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Spatially adaptive least squares image matching for monitoring slow-moving land slides

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The horizontal displacements of Earth surface mass movements are often measured using matching of repeat images based on the normalized cross correlation (NCC) coefficient. This approach assumes rigid body translation within the image subset (template) being matched with no or very limited change in orientation, size and shape. However in reality Earth surface masses move in different patterns leading to all forms of deformation including translation, rotation, shearing and scaling. These deformations may even vary spatially within a geographic region. Therefore, to obtain accurate and reliable deformation estimate, the approach that models these deformations preferred. Least squares image matching (LSM) is widely used in photgrammetry and computer vision as it models both geometric and radiometric distortions. The technique is also applied to measuring displacements in Earth surface mass movements with much lesser frequency. However, only one geometric model, i.e. affine model, is widely used. Extensions to other models such as projective and polynomial are very limited even in photogrammetry and computer vision let alone mass movements. The spatial variation of the patterns of movement of the Earth surface masses requires spatially adapting the geometric models. This study therefore presents an algorithm which uses the LSM with spatially adaptive geometric models to estimate horizontal displacements of slow-moving landslides. A pair of high resolution optical images over a slow-moving rock sliding is orthorectified and co-registered. Image matching is applied first using the conventional NCC, then using the LSM algorithm with image-wide single geometric model, and finally using the LSM with spatially adaptive geometric models. Four geometric models are included in the adaptive algorithm; namely, rigid-body translation, affine, projective and polynomial. The algorithm is spatially adapted in such a way that for each template the model that produces the lowest squared error (i.e. intensity deviation between the reference and the matching templates) is used. The algorithm is tested on artificially deformed image pair and the real bi-temporal images of rock sliding. The results of the adaptive algorithm are compared with that of the conventional NCC based image matching and LSM with image-wide single geometric model.