A Fast Hill-climbing Algorithm for Measuring Object Displacements with Subpixel Accuracy

by

Qi Tian and Michael N. Huhns

Department of Electrical and Computer Engineering
University of South Carolina
Columbia, SC 29208

ABSTRACT

A fast hill-climbing algorithm has been developed for determining the displacement of a two-dimensional object using two successive speckle images of the object. The method matches speckle patterns with an accuracy up to 0.05 pixel and a speed 10 times faster than a common iterative algorithm.

A main difficulty in registring images of translating object where the objects are man-made is that the correlation function has a very flat peak in the correct match position; therfore it is hard to determine accurately where the match position is located. A speckle pattern of an object is created by illuminating the object with a single divergent laser beam, yielding an image that has more high frequency components than images of man-made objects. The image consists of randomly scattered spots with an average diameter. Near the match position of the cross-correlation function there is an area where the function has only one peak. Based on this property, an estimate of the displacements can be found by either a coarse search or prior knowledge of the object motion, which is within a certain range from the registration position (in our experiments it is + or - 5 pixels). Then a hill-climbing algorithm can be succesfully performed to find the accurate displacement.

Currently the algorithm is being used for determining translations of an object. The results indicate that the new algorithm is at least 10 times faster than the iterative matching algorithm, with an accuracy up to + or - 0.05 pixel. The algorithm is being further developed to measure displacements caused by scaling and rotation. This method may be used in a variety of applications where displacements need to be measured as accurately as possible, such as in nondestructive evaluation, flow velocity measurements, circuit-board alignments, and VSLI lay-outs.

A set of test image pairs and results are presented to give empirical justification for theoretical predictions.

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1983