Rigorous Error Propagation for Topographic Displacements Derived from Image Correlation

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Multiple collections of high resolution topographic point cloud data over common areas are increasingly available as lidar and structure from motion techniques continue to mature and be widely deployed. These multi-temporal data provide the opportunity to quantify spatial change occurring between collections, with the most common method being 1D vertical differencing between digital elevation models. Horizontal spatial change is also relevant, however, particularly for measuring the non-rigid motion found in landslide or glacier environments. While techniques such as iterative closest point algorithms operate directly on unorganized point clouds to compute 3D displacements, existing correlation-based image processing algorithms, e.g., particle imaging velocimetry (PIV), are also being applied to rasterized point cloud products to capture 2D horizontal motion. Interestingly, although these correlation techniques are well known in the image processing community and significant work has been invested in quantifying the uncertainty in the computed displacement vectors, traditional error propagation has not been fully examined. This is unfortunate, as spatial uncertainties based on rigorous error propagation are fundamental to the surveying and geomatics communities. We will briefly review the PIV method, provide several example geospatial applications, and discuss the results of an analysis in which estimated horizontal displacement uncertainties were obtained through application of traditional Jacobian-based error propagation to the PIV technique.

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