

Title: Digital twins and image analysis for the numerical simulation of granular flow

Host institution: Ecole Nationale Supérieure des Mines de Saint-Étienne (MINES Saint-Etienne)
SPIN / LGF, UMR CNRS 5307

Compensation: ~500 euros/month

Candidate profile: Engineering student or research master student with a specialization in numerical simulation, scientific programming and/or applied mathematics.

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Description:

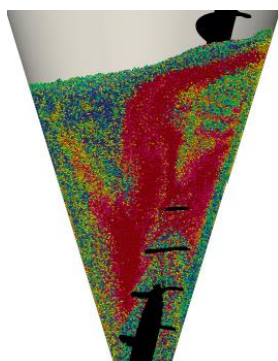
- **General context**

One of the specialties of the SPIN center at MINES Saint-Etienne is the numerical simulation of granular media as digital twins. Particle-based flows are found in many chemical processes. Numerical simulation is a standard approach to describe and understand the processes concerned. On the other hand, calculation times are often prohibitive for the optimization or control of processes in real time. Therefore, it is necessary to develop empirical substitution models, calibrated from numerical simulations, to speed up calculations. Geometric descriptors used in image analysis are good candidates for the development of such models.

- **Objectives**

In this context, the student will have to carry out the following tasks:

- Perform simplified simulations of fluid flows with particles,
- Generate images based on these simulations,
- Characterize the images using the most relevant geometric descriptors,
- Generate random virtual images similar (in the statistical sense) to the images from the simulation, using these geometric descriptors.



Numerical simulation (DEM) of a powder mixture [1]

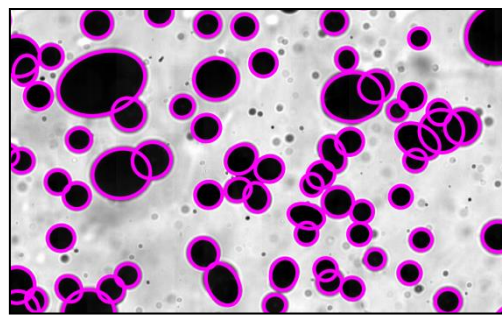
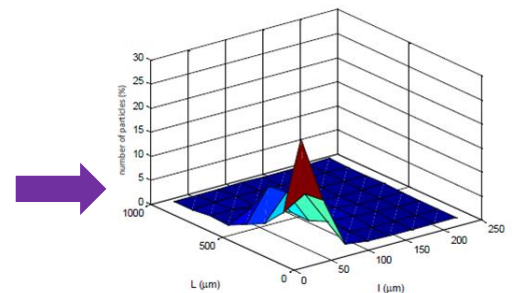


Image analysis (individualization of particles) and characterization (particle size distribution) of multiphase flows[2]



References:

[1] X. Bednarek, S. Martin, A. Ndiaye, V. Peres, O. Bonnefoy. Extrapolation of DEM simulations to large time scale. Application to the mixing of powder in a conical screw mixer. *Chemical Engineering Science*, 197:223-234, 2019.

[2] 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.