Expansion Microscopy Imaging Isotropic Restoration by Unsupervised Deep Learning

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Abstract

The development of fluorescence light sheets and expansion microscopy (ExM) in recent years enables the visualization of detailed neural structures to help unlock the secrets of neural functioning. Deep learning techniques have then become essential tools to process the ever-increasing amount of high-quality and high-resolution images. In this study, we developed a single-scale deconvolution model for extracting multiscale deconvoluted components (MDC) from the volumes of microscopy images of neurons and IsoGAN to translate images between the lateral and axial views. The results demonstrated that deep learning as a promising tool in approving image volume quality and comprehension of structural information of light sheet microscopy.

Methods

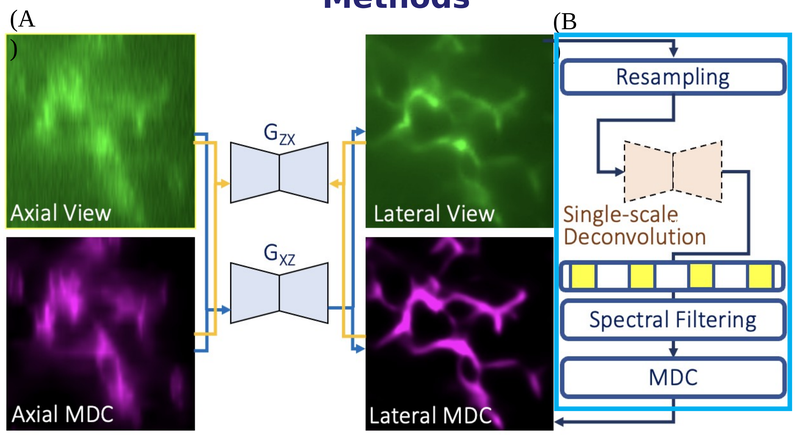


Fig. 1 The proposed model.
(A) IsoGAN is an unsupervised GAN-based domain-adaptation model with cyclic consistency. It consisted of two generators and discriminators to translate and ensure visual similarity between axial view and lateral view of images and MDCs.

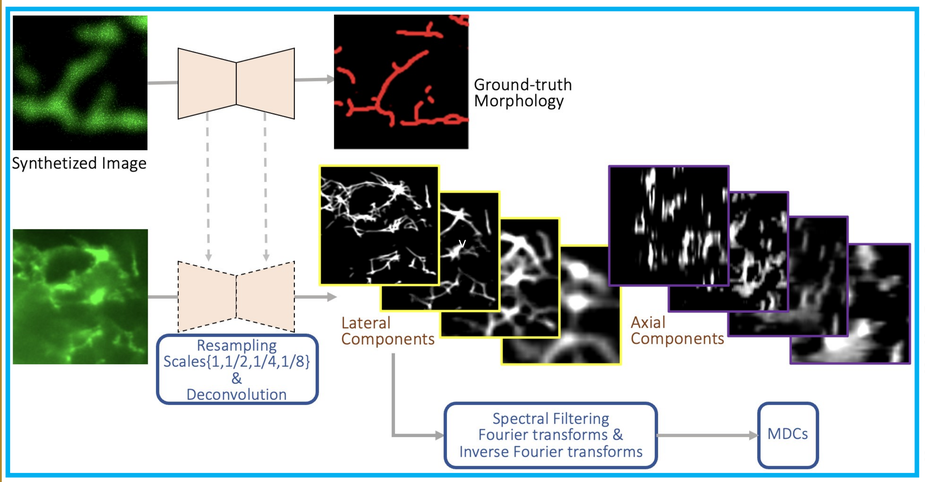
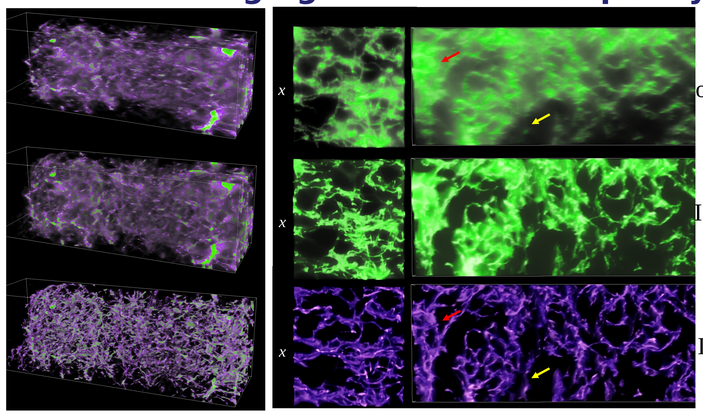


Fig. 2 The multi-scale deconvolution model (as shown in Fig. 1 (B)) maps microscopy images to their corresponding neural structure. The original image was resampled into different physical scales, and the muti-scale responses of the model were weighted to form MDCs at spectral space.

Imaging resolution and quality



original image

IsoGAN w/o MDC

IsoGAN

Fig 3. yellow arrow: IsoGAN is capable of enhancing the connectivity of those faint neuronal sections.

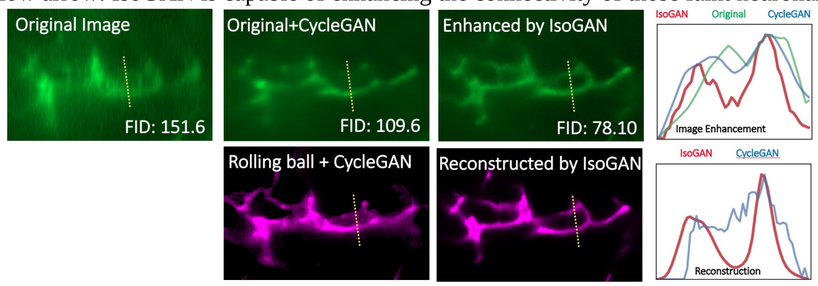
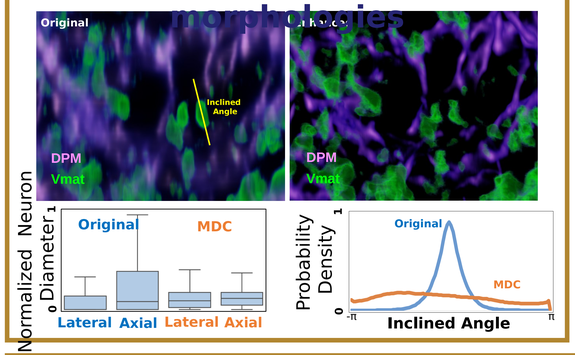
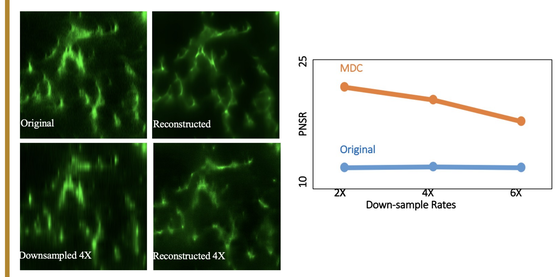


Fig 4. neurons in close proximity to be distinguishable from the background signal.

Quantitative measurements of the reconstructed morphologies



Reduced axial digital resolution



Conclusion

Our proposed model showed broad potential to faithfully enhance isotropic resolution in Expansion Microscopy imaging. This breakthrough has significant implications for understanding neuronal structures.