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Detection of gold nanoparticles in transmission electron microscopy images

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1 Introduction

Gold nanoparticles in transmission electron microscopy (TEM) serve for immunolabelling of antibodies in biological experiments [Von Byern (2016)]. The images are intensity (grayscale), there is no color defined in the electrons beam. The image properties (contrast, bit-depth, dynamic range, resolution, ...) are person-specific, since the experts have an individual imaging-behavior. Thus we are not able to control the acquisition before the image processing. The aim of this work is to detect the presence of the nanoparticles in the image area, label their position, and evaluate their amount. The particles are supposed to be spherical, however there are various imperfections during the manufacturing, as well as quantization effects of digital images. Moreover, the size of the particles is around 50 gold atoms. The particles should be always the darkest objects, except the very large areas. The background and type or size of other objects vary due to biological reasons.

2 Methods

The set of input images was separated into training and testing subsets. On the training images following methods were carried out, compared, and tuned. The sucessfull approach was evaluated using the testing images. Basic morphological operations [Urban (2012)] were performed using

- edge detectors;
- Beucher morphology [Beucher (1995)];
- Otsu between class segmentation [Otsu (1979)];
- and object parametrization (area, perimeter, circularity, convexity, inertia, center coordinates).

The Hough transformation [Duda (1972)] is not recommended for this task, the gold nanoparticles are too small and not perfectly round. The computational burden is the typical disadvantage of the Hough method. The edge detectors are quite successful due to particles low intensity. Otsu segmentation works perfectly to distinguish two classes of intensities. Object parametrization is the main subtask, while the specification of the criterion function determines the overall results of the detection algorithm. The processing of the Tiff images was performed using Matlab Image processing toolbox and Python with OpenCV. The size of the images was 2044×2048 pixels.

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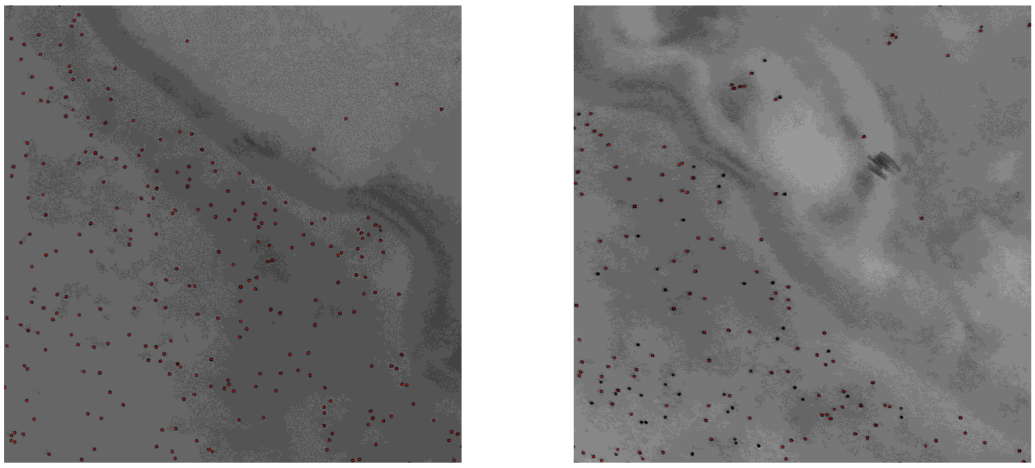
3 Results and discussion

Average time of detection was 58 [sec] on Intel Core2 Duo CPU E8400, 3GHz, 4GB, using double precision. During the detection some of the nanoparticles escaped from detection in both cases: on the training and testing set. The increase of multiplicator for standard deviation of circularity parameters suffers in false positive results occurrence. The future work will be focused on the background normalization, contrast enhancement, automatic multiparametric thresholding, and advanced morphological operations.



Obrázek 1: Example of results for gold nanoparticles TEM detection: left - on image of training set, right - on image of testing set. Detected particles are labeled by red marks.

4 Acknowledgement

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