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Assessing the Feasibility of Utilising Convolutional Neural Networks for the Detection of Cracks in Solar Cells

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1. Introduction

- Solar cell crack detection plays a vital role in the photovoltaic (PV) industry.
- Automated defect detection is becoming increasingly necessary due to the growing production quantities of PV modules and limited application of manual/visual inspection.
- Convolutional neural networks (CNNs) have emerged as a powerful tool for crack detection, offering several advantages over traditional methods [1].

4. Developed CNN Architecture

- To begin developing a CNN architecture for crack detection, we began by creating a training network from scratch.
- Three convolutional layers containing 32 filters with an initial input size of 227x227x3 pixels is connected through a double max pooling to a normalization layer and a ReLU layer, as shown in Figure 3.

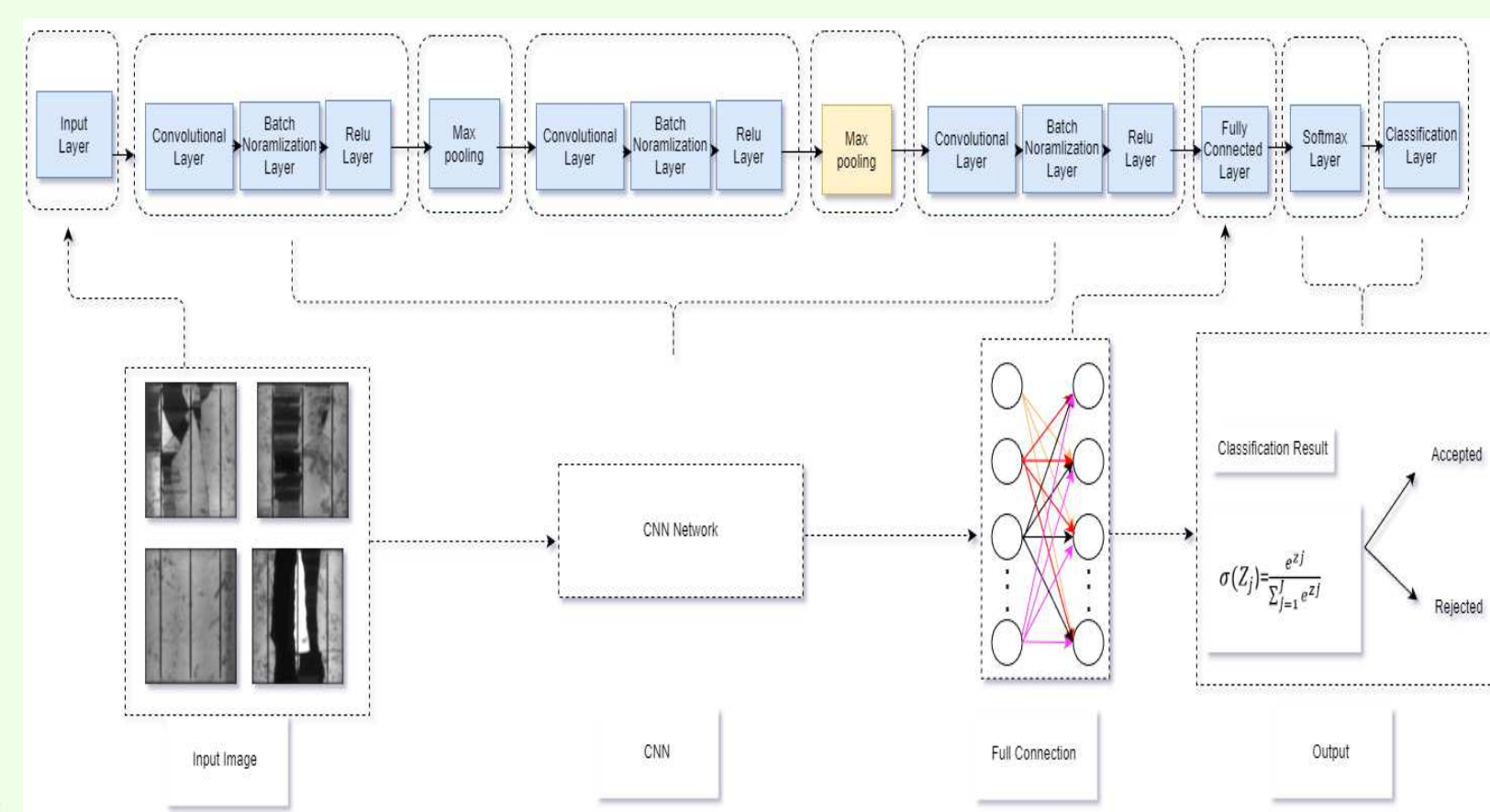
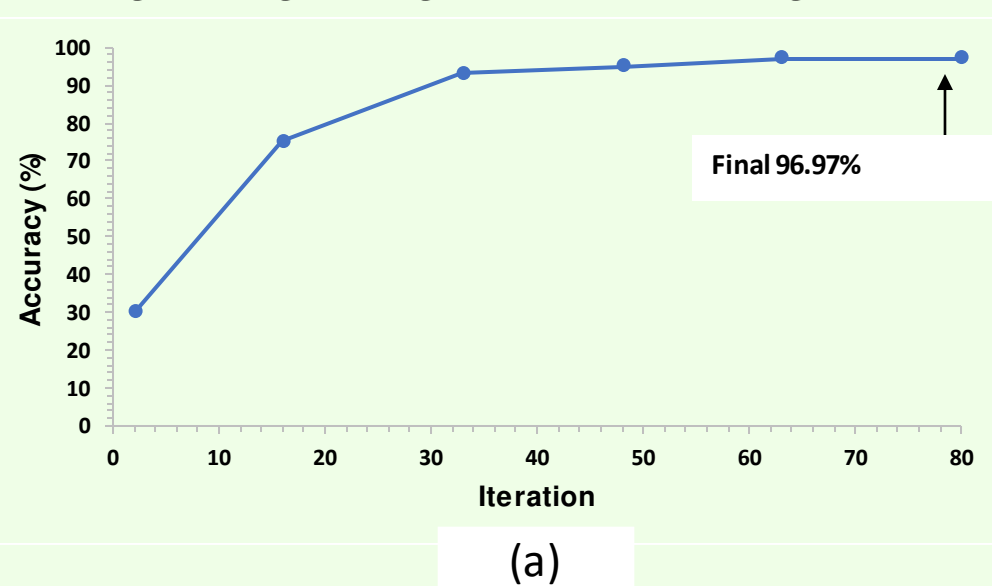


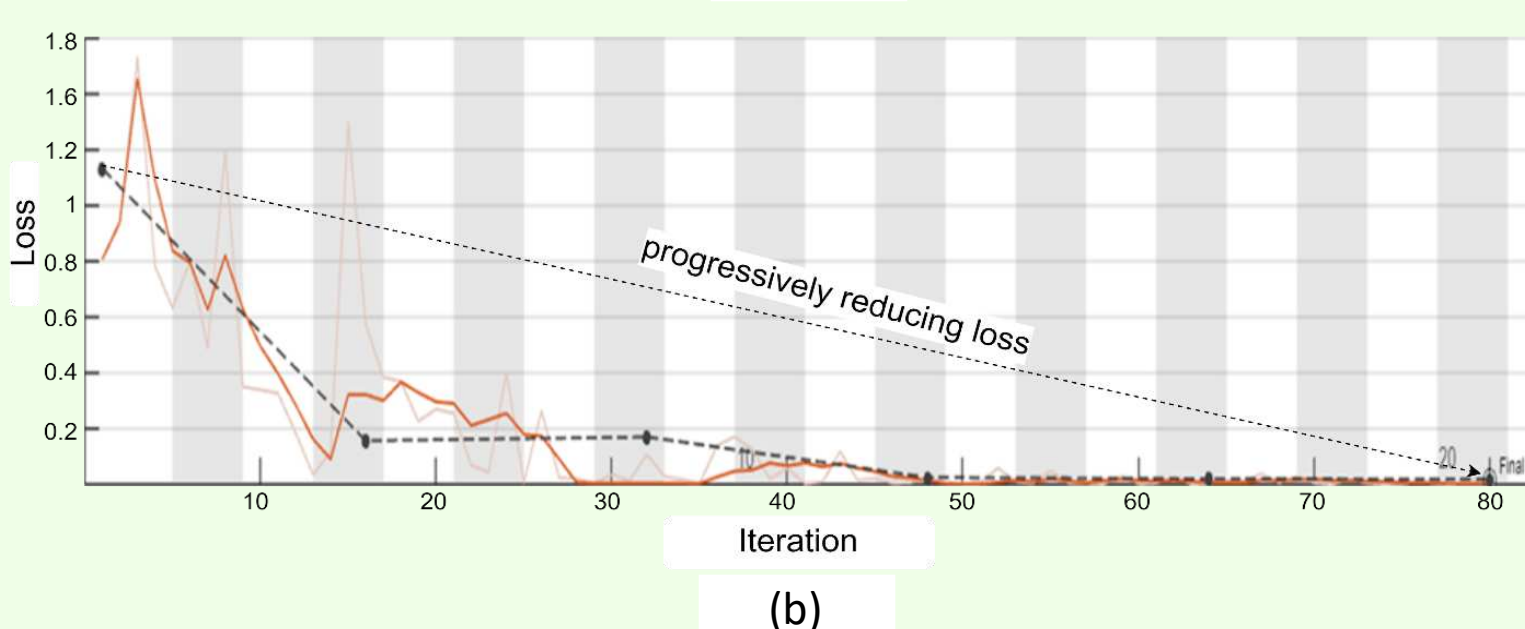
Figure 3. Developed CNN architecture.

5. CNN Network Accuracy

- According to the accuracy graph in Figure 4(a), the developed CNN architecture achieved an accuracy of 96.7%.
- Based on the developed CNN Architecture, as shown in Figure 4(b), it appears that initially, the loss of the model was a fraction higher, but progressively reduced towards zero, showing a high degree of learning.



(a)



(b)

Figure 4. (a) Developed CNN architecture learning Loss vs learning iterations (epochs), (b) Validation accuracy of Developed CNN architectures".

2. Framework

- As shown in Figure 1, the deployment of a CNN network for solar cell inspection begins by capturing an EL image of the solar cell.
- The CNN network is trained to recognize patterns and features in the image that indicate the presence of cracks or fractures.

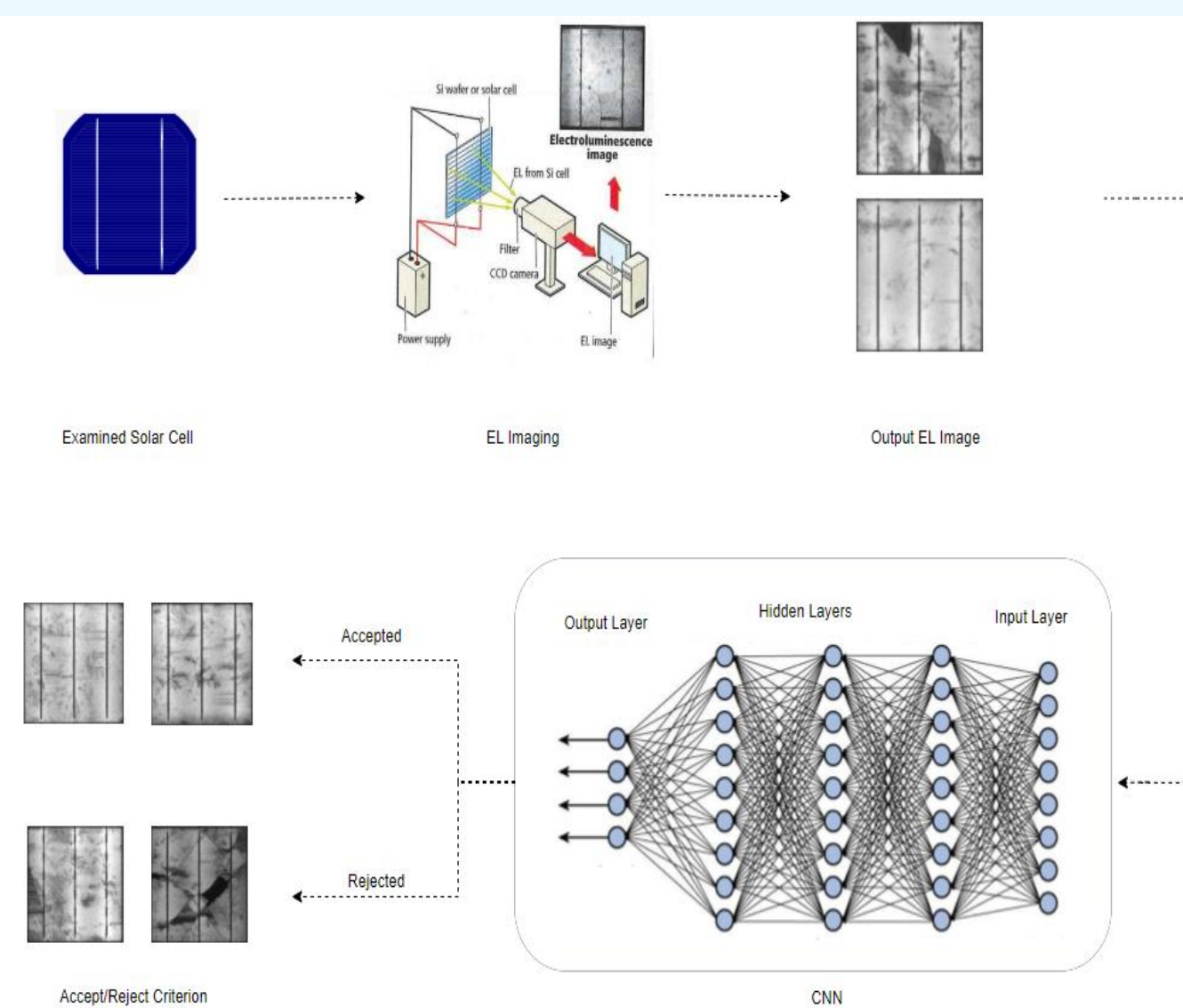


Figure 1. Incorporating the CNN network into decision making for the identification of solar cell cracks in an industrial setting application.

3. EL Imaging

- EL imaging is a technique used to visualize the electrical activity within a solar cell [2], as shown in Figure 2(a).
- In this work, the EL image resolution employed ranges from 1000x1000 pixels to 2500x2500 pixels.
- In Figure 2(b), five healthy (non-defective) solar cells are displayed, while defective solar cells are shown in Figure 2(c).

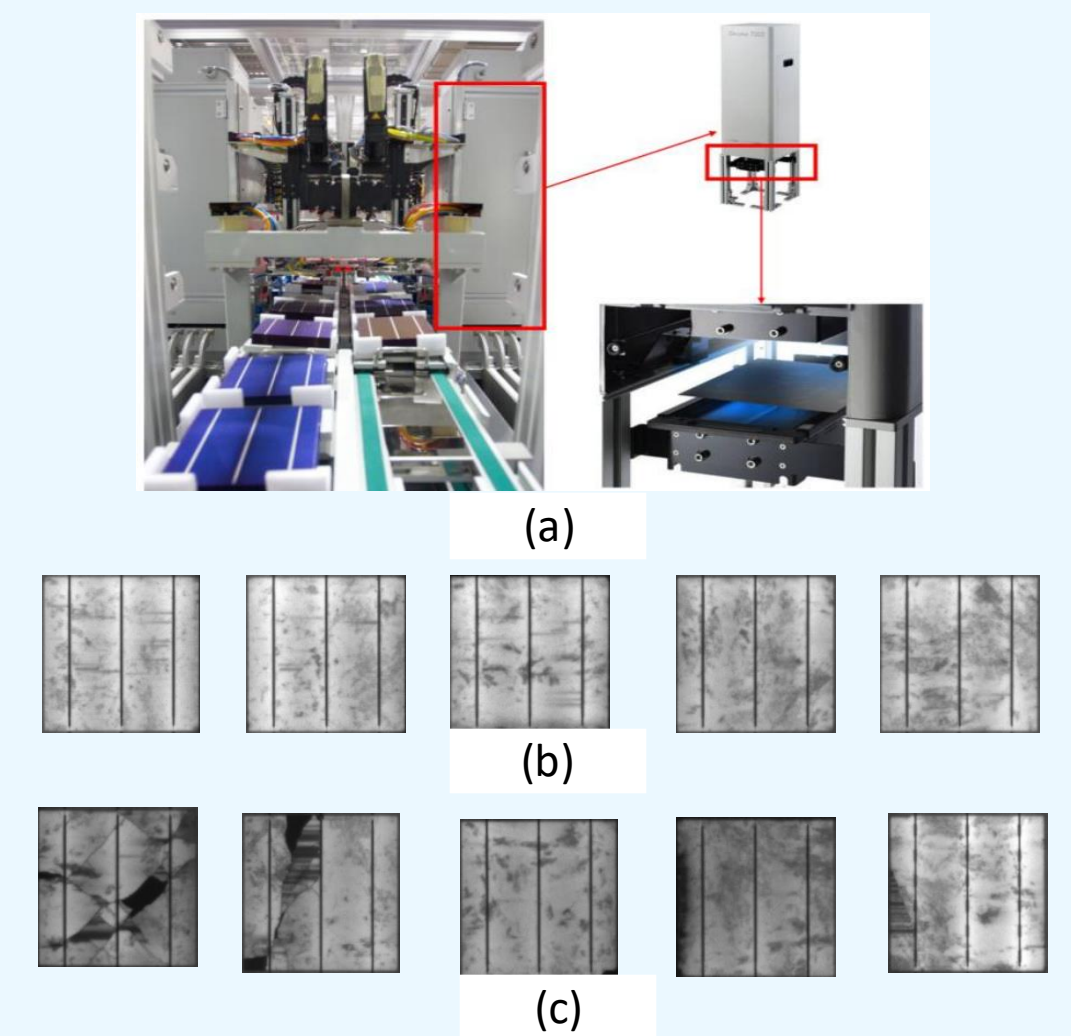


Figure 2. (a) Solar cell production line with in-house EL detection equipment, (b) Example of solar cells without any cracks "healthy samples", (c) Example of solar cells with cracks "cracked samples".

6. Results

- In Figure 5(a), health solar cells are examined, while in Figure 5(b), cracked solar cells are examined. Figure 5(c) is an examination of a solar cell with a PID, as well as Figure 5(d) is an examination of a solar cell with shading.

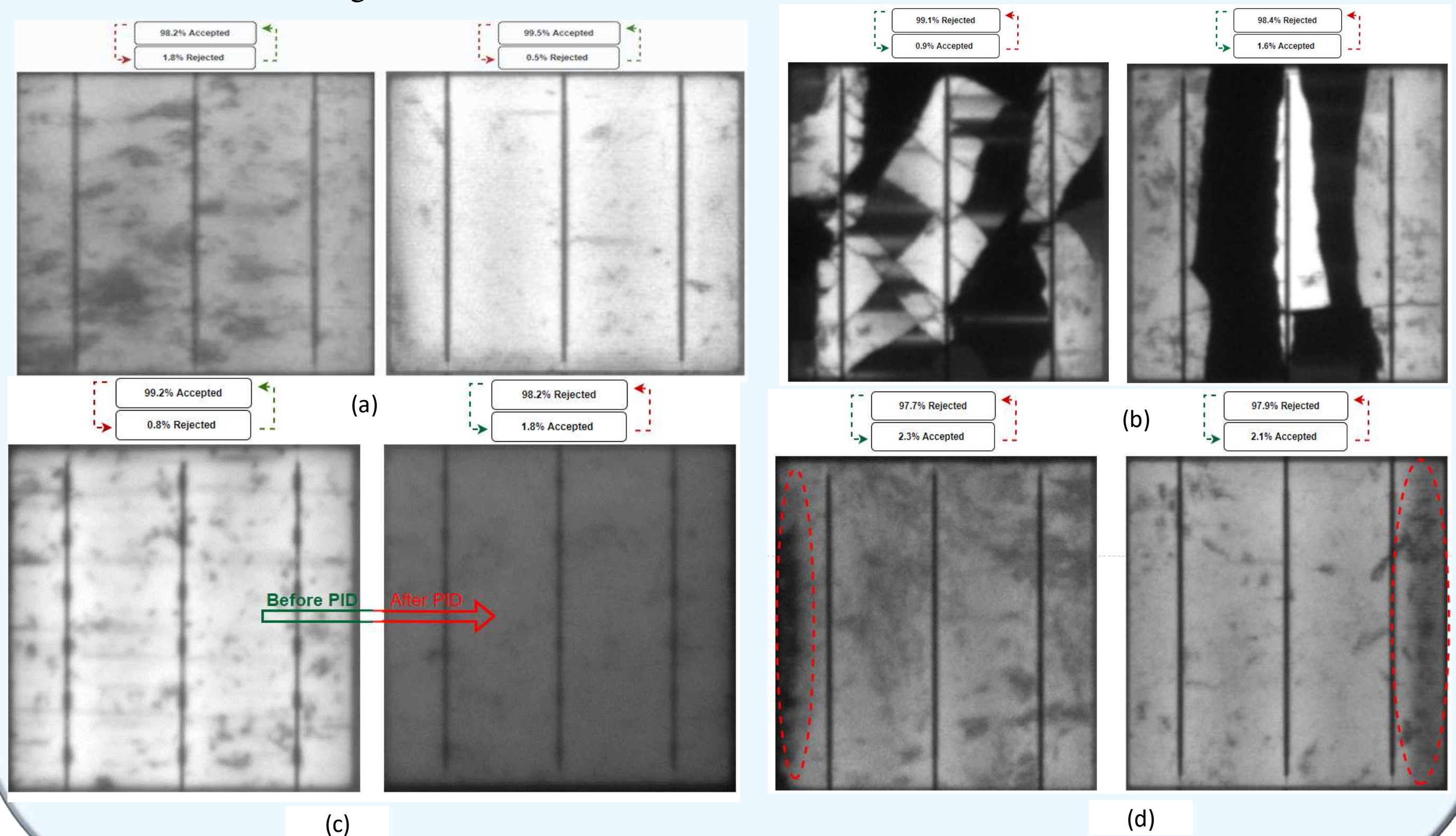


Figure 5. (a) Healthy solar cells, (b) Cracked solar cells, (c) Solar cells with PID, (D) Solar cells with shaded area.

7. Acknowledgment

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8. References

- Su, B., Chen, H. and Zhou, Z., 2021. BAF-detector: An efficient CNN-based detector for photovoltaic cell defect detection. *IEEE Transactions on Industrial Electronics*, 69(3), pp.3161-3171.
- Hassan, S. and Dhimish, M., 2022. Review of Current State-of-the-Art Research on Photovoltaic Soiling, Anti-Reflective Coating, and Solar Roads Deployment Supported by a Pilot Experiment on a PV Road. *Energies*, 15(24), p.9620.