## 3.3 REPORT OF SUBPANEL ON FEATURE EXTRACTION*

The feature extraction panel met during two sessions to define research needs in this subject area for earth resource observation systems. The panel consisted of:


Mr. Doug Carter
USGS

Mr. R. Kent Lennington
Lockheed

Mr. Michael Rassbach
Elogic, Inc.

Mr. John T. Dalton
NASA/GSFC

Dr. Thomas Lynch
NASA/GSFC

Dr. Ray Wall
JPL

Ms. Ruth Whitman
ORI

Dr. Robert Haralick
Virginia Polytechnic Institute


### 3.3.1 State of Knowledge

There are three issues in the subpixel feature estimation problem: 1) the identification of image models which adequately describe the data and the sensor it is using, 2) the construction of local feature models based on those image models, and 3) the important problem of trying to understand these effects of preprocesing on the entire process. We identified two classes of image models for subpixel feature estimation which we thought were worthwhile pursuing. We don't want to give the impression we thought that those were the only two, but in terms of both what we heard from Bob Haralick and the experience of the people on the panel, we first distinguished techniques based on surface fitting which have underlying assumptions about continuity and deferentiability of the intensity surface; these people tend to do their analysis on a pixel-by-pixel basis, without any direct concern for the overall organization of features of edges and lines to form long straight lines with smooth curves in the picture. This was opposed to what might be called structural models, which essentially accommodate geometrical models which describe the shape, size, and arrangement of pieces in a picture, and statistical models, which tell you about the ways in which they are colored. These second types have been distinguished from surface fitting models in terms of computations by the fact that the feature detection is done more on the basis of analyzing local neighborhoods to take advantage of the information in the geometric model. For example, assume that a picture is piecewise constant upon the edges between piecewise constant regions to better than a pixel. That doesn't preclude combinations of these approaches or others, but we certainly think it's important that people pay serious attention to this problem of being very specific about exactly what models they are using to describe the images and exactly what the local feature models are that they are using to estimate the location of these local features.

Another topic which we felt deserves some attention here, is integration of these features into high-level descriptions of content in the image. Some examples, in case people aren't sure what we were talking about, include line, curve, and intersection detection, shape detection for specific classes of

*Edited oral presentation.

shape that might be important, deriving information about the topology of areas in the picture, and more generally, segmentation techniques based upon construction of local features. It is important to note that the analysis of the effect of preprocessing on these local feature estimation techniques is going to vary from sensor to sensor.

The development of ground control point libraries for automated selection presents two concerns. One is the organization of these GCP libraries for rectification problems, i.e. the problems of automatically selecting by computer the specific GCP's for particular registration tasks. Of concern are the types of things that have to be contained in the description of any one of these patterns, because we were looking for more general representations that you can find in pictures besides just a range of spectral information say derived from a particular sensor in a particular time to represent that pattern for matching for all other times. Second is the importance of integrating ground control patterns in a data base management system, so that you can interface to a large number of sensor image types with an automatic selection system.

In terms of problems of operational and experimental validation, the issues include choosing appropriate simulated and real-image and ancillary data, and being able to establish validation criteria, to compare different techniques.

### 3.3.2 Recommended Research Tasks

We spent much of our time trying to establish a set of priorities in each one of these areas. Figures 1 and 2 summarize our conclusions. In the local feature detection area we felt that priorities should lie with the construction, design, and development of image and feature models. A second priority ought to be the actual data-set selection and the design of operational validation techniques. A third should be investigation of these feature integration mechanisms again; that is, compute more structural description of image patterns and put together the results of these local analyses. Then fourth, the effects of preprocessing on feature detection should be considered.

The other major topic was ground control point library priorities. Here, we felt that the first thing that needs to be looked at is what the content would be of such a library. Would it be an extended version of what's planned to be made available now, in terms of including standard types of chips you have now, or things like chain codes of shapes, information about texture and spectral content? A second effort should be creating an automatic selection system for a single sensor (based around a data base management system, feasibility study in that area). A third possibility is dynamic ground control pattern libraries; the idea here being that as you use chips over and over again, you begin to collect information about not only the reliability of particular points for rectification, but also information on the what patterns would be derived from map information only. Thus, when you start looking at different types of sensors, and try to use these patterns to rectify, you can collect information about the actual spectral properties on the ground for that type of sensor. Furthermore, you can integrate that into the definition of that chip and use it for subsequent selections. Then a fourth priority, a much longer range task, is to look at the feasibility of multisensor systems that have a much larger data base. Here we have to really face up to the problem

of whether or not you really can effectively construct patterns which can be used across sensors.

In Figure 3 we tried to show course approximations to times that should be allocated to these tasks and their ordering in time; i.e., which one can overlap, and which necessarily proceed others for logical or cost reasons.

1. IMAGE AND FEATURE MODELS

2. DATA-SET SELECTION AND OPERATIONAL VALIDATION

3. FEATURE INTEGRATION MECHANISMS TO COMPUTE MORE STRUCTURAL DESCRIPTION OF IMAGE PATTERNS

4. EFFECT OF PREPROCESSING ON FEATURE DETECTION

FIGURE 1. LOCAL FEATURE DETECTION - PRIORITIES

GCP LIBRARY DESIGN AND DEVELOPMENT/TESTING

1. INITIAL PATTERN CONTENT

   - STANDARD CHIPS

   - CHAIN CODES OF SHAPES

   - TEXTURE

   - SPECTRAL CONTENT

2. SINGLE-SENSOR OBMS FEASIBILITY

3. DYNAMIC GCP LIBRARIES

4. FEASIBILITY OF MULTISENSOR SYSTEMS

FIGURE 2. GCP LIBRARIES - PRIORITIES

FIGURE 3. TIME FRAME