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PROGRESS REPORT

TO THE

NATIONAL SCIENCE FOUNDATION

FOR

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ENTITLED

IMAGE PROCESSING ALGORITHMS FOR UTILIZING A PRIORI INFORMATION FOR EARTH SCENE SEGMENTATION

SUBMITTED BY

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FOR THE PERIOD

APRIL 1, 1983 - MARCH 31, 1984

1. SUMMARY OF OVERALL PROGRESS

Research activities in the first year of this grant focused on a parametric method for detecting lines and edges in an earth scene. The objective of the research is to develop a method of extracting descriptions of objects in the scene which give parametric descriptions so their existence can be tabulated rather than only pictorially displayed. Most existing edge detection and scene segmentation methods produce pictures from pictures and a parametric description of the coordinates of the object is not produced.

In the research done on this grant in the first year, the parametric or Hough transform is applied to the scene segmentation task. This transform can provide a parametric description of objects useful for image description and registration.

Initial stages of the research investigated methods for first generating an edge image of a scene and for then detecting edge or line segments needed for certain Hough implementations. Many edge detection methods exist and their performance is well documented in the literature. We found the performance of many methods similar and chose the Sobel algorithm[1] as sufficient for purposes of this research. Setting up a suitable threshold level

appeared to be a more significant problem and methods were compared for choosing a threshold. The a priori maximum likelihood and Heyman-Pearson methods were chosen as candidates. The a priori method produced the best results and was used in subsequent research.

The second activity focused on methods for obtaining the Hough transform of an edge image. Three methods are under study and are described briefly as follows:

1. Direct Hough transformation: The uniqueness of the method was observed by Hough in a U.S. patent[2] which describes the transformation from points in image space to sinusoidal curves in parameter space. Each edge or line pixel at location x,y in image space is transformed as:

$$\rho = x\cos\theta + y\sin\theta$$

Colinear pixels will have sinusoidal curves which all intersect at the same point. The ρ,θ space is quantized and occurrences of curve coordinates are accumulated; cells having large counts indicate the existence of lines in the image.

2. Least Squares Disk: A small disk is used as a window on the edge image and a least-squares line is filled in the disk. The disk is moved over the image and the results are the location and angle of the short line segment in the disk.

The process produces one point in Hough space for each position of the disk if a line segment was judged by the algorithm to exist in the disk.

3. Hueckel Edge and Line Detection: The Hueckel[3] algorithm uses a sequence of masks to determine the existence and orientation of a line or edge segment in a disk, as in Method 2. The philosophy and output are similar to Method 2.

The goal of the research is to determine the accuracy achievable using parameter space methods and to compare the results to those for existing correlative or template-matching methods. To do this, the methods were first evaluated using analytical models. The methods were then implemented and simulated and real satellite imagery was used to obtain accuracy estimates.

Specific-progress items include the software implementation of the Hough transform methods and of simulation algorithms for generating edge images with varying signal-to-noise ratios. Data collection is in progress for signal-to-noise ratios from .05 to 10. It has been observed that the Hough method has the ability to detect the existence of a line at very low signal-to-noise ratios. Theoretical results for conventional correlation methods indicate that these methods fail for signal-to-noise ratios below .3 to .5, as described by Svedlow[4]. We feel the parameter space methods will offer an improved method of finding objects in

earth scenes and will be especially useful for registration of scenes which have undergone significant temporal change or are very different because they were gathered by different types of sensors, i.e., multispectral scanner and imaging radar.

2. CURRENT PROBLEMS

No unusual problems exist which would impede the progress of the research.

3. WORK TO BE PERFORMED

The research to be performed during the second year will continue and complete the parameter space line and edge finding investigation and provide the basis for further scene segmentation method development. The concept of the use of a priori information is implicit in the present research via the search for long lines and edges which are assumed to be roads or other significant features relative to shorter, more local features.

Research in the second year will expand on the use of a priori information as it applies to finer structures in the scene. Statistical representation of such a priori information as size and orientation of crop fields, size and shape of buildings, road orientation, and spacing will be developed.

A report on the parameter space investigation[5] is expected to be produced during the second year.

REFERENCES

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2. Hough, P.V.C., "Method and Means for Recognizing Complex Patterns," U.S. Patent 3069654, Dec. 18, 1962.

3. Hueckel, M.H., "An Operator Which Locates Edges in Digitized Pictures," Jour. Assoc. Comp. Machinery, Vol. 18, No. 1, Jan. 1971, pp. 113-125.

4. Svedlow, M., C.D. McGillem, P.E. Anuta, "Analytical and Experimental Design and Analysis of an Optimal Processor for Image Registration," Laboratory for Applications of Remote Sensing, Purdue University, West Lafavette, IN 47906-1399. LARS Technical Report 090776.

5. Anuta, P.E.; C.D. McGillem, "Parameter Space Techniques for Image Registration," to be published.