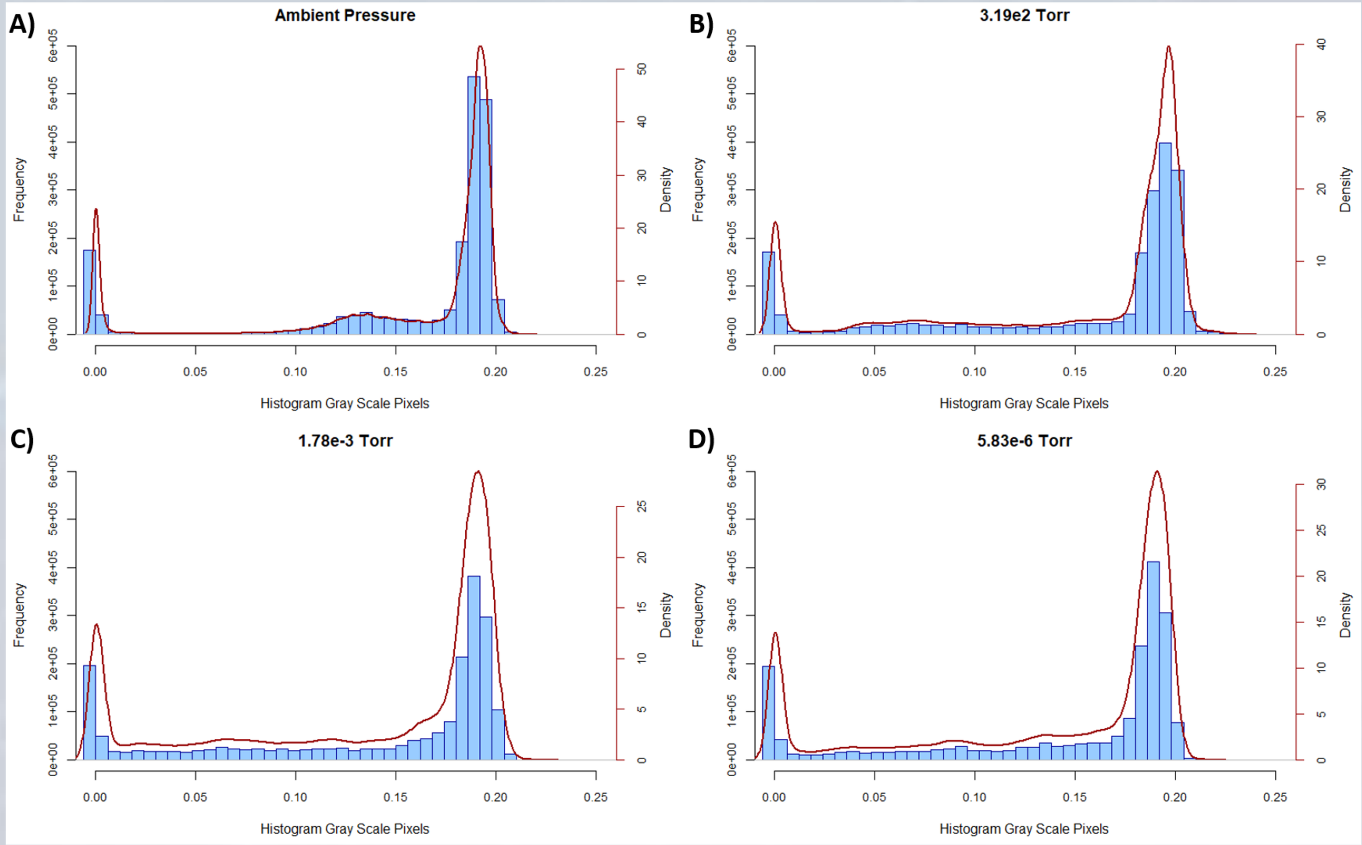


Image brightness histogram plot of solar cell at A) Ambient pressure, B) 3.19e2 torr, C) 1.78e-3 torr, and D) 5.83e-6 torr.

- Histogram shape and bin heights stabilizes around 0.4e6 ± 0.01 after initial vacuum pump down begins.
- Raspberry Pi maintained performance in vacuum, even with minimal heat dissipation capabilities.

CONCLUSION

- Electroluminescence imaging and image processing provides a simple and effective means of characterization that requires little additional hardware.
- Image processing differentiates between pristine and dusted solar cells with relative uniformity.
- This will be further tested using solar array test coupons and a lunar simulant deposition system.

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