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Towards automated Virus Detection and Identification using TEM

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Transmission electron microscopy (TEM) is an important virus diagnostic tool. The main drawbacks are that an expert in virus appearance in electron microscopy needs to perform the analysis at the microscope, and the cost and bulkiness of the microscope. Relatively few experts exist around the world that have the capability to perform such image based diagnoses. In addition, in emergency situations due to suspected viral pathogens or infectious viral disease outbreaks, important time might be lost due to transporting the sample to the expert's microscope. A cheaper and smaller microscope and software that could automatically detect virus particles and determine the species in high resolution TEM images would hence be desirable virus diagnostic decision support tools. The sample could be imaged and analyzed at the closest TEM to save transporting time. Only images of the detected and identified virus particles could then be sent/shown to the expert for verification. The software would also be useful as an educational tool for new virologists and electron microscopists.

Here we present our work towards building such a system. Our final goal is to combine automated microscopy with image analysis into a system that efficiently and automatically searches for virus particles in a sample and identifies the viral pathogen. A new table-top 25keV TEM suitable for biological specimen is currently under construction as is software for automated content driven image acquisition and analysis to detect and identify viruses in TEM images.

Figure 1 illustrates the tasks/steps that need to be performed for automated virus identification. Samples are prepared using standard techniques that require only ordinary lab equipment. The sample is inserted into the microscope and low and medium magnification images at multiple scales (low and medium resolution) are acquired to automatically determine likely virus containing areas for high resolution image acquisition. This is an important step towards automating the virus identification process and thereby creating a rapid, objective, and user independent virus detection and identification system. By introducing the multi-scale acquisition approach the grid area where high magnification images need to be acquired is estimated to be reduced with more than 99.99% [1]. Once high resolution images eventual virus particles need to be identified. The identification task consists of segmenting virus particles with different shapes and sizes [2] and extracting descriptive features of both shape and texture to enable the classification into virus species by comparing the descriptive features with those extracted from images of known and manually annotated samples. Using only texture (surface morphology) measures we currently achieve a mean classification accuracy of 86% on 16 classes (15 virus classes plus one debris/false class) on automatically segmented particles.

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2. G. Kylberg, M. Uppström, K. Hedlund, G. Borgefors, I. Sintorn, Segmentation of Virus Particle Candidates in Transmission Electron Microscopy Images, *Journal of Microscopy, Vol. 245, pp. 140-147, 2012.*

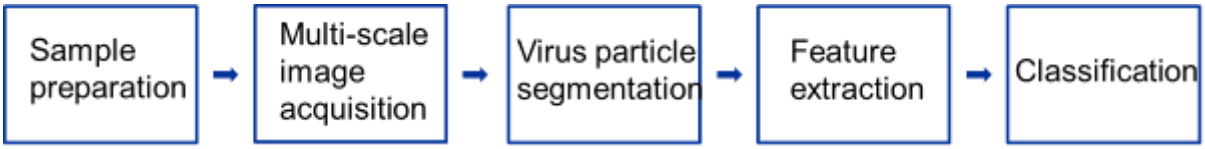

Figure 1. The steps in our virus identification system under development. All steps but the sample preparation are fully automatic.