APEER: The open digital microscopy platform.

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What is APEER?

APEER is an open and free digital microscopy platform that enables creation and customization of image processing workflows for specific jobs. The platform connects Microscopists, Image Analysts and Data Scientists with the aim to address current and future microscopy challenges such as fragmented software solutions, incompatible file formats, data storage and processing of large data.

On APEER, microscopy software developers can easily package their code and share it with other users in the form of modules and workflows. A module is the central element that is designed to perform a specific task and development is possible in nearly every programming language. Users can then combine several modules to project-specific workflows. As APEER runs in a cloud environment, the processing can be easily scaled up on demand for computational intensive modules.

Showcasing APEER in Nanoparticle Research

Introduction

Engineered nanoparticles have a wide range of industrial applications including catalyst research, electronics, inks and pigments, coatings, cosmetics, filtration, energy materials, pharmaceuticals and biomedical applications. With nanotechnology applications likely to develop rapidly in these and other industries, advancing nanoparticles research will play an important role in improving the quality of life.

Challenges

1. Separation and classification of individual nanoparticles from an agglomeration of particles.
2. Automation of analysis of what can typically be hundreds of nanoparticles in a single micrograph.

Conventional image segmentation methods use the watershed approach after initial thresholding by greyscale or RGB values. However, in the case of separating agglomerated particles, the problem is more challenging and measurement of nanoparticle size is still a highly manual process which is often not repeatable or reliable.

The Task

ZEISS GeminiSEM 500 was used to acquire a high-resolution micrograph of particles from the sparks of ferrocerium collected on a silicon substrate (Fig. 2a).

These were imaged using Secondary Electron (SE) imaging, a technique which is extremely sensitive to surface topography.

It is this variation in surface topography which (during visual inspection) can be used to separate otherwise overlapping particles.

The Approach

In this study we use machine learning trainable image segmentation with ZEISS ZEN Intellesis.

Instead of performing standard image processing operations on the 2D image, it classifies images on local and non-local greyscale, gradient and texture features, effectively creating a 33-dimensional hyper-image.

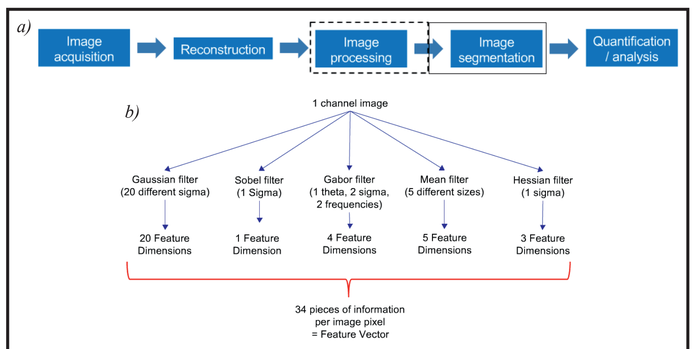

Fig. 1: (a) Standard image analysis workflow, (b) Intellesis pixel classification approach

The Final Solution

An end-to-end automated workflow is proposed that combines image acquisition, machine learning advanced image segmentation, particle analysis, and report generation - all on a digital solutions platform, APEER.

APEER enables the combination of easy-to-use modules into workflows that can be personalized to address the most challenging research problems.

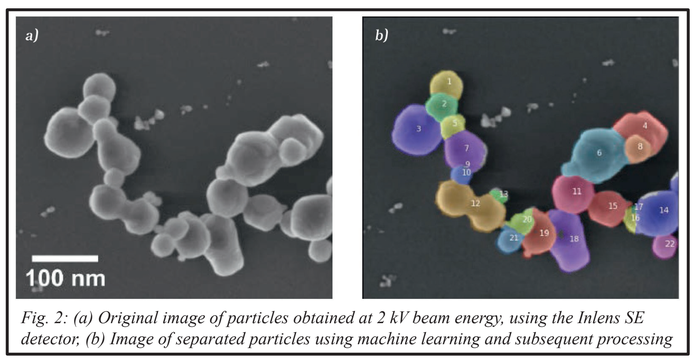

Fig. 2: (a) Original image of particles obtained at 2 kV beam energy, using the Inlens SE detector, (b) Image of separated particles using machine learning and subsequent processing

Conclusion

The size and size distribution of nanoparticles strongly affects quality, properties and applications of materials.

In this application, accurate and automated measurement of nanoparticles was made possible by a combination of advanced microscopy and image analysis techniques in a single end-to-end workflow, using APEER.

The described workflow can be used to optimize synthesis processes of nanoparticles and better understand the relationship between size of nanoparticles and material properties.

This allows researchers to expand the use of these materials to novel industrial applications.

The Advantages of APEER

One of the principal challenges associated with complex image processing and analysis workflows is modularity. Single software packages, while offering powerful analytical capabilities, do not provide an end-to-end complete solution for every application. As such, multiple disparate packages must be used (or even created from scratch) making workflow replication at an industrial scale extremely challenging.

APEER provides a platform where such custom or disconnected components can be defined, developed and connected to create complete workflows, ready to be shared for use. Detailed analytical workflows can be made without the requirement of a deep expertise in computer vision.

Using the information achieved through image segmentation, a new platform, APEER, is now available to allow the integration of customized modules in a full workflow, to gain flexibility and save research time.

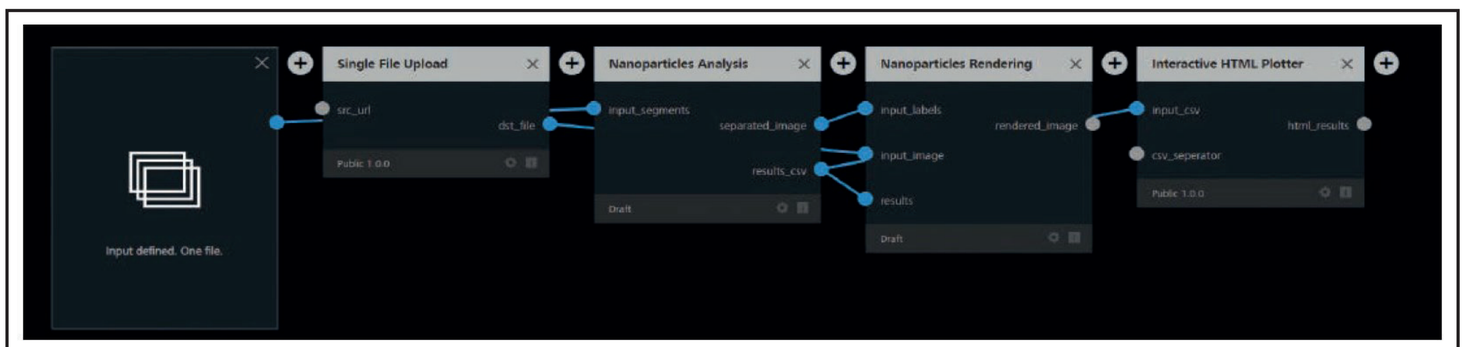

Fig. 3: APEER interface for nanoparticle segmentation and analysis, showing how modules can be connected to create a full workflow.

The Vision behind APEER

APEER as a vision goes beyond a simple processing tool and has the potential to become an ecosystem for community-developed solutions for complex image analysis solutions.

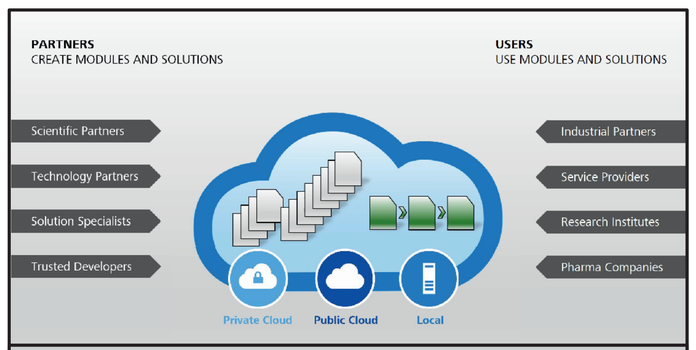

Fig. 4: The APEER Vision of bringing together a diverse range of experts in their respective fields to create unique image analysis solutions for everyone

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