Aberrant pixel removal tool for electron microscopy images

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Recent approaches in electron microscopy have been facilitated by the use of ssCCD camera that quickens the images digitalization process. Digitized images can then be processed to recover three-dimensional or chemical information by computing methods such as single particle analysis, electron tomography or energy filtered electron microscopy. Theses techniques make use of quantitative information in the image. Therefore, they are highly dependent on the values present in each pixel. Nevertheless, ssCCD cameras produce some artifacts due to X-rays or electrical noise that induce very bright or dark "aberrant" pixels with inconsistent values. The aberrant pixels can sometime be detected by thresholding and can be eliminated by using classical image filtering such as median filter. However these filters modify the values of all pixels in the image. So it cannot be used in quantitative methods. We propose here a new method to detect aberrant pixels and individually replace them with values coherent with the surroundings.

As an aberrant pixel has high variation with its neighborhood, we evaluate this criterion for each pixel in the image. To this purpose a distance algorithm is used. The scoring of the distance between central pixel and its neighborhood is calculated using the mean square difference. $Msd=\Sigma(P(x,y)-P(x0,y0))^2/N$ where P(x,y) is the value of the pixel in the image at the coordinate (x,y), x0 and y0 are the coordinates of the central pixel of the neighborhood and N is the number of pixels of the neighborhood considered. The higher this score is the higher is the difference between a pixel and its neighborhood. Using this approach, we obtain an image of distance. Then, we determine where is the limit of distance value above which we consider the pixel aberrant. To this purpose the histogram of the image of distance is considered. On the histogram, non aberrant pixels will have low distance values and aberrant pixels will have high values and will be represented by a very few numbers of pixels with the same value of distance. The distribution of distances in the histogram follows a curve that decrease to 0 and then stabilize at zero except for values corresponding to aberrant pixels. To determine the limit between normal and aberrant distance values we detect where the histogram curve becomes zero and remains constant. From this point, all values of the histogram different from 0 are considered as aberrant pixels and replaced by the average value of their neighborhood but excluding any other aberrant pixels in the neighborhood.

The procedure has been applied on experimental tilt series and their tomograms have been computed before and after aberrant pixels elimination.