Geophysical Research Abstracts,
Vol. 11, EGU2009-7781, 2009
EGU General Assembly 2009

Collection, processing and error analysis of Terrestrial Laser Scanning data from fluvial gravel surfaces

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The ability to collect 3D elevation data at mm-resolution from in-situ natural surfaces, such as fluvial and coastal sediments, rock surfaces, soils and dunes, is beneficial for a range of geomorphological and geological research. From these data the properties of the surface can be measured, and Digital Terrain Models (DTM) can be constructed. Terrestrial Laser Scanning (TLS) can collect quickly such 3D data with mm-precision and mm-spacing. This paper presents a methodology for the collection and processing of such TLS data, and considers how the errors in this TLS data can be quantified.

TLS has been used to collect elevation data from fluvial gravel surfaces. Data were collected from areas of approximately 1 m^2, with median grain sizes ranging from 18 to 63 mm. Errors are inherent in such data as a result of the precision of the TLS, and the interaction of factors including laser footprint, surface topography, surface reflectivity and scanning geometry. The methodology for the collection and processing of TLS data from complex surfaces like these fluvial sediments aims to minimise the occurrence of, and remove, such errors. The methodology incorporates taking scans from multiple scanner locations, averaging repeat scans, and applying a series of filters to remove erroneous points.

Analysis of 2.5D DTMs interpolated from the processed data has identified geomorphic properties of the gravel surfaces, including the distribution of surface elevations, preferential grain orientation and grain imbrication. However, validation of the data and interpolated DTMs is limited by the availability of techniques capable of collecting independent elevation data of comparable quality. Instead, two alternative approaches to data validation are presented. The first consists of careful internal validation to optimise filter parameter values during data processing combined with a series of laboratory experiments. In the experiments, TLS data were collected from a sphere and planes with different reflectivities to measure the accuracy and precision of TLS data of these geometrically simple objects.

Whilst this first approach allows the maximum precision of TLS data from complex surfaces to be estimated, it cannot quantify the distribution of errors within the TLS data and across the interpolated DTMs. The second approach enables this by simulating the collection of TLS data from complex surfaces of a known geometry. This simulated scanning has been verified through systematic comparison with laboratory TLS data. Two types of surface geometry have been investigated: simulated regular arrays of uniform spheres used to analyse the effect of sphere size; and irregular beds of spheres with the same grain size distribution as the fluvial gravels, which provide a comparable complex geometry to the field sediment surfaces. A series of simulated scans of these surfaces has enabled the magnitude and spatial distribution of errors in the interpolated DTMs to be quantified, as well as demonstrating the utility of the different processing stages in removing errors from TLS data. As well as demonstrating the application of simulated scanning as a technique to quantify errors, these results can be used to estimate errors in comparable TLS data.