ELAS - A POWERFUL, GENERAL PURPOSE IMAGE PROCESSING PACKAGE

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ABSTRACT

ELAS is a software package which has been utilized as an image processing tool for more than a decade by Universities, State and Federal agencies and the private sector. It has been the source of several commercial packages. Now available on UNIX workstations it is a very powerful, flexible set of software. Applications at Stennis Space Center have included a very wide range, including medicine, forestry, geology, ecological modeling, and sonar imagery. It remains one of the most powerful image processing packages available, either commercially or in the public domain.

INTRODUCTION

ELAS was developed in the late 1970's by the Earth Resources Laboratory of the National Space Technology Laboratories. Known today as the Science and Technology Laboratory (STL) of Stennis Space Center, this organization is still involved in the development and application of ELAS software.

Originally created to process digital images acquired by the Landsat Multispectral Scanner, ELAS has developed into a very broad, general purpose raster processing tool. It has been used to process data from satellite and aircraft; images of Egyptian tomb paintings; fish scales and turtle flippers; MRI images of the human head, breast and heart; aerial photographs; soil maps; gravity potential fields; topographic data; and submarine sonar images. Areas of application have included forestry, agriculture, geology, archaeology, oceanography, medicine, ecology, environmental analysis, sonar imagery, and microclimatology.

DESCRIPTION

The ELAS software package is a modular approach to image processing. Predetermined processing runstreams are not provided. Image processing capability is broken down into components called application modules. These modules are considered building blocks which can be arranged by the user in an infinite variety of ways. The ELAS user has considerable control over how a module performs its task, as well as the order of execution. Each module allows the user to set the value of a number of processing parameters which define or control the module's operation.

Much of ELAS processing is performed on raster data which is stored in an ELAS specific format. This raster data may be images or any other type of data which could be stored as a two- or three-dimensional array. These data sets may be 8, 16, or 32 bit integer, 32 bit floating point, 64 bit floating point, complex or ASCII strings.

The package also has extensive ability to define and manipulate data defined in an x,y string format (polygons, line segments, and points). These are stored within the control file and allow a single numeric attribute, 0 - 255, to be attached to each vector. "Handedness", nodes, or other types of information are not retained.

ELAS consists of 239 applications modules. These modules can be categorized into one or more of the following functional groups:

FILE MANAGEMENT

This group consists of utilities to allocate, assign, release, copy, etc. various types of files used in ELAS.

REFORMATTING

Modules belonging to this group are used to import data into ELAS format files and to export ELAS files to other data formats. These foreign formats may consist of satellite, aircraft, vector, digital elevation, or various other raster and non-raster data.

DATA FILE UTILITY

These are modules that allow the user to manipulate the format, geometry, and contents of raster, and vector data files.

SUBFILE AND EXTERNAL FILE UTILITY

These modules are designed to build or manipulate various ELAS files which are not raster or vector data.

INTERACTIVE DATA DISPLAY

These modules are used for interactive work involving the display of images. The display medium may be a color display device or a window on a graphics terminal.

DESCRIPTIVE STATISTICS

This functional group includes routines which permit the user to examine specific characteristics of a data set without use of advanced statistical techniques.

STATISTICAL DATA ANALYSIS

These algorithms characterize a data file by some relatively sophisticated statistical measurement or property.

GENERATION OF TRAINING STATISTICS

This functional group consists of processes which gather statistical information to generate a definition of a class.

MANIPULATION OF TRAINING STATISTICS

These modules are designed to manipulate training statistics or display the relationships between selected classes.

CLASSIFIERS

These modules are used to assign a pixel to a class. It utilizes the class definitions generated by the training modules.

OPERATIONS ON CLASSIFIED DATA

This functional group contains a variety of operations requiring a classified data set to guide or define processing.

GEOMETRIC OPERATIONS

The modules in this functional group are designed to change the geometry of an image contained in an ELAS data file. The major use of these modules has been to correctly locate an image with respect to the globe.

CORRECTIONS AND CLEANUP FILTERS

These modules are used to correct both random and systematic errors in data or removal of noise and anomalies.

MODELING

This functional group contains modules to evaluate or model relationships within the data. The user may select either previously specified models or define his own.

POLYGON MANIPULATIONS

These modules give the capability to build, manipulate, and utilize vector data.

FILTERS

This functional group includes those modules that generate, use, or evaluate filters in either the time or frequency domain.

TOPOGRAPHIC DATA

This functional group includes modules which operate on digital elevation data.

PLOTTER AND FILM RECORDER

Modules that generate files for plotting to a special device or writing to film are in this group.

DIGITIZER

All modules directly linked to digitizing, either automatic or manual, are in this group.

SPECIAL PURPOSE AND MISCELLANEOUS

These modules do not conform to any of the previous functional groups.

STRUCTURE

Each application module is implemented as a separate program unit. This program unit consists of a main driver, UXMAIN, and a major subroutine containing the application specific code. The driver routine controls loading of the next module and maintains a common block of information necessary for execution of the modules.

Modules are swapped in and out of memory as a user executes them. Only one module is resident in memory at any given time during a single ELAS session. This minimizes the memory requirements based on program size. In addition, data files are read and processed a raster line at a time, reducing the memory requirements for file processing. Many ELAS modules can be executed with as little as 300 KB of memory.

Each ELAS session requires the user to allocate a "control file" or use a pre-existing one. A control file is used for each project to maintain continuity between multiple processing sessions. This control file keeps track of device and file assignments, and stores processing control information for each of the modules that have been used. Other ancillary information such as vectors, various look-up tables, and statistical data, also reside in the control file.

The ELAS data file is the only file structure in ELAS for storing raster data. As mentioned earlier, data may be in any of several numeric representations. The ELAS file can contain any data which can be expressed in a two- or three-dimensional array. This is typically image data, but the data are not restricted to this. Most application modules are designed to process the ELAS files regardless of the contained data type. In combination these attributes allow the user to largely ignore limitations normally imposed in image processing for reasons of limited range in numeric representation.

OPERATION

As noted, on entry to ELAS the user is prompted to supply a control file name. During a single session all operations and control will be within this single environment. After selecting files for input and output, display and input devices the user may go to any of the modules. Once in the module a list of "directives" are available. Directives are major processing options within the program. One of the standard directives is an option to set parameters. Parameters are variables which control such things as regions of the input or output file to be processed, or number of classes to produce.

At any time the user may leave a module and go directly to any other module. The only exception is when the computer is executing a previous command. All program control information (parameters) will have been written into the appropriate portions of the control file, thus the user can return to any previously used module and continue processing where ever execution was finished. This also permits the user to determine the conditions under which file was manipulated. This ability to return also extends to abnormal terminations, such as system crashes. Almost all operations can be restarted with loss only of the last scan line of imagery needing to be rerun.

The user can also switch processing control to an ASCII file containing commands. Built by any ASCII capable word processor or system editor, these files permit the user to create processing runs consisting of thousands of commands. This facility realistically allows the knowledgeable operator to treat whole modules as building blocks, effectively creating new capabilities.

The documentation for each module is also on-line. This is the equivalent of a manual 3 1/4" thick. Documentation gives the purpose of the module, operating instructions, parameter settings, functions of directives, file and program restrictions, resources used and formats, and one or more examples.

HOST SYSTEMS

At this time, four versions of ELAS have been implemented on UNIX platforms by STL. The source code for the application modules are identical for each of the versions. The major difference in these UNIX versions is the interface to the graphical display device for image visualization. The following versions are currently supported by STL:

Masscomp

This version utilizes a separate GA1000 display terminal with the graphics calls implemented through Masscomp's GP library.

Sun

This version uses X11 and the XView toolkit to implement a display window. This requirement may be met with MIT X11.4 or the Sun OpenWindows Version 2. The Open Look Window Manager is required. Currently, only 8-bit color look-up display is available in this version.

Silcon Graphics

This version uses the Silicon Graphics specific window system, Foresight, to implement display windows. This also requires use of the GL graphics library. This version was developed for a machine with the Super Graphics giving true-color capability and an extended color look-up table. Multiple ELAS tasks can be executed, each with an independent 8 bit pseudo-color display or a true color (24 bits - 8 bit each RGB) display. All displays will also have multiple independent graphic overlays. Multiple displays on the other UNIX window versions share a common 256 color look-up table.

Data General

This version uses X11 and Xt libraries to implement a display window. The Athena widget set is required. As with the SUN version, this is an 8 bit implementation for display.

The above versions are all public domain and can be obtained from:

COSMIC
University of Georgia
Athens, Georgia 30602
(404) 542-3265

Other, non-UNIX versions of ELAS have been created in the past for a large number of machines. Included are the Concurrent, VAX, Prime, SEL, Varian. ELAS has also been used as the root of commercial packages, such as ERDAS and ATLAS.

CONCLUSION

ELAS is an extremely powerful image processing package. It is well suited to applications which need a very large degree of flexibility. Indeed, one of the programming axioms is to not prohibit the user from gaining access or doing anything, unless it directly violates the basic algorithm or mathematics. This freedom means power; it also means the user has no single "yellow brick road". The software is command line driven, not menu oriented. These characteristics mean that an experienced user can make the software do more, do it faster, and in more ways. However, this requires the novice to invest some time in training.

With the availability of commercial spin offs and image processing software from many other sources, much of ELAS is no longer unique. There remain however several areas in which ELAS is not equalled or excelled. Filtering, statistical analysis, geometric correction, high degree of user control over algorithm execution, and flexibility gained through modularity are still major strengths.

Because of the nature of the software, ELAS has always been regarded as a significant burden for most machines. The workload of its algorithms have outweighed the power of the cpu and I/O capacity. The development of low-cost, high-performance workstations during the past few years, may help to overcome this problem and allow ELAS to reach its true potential. With the availability of ELAS on UNIX workstation platforms such as SUN, MassComp, Silicon Graphics, and Data General, the popularity of ELAS will continue to grow.