Size sorting in bedload sediment transport with image analysis

Bedload transport is characterized by a granular medium sheared by a turbulent fluid flow driven by gravity. Bedload is defined as the part of the sediment load in "contact" with the bed (Fig.A), in which the granular interactions are important. This represents typical situations observed in rivers or mountain streams, which are important to predict, for flood prevention or aquatic ecology for example. Despite more than a century of research efforts, our understanding of bedload transport is still limited. The polydispersity of the grains leads to size sorting processes (see Fig. A) in the granular bed, which is suspected to be one of the main processes responsible for this inaccuracy. Most studies have concerned the spontaneous percolation of fine grains into immobile gravels, because of implications for salmonid reproduction, placer mineral concentration, and sedimentology. However when the substrate is moving, the segregation process is different as statistically void openings permit downward percolation of larger particles (Fig. B). Both processes occur in natural streams.

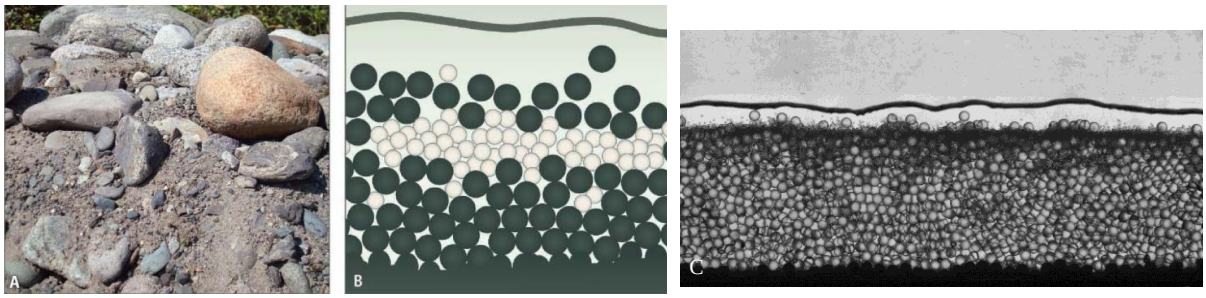

Fig. A : armouring in a river B kinetic sieving experiments (Frey and Church 2009) C. degradation by fine material (Dudill et al.2017)

Segregation in bedload was studied at Inrae (ex-Irstea) Grenoble experimentally with two-size mixtures, in a narrow inclined channel which enabled us to film each particle trajectory (see example of acquisition on fig. B and C). Both processes of kinetic sieving and spontaneous percolation were studied. The idea of the experimental setup is to analyze the phenomenon from a granular point of view. Depending of the size ratio and the fine sediment rate, either aggradation or degradation was observed (Dudill et al.2017,2018).

The internship will consist in analyzing existing datasets to determine the location and the trajectory of the moving particles, ultimately permitting improving existing size sorting theories. This computer vision problem falls into the scope of Multiple Objects visual Tracking (MOT). We will rely on algorithms previously developed (Lafaye de Micheaux et al. 2018) which will have to be improved using innovative machine learning based methods.

The internship is a collaboration between INRAE, ETNA, Univ. Grenoble Alpes (P. Frey) and Laboratoire Hubert Curien, univ St-Etienne (C.Ducottet, image analysis group) in the framework of the ANR SegSed project 'Size Segregation in sediment transport'.

Location : Inrae, ETNA, Grenoble campus philippe.frey@inrae.fr or LaHC, St Etienne ducottet@univ-st-etienne.fr

Candidate profile: -Fluid mechanics or Earth science with interest in image analysis.
- Alternatively applied maths or image analysis with interest in Earth science

Required :excellent academic level, and a good programming experience (matlab, python, C++, …).

References

Frey P, Church M. 2009. How river beds move. Science 325(5947): 1509-1510.

Dudill A, Frey P, Church M. 2017. Infiltration of fine sediment into a coarse mobile bed: A phenomenological study. Earth Surface Processes and Landforms 42(8): 1171-1185.

Lafaye de Micheaux H, Ducottet C, Frey P. 2018. Multi-model particle filter-based tracking with switching dynamical state to study bedload transport. Machine Vision and Applications 29(5): 735-747.

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