

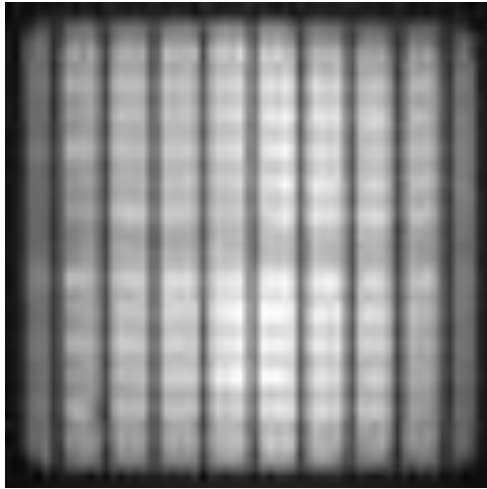
High-resolution luminescence imaging using deep learning

Priya Dwivedi, Robert Lee Chin, Thorsten Trupke, and Ziv Hameiri

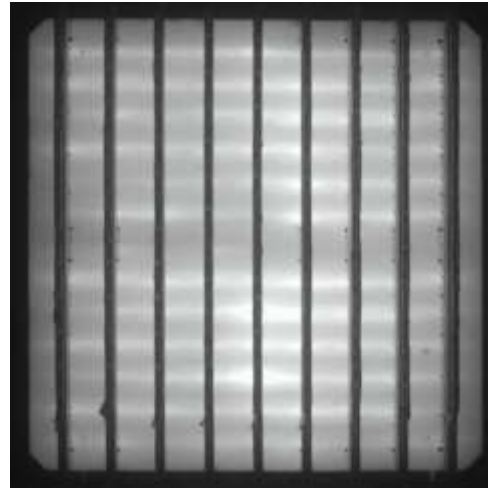
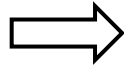
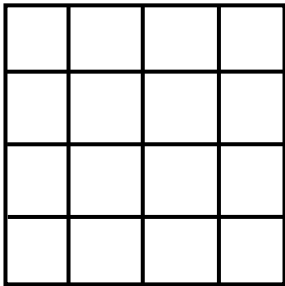
Asia-Pacific Solar Research Conference, Sydney
16 December 2021



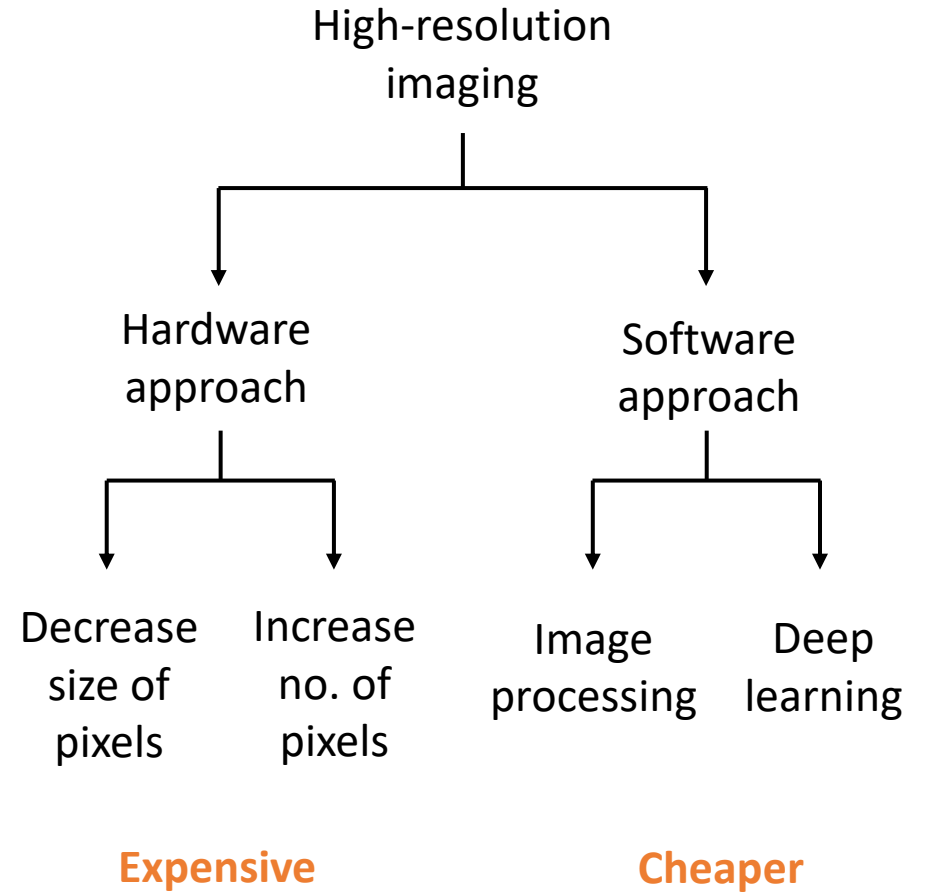
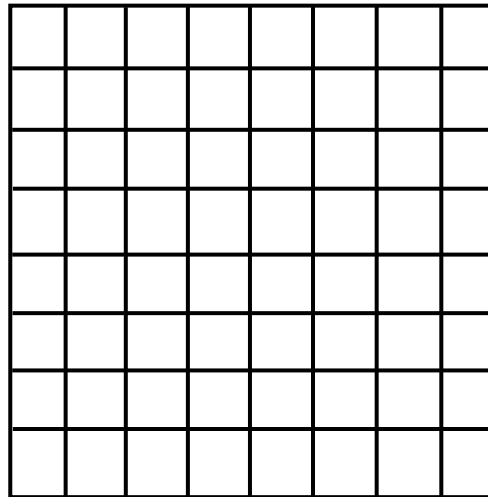
Motivation



130×130 px
Low-resolution

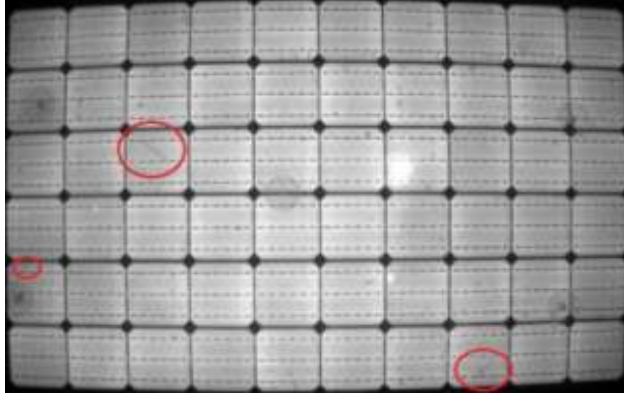


520×520 px
High-resolution

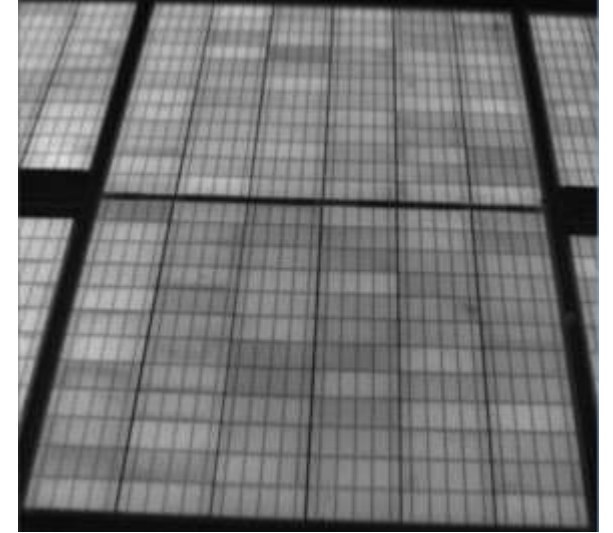


Applications

Reliable
detection of
defects in
cells/modules



Increase
throughput of
outdoor
characterization
tool



Reduce flight time of
drone for PV field
inspection

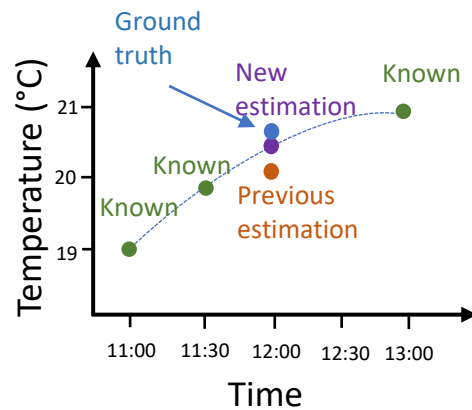
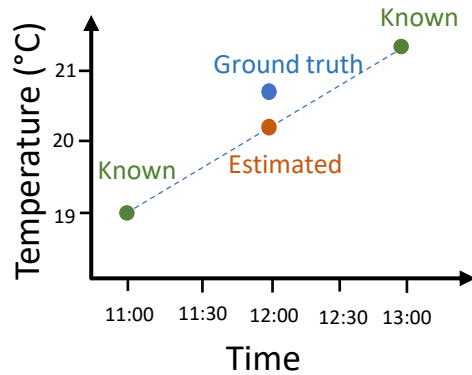


Compress
images

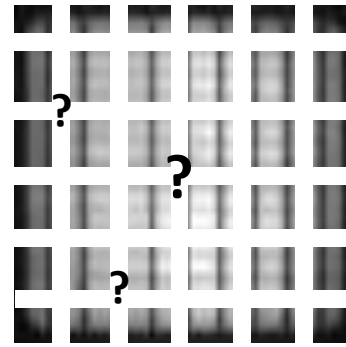


Methods

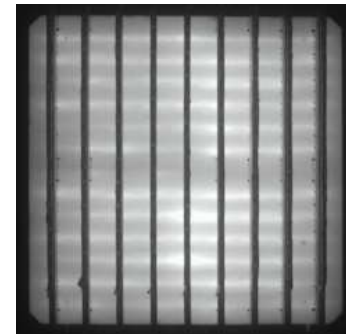
What is interpolation



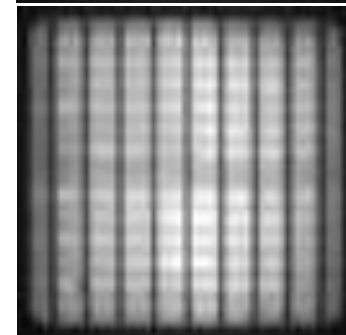
Interpolation in images



Before processing



After processing



No processing

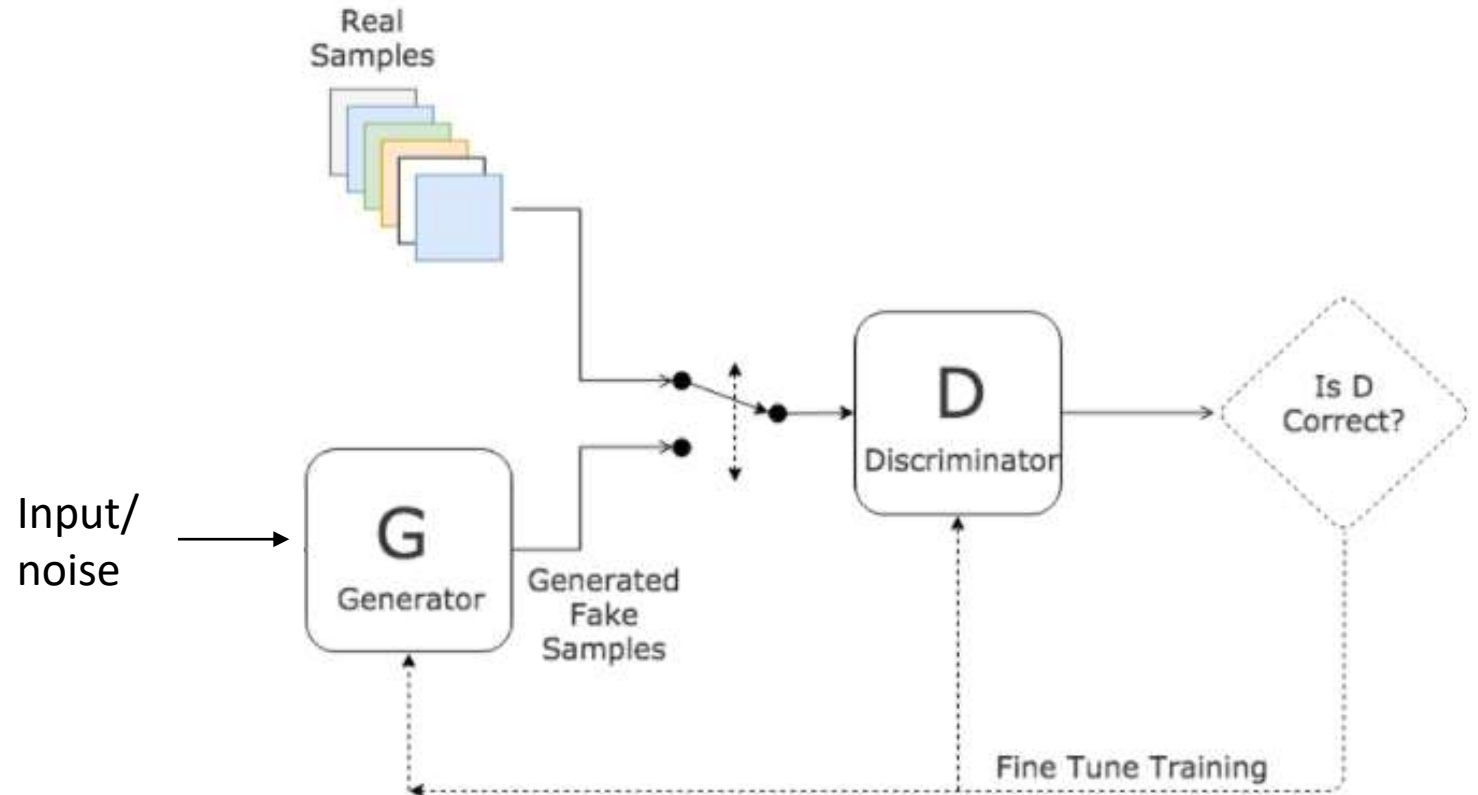
Used techniques

- Bicubic interpolation
- Deep learning-based technique: ESRGAN

Deep learning-based technique

A GAN based network, **ESRGAN**,^[1] is used.

Generative Adversarial Networks (GAN)



[1]. Xintao Wang et. al, "ESRGAN: Enhanced Super-Resolution Generative Adversarial Networks", Proceedings of the European Conference on Computer Vision (ECCV) Workshops, 2018
[Fig.]. <https://www.kdnuggets.com/2017/01/generative-adversarial-networks-hot-topic-machine-learning.html>

Image metrics

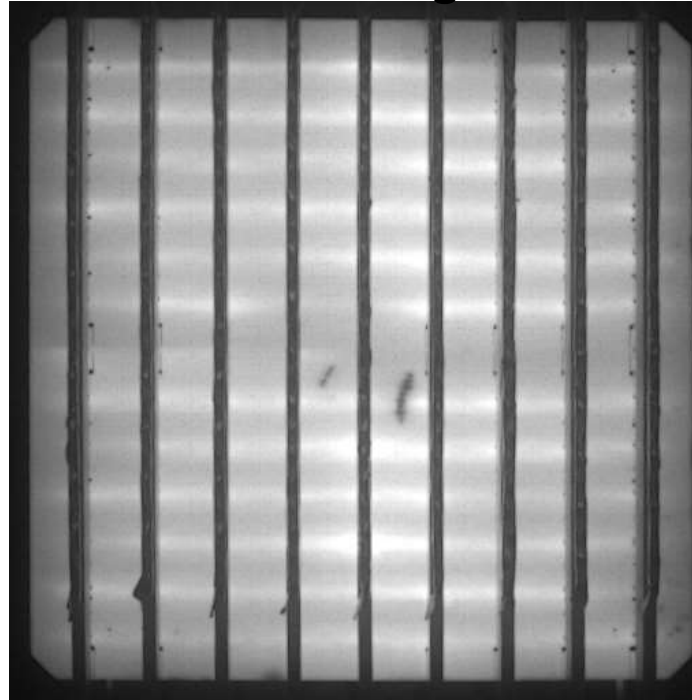
Peak signal-to-noise ratio

$$\text{PSNR} = 10 \log_{10} \left(\frac{L^2}{\frac{1}{N} \sum_{i=1}^N [I(i) - \hat{I}(i)]^2} \right)$$

Structure similarity

$$\text{SSIM}(I, \hat{I}) = \underbrace{[l(I, \hat{I})]^\alpha}_{\text{luminance}} \underbrace{[c(I, \hat{I})]^\beta}_{\text{contrast}} \underbrace{[s(I, \hat{I})]^\gamma}_{\text{structure}}$$

Identical to ground truth image



PSNR = ∞ dB
SSIM = 1

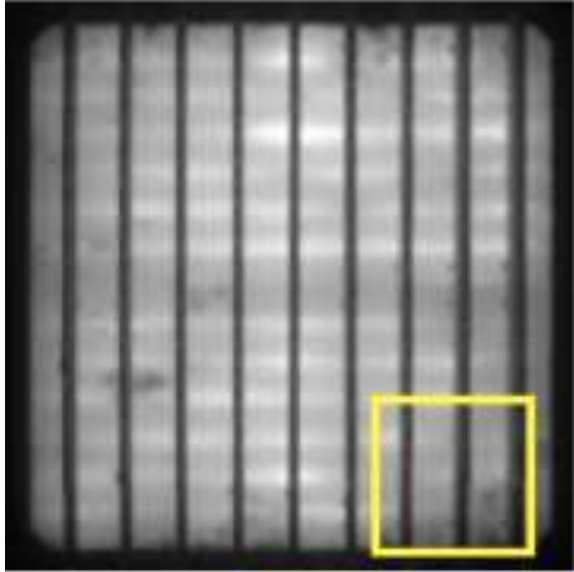
Different from ground truth image



PSNR = 9.8 dB
SSIM = 0.17

Results

Low-resolution

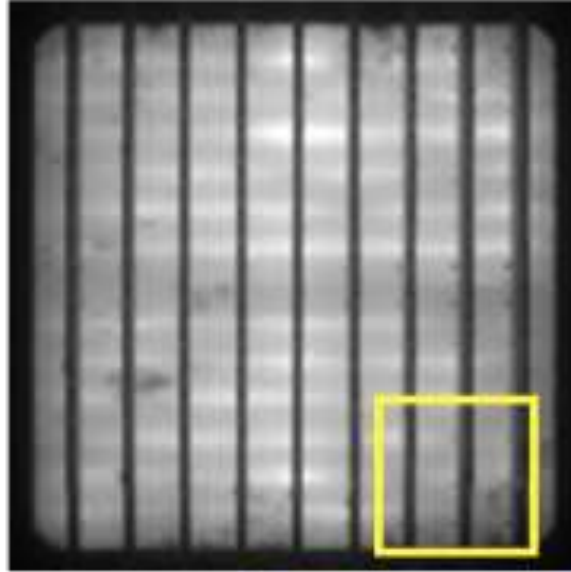


PSNR
/SSIM



130×130 px

Bicubic

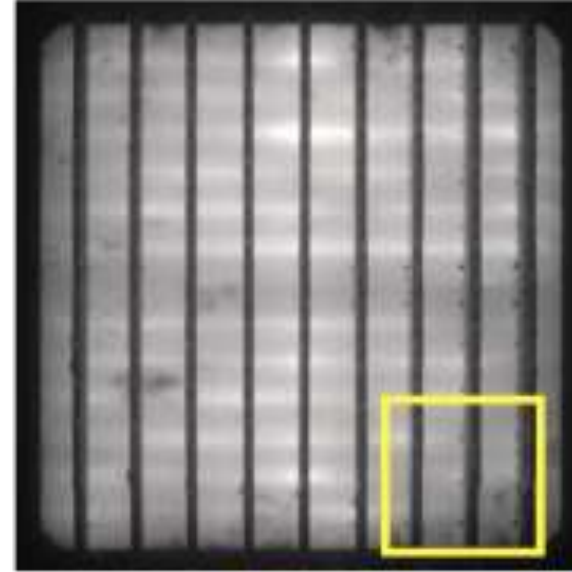


32.35 dB
/0.9039

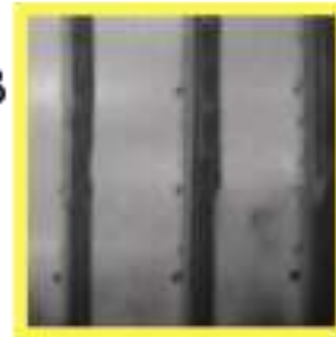


520×520 px

ESRGAN

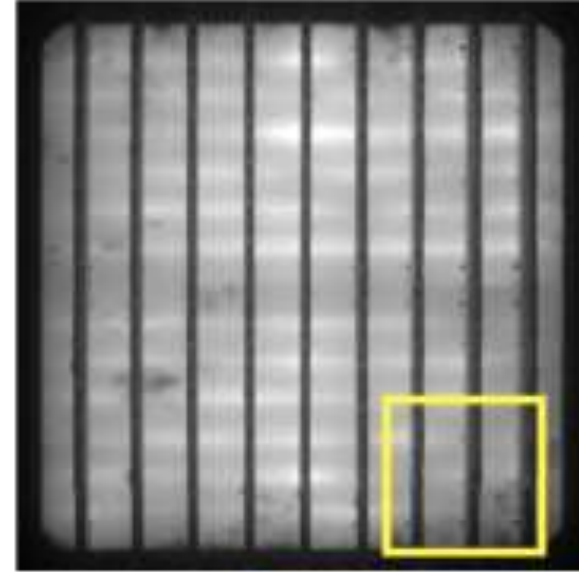


34.31 dB
/0.9138

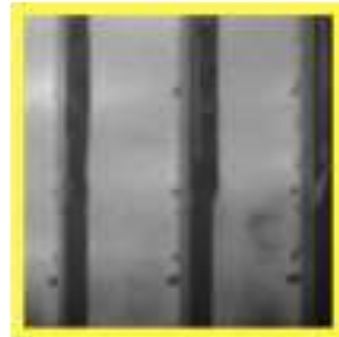


520×520 px

Ground truth

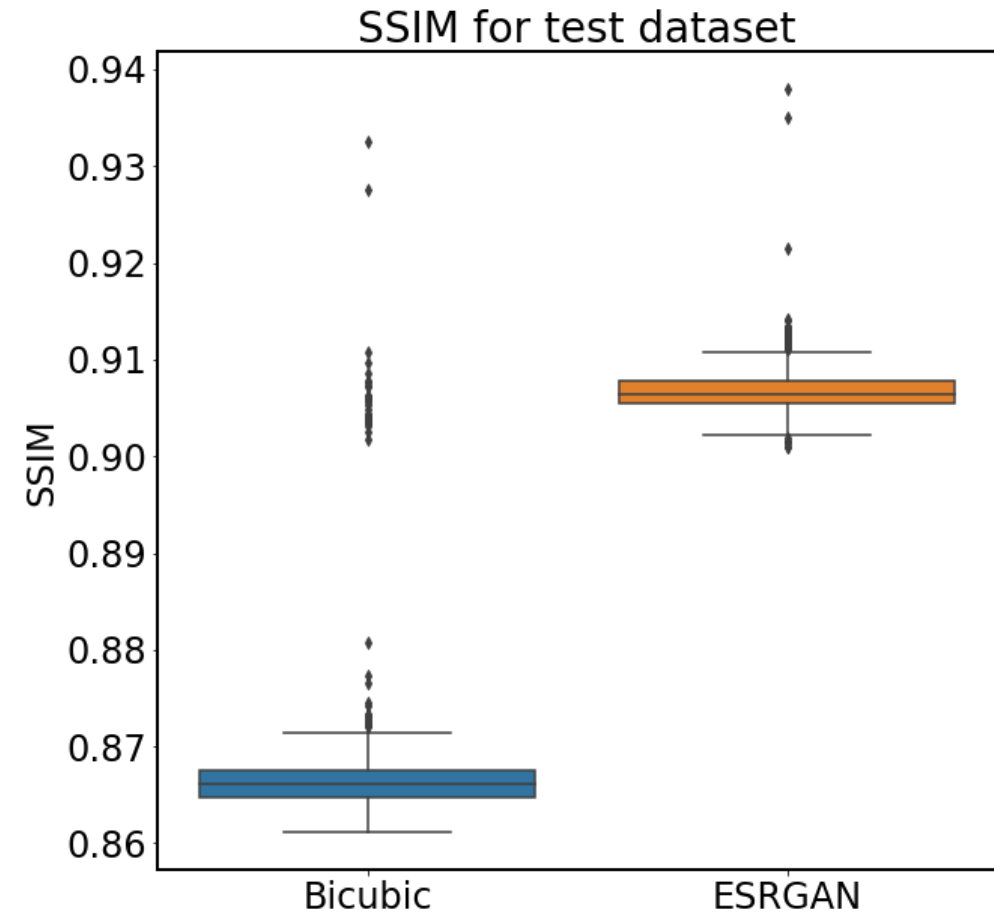
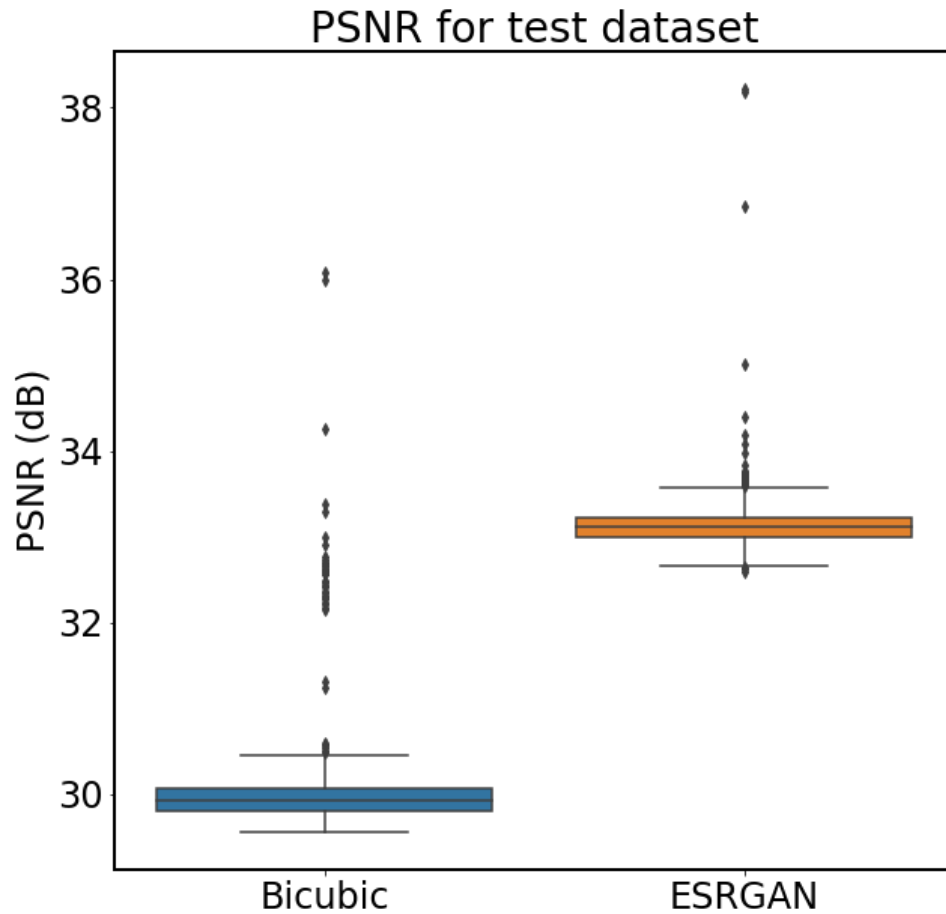


inf.
/1.0



520×520 px

Results



Test dataset has 430 images.

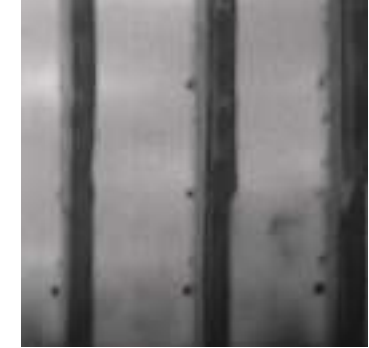
Conclusions

- ESRGAN outperforms bicubic interpolation.
- Enhanced images using ESRGAN are visually indistinguishable with real images.
- This can be used to enhance the existing luminescence imaging systems.
- It can also be used for other image modalities.

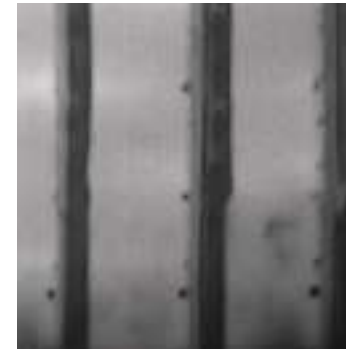
Bicubic



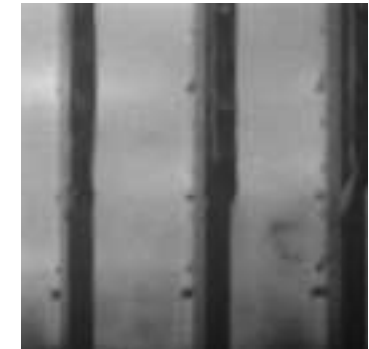
ESRGAN



ESRGAN



Ground truth



Questions?

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ARENA



Australian Government
Australian Renewable
Energy Agency



ACAP



UNSW
SYDNEY