Wavelet-Based Filter for Fluorescent Noise and Background Removal in Extended Depth of Field Imaging

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Miniaturized fluorescence microscopes, or miniscopes, have a limited focal range, so only neurons within a narrow depth-of-field can be imaged. Because of this, one typically must probe over extended depths to study large neuronal populations. Extended depth-of-field (EDoF) systems are being built to improve the depth at which we can see neurons using miniscopes. However, current systems cannot effectively reject out-of-focus fluorescent noise and background, leading to suboptimal performance from the EDoF system. We implement a wavelet-based filter in the preprocessing steps of an EDoF system's reconstruction network to remove the out-of-focus high-frequency noise and low-frequency background from images and analyze its impacts by testing it on neuron samples from mice brains. Mean squared error (MSE), gradient-based loss (GradLoss), and mean average error in the Fourier domain (fMAE) are used to compute the loss of the network. With the wavelet filter, we achieve an overall loss ($MSE + GradLoss + fMAE$) of 0.9585 in our training set and 0.9809 in our validation set. In the future, we plan to test more combinations of wavelets and further tune our hyperparameters to decrease loss within the Fourier domain. Our study suggests that wavelet-based filters can be a powerful preprocessing tool in various EDoF deep learning pipelines with fluorescence microscopy data to remove unnecessary noise and background from the image, allowing models to focus training on the most important aspects of the data.