Neural network-based analysis of high-resolution transmission electron microscopy images of ultrasmall metallic nanoparticles

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Ultrasmall metallic nanoparticles (diameter 1 to 2 nm) are of interest in research as they can be functionalized and used in biomedical applications. Due to their small size they are of special interest for interactions with proteins. The degree of functionalization as well as their biological properties critically depend on their structure and size [1,2]. Consequently, more information on the size of the particles and the synthetic parameters that influence their structure is essential.

One of the most prominent methods for analyzing ultrasmall nanoparticles is high-resolution transmission electron microscopy (HRTEM). With this method the size, morphology and crystal structure of the particles can be imaged. However, analyzing HRTEM images is time-consuming as it generally has to be done manually. Therefore, usually only a few particles within a given image are analyzed in more detail. To effectively use HRTEM for a large-scale analysis of ultrasmall nanoparticles, an automated image processing is desirable. This has the potential of extracting statistically significant quantitative information about the particles in less time. As a first step, an algorithm is needed to extract the single particles from the HRTEM image. For this step, a neural network is trained to perform image segmentation and to differentiate between the particles and the image background. A neural network, which was pretrained on natural images, was used for this process and transfer learning with labelled HRTEM images of ultrasmall nanoparticles was applied. From the segmentation, a high degree of information about the single particles can be extracted e.g. circularity, equivalence diameter, or Feret diameter. Further algorithms can be implemented to extract more information about the particles, e.g. crystallographic properties.

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