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COMBINING HUMAN AND COMPUTER INTERPRETATION

CAPABILITIES TO ANALYZE ERTS IMAGERY

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I. ABSTRACT

The human has the ability to quickly delineate gross differ-
ences in land classes, such as wildland, urban and agriculture on
appropriate ERTS images, and to further break these gross classes
into meaningful subclasses. In agricultural areas, the subclass-
es can be delineated on the basis of general tone and texture
differences that relate to crop type and field size. In the
wildland areas, delineations can also be made, based on tone and
texture, which represent general vegetation systems, such as
grasslands, brush, trees, and barren areas. The computer, how-
ever, can more efficiently analyze point-by-point spectral infor-
mation and localized textural information which can result in a
much more detailed agricultural or wildland classification based
on species composition and/or plant association.

These complementary capabilities are combined to provide the
"minimum cost" processing of Remote Sensing data for resource in-
ventory.

II. INTRODUCTION

When processing ERTS imagery, several factors affecting the cost and accuracy of land use
classification become apparent. (1) There are numerous, irregularly shaped areas in the imagery
which can be rapidly delineated into classes by the photo interpreter accurately enough to meet
user requirements. (2) Some of these areas, because they are of little or no interest to the user,
can be disregarded. (3) In localized areas, detailed automatic spectral pattern classification of
plant species and plant communities can be done with a high degree of accuracy. (4) Computer clas-
sification costs increase rapidly with the number of classes being considered for each picture ele-
ment. (5) There is a one-to-one relationship between the number of points being classified and the
cost of computer classification.

With these factors in mind, a hardware-software system has been developed at the Center for
Remote Sensing Research that integrates human and computer capabilities to increase classification
accuracy and reduce processing costs.

III. PROCESSING

Human and automatic processing of the ERTS data goes on in parallel as shown in Figure 1 to
the point where the information generated by both methods is merged and the final product is out-
put in the form of a classified image and summary statistics.

Human processing starts using the appropriate ERTS image of the study area. The interpreter
quickly delineates gross differences in land use classes, such as wildland, urban and agriculture.
If possible, these classes are further   divided into meaningful subclasses. In agricultural
areas, they can be delineated on the basis of general tone and texture differences that relate to
crop type and field size. In wildland areas, delineations which represent general vegetation

Reformat
ERTS CCT
of Bulk MSS
Data

Photo Interpreter
Stratification
of ERTS Image

Extract and
Build Study
Area from
Reformatted
Tape

Digitize Strata
Boundaries
on Photo

Determine Tape
Coordinator of
Control Points

Determine Photo
Coordinates of
Control Points

Extract Class
Training Data
by Strata

Transform Photo
Coordinates of
Strata to ERTS
TAPE Coordinates

Compute
Classification
Statistics from
Strata

Generate Strata
Mask in Terms
of ERTS TAPE
Coordinates

Read Mask Point
and Corresponding
ERTS TAPE
Point

Classify Point
and place It in
Output Image

Yes ◄ Is
This Point
To Be Classified ► No

Put Photo
Interpreter Class
in Output Image

Is
Classification
Complete ► No
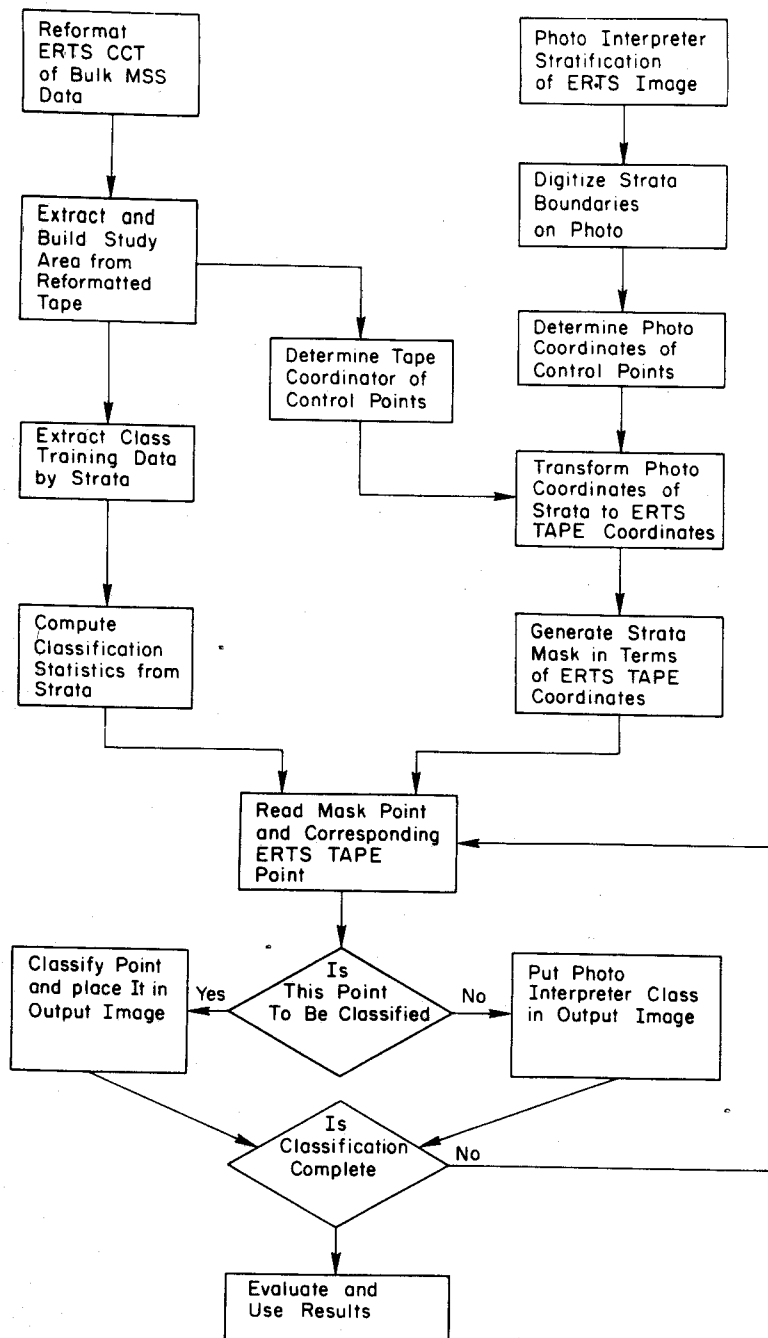
Evaluate and
Use Results

Figure 1. This flow chart represents the basic processing of an ERTS image that integrates the human and computer information extraction capabilities to optimize the cost effectiveness of the system.

systems such as grasslands, brush, trees, and barren areas, can also be made based on tone and texture. The boundaries of the strata are then digitized and recorded on magnetic tape, using either the comparator or coordinate digitizer, and a description of the individual stratum is entered on the tape. The image coordinates of control points are also recorded to be used to relate the image coordinate system to the ERTS tape coordinate system.

At this point in the processing, the tape coordinates of the control points obtained from the reformatted study area along with scale and skew data are input into a transform which then converts photo interpreter strata coordinates to tape data coordinates. This transformation is verified and then applied to the digitized coordinates of the strata boundaries. This produces a point-by-point overlay in which each boundary point corresponds to an ERTS picture element. Within these boundaries each point on the ERTS tape is then assigned to the corresponding photo interpreter strata. The training set for automatic classification is extracted by stratum from the ERTS image, statistics computed and test sets classified to ensure accurate classification within each stratum.

The next step is the detailed classification of each of the ERTS picture elements. A picture element and the corresponding stratification point are read. If the strata is one to be spectrally classified, the classification is done and the results put in the corresponding point of output image. If not, the photo interpreter stratum is put in the output image. This is continued point-by-point or by some sampling scheme until the processing is completed. The resultant image is a combination of photo interpretation and automatic classification with a statistical summary of the classification. As an alternative to photo interpreter delineation of strata, existing geological, geographical, or political maps can be used to stratify the ERTS data for classification or used to partition the statistical summary into meaningful reporting areas after classification.

Evaluation of Combined Analysis

To evaluate the utility of the combined human and computer discriminant analysis of ERTS-1 multispectral multidate imagery in estimating the area of agricultural crops, the information obtained from the discriminant analysis, ground data and high flight imagery of the intensive test site was used to determine the optimum size of the "Sampling Unit" (SU) and the number of sampling units required to obtain acceptable estimates of crop area for San Joaquin County.

The size of the sampling units required for agricultural estimate in San Joaquin County using ERTS-1 data in the first phase is 25 x 35 picture elements ("Pixels") 386 hectares, on the ground This was chosen based on the estimate of the coefficient of variation as shown in Figure (2) and the plot of expected error in transferring the ERTS SUs to the corresponding low altitude photography for precise area measurement Figure (3).

Based on the error between the ground and discriminant analysis, estimates of the value of each sampling unit (SU), the number of ground samples (n) required to estimate the area of each of the major crops present in San Joaquin County using both a stratified and unstratified model was computed using a probability sampling scheme.

$$n = \frac{N\ t^2\ (S_e)^2}{N(AE) + t^2\ (S_e)^2}$$

N = total number of SU in population
t = t value from "students t" distribution for .95
AE = Allowable error in acreas
S_e^2 = Variance between ERTS estimate and ground estimate.

The S_e^2 was computed for single and multidate discriminant analysis estimates. For crop classes where harvesting had taken place prior to or shortly after the ERTS-1 launch on estimates of S_e^2 were based on previous results from multispectral photographs and multispectral scanner surveys.

The estimates of n were based on an allowable error of ±5% with a probability of .95.

An estimate of the cost of a survey (Table 1) was made, based on the estimated n, the cost of the processing of the ERTS-1 data, and the subsequent costs of processing the selected SU. The costs used are estimates and used here to demonstrate the relative utility of each of the
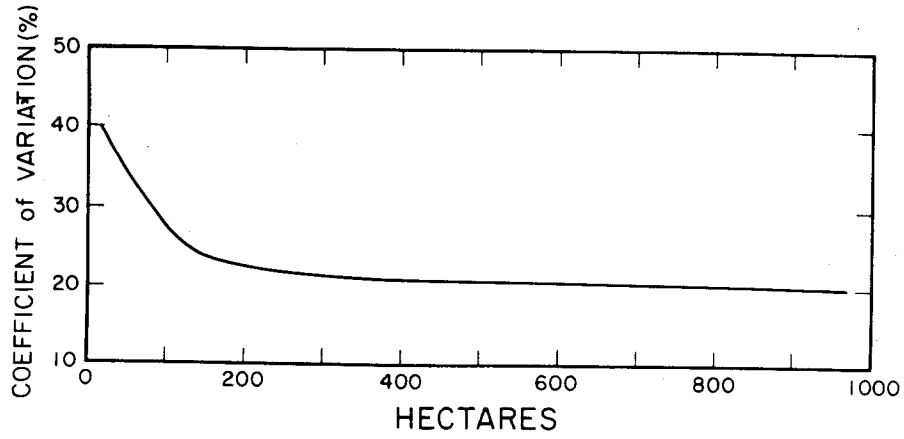
Figure 2. This plot of the coefficient of variation of the crop value
estimated by discriminant analysis of ERTS-1 data versus
the size of the Sampling Units (SU) was used to determine
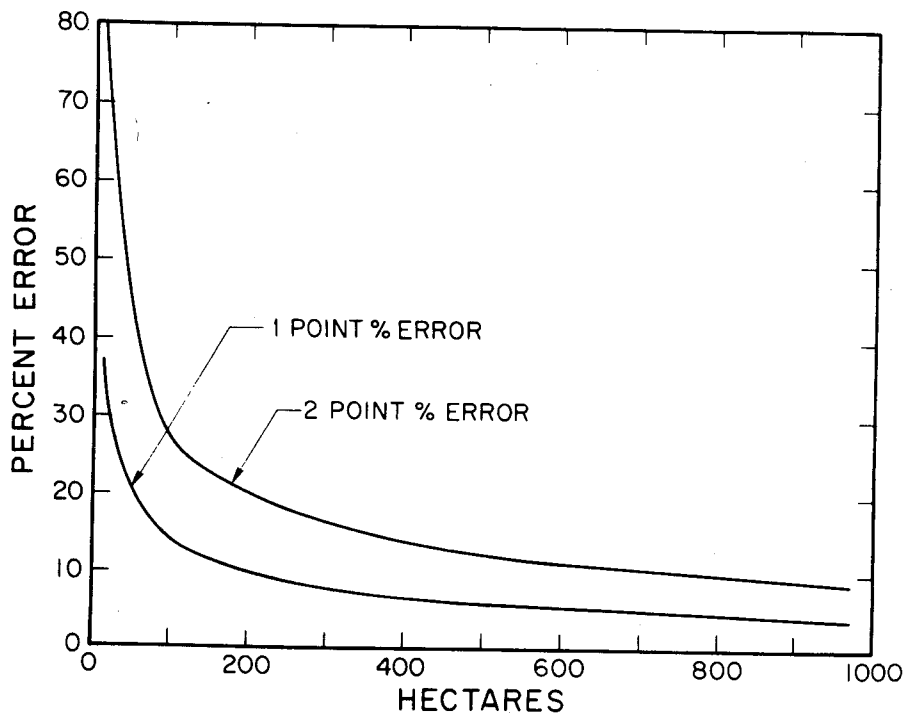the optimum SU size for random sampling.

Figure 3. This plot of the expected error in transferring the Sampling
Unit (SU) to the aircraft photography for further field size
measurements was used in determining the optimum SU size.

1A-22

information inputs from the human and computer analyses of the ERTS data.

IV. CONCLUSIONS

The plot of the relative costs (Figure 4) of the various types of inventory procedures shows the combined human-computer processing using two dates of ERTS information provides the least cost method. This least cost point is caused by reductions in computer costs due to the human stratification, reduction in the number of ground samples required, and increased computer cost as the number of dates used increases. Computer costs are reduced significantly by reducing the number of classes to be considered during automatic point-by-point classification. If, for example, 40 classes exist over the entire study area but through stratification only 8 classes are considered for each point using ten strata, a 4 to 1 reduction in computer costs would be realized. A second source of saving is the elimination of areas from automatic classification by interpreter delineation when the human can adequately specify the land use or that the area is not of interest to the resource manager. This saving is nearly one to one for each point eliminated, but the saving is reduced by the computational overhead needed to determine the point-by-point strata assignment. The sample size is reduced because the classification accuracy is increased significantly by separating, through stratification, classes that have spectral signatures so similar that they cannot be separated by the discriminant analysis routine. The sample size (n) is further reduced by the additional information obtained from the multidate discriminant analysis. The cost reduction from the remote sensing information is counteracted by the increased processing cost of utilizing more dates of imagery.
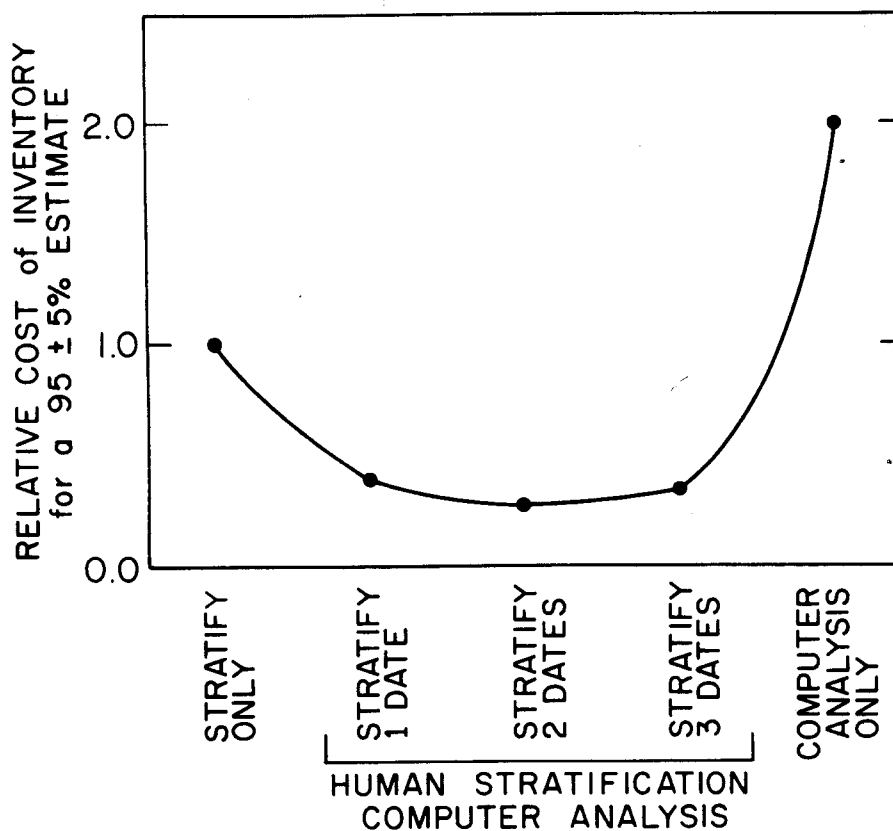

Figure 4.   This plot illustrates estimated relative costs of performing a crop inventory in the San Joaquin County test area using various information inputs, with an accuracy of ±5% at the 95% confidence level.

	STRAT-IFIED NO CALSCAN	MULTI DATE CALSCAN			CALSCAN NO STRAT-IFICATION
		ONE DATE	TWO DATES	THREE DATES	
STRATIFICATION	120	120	120	120	0
TRAINING EXTRACTION	0	660	660	660	1370
CALSCAN ANALYSIS	0	210	570	1176	8260
SAMPLING GROUND ENUMERATION and CALCULATION	n=82 8835	n=22 2430	n=11 1275	n=9 1060	8835
TOTAL COST	8955	3420	2625	3021	18,465
RELATIVE COST	1.0	.38	.29	.34	2.06

TABLE I.