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THE KARS IMAGE ANALYSIS SYSTEM: A LOW COST INTERACTIVE SYSTEM FOR INSTRUCTION AND RESEARCH

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I. ABSTRACT

The Kansas Applied Remote Sensing (KARS) Program and Department of Geography-Meteorology have developed an interactive digital image processing program package that runs on the University of Kansas central computer. The module form and simple Fortran programming of the package has allowed easy and rapid upgrades and extensions of its capabilities. The package is comprised of subimage extraction and rectification,image display and enhancement, and both supervised and unsupervised classification routines. It has been used in both instructional and research settings at the University.

II. INTRODUCTION

The Kansas Applied Remote Sensing (KARS) Program and Department of Geography-Meteorology at the University of Kansas have developed an interactive digital image processing program package that runs on the University central computer, a Honeywell Level 66 multi-processor system. The package was primarily developed for use in a graduate level remote sensing course in the Geography Department and in five-day short courses offered by the KARS program. The modular, subroutine -oriented structure, simple programming and interactive time-sharing mode of operation of the package have also made it a suitable vehicle for image processing research. The program package is written in near-ANSI 1966 Fortran and is easily transportable to most systems with Fortran compilers. It has no specialized input-output requirements. However, the authors use a hard-copy terminal with variable character spacing in order to produce scale-corrected grey-shade images and maps.

The program package is comprised of three modules of processing functions: subimage extraction, rectification and preprocessing; image display and enhancement; and image classification. Details of each module are given in the following sections.

III. SYSTEM CHARACTERISTICS

A. SUBIMAGE EXTRACTION, RECTIFICATION AND PREPROCESSING

A complete Landsat scene is transferred from tape to random-access files on a dedicated disc. Program SUBIMAGE then extracts, unpacks and deskews a 120x120 pixel subimage and writes each band to a separate random-access file. SUBIMAGE is the only batch program in the package. Programs HAZE and DESTRIPE are used to preprocess the image data. Program DROPOUT replaces a bad or missing line of data with the mean of the adjacent lines.

B. IMAGE DISPLAY AND ENHANCEMENT

Program HISTO produces raw image histograms and generates, on a hard-copy terminal, enhanced grey-shade images having between three and ten grey levels. Linear contrast-stretching, histogram normalization and direct specification of histogram intervals are available enhancement options. The images are output on a DecWriter LA34 line-printer terminal, or equivalent, that has variable character and line spacing. By using 16.5 characters per inch (cpi) and 12 lines per inch (lpi), X-format Landsat scenes can be displayed with a linear distortion of less than 1-1/2 percent. EDIPS format images, which are resampled to a 57x57 m square pixel, require settings of 12 cpi and 12 lpi.

Various image enhancement options are available. Program SMOOTH uses a 3x3 moving window average to generate a smoothed image. Program EDGE employs a 3x3 moving window and doubles the deviation of a pixel from its local neighborhood mean to edge-enhance the image. Program TEXTURE employs a 3x3 window and computes the absolute deviation of a pixel from its local neighborhood mean. Program RATIO computes and rescales the ratio of two bands. Program TVI computes a modified form of the Transformed Vegetation Index. The modified images can be saved and used later in the classification routines, if desired.

Programs to perform data-reduction using SCSS factor analysis routines are also available.

C. CLASSIFICATION

Both supervised and unsupervised classification routines are available in the package. Utility programs PIXVAL and SCATPLOT can be used to print out the digital number values and generate scatter plots for specific areas of interest in the image, either to refine training sites in the supervised classifier routines, or to investigate cluster categories in the unsupervised classifier.

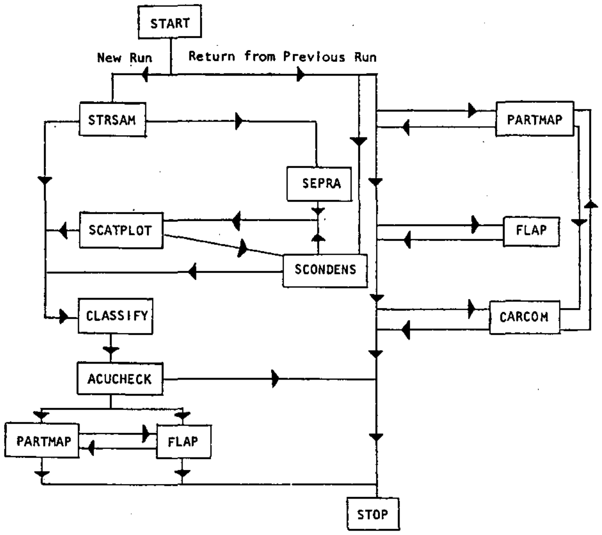

Figure 1. Schematic Diagram of SCLAS, the supervised classifier.

A schematic diagram of the supervised classifier SCLAS is given in Figure 1. Training site data is interactively entered using subroutine STRSAM, and training sample statistics are computed and printed out. Subroutine SEPRA uses a modified version of the transformed divergence statistic to compute pairwise category separabilities. Training sample data can be displayed by subroutine SCATPLOT, and inseparable categories combined by subroutine SCONDENS. The refined training sample data is input to subroutine CLASSIFY, which is a per-point classifier using one of three classification algorithms: parallelepiped; minimum euclidean-distance-to-mean; or maximum likelihood classifier with probability thresholding. Subroutine ACUCHECK uses the training sample data to provide an (optimistic) classification accuracy contingency table. Subroutine PARTMAP produces partial maps of selected categories. Subroutine FLAP produces binary maps of individual or groups of categories, and is used to generate a final color map using diazo transparencies. The final option available in producing classified maps is individual selection of category map symbols. This is used to cartographically combine (CARCOM) categories that are spectrally distinct but may be informationally similar with regard to a specific application. The classified image and training sample statistics are written to file at the end of each program run, allowing successive passes through the data to refine the analysis.

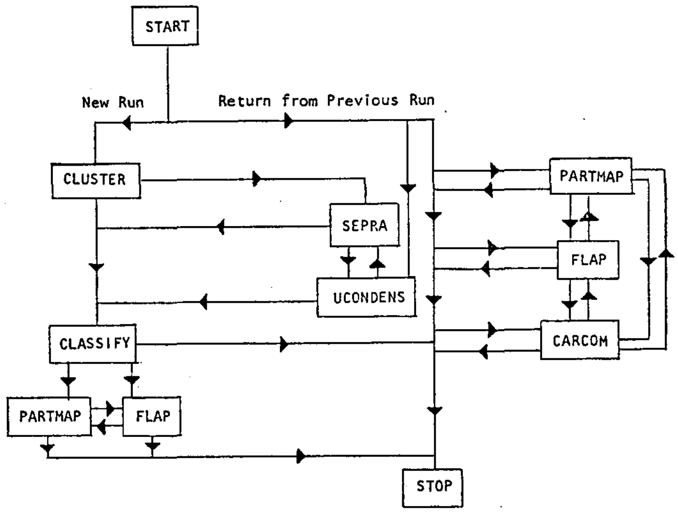

Figure 2. Schematic Diagram of UCLAS, the unsupervised classifier.

A schematic diagram of the unsupervised classifier UCLAS is given in Figure 2. Subroutine CLUSTER selects a random sample of pixels from the image and clusters them into a user-specified number of cluster categories, using euclidean distance and the sum-of-squared-errors criterion to define the clusters. The user has the option to seed the initial cluster centers, or to accept random initial values. Cluster category statistics and a bispectral plot of cluster means are produced. A separability analysis is normally performed (SEPRA) followed by a classification (CLASSIFY) and production of partial maps of selected categories (PARTMAP). The cluster categories are labelled using ground truth data in conjunction with the full and partial classified maps. Based on the category labels, separability analysis and bispectral plots, category combinations are planned using either statistical category combination (the categories are merged and a new cluster analysis (UCONDENS) and classifier run) or cartographic combination (the categories are kept separate in the classifier and combined cartographically (CARCOM) by using the same symbols in the final map). As with SCLAS, the results are written to file after each run, allowing later refinements of the classification.

D. SOFTWARE CONSIDERATIONS

The programs are written in Honeywell Level 66 time-sharing Fortran, formerly known as FORTRAN-Y, running under the operating system GCOS. This is an extended ANSI-1966 version similar to WATFOR and other common extensions. The program code differs from standard in its use of free-form statement positioning, upper and lower case, variable names of up to eight characters and character data strings delimited by " or '. The programs use both sequential and random-access disc input and output. Random I/O supports user-specified record lengths. Terminal I/O requires 132-column lines. The KU Honeywell computer does not support byte-oriented (LOGICAL*1) or INTEGER*2 memory allocation. An implementation allowing these would be somewhat more efficient.

All the programs, with the exception of SCLAS and UCLAS, have moderate central processor core requirements. However, SCLAS and UCLAS require approximately 300K bytes of core in their present form. A layered program structure would be more efficient in terms of core requirements. However, this would greatly limit the transportability of the package as layering structures are highly system-dependent.

IV. CONCLUSIONS

The program package described in this paper was developed primarily for use in an instructional setting. While it does not employ the more sophisticated classification strategies (e.g. the per-field and contextual classifiers), it does incorporate the 'basic' operational analysis and classification algorithms (e.g. the maximum likelihood algorithm). It can thus provide a fairly complete overview of digital image processing for the non-specialist, while at the same time serve as a first course in image processing for the specialist. It is highly transportable and can be implemented on most time-sharing systems with Fortran. Moreover, its simple Fortran programming has proven to be an incentive to student research in digital image processing.

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