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Motion Detection in Astronomical and Ice Floe Images

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Two approaches are presented for establishing correspondence between small areas in pairs of successive images for motion detection. The first one, based on local correlation, is used on a pair of successive Voyager images of the Jupiter which differ mainly in locally variable translations. This algorithm is implemented on a sequential machine (VAX 780) as well as the Massively Parallel Processor (MPP). In the case of the sequential algorithm, the pixel correspondence or match is computed on a sparse grid of points using nonoverlapping windows (typically 11 x 11) by local correlations over a predetermined search area. The displacement of the corresponding pixels in the two images is called the disparities to cubic surfaces. The disparities at points where the error between the computed values and the surface values exceeds a particular threshold are replaced by the surface values. A bilinear interpolation is then used to estimate disparities at all other pixels between the grid points. When this algorithm was applied at the *red spot* in the Jupiter image, the rotating velocity field of the storm was determined.

The computation required for this algorithm is proportional to the area of the image and is about one-half hour for a 128×128 image with local window of size 11×11 and search area of 11×11. The parallel implementation on the MPP is exactly same except that correspondences are established at every point rather than on a sparse grid of points. Thus this implementation needs no interpolation step. The results obtained in both cases are comparable for this image. However for images which are not smooth, the implementation on the MPP giving results at each pixel is more accurate. The time taken on the MPP is about 10 seconds.

The second method of motion detection is applicable to pairs of images in which corresponding areas can experience considerable translation as well as rotation. Ice floe images obtained from the synthetic aperture radar (SAR) instrument flown onboard the Seasat spacecraft belong to this class. The time interval between two successive images of a given region was as much as three days. During this period, large translations and rotations of ice floes can occur. Therefore, conventional local correlation techniques which perform searches in a small neighborhood to detect translated features have a very small chance of success. To account for large translations and rotations, it is necessary to perform large area searches in a three-dimensional space (two translational and one rotational). This makes conventional correlation techniques computationally intensive even on a high-speed parallel computer such as the MPP. A parallel algorithm has been developed and implemented on the MPP for locating corresponding objects based on their translationally and rotationally invariant features. The algorithm first approximates the edges in the images by polygons or sets of connected straight-line segments. Each such "edge structure" is then reduced to a "seed point." Associated with each seed point are the descriptions (lengths, orientations, and sequence numbers) of the lines constituting the corresponding edge structure. A parallel matching algorithm is used to match packed arrays of such descriptions to identify corresponding seed points in the two images. The matching algorithm is designed such that fragmentation and merging of ice floes are taken into account by accepting partial matches. The technique has been demonstrated to work on synthetic test patterns and real image pairs from Seasat in times ranging from 0.6 to 0.7 seconds for 128×128 images.