Elektroluminescence with Consumer Grade Cameras

Oliver Usher, Plan-E AG

Electroluminescence (EL) is a method for analyzing photovoltaic (PV) modules, enabling the detection of broken or defective cells. Traditionally, this technique requires expensive specialized equipment. Unlike thermography, EL imaging allows for detailed fault analysis at the cell level. This project explores the feasibility of modifying consumer-grade cameras for EL imaging by extending spectral sensitivity. Results show that EL images can be captured at low cost, though image quality varied across different camera models. Based on the insights gained, a cost-effective approach was developed for EL inspections using an aerial platform, enabling successful identification of damaged modules in PV installations. These findings confirm the potential for EL inspections using accessible, low-cost camera systems.

Goal

The goal of this project was to develop a concept to capture EL Images in a cost-effective manner from an aerial platform.

What is Electroluminescence?

When electrical current is applied to a solar module, it behaves like a forward-biased diode and emits light. This light is extremely faint, lies in the infrared (IR) spectrum, and is invisible to the human eye. Capturing this emission requires cameras sensitive to the near-infrared range.

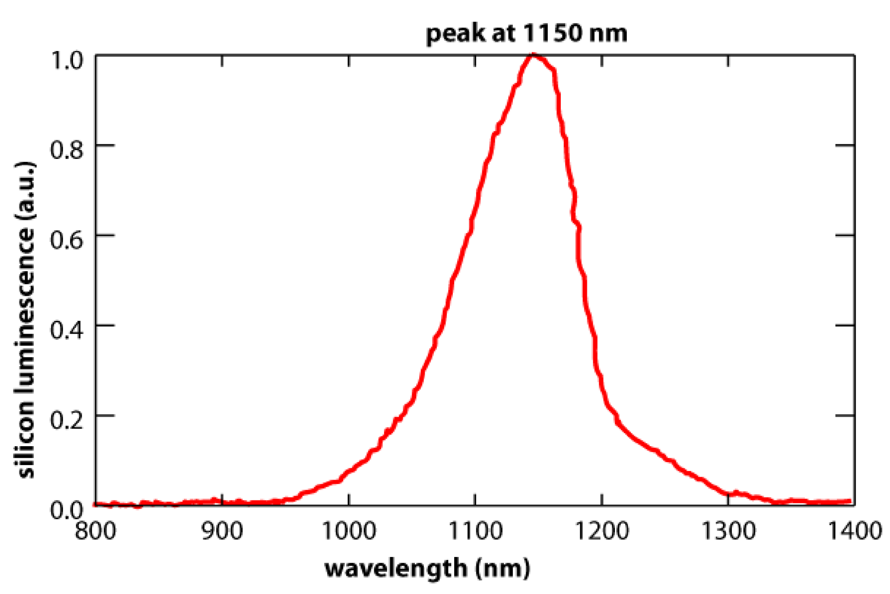


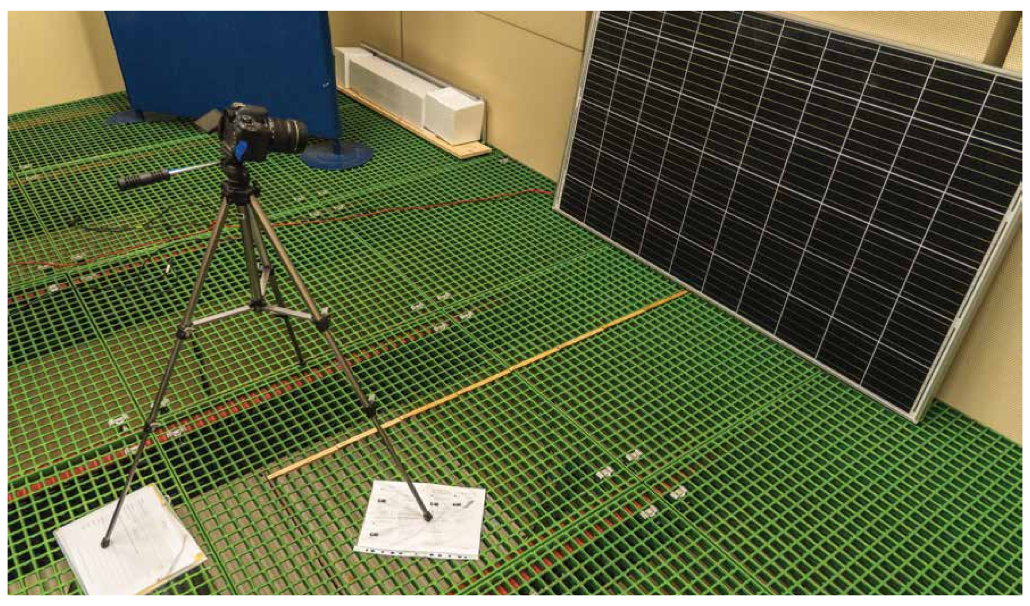
Photo: Ciocia, Alessandro & Carullo, Alessio & Di Leo, Paolo & Malgaroli, Gabriele & Spertino, F.. (2019).

Why Electroluminescence?

Electroluminescence is an alternative to thermography, which is useful for identifying issues such as inactive modules, faulty bypass diodes, or disconnected cells but cannot detect microcracks or fractures within cells. These defects may result from storms, improper installation, transport, or mechanical stress and can cause immediate or delayed performance losses. Over time, through thermal cycling, microcracks may expand, electrically isolating parts of a cell. EL imaging allows for early detection of such faults, allowing for the module to be replaced, preventing long-term degradation.

Methodology

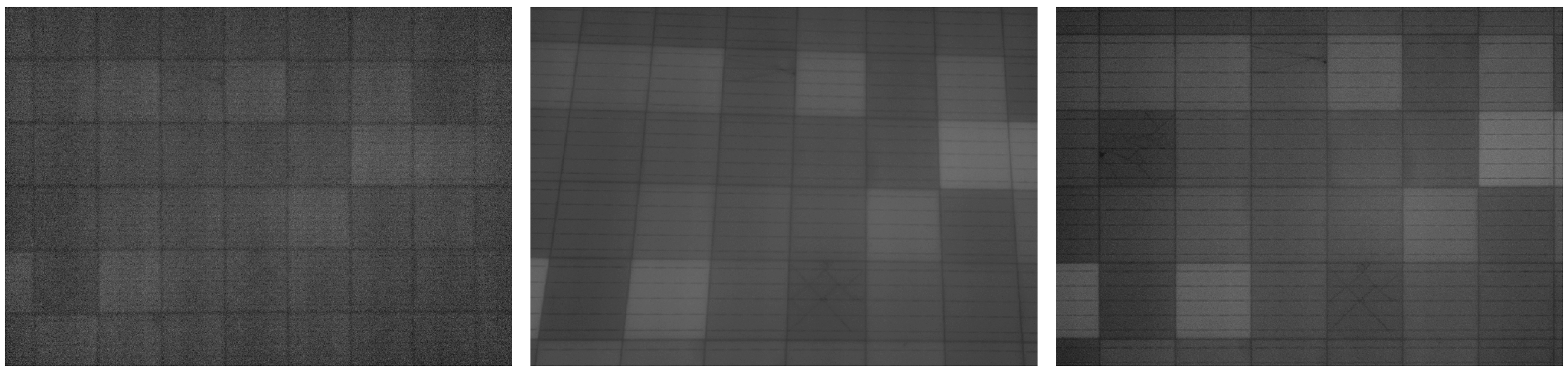
Three modified consumer cameras with varying sensor sizes and lenses were evaluated to develop the final imaging system. Initial experiments were conducted in the anechoic chamber at HSLU, which provided complete darkness—essential for eliminating ambient light that would otherwise overpower the emitted IR-light without proper filtering. All three cameras were tested at a distance of ~1.5 , with the module operated with applied forward current of different intensities. Aperture, ISO, and shutter speed were individually adjusted to assess their influence on image quality and usability.



Results

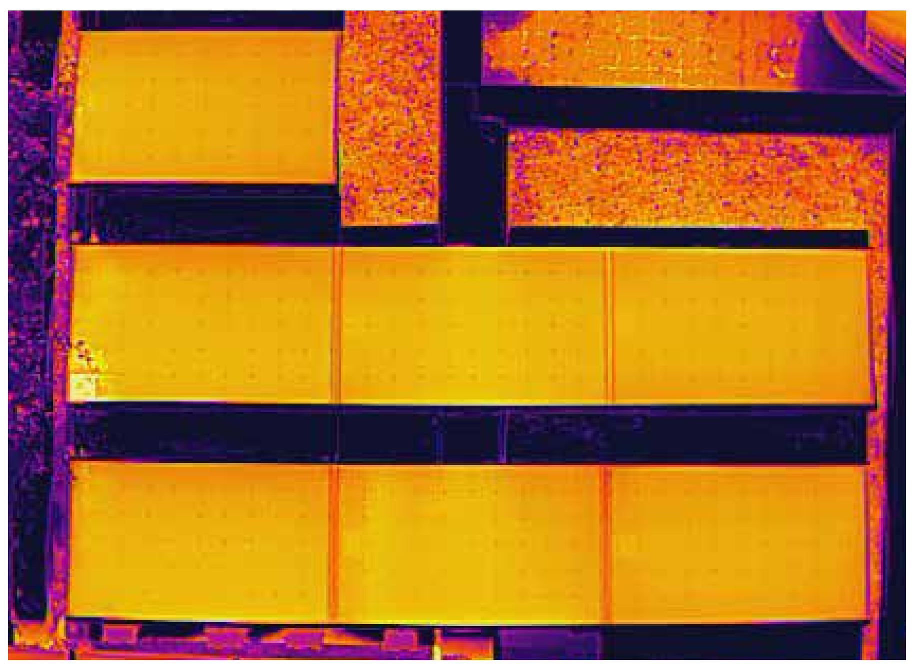
EL images were successfully captured in which damage could be identified with all three tested cameras. However, image quality and ease of use varied significantly. For example, Camera A required a 30-second exposure to achieve usable results, whereas Cameras B and C required only 2–3 seconds. Based on the findings, after testing camera A and B, Camera C was chosen to be tested due to its performance and compatibility with aerial deployment.

Camera A | Camera B | Camera C

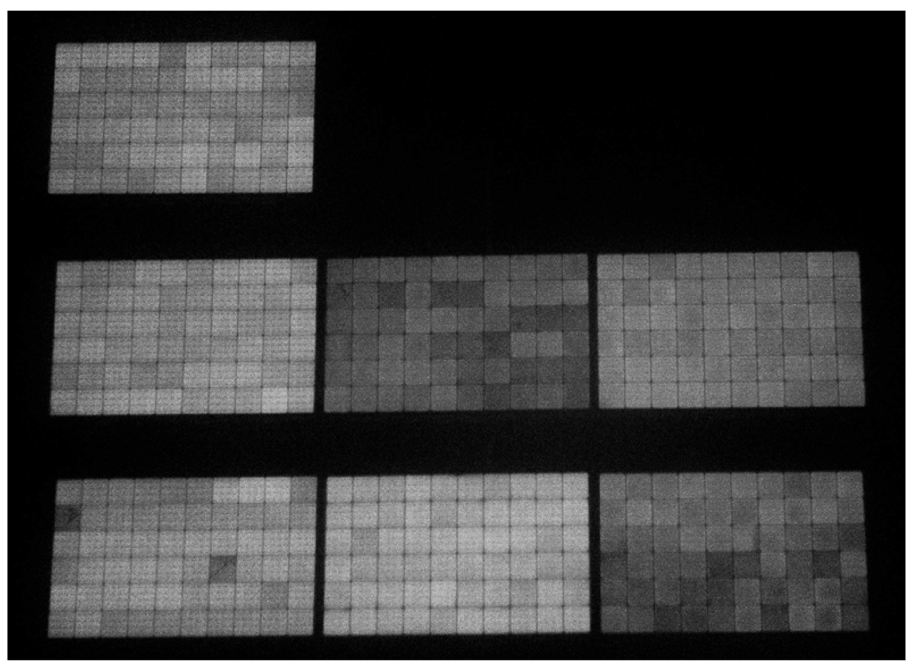


Field Tests

With the developed concept to conduct EL-imagining, field tests were necessary to determine the effectiveness of the system. These preliminary field tests showed promise in the ability to capture images with which damage could be identified, however the image is slightly blurred. This could likely be the result of multiple factors including high winds, slow shutter speed or auto focus issues. With further testing settings will be found to allow for focused field images to be taken.



Thermography image



Electroluminescence image

Conclusion

This project demonstrated that it is possible to take EL images using modified consumer-grade cameras on aerial drone systems. These images can be used to identify defective or cracked cells. Successful EL images were produced with all three consumer grade cameras, although the image quality and usefulness varied significantly. This variation in image quality may be due to differences in sensor architecture, sensor size, lenses and filters.

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