Measuring radial particle velocity of granular flows in the annular shear cell

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Background

Granular flows are widespread particle transport mechanisms in nature and industries. Particle velocity profile is an important reference to distinguish motion regimes in granular flows. For example, Forterre et. al [1] defined three regimes in granular flows: (1) gas regime, (2) flow regime, and (3) solid regime. Each regime has a unique velocity profile and determines corresponding particle behavior [2, 3].

To date, most studies on measuring particle velocity focus on the streamwise direction, and less is studied on the spanwise direction. In an sheared annular cell (Fig.1), small particles accumulate inwards, indicating a spanwise particle velocity at the bottom of the channel. This particle velocity causes spanwise convection and further triggers radial segregation in granular flows. This phenomenon probably relates to the radial sediment transport in meandering rivers. **Measuring radial particle velocity is essential to understanding spanwise particle transport mechanism.**

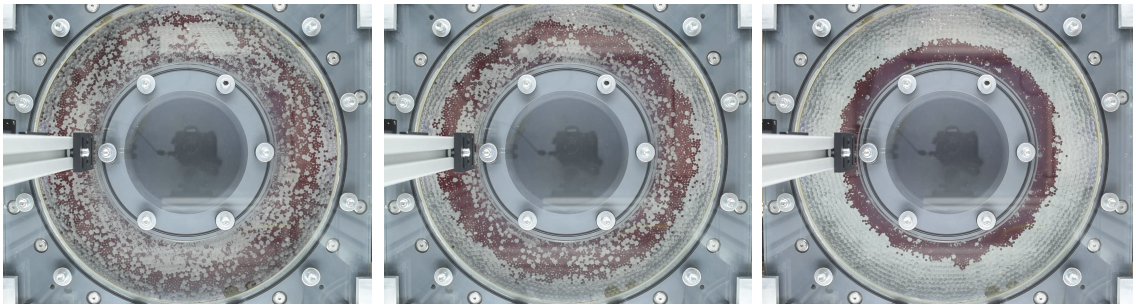

Figure 1: Bottom view of the sheared granular flows in the annular shear cell. Small particles (red in figures) have a diameter of 4 mm while large particles (transparent) have a diameter of 8 mm. From left to right: sheared for 2 minutes, 6 minutes, and 10 minutes.

Purpose

This project aims to measure the radial particle velocity in the annular shear cell. We use high-speed cameras to capture images of particles, and then **obtain radial velocity profiles through image analysis in Python or Matlab.**

Methods

Three steps for achieving the purpose:

- Set the high-speed camera based on the optical conditions of experiments,
- Capture particle motions using the high-speed camera,
- Calculate particle velocity based on the particle displacement in neighbouring image frames.

Prerequisites

Basic coding ability and interest in image analysis.

What You Will Learn

- Conduct simple experiments on granular flows,
- Understand the method of estimating particle velocity,
- Improve your coding ability in Matlab or Python.

Final Report

The student should submit a report that includes: (1) a summary of the work done by the student, (2) the methodology to obtain the particle velocity, and (3) the qualitative description of the spanwise velocity profile. The report can be written in either Jupter notebook or Matlab live script.

References

1. Forterre, Y. & Pouliquen, O. Flows of Dense Granular Media. *Annual Review of Fluid Mechanics* **40,** 1–24. doi:10.1146/annurev.fluid.40.111406.102142 (2008).
2. Gray, J. M. N. T. Particle segregation in dense granular flows. *Annual Review of Fluid Mechanics* **50.** doi: 10.1146/annurev-fluid-122316-045201, 407–433. doi:10.1146/annurev-fluid-122316-045201 (1 2018).
3. Houssais, M., Ortiz, C. P., Durian, D. J. & Jerolmack, D. J. Onset of sediment transport is a continuous transition driven by fluid shear and granular creep. *Nature Communications* **6,** 6527. doi:10.1038/ncomms7527 (2015).