

Image Processing, Analysis and Modeling of Particle Populations

Author: Prof. Johan DEBAYLE

Institution: Ecole Nationale Supérieure des Mines / Saint-Etienne, France

Contact: debayle@emse.fr - <http://www.emse.fr/~debayle/>

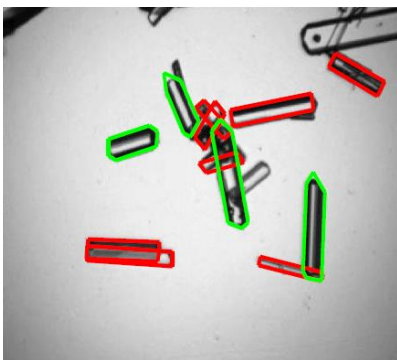
Abstract:

Particle populations are widely used in many industrial applications and fields of science from physics to biology or agronomy. In chemical engineering, in particular, it is generally desired to extract information on geometrical characteristics and on spatial distribution from 2D images of the population of particles involved in the process. For example in pharmaceuticals, the size and the shape of crystals of active ingredients are known to have a considerable impact on the final quality of products, such as drugs. Hence, it is of main importance to be able to control in real time the granulometry (size and shape) of the crystals during the process.

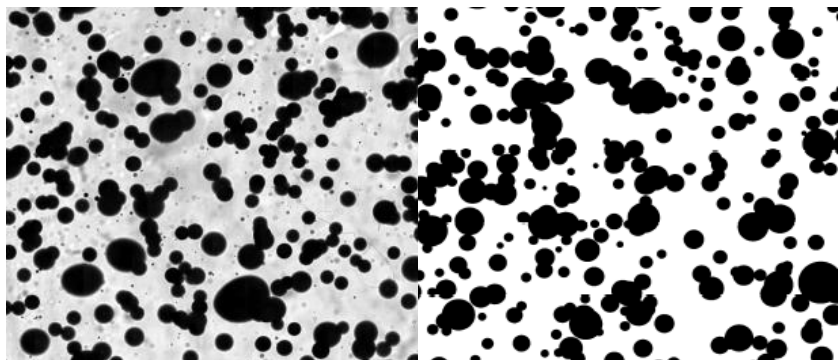
The purpose of this talk is then to show different ways (deterministic and stochastic methods) of image processing, analysis and modeling to geometrically characterize the particles from a sequence of 2-D images acquired by a camera (visualizing the particles during a particular process). The developed methods will be presented by addressing different issues: the perspective projection of the 3-D particle shape onto the image plane, the blurred appearance of unfocused particles, the degree of agglomeration or overlapping, and the random variation in size/shape of the observed particles. The methods are mainly based on image enhancement, restoration, segmentation, tracking, modeling, feature detection, stereology, stochastic geometry, pattern analysis and recognition.

The methods will be particularly illustrated on real applications of crystallization processes (for pharmaceuticals industry) and multiphase flow processes (for nuclear industry).

Illustrations



(a) Image processing and analysis of a 2-D image of oxalate ammonium crystals to individualize and characterize the particle shape and size distributions.



(b) Image modeling (right side) of a 2-D real image (left side) of a gaz-liquid flow. The model image is statistically equivalent to the real data which indirectly enables the particle size and shape distributions to be extracted.

Main references (journal articles):

- M. De Langlard, F. Lamadie, S. Charton, and J. Debayle. A 3D stochastic model for geometrical characterization of particles in two-phase flow applications. *Image Analysis and Stereology*, 37(3):233-247, 2018.
- M. De Langlard, H. Al Saddik, S. Charton, J. Debayle, and F. Lamadie. An efficiency improved recognition algorithm for highly overlapping ellipses: Application to dense bubbly flows. *Pattern Recognition Letters*, 101:88-95, 2018.
- S. Rahmani, J. C. Pinoli, and J. Debayle. Description of the the symmetric convex random closed sets as zonotopes from their Feret's diameters. *Modern Stochastics: Theory and Applications*, 3:325-364, 2016.
- O. Ahmad, J. Debayle, N. Gherras, B. Presles, G. Fevotte, and J. C. Pinoli. Quantification of overlapping polygonal-shaped particles based on a new segmentation method of in situ images during crystallization. *Journal of Electronic Imaging*, 21(2):1-12, 2012.
- B. Presles, J. Debayle, and J. C. Pinoli. Size and shape estimation of 3-D convex objects from their 2-D projections. Application to crystallization processes. *Journal of Microscopy*, 248(2):140-155, 2012.
- O. Ahmad, J. Debayle, and J. C. Pinoli. A geometric-based method for recognizing overlapping polygonal-shaped and semi-transparent particles in gray tone images. *Pattern Recognition Letters*, 32(15):2068-2079, 2011.
- B. Presles, J. Debayle, G. Fevotte, and J. C. Pinoli. A novel image analysis method for in-situ monitoring the particle size distribution of batch crystallization processes. *Journal of Electronic Imaging*, 19(3):1-7, 2010.