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Machine Learning based Automatic Microscopic Image Analysis

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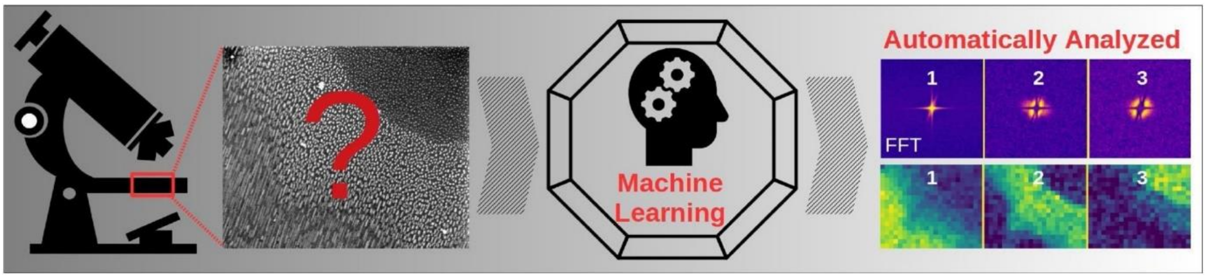

Diverse imaging techniques are commonly applied in contemporary investigations of diffusion phenomena. Due to digital data acquisition and storage, a big amount of image data is collected during microscopic sessions from a single sample. These images are later analyzed by the microscopist to extract the valuable information usually about a local structure of the measured samples. The analysis requires practice and patience and it is usually tedious, time consuming work for microscopist. The results of such analysis might be biased by the human who performed the analysis by introducing hardly controllable systematic effects in the final results.

During the workshop an approach of automatic image analysis will be introduced [1]. The approach is based on locally applied Fourier Transform and Machine Learning methods. In this approach, a whole image is scanned by a local moving window with defined size and the 2D Fourier Transform is calculated for each window. Then, all the Local Fourier Transforms are fed into Machine Learning processing. Firstly, a number of components in the data is estimated from Principal Component Analysis (PCA) Scree Plot performed on the data. Secondly, the data are decomposed blindly by Non-Negative Matrix Factorization (NMF) into interpretable spatial maps (loadings) and corresponding Fourier Transforms (factors). As a result, the microscopic image is automatically analyzed and the features on the image are automatically discovered, based on the local changes in Fourier Transform, without human bias. The user selects only a size and movement of the scanning local window which defines the final analysis resolution. The analysis of a single image with a typical size of ~2000×2000 pixels with default parameters takes about a minute on a standard desktop or notebook computer. The successful application of this automatic approach [1] will be shown during the workshop on different examples of microscopic images i.e. atomically resolved High Angle Annular Dark Field (HAADF) Scanning Transmission Electron Microscopy (STEM) image of Au nanoisland of fcc and Au hcp phases, Scanning Tunneling Microscopy (STM) image of Au-induced reconstruction on Ge(001) surface, Scanning Electron Microscopy (SEM) image of metallic nanoclusters grown on GaSb surface, and Fluorescence microscopy image of HeLa cell line of cervical cancer. The automatic approach could be also successfully applied to other than microscopic images like photography or a painting, to analyze local features on them [1].

The analysis approach [1] is freely available as a Python analysis notebook and Python program for batch processing from Mendeley Data [2] (https://doi.org/10.17632/25x46xjyr5.2).

[1] B.R. Jany, A. Janas, F. Krok, Automatic microscopic image analysis by moving window local Fourier Transform and Machine Learning, Micron 130, 102800 (2020) doi:10.1016/j.micron.2019.102800

[2] B.R. Jany, Python Jupyter Notebook to Perform Automatic Microscopic Image Analysis by Moving Window Local Fourier Transform and Machine Learning, Mendeley Data, v2 (2020) doi:10.17632/25x46xjyr5.2

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