REMOTE SENSING APPLICATIONS IN FORESTRY

THE DEVELOPMENT OF AN EARTH RESOURCES INFORMATION SYSTEM USING AERIAL PHOTOGRAPHS AND DIGITAL COMPUTERS

by

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WORK PERFORMED DURING PERIOD COVERED BY THIS REPORT.

Automated Digital Terrain Modelling.

This work in analytical photogrammetry was provided by Dr. Jan Van Roessel. He demonstrated that automatic three-dimensional mapping of forest terrain was technically feasible. The examples were black and white photography at scales of 1:10,000 and 1:24,000. However, extensive testing will be required to accurately predict costs for a wide range of conditions. For example, obtaining a standard error of elevation of 1.5 meters would cost about 33 cents per acre at a scale of 1:30,000. But we don't know the cost per acre if the standard error were doubled.

The major improvement in terrain modelling was the addition of the capability of joining small quadrangles together to form one large model about equal to the effective area of the pair of photographs.

Improvements of somewhat lesser importance include; 1) the use of up to 16 grey levels, 2) the elimination of several coordinate transformations, and 3) the annotation of three-tone hysocline maps with elevations.

The evolution of the digital mapping system can be traced in annual progress reports beginning in 1969 (1, 2). A thorough description of the system is contained in his doctoral thesis (3). The most recent published description is contained in a paper delivered at the International Union of Forestry Research Organizations in the spring of 1971 (4). This last item demonstrates the need for incorporating forest recognition capabilities into the system.

Earth Resources Information System.

This work in computer mapping was provided by Elliot Amidon, David Sharpnack and Robert Russell. The following algorithms of the Earth Resources Information System have been completed and are available for distribution:

A. Subprograms

1. Data acquisition and editing
    a. Read digitizer tapes
    b. Convert digitizer data to computer form
    c. Edit digitizer data and check for errors
    d. Remove superfluous points from a boundary

2. Processing
    a. Close a boundary
    b. Thin a boundary
    c. Compute the area within a boundary
    d. Determine whether a given point is within a boundary
    e. Intersection of 2 boundaries
    f. Union of 2 boundaries

3. Output
    a. Print points or boundaries
    b. Plot points or boundaries on digital plotter

B. Main (utility) Routines

1. Print contents of a digitizer tape

2. Plot contents of a digitizer tape

A U. S. Forest Service mapping contractor used 1:55,000 IR color, RB-57 photography of the Stanislaus National Forest to up-date 1:15,840 panchromatic photography. This work is a part of a pilot project to apply our research on multi-stage sampling and the Earth Resources Information System to the current problem of developing a management plan for the Stanislaus National Forest.

Programming of the Resource Information System continues. One program will transform digitizer coordinates to the Lambert Conformal coordinate system. Another program will enable the use of Universal Transverse Mercator coordinates. One system can be transformed to another via geodetic coordinates.

A systematic work-flow procedure is being devised and tested using 110 maps of the Stanislaus National Forest. Map data are combined with multi-stage sampling to estimate current timber volume and with growth information to predict future volumes. About 20 maps have been manually digitized, processed on an Univac 1108, and plotted on a CalComp plotter.

Automated Photo Interpretation

This pattern recognition work was provided by David Sharpnack. The development of an automated photo interpretation scheme for classifying land classes on 1:110,000 Ektachrome transparencies is continuing. The data was collected on a PDS micro-densitometer. Ninety to 180, 32 x 32 blocks of density readings on each of 11 land types was recorded.

Densities were recorded using red, green, and blue filters as well as with no filter. Land classes include water, rock, brush, grass and 7 sizes and densities of timber.

The screening of variables for inclusion in a classification model has been started. The first variables examined were the first four moments of the distribution of densities in each 32 x 32 data block. The distribution of these variables were plotted for each land class for the four filter types. We found that the distributions of these moments were essentially the same over all land classes. Differences that were found were due to the distinctly multi-model nature of the distributions. These variables do not appear to be useful for a linear discriminant function but might be used in an empirical distribution classification model. A comparison of the plotted distributions showed very little difference between filters.

To examine this lack of difference more closely sample points were selected from each land class and moment correlation coefficients were calculated for all filter pairs. For example, the r between the red filter density and the green filter density was computed for 100 points. This was done for 3 separate samples of 100 points in each of 11 land classes. The r was calculated for all possible pairs of filters; e.g. red-green, red-blue, red-clear, green-blue, green-clear, and blue-clear. All 198 r's were highly significantly different from zero. They ranged from about .3 to .99. Thus over most land classes the information provided by the second, third, and fourth filter is slight. Following a suggestion by Nancy Norick of the Remote Sensing Project at PSW, the r's were recalculated after subtracting the clear reading from the red, green, and blue readings. Of these

198 r's only 151 were highly significantly different from zero. The absolute values of the coefficients ranged from .002 to .840. This improvement in the independence of the filter readings was most noticeable for water where the r's ranged from .002 to .318. A separate study has been started to search for better filters and filter combinations to further improve the usefulness of multi-filter density readings.

The second set of variables to be tested is the coefficients of the power function of the Fourier Transform. The Fourier Transform was found for each 32 x 32 data block using a Fast Fourier Transform program. To facilitate the examination of the frequency distributions of the 1024 power coefficients for 1278 data blocks in 11 land types, the coefficients were summed into 16 groups. Each group sum is a measure of the power in 1/16th of the two dimensional frequency spectrum. The distribution of these 16 variables was plotted for each land class for the red filter minus no filter data. Because of the high cost of these calculations on a digital computer only the red filter densities have been studied so far.

Of the 11 land types only water has a distinctly different distribution for some of the power coefficients. The importance of this difference and that of some smaller differences will be tested using linear discriminant functions.

WORK CURRENTLY IN PROGRESS

A. Automated Digital Testing

Automated digital terrain modelling operational testing of this system ceased with the resignation of Dr. Jan Van Roessel in 1971.

B. Earth Resources Information System

The work-flow procedure for manually digitizing the 110 maps of the Stanislaus National Forest is being refined continuously. An alternative data input device is also being examined -- the PDS scanning micro-densitometer. The maps are reduced 8 times onto a panchromatic negative. An appropriate combination of spacing and aperatures is sought so that the lines are neither too wide or broken. Algorithms are being developed to thin the lines, find nodes, and number the segments correcting nodes. These segments then enter the established system and are processed like hand-digitized segments.

C. Automated Photo Interpretation

Testing of the power coefficients of the Fourier Transform will continue by estimating and testing coefficients for the linear discriminant functions.

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