Brigg's Group Subtomogram Averaging

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1 Creation of Noise Amplitude Spectra

The first part of the processing that is done is the creation of the Fourier weights used for reweighting the raw volume average. Our current choice of weight is the average amplitude spectrum of subvolumes containing only background noise. The tomograms have been CTF multiplied by a 3D-CTF and the tilt-series used to reconstruct the tomogram have been dose-filtered. These averages are calculated for all T tomograms in the dataset as follows:

$$w_t = \frac{1}{N}\sum_{i=1}^{N}\sqrt{\mathcal{F}(n_i) * \overline{\mathcal{F}(n_i)}};\ \text{for } t = 1, \ldots, T \tag{1}$$

Where w_t is the weight used for subvolumes from tomogram t and n_i is the i^{th} out of N noise volumes extracted from the the tomogram. The weight volume is also scaled to a maximum value of 1.

$$w_t = \frac{w_t}{max(w_t)} \tag{2}$$

2 Weighted Average

We begin by creating the raw average of the aligned subvolumes and weights.

$$V = \frac{1}{M}\sum_{j=1}^{M} A_{\phi_i}(s_i); \quad W = \frac{1}{M}\sum_{j=1}^{M} R_{\phi_i}(w_{t_i}) \tag{3}$$

Where V is the raw subvolume average of M subvolumes s_i and A_{ϕ_i} is the affine transformation (rotation and shift) that brings s_i into register with the reference. W is the average of the amplitude spectra, where R_{ϕ_i} is the rotation matrix portion of A_{ϕ_i}, and w_{t_i} is the noise amplitude spectrum from the tomogram t from which s_i was extracted.

Finally we calculate the weighted average as:

$$V' = \mathcal{F}^{-1}\left(\frac{\mathcal{F}(V)}{W}\right) \tag{4}$$

3 Low Frequency Reweighting

Because the above structure greatly improved the isotropy of the structure, but still seemed to over-dampen low-frequency components of the structure at around 3-9 nanometer resolution, the following was tried as a way to appropriately boost the structure in this region. A second Fourier weight W' was generated in the same way as the noise amplitude spectrum, however the subvolumes were extracted from a tomogram of white Gaussian noise, and this simulated tomogram has been multiplied by the CTF squared. The idea being that this volume lacks the background structural noise that exists in the collected tomogram, and the weighted average is calculated as:

$$V'' = \mathcal{F}^{-1}\left(\frac{W'\mathcal{F}(V)}{W^2}\right) \tag{5}$$