Super-resolution imaging using deep learning

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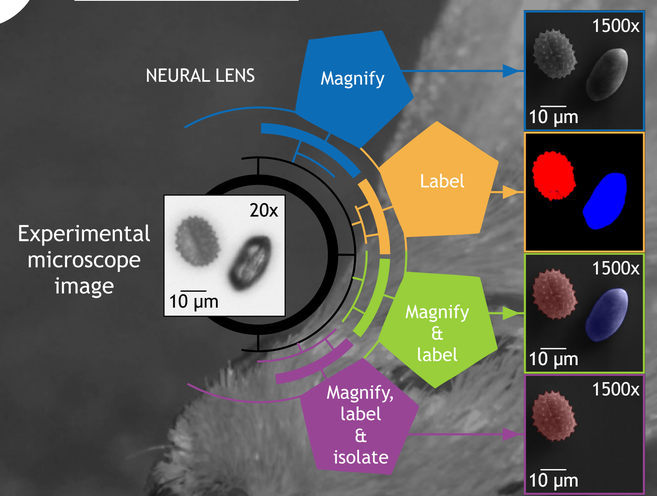
1 Motivation

- Optical microscopes are convenient, relatively low-cost, and are an invaluable invention tool for biological imaging, but they have a resolution limited by the diffractive properties of light.
- Scanning near-field optical microscopy, photo-activated localization microscopy and stimulated emission depletion can achieve resolutions ten times smaller than from optical microscopes, and scanning electron microscopy (SEM), which can achieve a resolution of ~ 10 nm.

These can be expensive, require long scan times or vacuum.

2 Concept



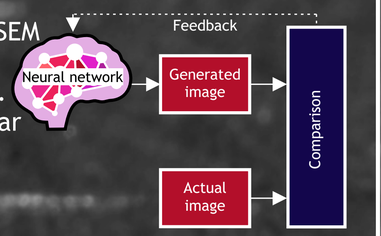
Concept of the neural lens. An experimental 20x microscope image was processed by the neural lens, which automatically produced an array of different output images, including the ability to magnify, label and isolate images of pollen grains.[1]

3 Experimental setup

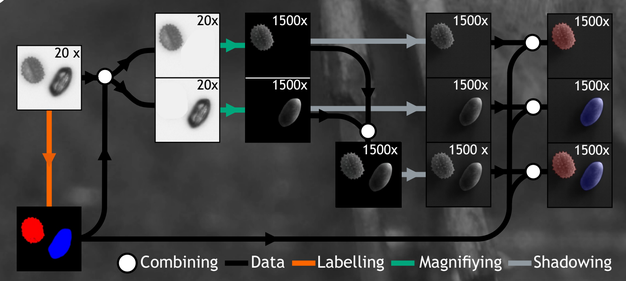
- Pollen grains from Iva xanthiifolia and Galanthus were deposited on a slide.
- Pollen was imaged using a Nikon microscope with an image magnification of 20x and CMOS camera.
- The SEM images of the pollen were recorded using a Zeiss Evo SEM to produce 2048 pixels x 1536 pixels sized images.

4 Training neural network

- Microscope images and associated SEM images were paired via scaling and cropping of the microscope images.
- When generated images were similar to the actual image, the neural network was applied to new pollen grains.

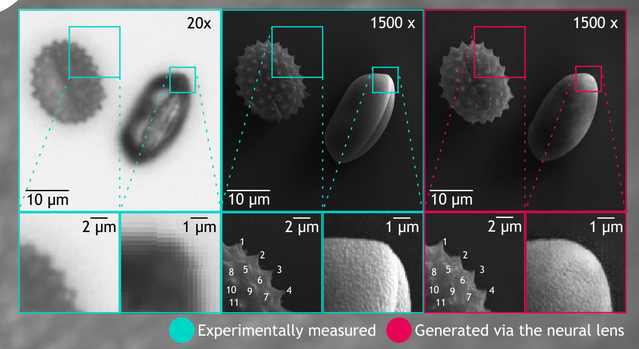


5 Neural network

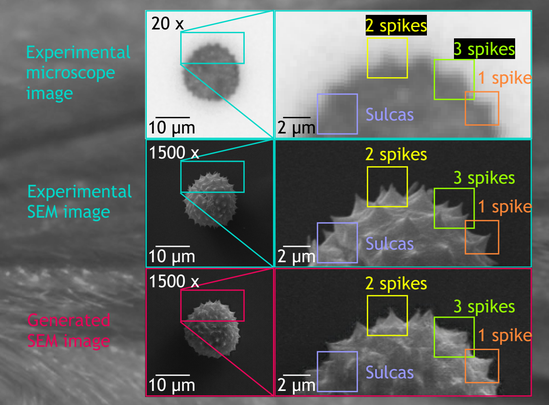


- The 20x microscope image was the only required input, and all other images were generated automatically.
- A labelling NN transformed a 20x microscope image into a colour-labelled sample map.

6 Super-resolution



- The neural lens determined the position and orientation of the two pollen grains, and produced a realistic lighting and shadowing effect.
- The generated surface texture on the Galanthus closely matched the experimental image. The spikes are labelled in the experimental and generated 1500x images of Iva xanthiifolia.



The generated SEM image shows features that were not resolvable in the experimental microscope image.

7 Future work

Real-time imaging

- This work will be employed in table-top microscopes for real-time biological imaging.

Mobile phone

- Super-resolution will be developed for mobile phones for microscopic and telescopic imaging.

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References

1. James A Grant-Jacob et al 2019 J. Phys. Commun. 3 065004

Acknowledgements

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