NOISE ANALYSIS IN 3D ELECTRON MICROSCOPY

Joris Roels*,†, Jan Aelterman†, Jonas De Vylder†, Hiep Luong†, Saskia Lippens‡, Wilfried Philips† and Yvan Saeys‡,1

†Ghent University, TELIN-IPI-iMinds,
Sint-Pietersnieuwstraat 41, 9000 Ghent, Belgium
‡Inflammation Research Center, VIB,
1Department of Respiratory Medicine, Ghent University Hospital
Technologiepark 927, 9052 Ghent, Belgium
e-mail: jbroels@telin.ugent.be
Web page: www.telin.ugent.be/ipi

ABSTRACT

3D Electron Microscopy (EM) has already proven to be useful in several fields such as Biotechnology and Healthcare, especially for ultrastructural analysis. However, images produced by 3D EM are in most cases severely degraded. These degradations arise due to a multitude of reasons, e.g. the complex electronics in the system, magnetic lens aberration, heating, motion stability, charging, etc. Although the raw, degraded images are currently used for analysis, their usefulness is limited because the degradations make visual distinction and automated analysis of biological features difficult. Recent research has shown the significant importance of noise characteristics as a prior in probabilistic image restoration algorithms such as Maximum A Posteriori (MAP) and Linear Minimal Mean Squared Error (LMMSE) [1, 2]. However, specific analysis of the noise characteristics in EM imaging is still an unexplored research domain and yet very important because of the unique imaging conditions, compared to ordinary light microscopy.

In this work, we present a thorough analysis of noise, as one of the most important degradations in 3D EM imaging. We used statistical techniques to analyse characteristic noise properties such as distribution, stationarity, spatial correlation, signal and dwell-time dependency. This analysis allowed us to model EM noise as Gaussian, stationary noise. Furthermore, we found a horizontal correlation between neighbouring noise pixels due to horizontal scanning. This explains the striping effect we observe in noisy EM images. Also, a significant, linear signal dependency relation was derived, since low-intensity (dark) regions revealed low noise levels, compared to high-intensity (bright) regions. Lastly, we observed a significant dwell-time dependency, yielding high signal-to-noise ratios (SNR) at long dwell-times and vice versa. Therefore, the user is allowed to set the dwell-time parameter according to the desired SNR.

Future work consists of a further analysis of additional artefacts (blur, charging, contamination, etc.) in 3D EM. Similar to [1], a Bayesian restoration algorithm will be developed, exploiting the artefact characteristics, in order to improve state-of-the-art techniques.

REFERENCES

[1] Aelterman, J., "Multiresolution Models in Image Restoration and Reconstruction with Medical and Other Applications," PhD Thesis, 2014.

[2] Golshan, H. M. and Hasanzadeh, R. P. R., “An Optimized LMMSE based Method for 3D MRI Denoising,” Computational Biology and Bioinformatics, IEEE/ACM Transactions on, 2014.