University of Maryland
College Park, Maryland 20742

Techniques for the Processing of Remotely Sensed Imagery

Final Technical Report covering the period April 1972-June 1974

NGR-21-002-351

Principal Investigators:
E. S. Deutsch (April 1972-Dec. 1973)
A. Rosenfeld (Jan.-June 1974)

Computer Science Center
This project was concerned with the development of image processing techniques applicable to the analysis of satellite imagery. Further detail as to the specific areas investigated are given in the abstracts of the technical reports listed below.

1. A comparison of techniques for the classification of low resolution satellite imagery
   N. J. Belknap
   (Computer Science Center Technical Report 215)
   December, 1972

   The work presented here investigates the use of a variety of techniques which might be used in the classification of low resolution satellite imagery. Broadly speaking, these consist of gradient operations, histogram methods, gray level detection, and frequency domain operations. The techniques are first examined on a local basis within images (Phase I). Those found useful are then used in the global classification scheme (Phase II) in that the results derived locally are used to guide the global classification decision which is finally based upon the type of interface between two possible classes. The resulting approach is applied to satellite imagery containing considerably complex visual information from the photointerpreter's point of view. As anticipated only partial classification of images was possible for reasons which are discussed. It is concluded that factors entirely external to the image (e.g., season) must be employed in order to achieve superior classification.

2. On the use of the Hadamard transform in digital image matching
   E. S. Deutsch and Z. F. Wann
   (Computer Science Center Technical Report 216)
January, 1973

The use of Hadamard transform filtering in digital image matching applications is described. In most applications of Hadamard transforms emphasis has been placed upon the fidelity of the reproduced image; typically, the objective was to minimize the amount of information required to represent an image. In image matching applications -- here one wishes to establish whether two given images are largely the same -- it turns out that the opposite is the case since in initially establishing the possible existence of a match, or a mismatch, one is no longer interested in minute detail. Because it is usually costly in terms of computer operations to determine the potential of a match between two images, the matching philosophy adopted here is one whereby a coarse matching criterion is sought first. Only thereafter should a finer matching process be undertaken. This approach will find applications in the analysis of satellite imagery when temporal change is to be detected. Indeed the large size of the images, as well as their overwhelming number, seems to dictate such an approach.

Hadamard domain filtering to an excessive degree has been found to be extremely useful in coarse image matching. Since one is interested in global matching first, the problem becomes one of how much filtering can be tolerated before the images are rendered useless at this level. The paper shows that compared to conventional matching methods, this technique reduces the average number of operations required to establish a match criterion, thus giving an overall reduction in the time taken to produce a match or mismatch decision. It also reduces the positional error of mismatch.

In situations in which one of the images contains
noise, the matching problem is aggravated still further. The paper will show that the approach adopted is useful under these circumstances, too.

3. On the quantitative evaluation of edge detection schemes and their comparison with human performance
J. R. Fram and E. S. Deutsch
(Computer Science Center Technical Report 221)
March, 1973

A technique for the quantitative evaluation of edge detection schemes is presented. It is used to assess the performance of three such schemes using a specially-generated set of images containing noise. The ability of human subjects to distinguish the edges in the presence of noise is also measured and compared with that of the edge detection schemes. The edge detection schemes are used on a high-resolution satellite photograph with varying degrees of noise added in order to relate the quantitative comparison to real-life imagery.

4. Digital matching using the Hadamard transform: further experiments
Z. F. Wann and E. S. Deutsch
(Computer Science Center Technical Report 222)
May, 1973

Further work in image matching using the Hadamard transform is presented. It is shown that low pass filtering the imagery initially, produces superior matching results all round. It is shown that simple remapping of gray levels, while increasing the number of operations required to produce a match, does not increase the mismatch error. Some equivalences between image averaging and low pass filtering in the Hadamard domain are also shown.

5. A quantitative study of the orientation bias of some edge detection schemes
Further work on the evaluation of a particular set of edge detection schemes is described. The results obtained are compared with those obtained from an edge detection scheme using a texture oriented approach. The orientational bias of these schemes is addressed in particular. Improved qualitative observations are reported and a comparison of the evaluation method discussed here with another edge detection evaluation method is presented.

6. Edge and line detection in ERTS imagery: a comparative study
R. Eberlein, G. J. VanderBrug, A. Rosenfeld, and L. S. Davis
(Computer Science Center Technical Report 312)
June, 1974

Several local edge detection operators were applied to a set of ERTS pictures of the Monterey, Calif. area. Gradient operators performed consistently better than Laplacian operators in detecting edges. It was also found that if a grayscale normalization operation, "histogram flattening," was applied to the pictures first, the edge detector outputs were greatly enhanced. The use of interpolation for more accurate location of edges on a digital picture was also briefly investigated. Curve detection operators were applied to the edge detector outputs; this had the effect of enhancing the edges while suppressing noise.