Report for MASTS TPS Small Grant Award Scheme:

Extension of IMU sensor (smart pebble) for use in situ in coastal environments.

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Overview.

The MASTS small grant has been used to perform battery life extension tests to already customized and purpose specific Inertial Measurement Units (embedded accelerometers and gyroscopes). The custom IMUs are build and calibrated for monitoring grain scale dynamics in fluvial environments. The purpose of this project is to extend the testing of the custom sensors from river to coastal regimes.

Benefits of the award and Results so far.

At a first stage, a small part of the grant was used to purchase 3 USB battery banks which were used to test the concept of ad-hoc battery extension. The results were encouraging as the motoring time was extended form 5 hours to 8. However, the size of the resulting assembly increased significantly (compared to the non-extended versions). The latter is critical as it prohibits the monitoring of smaller sediment classes.

In parallel to the above testing, the grant supported an initial tracer study performed at Barns Ness beach in Dunbar (East Coast of Scotland). Kelsey Hill (BS Candidate, GES, University of Glasgow), and Mairi Macarthur (PhD Candidate, GES, University of Glasgow) deployed painted and magnetically tagged natural stones during a tidal cycle in summer 2016. In addition, a detailed dataset of grain size distribution was developed as part of an ongoing study supervised by Dr. Larissa Naylor and Professor Trevor Hoey. The results are now used to parametrize the deployment conditions for the smart pebbles in terms of the magnitude and direction of individual grain trajectories (Figure 1) and the statistical representativeness of those for this particular area.

Finally, the remaining funds were used to purchase a high accuracy IMU sensor developed for use in extreme industrial settings. This sensor will be deployed for calibration under shaking random motions (Figure 2) and for extending the battery life of the existing sensors in an indirect way as follows:

By having an accurate measurement for the rotation of local forces it is possible to decrease the frequency of the measurements for the existing custom sensor assemblies. Initial tests suggest that, by monitoring at 30Hz Hertz with the custom sensors and at 25 Hertz with the purchased high-accuracy IMU, we can reconstruct the dynamics at an accuracy comparable to a 50Hz measurement from the custom IMUs. The reduction of frequency will increase the battery life of the custom IMU sensors from 5 to 6.5 hours without affecting their size.

Future Work

A smart pebble deployment in Barns Ness is scheduled for early April. The results will be combined with river (in co-operation with Dr. Richard Williams) and hillslope (in co-operation with Charlotte Gilles, PhD Candidate) smart-pebble deployments towards composing a summative paper regarding the use of IMU sensors in geomorphological studies.

Figure 1– Arrow diagrams showing to scale tracks of particle movement magnitude and direction in terms of Eastings and Northings in metres. All tracks are from the Sandstone site where size class ‘a’ (<20mm) movement is shown in red, size class ‘b’ (20-80 mm) in blue and size class ‘c’(>90 mm) in green.

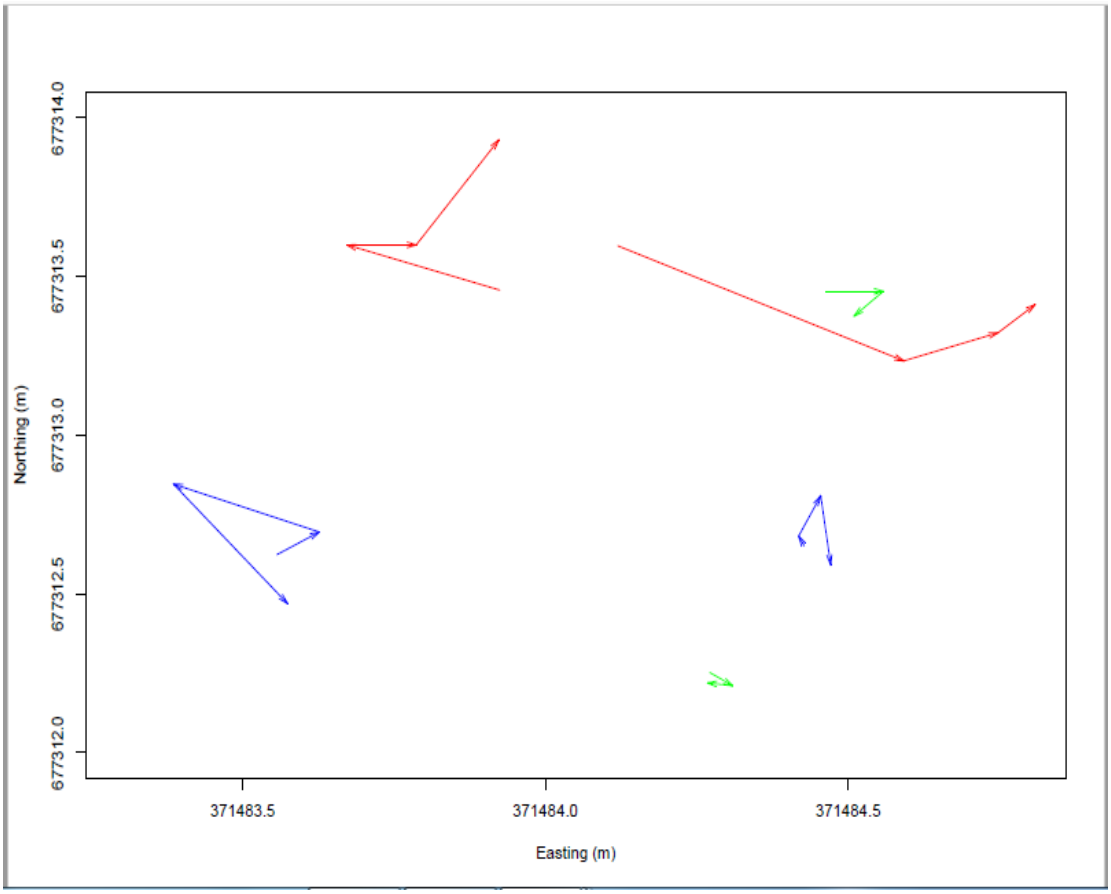
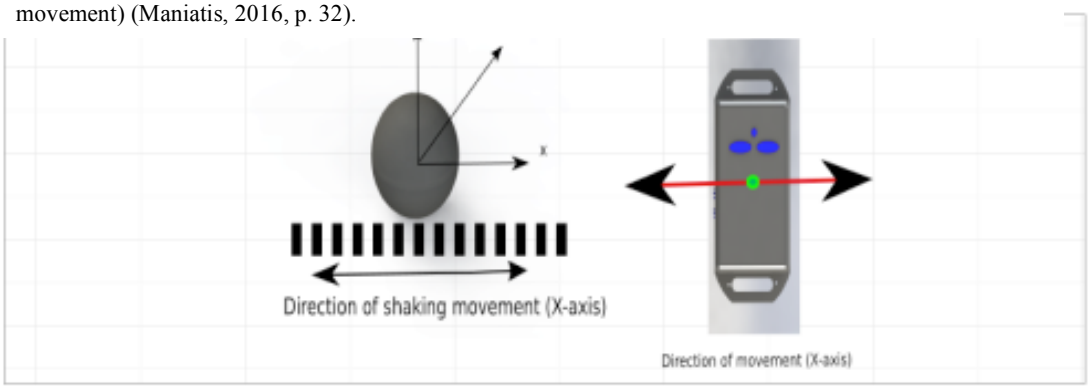


Figure 2 – (a) the orientation of the sensor in terms of the shaking table; (b) x-dimension signal output of acceleration from random displacement (10 second intervals of no movement and 10 seconds of table movement) (Maniatis, 2016, p. 32).

a.



b.