Dynamic X-ray analysis of particle shape and size orientation fields during granular flow

Benjy Marks *[1], Francois Guillard[1], and Itai Einav[1]

[1]School of Civil Engineering, The University of Sydney, Australia

Keywords: x-ray radiography, granular materials, granular flow, hopper discharge

Summary: Granular materials exhibit many complex and varied behaviours. When flowing, the constituent particles segregate by size and align by shape. These changes in fabric feed back on the flow itself, changing the rheology. Here, dynamic X-ray radiography is used to observe the interior of the material, measuring spatiotemporal fields of internal particle size and shape orientation distributions during flow, in addition to complementary measurements of velocity fields. The results are compared with static measurements from conventional tomography.

1. INTRODUCTION

Granular materials are naturally opaque, hence viewing their interior is an ongoing experimental challenge. A number of non-invasive experimental techniques have been developed to track the internal kinematics within such materials. These techniques have tremendously advanced our understanding, yet their range of applicability is still quite narrow, especially in their ability to recover descriptions of fabric during granular flow. Here, we advance a new experimental technique for determining the evolution of fabric during granular flow in terms of internal particle-size and particle-shape orientation distribution fields, in addition to complimentary measurements of internal velocity fields.

2. EXPERIMENTAL METHOD

Radiographs of flowing granular media have been taken in the DynamiX facility at The University of Sydney, Australia. This consists of two Spellman XRV Generators, emitting X-ray radiation along orthogonal paths towards two PaxScan 2520DX detectors, as shown in Figure 1.

A rectangular silo of dimension $300\,\mathrm{mm}\times150\,\mathrm{mm}\times130\,\mathrm{mm}$ is discharged with a channel opening at the bottom of variable width. An experimental campaign is conducted, varying both the discharge rate and the aspect ratio of the material being discharged; either glass beads, rice or red lentils.

3. RESULTS

Measurements of the velocity field is done by applying a 2D DIC algorithm directly to the radiographs, to recover the median velocity field orthogonal to each X-ray beam. Additionally, measurements of the grain size and shape distribution fields are recovered using a new technique.

*e-mail: benjy.marks@sydney.edu.au

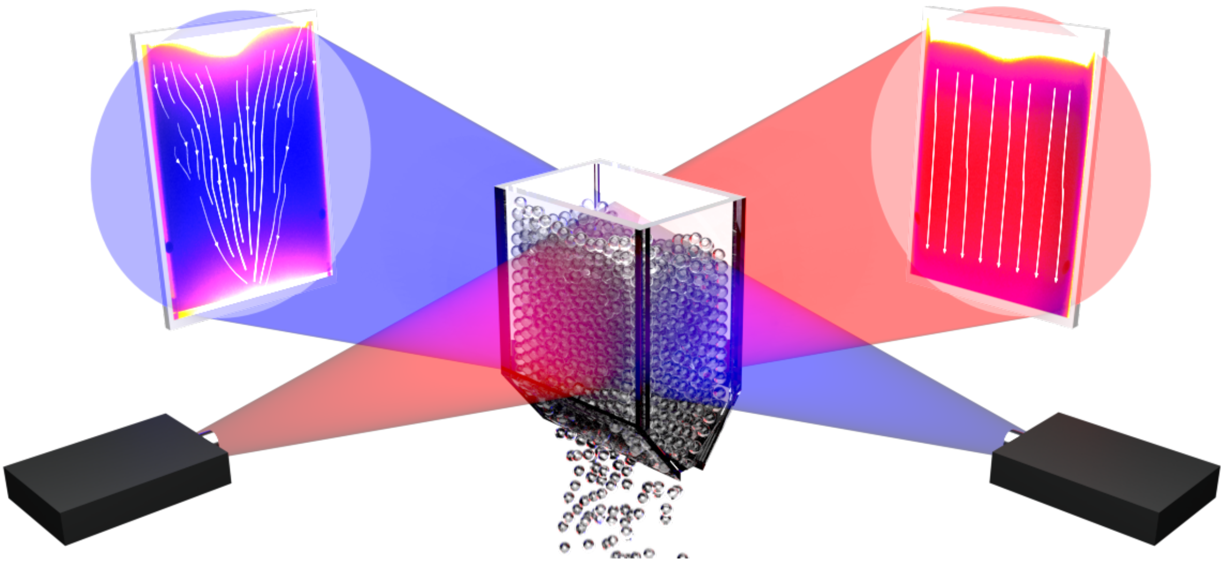

Figure 1: Schematic diagram of the dual X-ray radiography setup at DynamiX Laboratory at The University of Sydney. Digital image correlation is used on successive images from each radiograph, allowing the velocity field to be overlaid on each radiograph (shown in white).