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Sub-pixel precision algorithms for normalised cross-correlation based image matching of mass movements

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This study evaluates the performance of two fundamentally different approaches to sub-pixel precision of normalised cross-correlation for measuring the surface displacement on mass movements from repeat images. In the first approach, image intensities are interpolated to a desired sub-pixel resolution using a bi-cubic interpolation scheme prior to displacement matching. In the second approach, the image pairs are correlated at the original image resolution and the peaks of the correlation coefficient surface are then located at the desired sub-pixel resolution using three techniques, namely bi-cubic interpolation, parabola fitting and Gaussian fitting. Both principal approaches are applied to three typical mass movement types, i.e. rockglacier creep, glacier flow and rock sliding. In addition, the influence of pixel resolution on the displacement accuracies through image matching is evaluated using repeat images resampled to different spatial resolutions. Our results show that intensity interpolation using bi-cubic interpolation performs best followed by bi-cubic interpolation of the correlation surface. Both Gaussian and parabolic peak locating perform weaker. By interpolating the matched images by a factor of 2 to 16, 40 to 80 percent accuracy gain in reference to comparable resolution image could be achieved. The study also quantifies how the mean error, the random error, the proportion of mismatches and the proportion of undetected movements increase with increasing pixel size (i.e. decreasing spatial resolution) for all of the three mass movement types investigated.

Keywords: Normalised cross-correlation, Sub-pixel, Image matching, Displacement measurement, Rockglacier, Glacier, Rock slide