IMAGE RESTORATION OF PHASE MODULATED EDF-MICROSCOPY IMAGES BY AN ARTIFICIAL NEURAL NETWORK APPROACH

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Phase modulation is an interesting tool in optical microscopy to obtain out-of-focus information, so as in extended depth-of-field (EDF) microscopy [1,2]. This technique generates projection images of 3D object information. Since the encoding is well defined in EDF microscopy image reconstruction can be simply done by deconvolution. This is a linear restoration procedure and hence accompanied by simultaneous enhancement in noise contribution that just can be reduced by additional filtering. As a result, image reconstruction by deconvolution means a tradeoff between adequate SNR and preservation of diffraction limited lateral resolution compared to single focal plane images [3].

In this paper the performance of image restoration on the basis of artificial neural networks (ANN) has been investigated. As long as information density is low as in fluorescence microscopy of isolated molecules, it is easy to restore images with an extended depth of field by pattern recognition. Restoration becomes a challenging problem as soon as the information density in an image is high causing multiple overlapping of the outspread phase modulated microscope PSF of each object data point (e.g. in bright field or phase contrast EDF images).

Two approaches for image restoration are discussed in this work: First a supervised learning ANN taking into account the entire microscope PSF as a feature assuming a stack data set as training set, and second a semi-supervised learning approach using a particle swarm optimization method for parameter optimization and training of an ANN due to Meissner [4] are applied to the problem.

The performance of these methods are evaluated for the reconstruction of fluorescence and phase contrast microscope EDF images and compared to results from image reconstruction by deconvolution including Wiener filtering [3].