Primary Particle Size Analysis of Agglomerates on Transmission Electron Microscopy Images via Artificial Neural Networks

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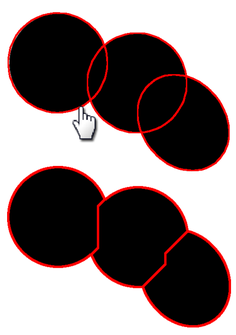
Introduction 1

Transmission electron microscopy (TEM)
- widely used method for the analysis of particle size distributions (PSDs)

Imaging particle size analysis

Manual method
+ highest accuracy available
– laborious and expensive



Established automated methods
+ quick and easy
– low accuracy for agglomerates

How about artificial neural networks (ANNs)?
+ self-learning mathematical structures
  → very flexible and adaptive
– require large amounts of training data
  → ~100.000 samples with known particle areas

Problem: very little training data available
Solution: synthesis of life-like TEM images

Workflow 2

Image distortion analysis
- basis of the image synthesis

Image synthesis
- as life-like as possible
  → realistic training conditions
- optional: tailoring to known sample properties, to improve the training

ANN training
- synthetic images as input data
  → known particle areas
  → error of the ANN's output can easily be quantified
- training ends when error is small enough

Measurement
- real images as input data

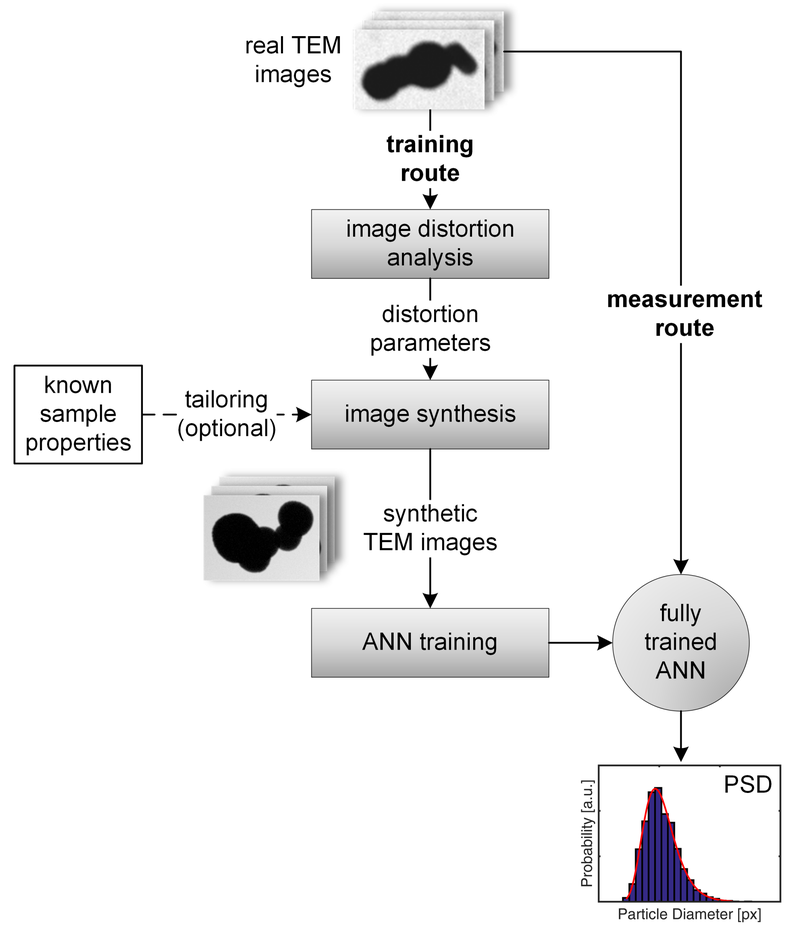
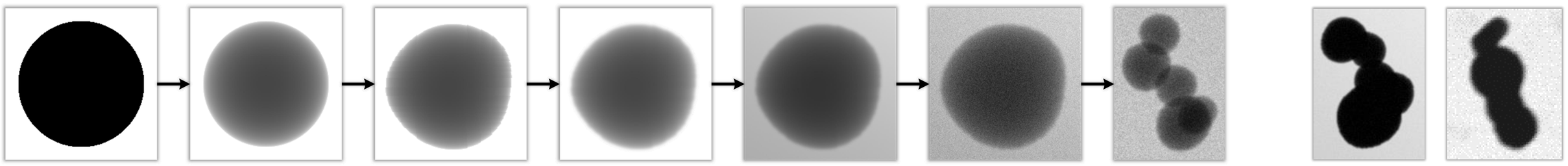


Image Synthesis 3

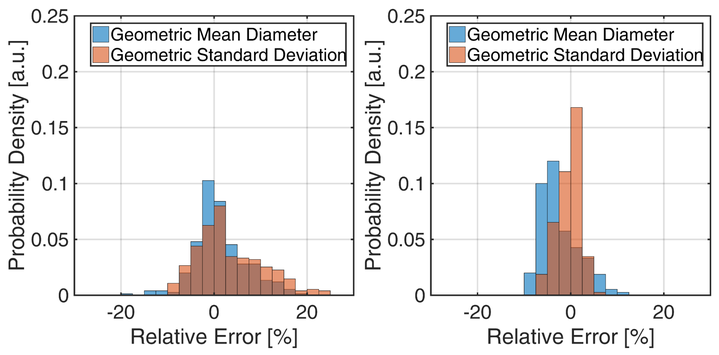


Results 4

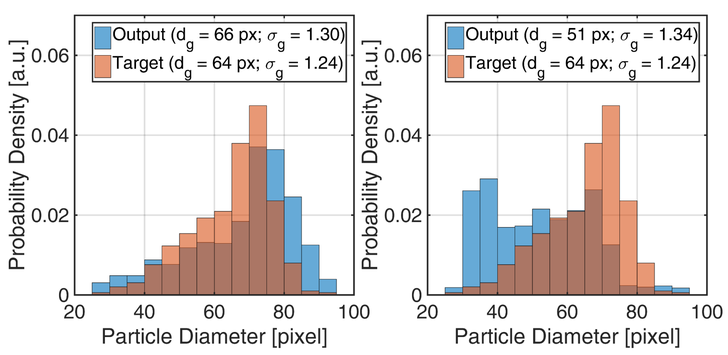
Synthetic TEM images
- benchmark
- 300 samples of 500 images each
- ground truth: well defined and known
- comparison: proposed method and Hough transformation (established automated method)

Real TEM images
- validation
- 1 sample of 500 images
- ground truth: manual analysis → labor-intensive
- comparison: proposed method and Hough transformation (established automated method)

Proposed method | Hough Transformation



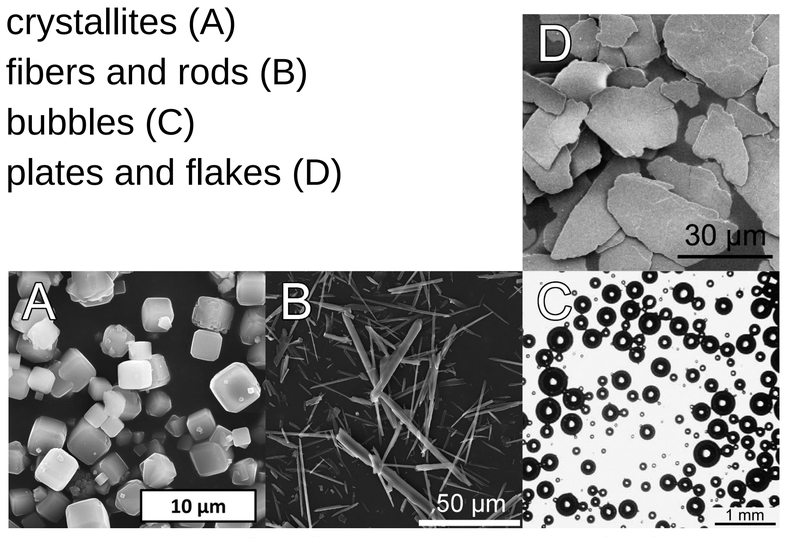
Proposed method | Hough Transformation



Summary and Outlook 5

ANNs for imaging particle size analysis
+ performance comparable to Hough Transformation
– currently limited to small agglomerates
  → up to five primary particles

Expansion to other morphologies
- crystallites (A)
- fibers and rods (B)
- bubbles (C)
- plates and flakes (D)



Possible future applications [1-4]

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