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EL Imaging Analysis in the PV Solar Industry

BACKGROUND

Electroluminescence (EL) Imaging helps to detect hidden defects in the structure of PV cells. It is a non-destructive testing (NDT) technique used to visualize the electrical activity of solar cells and modules. It can identify defects and faults in solar cells, such as cracks, broken cells, interconnections, and shunts.

EL imaging works by applying a small current to a solar cell or module and then capturing the light that is emitted. The intensity of the light is proportional to the electrical activity, so poorly contacted and inactive regions show up as dark areas. This allows for the visualization of defects that would not be visible with other methods, such as visual inspection or electrical testing.

OBJECTIVE

EL imaging analysis is becoming critical for all stakeholders to manage the underperformance risk better. It can help identify manufacturing defects, transportation, shipping damage, improper installation damage, and force majeure events.

Machine vision can automate the defect detection process and speed up the EL image analysis process. Results will show the capabilities of the tool we developed to automate EL imaging analysis using the YOLOv8 computer vision model.

METHODS

- Step 1 – Finding individual cells. We used the predefined cell dimension to crop a solar panel in individual cells.
- Step 2 – Utilizing YOLOv8 instance segmentation model. Cropped cell images from Step 1 are passed through the YOLOv8 model.
- Step 3 – Instance Segmentation Analysis. Cell images are identified with defects such as dark spots, small dots, and dark areas.
- Step 4 – Quality Assessment. The instances from step 3 are analyzed to determine the quality of the solar panel.

RESULTS

Analyzing every image manually is tedious and inefficient. Our tool can automate this critical process to provide a detailed breakdown of solar panel health. Once the EL image is uploaded, our program lists the defective cells in a list pattern, as shown in Table 1. The listed defects in the table can be represented in a pictorial format, as shown in Figure 2. The defective cells are marked with red color and indicate the actual location for the EL image analyzed.

The machine learning tool can also analyze the edge cells separately. As shown in Figure 3, defects present in edge cells can be marked with a box around them and provide a visual output indicating status of edge cells. Cells on the edge of a PV module are critical to structural longevity and impact the crack propagations significantly.

We decided to segment the module image into individual cells for a better understanding of the impact of defects. The following section explains the four-step process mentioned in the methods section in further detail.

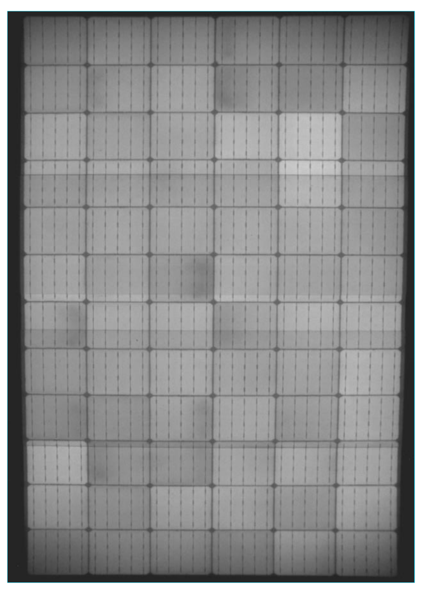


Figure 1 – Sample EL Image Input, typical Monocrystalline EL Image

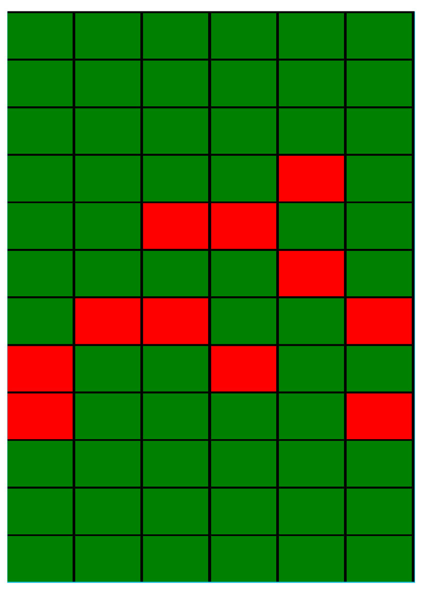


Figure 2 - Defective cells – Actual location with respect to the sample EL image

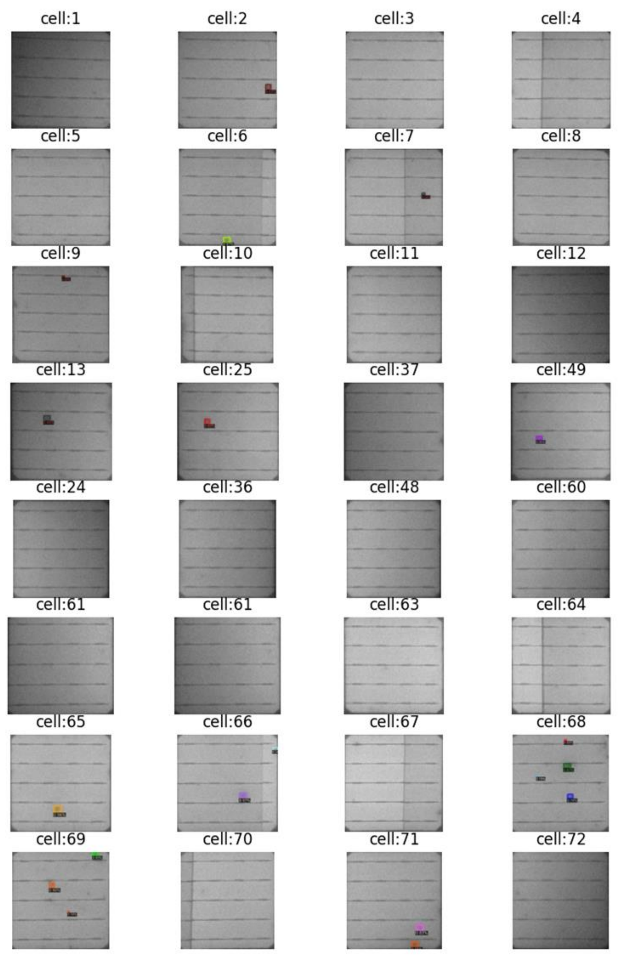
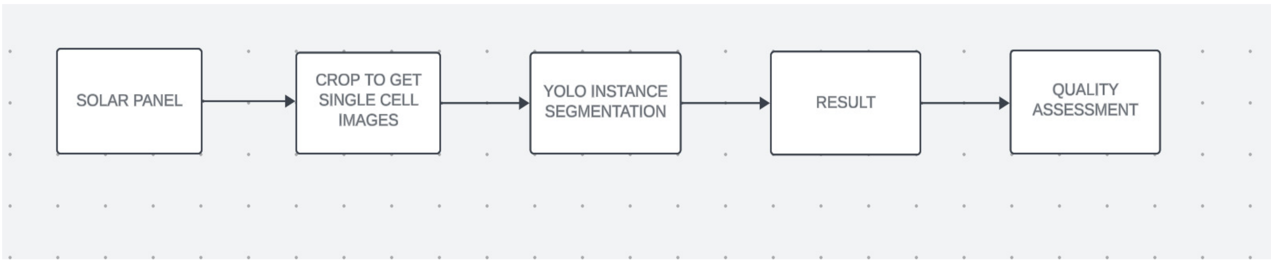


Figure 3 - Defects at the edge of a PV module

Cell 2 ['spot']
Cell 6 ['spot']
Cell 7 ['spot']
Cell 9 ['spot']
Cell 13 ['spot']
Cell 16 ['spot', 'spot']
Cell 17 ['spot']
Cell 19 ['spot']
Cell 20 ['spot', 'spot']
Cell 21 ['spot']
Cell 25 ['spot']
Cell 26 ['spot']
Cell 28 ['spot']
Cell 33 ['spot']
Cell 34 ['spot', 'spot']
Cell 41 ['spot']
Cell 42 ['crack', 'crack']
Cell 44 ['spot']
Cell 45 ['spot', 'spot', 'spot']
Cell 47 ['spot', 'spot']
Cell 49 ['spot']
Cell 50 ['spot']
Cell 52 ['spot', 'spot']
Cell 53 ['spot', 'spot']
Cell 55 ['spot', 'spot', 'spot', 'spot', 'spot']
Cell 56 ['spot']
Cell 65 ['spot']
Cell 66 ['spot', 'spot']
Cell 68 ['spot', 'spot', 'spot', 'spot']
Cell 69 ['spot', 'spot', 'spot']
Cell 71 ['spot', 'spot']

Table 1 - List of defects for the entire solar module

- The initial process focuses on isolating individual cells from a solar panel through cropping, utilizing a pre-established cell dimension. This allows for the extraction of specific cell images.
- These extracted images are used as an input into a custom-trained YOLOv8 instance segmentation model, which applies an advanced convolutional neural network (CNN) architecture.
- Within this model, the instance segmentation process involves identifying and classifying anomalies such as dark spots, cracks, small dots, and dark areas within each cell image.
- By utilizing the YOLOv8 model's sophisticated segmentation capabilities, it becomes possible to accurately delineate and classify these different instances. The output of this process provides valuable insights into the quality assessment of the solar panel, enabling the identification of specific issues or anomalies that might affect its overall performance and efficiency. [1]



CONCLUSIONS

- **Identification of Defects: EL imaging can identify any defects in the solar panel such as cracks, hotspots, or any other issues that may affect its performance. These defects are not always visible to the naked eye and can only be detected through EL imaging.**
- **Root Cause Analysis: EL imaging can be used to determine the root cause of the problem, whether it is a manufacturing defect, installation issue, or something else. This information is critical in resolving any performance issues and determining the appropriate course of action.**
- **Warranty Claims: EL imaging can provide valuable evidence to support warranty claims. For example, if the EL image reveals a manufacturing defect, the manufacturer may be liable for the repair or replacement of the panel.**
- **Machine vision can simplify and speed up large image data processing.**

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REFERENCES

1 https://yolov8.com

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Please reach out if you want to get the EL images analysed for free