

KERN PHOTOGRAMMETRIC SOFTWARE

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Abstract

The concepts involved in the development of Kern Photogrammetric software are described and an overview is given of the software products which are currently available.

1. Introduction

Kern Photogrammetric software is developed with the concept that for both user and manufacturer, the software is an investment which may be built upon. The user invests expense in purchasing software and learning how to use it. This experience should never be lost when adding to or upgrading this system.

The manufacturer invests years of work in developing a software product. Future products and further development must be built upon existing software and not started from the beginning each time.

2. Software Philosophy

Basic concepts for software development were defined and implemented using a suitable development environment.

2.1 Design Concepts

A few concepts have been chosen as the guide lines for the development and maintenance of our photogrammetric software.

- the software development environment should be as machine independent as possible.
- program design should utilise effective software tools to allow rapid software development and continued maintenance.
- software must be user friendly, with logical operational sequences.
- tools are provided to allow the user to develop his own software.

By adhering to these criteria, it was then possible to develop a style of programming to produce software which is easy to transport and maintain from the manufacturer's point of view,

also easy to use, modify and add to from the customer's point of view.

2.2 Development Environment

Ideally, a machine independent environment, such as ADA, should have been chosen, or at least a machine independent operating system e.g. UNIX. However, at the time of decision at the end of the last decade, these systems were not available, and so the choice of programming language and, to a lesser extent, operating system were critical.

PASCAL was chosen as our programming language as it encourages standards, transparency and documentation of programs. Also, it is a language which allows ease of transportation to other systems in order to preserve the knowledge and time invested in the program development.

Kern photogrammetric instruments use DEC and IBM AT compatible equipment for computer support. Previously, computers from the PDP and Micro 11 family were used with RT-11 single user operating system and TSX multi-user operating system.

Nowdays, in addition to the PDP line, Kern photogrammetric equipment is available with DEC MicroVAX computer running under VAX/VMS operating system and also IBM AT compatible PC running under MS-DOS.

2.3 Concept Implementation

The concepts were implemented by using various software techniques.

Software Standards

- programming standards were specified thus software is easily augmented and maintained
- subroutine generators were written which produce code according to input parameters.
- operational and command standards were introduced for software use thus new programs are quickly mastered by the operator.

Modularity

- modular software eases development and maintenance.
- users may combine selected portions of Kern software with user developed programs.

Interactive Operation

- easy input of program parameters.
- effective examination and processing of results.
- automatic driving of the DSR instrument when possible.

ASCII Files

- self documenting files.
- ease of interface by user with outputs from the Kern software.

Help

- at the touch of a key, an explanation is given of the input parameters which are expected or the commands and options which are available.

Libraries

- libraries of subroutines have been developed to aid the development of software by both Kern and the customers.
- libraries for customers are written in both PASCAL and FORTRAN.
- internal libraries are used by Kern to provide building blocks for rapid software development.

3. Model Orientation

The DSR may be used to orient different types of imagery e.g. perspective, SPOT, panoramic. After orientation, the various other application software packages may be used for data collection, e.g. DTM collection, MAPS 200 On-line Compilation.

3.1 DSR1B Operating System

The DSR1B Operating System is a series of programs which allow the operator to perform the basic functions of the DSR analytical plotter such as instrument calibration and setting up of models :

- | | |
|--------------------------|--|
| - Plate Processor | - controls stage movement according to image geometry. |
| - Instrument Calibration | - using a calibrated grid plate. |
| - Camera Management | - for editing or creating a file of camera data e.g. focal length, fiducial coordinates etc. |
| - Coordinate Management | - for editing or creating a file of ground control points. |
| - Project Definition | - defining project parameters e.g project identification, terrain and flying heights for earth curvature and refraction corrections. |

- Inner Orientation
 - Relative Orientation
 - Absolute Orientation
- model definition and fiducial measurements.
 - automatic driving to user defined scheme points.
 - automatic driving to user defined scheme points.
 - interactive analysis of results.
 - automatic driving to ground control points.
 - interactive analysis of results.

3.2 DSR SPOT Orientation

The DSR SPOT Orientation Package is a series of programs which allows the user to orient a stereo pair of SPOT images in the DSR. The SPOT plate processor works with a geocentric coordinate system, and makes coordinate values available to the main processor in various systems. The package comprises:

- SPOT Plate Processor
 - SPOT Project Definition
 - SPOT Orientation
 - SPOT Coordinate Systems
 - Data capture, plotting
- controls stage movement according to SPOT image geometry.
 - defining project parameters e.g. project identification, constant values, chosen unknowns etc.
 - measurement of control points on SPOT imagery computation of parameters, and interactive analysis of results.
 - coordinates may be transformed between geocentric, geographical and UTM coordinate systems.
 - using the standard MAPS 200 software.

3.3 DSR BUNDLE Orientation

The DSR BUNDLE Orientation Package is a series of programs which allows the user to orient a stereo pair of images in the DSR, using a single model bundle adjustment. As the plate processor contains the possibility of applying corrections to computed perspective image positions by means of a correction grid, many types of distortion and parameters may be taken into account e.g. panoramic imagery, reseau cameras, additional parameters.

- BUNDLE Orientation
- measurement of control points on imagery and computation of orientation elements and additional parameters.
- Interactive analysis of results.

3.4 DSR1C Operating System

For DSR's which have been equipped with correlator hardware, i.e. CCD array cameras and image processing boards, the DSR1C software package may be used for some automation of the orientation procedure.

- Instrument Calibration
 - Inner Orientation
 - Relative Orientation
 - Absolute Orientation
- .automatic calibration grid measurement.
 - .automatic fiducial point measurement after fiducial mark shape digitally defined.
 - .automatic parallax measurement after approximate operator positioning.
 - .automatic point measurement after approximate operator positioning.

3.5 MAPABS Analogue Instrument Orientation

If the user has a hardware configuration with any analogue stereoplotter, then programs for Analogue Absolute Orientation are included in the MAPS 200 package.

- Analogue Absolute Orientation
- analogue instrument scheme definition to define instrument elements, rotation direction and limits. control point management to create and/or edit control point files analogue absolute orientation with interactive editing of results.

4. Data Collection

4.1 MAPS 200 On-Line Data Compilation

MAPS 200 is a system containing programs for on-line compilation with graphical or digital output. The system has been continuously developed for a number of years and has become a de-facto standard in photogrammetric data collection.

MAPS 200 may be used to collect data using input devices such as the Kern analytical plotters, analogue plotters, digitizers etc. Graphical on-line or off-line output may be on devices such as the Kern GP1 plotting table, the less expensive Houston drum plotter, or graphic monitors e.g. in DEC MicroVAX workstations.

Digital output is in user defined ASCII files which may be output onto a device connected to the user's computer, data may be output directly to an external computer or the data may be input into a data base e.g. Kern INFOCAM, for further processing and organisation.

The package includes programs for manuscript preparation and on-line compilation.

- On-Line Compilation
 - .selection of data collection modes e.g. point to point, continuous sampling etc.
 - selection of lines and symbols.
 - O.R.D.E.R. feature squaring
 - parallel line construction.
 - .hidden point construction.
 - .on-line closing and clipping of features.
 - contour annotation.
 - include user defined messages in the data file.
 - profiling between user defined points.
 - edit the data through several editing functions.
 - area computation.
 - user-defined symbol construction.

- Manuscript Preparation
 - manuscript gridding with user defined grid size, rotation, scale.
 - control point plotting with user defined symbols and annotation for coordinates entered by hand or read from a file.
- Sheet orientation
 - when using a Kern GP1 flatbed plotter, a pre-existing mapsheet can be oriented, allowing collected data to be overplotted.

4.2 KRISS Image Superimposition

The Kern Raster Image Superimposition System, KRISS, may be installed on the Kern DSR analytical plotter. Additional optics are fitted into the DSR which allows the image on the KRISS display screen to be projected into the operator's field of view in the DSR.

The image superimposition hardware may be configured to allow

- . mono image superimposition fine
- . mono image superimposition coarse
- . stereo image superimposition fine
- . stereo image superimposition coarse

and the user may select the configuration which best fits his requirements.

5. Off-Line Plotting

The Off-Line Plot Program, PLOTR, is a program for obtaining a graphical plot of the contents of digital data files e.g. data collected using MAPS 200. Graphical off-line output may be on devices such as the Kern GP1 plotting table, the less expensive Houston drum plotter etc. The user specifies all the parameters of the output e.g. plotting scale, sheet size etc., and the complete data file may be plotted, or only selected features.

6. Aerial Triangulation

The Kern DSR Aerial Triangulation System, AETRI, contains programs which allow the user to collect plate or model coordinates with the DSR. The data may then be adjusted using polynomial strip and block adjustments in order to detect any possible errors, before inputting the data into a bundle adjustment e.g. BLUH or BINGO from the University of Hannover, PATB from the University of Stuttgart, or an independent model adjustment e.g. PATM from the University of Stuttgart. The program for data collection allows the operator to measure in a model mode to obtain model coordinates or a comparator mode to

obtain image coordinates. The program includes many operator aids to ensure blunder free measurements e.g.

- default point numbering.
- checks for duplicate point names.
- digital transfer of common points.
- automatic driving of the DSR to common points.
- immediate display of model connections.

The user may then carry out some preliminary adjustments, in order to check for any errors, using the polynomial adjustment programs in the AETRI package e.g.

- strip formation.
- polynomial strip adjustment.
- block adjustment.

After any computations are carried out, the results and residuals are displayed, and the operator has the capability of interactively editing the results.

If necessary, models may be remeasured and the data reorganised to eliminate any repeated model measurements.

A similar Kern Aerial Triangulation System also exists for the analogue instrument Kern PG2.

7. DTM Collection and Processing

The Kern DTM Collection Packages, DTMCOL and DOTXS, contain programs to define areas for data collection and collect information from the DSR in the form of regular grids, parallel profiles and user defined profiles i.e.

- model window definition
 - specify an area by coordinates or digitising in the DSR.
 - define multiple windows.
 - define windows within windows.
- grid measurements
 - define grid spacing.
- profile measurements
 - define parallel profile direction and spacing
 - define start and end points of user's profiles.
 - define spacing of cross sections and extent to the left and the right of the profile.
 - define which instrument controls are active for speed and height functions.
- route design
 - define highway centre line.
 - define highway cross sections.

DTMCOR, a program using the Kern correlator's hardware, is available to allow the automatic measurement of regular grid DTM data, within user defined areas.

For processing results, a contour interpolation program, CONTUR is available which uses grid or profile data as input, and may also include break line information.

8. Software Libraries

To aid the development of software by both Kern and the customers, a number of libraries of subroutines have been developed.

The libraries which are available to customers are written in both PASCAL and FORTRAN. Both the source code of the library subroutines and the library object code are delivered.

All libraries, and in fact all of the Kern software, are independent of restrictions with regards to connection of devices to the main processor, as the user may define his own addresses and vectors for any device to suit his particular hardware configuration.

8.1 P2 Plate Processor Library

The P2 Library allows the user to control the stages of the DSR analytical restitution instrument :

- select movements of stages (upper stage only, both stages parallel etc.).
- drive stages to a point by plate, model or ground coordinates.
- obtain current position in plate, model or ground coordinates.
- profile along a vector between user defined start and end points.
- send image orientation parameters to the plate processor

8.2 Utilities Library

The utilities library, which is delivered with the P2 plate processor library, allows the user to read the orientation parameter files, and thus coordinates may be transformed between any systems, e.g. model to ground, and the DSR stages may be driven in any of these coordinate systems.

8.3 Correlator Video Library

The Video Library can be used when correlator equipment is mounted on the DSR analytical plotter i.e. cameras, analogue

processor and frame buffer.

The Video Library allows the user to :

- initialize all registers.
- grab an image, store the digital values in the frame buffer or on disk and display the image on a monitor for one or both cameras.
- manipulate lookup tables.
- obtain the digital value associated with a defined pixel.
- continuously receive and display images of one camera.
- create graphic primitives, such as lines and points.

8.4 GP1 Graphic Peripheral Library

The GP1 Library allows the user to control the GP1 plotting table :

- select on-line or off-line mode.
- connect given points with straight lines or curves.
- select line types, select, scale and rotate symbols and text.
- draw full and partial circles and spirals.
- define a table window and origin.
- select pen speed, pen number and pen position (up or down).
- obtain table coordinates of a point.
- download user defined symbols.

9. External Software

Software has been written by DSR users which either use the Kern photogrammetric equipment directly or interface to outputs from KERN software. Some of these software packages are available to other DSR users e.g.

CRISP, a close range photogrammetry package for the DSR from the University of Graz which includes

- project management.
- set up of metric and non-metric photography.
- bundle adjustment.
- programs for DTM collection, profiling, on-line compilation.

BLUH, a bundle adjustment system from the University of Hannover, which directly uses the output from the Kern AETRI Aerial Triangulation System as input to the adjustment. BLUH includes

- initial value computation.
- error detection.
- additional parameters.
- analysis of results.

COPS, a Composite Sampling DTM Collection Package for the Kern DSR from the International Institute for Aerospace Survey and Earth Sciences, ITC, includes modules for

- project window definition.
- process parameter definition e.g. minimum grid spacing, threshold value.
- selective sampling.
- progressive sampling.

KDOS, the Kern Digital Orthophoto System from the University of Karlsruhe generates digital orthophotos from perspective imagery using the Kern DSR fitted with correlator hardware. The package includes modules for

- orthophoto parameter definition e.g. pixel size.
- digital orthophoto generation.
- digital cartographic enhancement.

Other software packages were written by users to suit their own requirements e.g.

At Imperial Chemical Industries (ICI) in England, a system has been developed for obtaining information to form a data base to describe piping installation structures, and the Kern DSR is used to collect pipe information under the control of software developed by ICI, based on the Kern DSR P2 Plate Processor Library.

The Ministry of Transport and Public Works in The Netherlands have developed a production system for their DSR analytical plotter which demonstrates how user's programs may be combined with Kern software. In their environment, the following programs are used

Inner orientation	- Kern software
Relative orientation	- user software
Absolute orientation	- Kern software
Profiling	- user software
Triangulation data collection	- Kern software
Triangulation adjustment	- user software
Data base management	- user software

10. Future Developments

Eventually, as Artificial Intelligence and Expert Systems become more widely available, a system will emerge in photogrammetry where little or no expertise is required. All the project management will be carried out by computer deduction built up from previous experience.

Truly hardware independent systems will become available, with UNIX at present emerging as the standard operating system.

Kern has rapidly transported the DEC PDP software to both MicroVAX and PC, using available Pascal compilers and it is

anticipated that transportation to other chosen systems, e.g. UNIX based systems, will be equally straight forward.

Kern, and users of Kern equipment, will keep building upon the wide range of available program packages and continue implementing the newest technology into the software in a fast and efficient manner.

11. Conclusion

Kern's philosophy for the design of photogrammetric software systems has proven itself to be a sound approach. Once a basic set of tools for software development had been established, programming and software maintenance could be carried out very efficiently. A large selection of software is available, and maintained, for Kern equipment, based on a variety of computer hardware. Also, with many DSR installations world wide, experience has shown that photogrammetric operators very quickly master the software once a few basic instructions are explained, and the system can rapidly form part of the customer's production line.

New versions of Kern software, computer operating system and new computer hardware have not required operator retraining, except to point out additional new features. Both Kern and many customers have successfully changed operating systems for newer versions or migrated from RT-11 to VAX/VMS. Similarly, the PDP computers have been upgraded as new technology appeared on the market or changed for MicroVAX hardware.

Kern equipment users feel assured that they have made the correct decision in their choice of the Kern Photogrammetric System as they can upgrade and expand the system as required to suit their particular needs of the moment, and any previous investment of money and manpower is still valid with the most current technology.