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COMBINING HUMAN AND COMPUTER INTERPRETATION CAPABILITIES TO ANALYZE ERTS IMAGERY

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Abstract

The human photo interpreter and the computer have complementary capabilities that are exploited in a computer-based data analysis system developed at the Forestry Remote Sensing Laboratory, University of California. This system is designed to optimize the process of extracting resource information from ERTS images.

The human has the ability to quickly delineate gross differences 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 subclasses 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, however, can more efficiently analyze point-by-point spectral information 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 human and computer capabilities have been integrated through the use of an inexpensive small scale computer dedicated to the interactive preprocessing of the human inputs and the display of raw ERTS images and computer classified images. The small computer is linked to a large scale computer system wherein the bulk of the statistical work and the automatic point-by-point classification is done.

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 classification costs increase rapidly with the number of classes being considered for each picture element. (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 Forestry Remote Sensing Laboratory that integrates human and computer capabilities to increase classification accuracy and reduce processing costs.

The System

Because of the higher cost of tying up a large scale computer to do interactive processing, a "mini" computer with a substantial set of interactive peripherals (Figure 1) has been implemented. All of the ERTS tape reformatting, training area extraction, coordinate digitizing and image display can be done on this interactive system. This system is linked via dedicated, high speed communication lines to the CDC 6600-7600 computer complex at the University of California Lawrence Berkeley Laboratory, where the major computational tasks are performed. Although the system is used in the processing of ERTS data both manually and automatically, of greater interest here is the integration of human and computer capabilities.

Processing

Human and automatic processing of the ERTS data goes on in parallel as shown in Figure 2 to the point where the information generated by both methods is merged and the final product is output 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 subdivided 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 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.

Conclusions

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 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. Preliminary results indicate that this separation is important between strata in the agricultural areas and between wildland and agricultural areas.

Future Work

This interpretation technique will be tested in the wildland agricultural complex to determine the optimum mix of human and computer efforts. The next major developmental step along these lines will be the joining of adjacent images through the use of computer mapping techniques. This will allow the inventory and mapping of large geographic regions to a common base through the integration of human and computer capabilities.

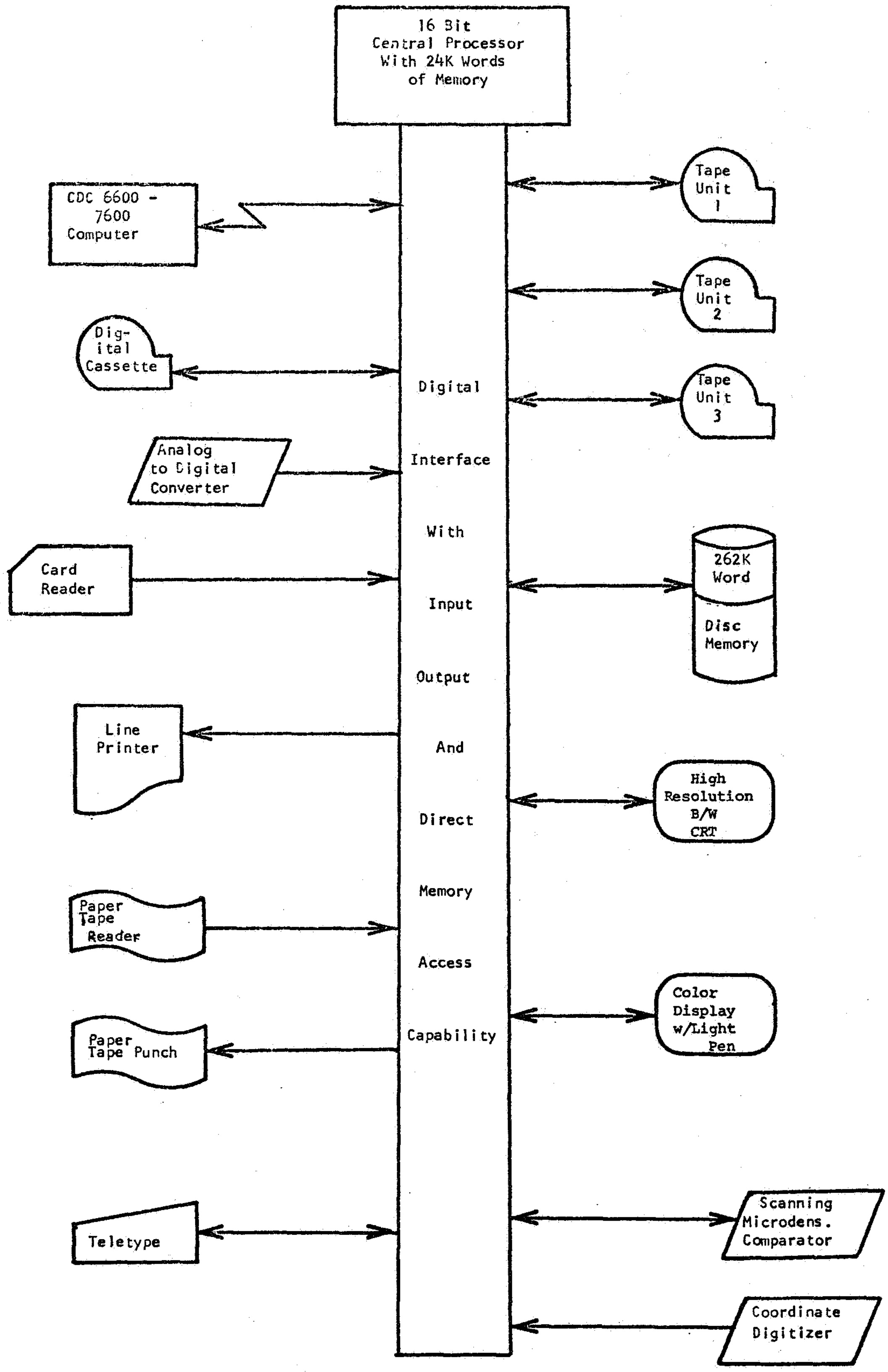

Figure 1. Forestry Remote Sensing Laboratory Computer display system.

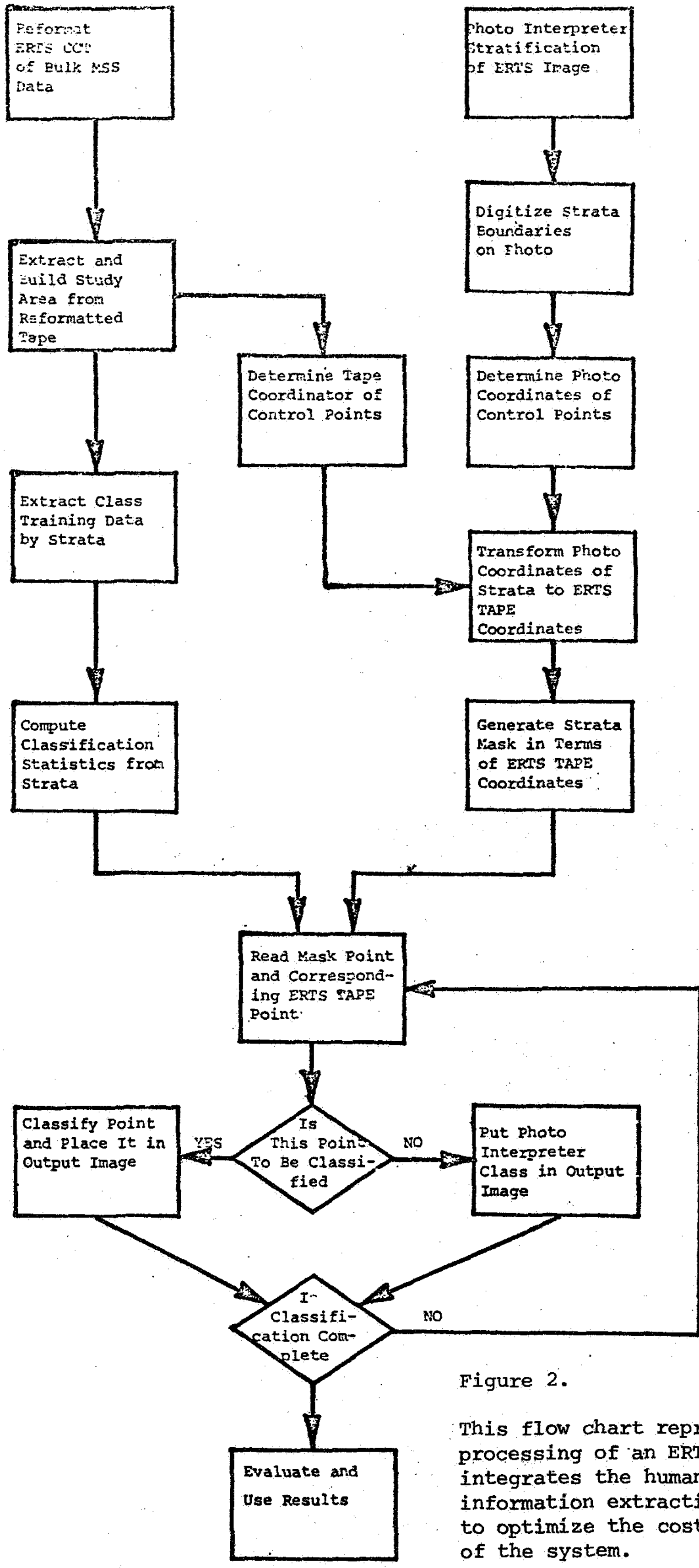

Figure 2.

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.