IMAGE ORIENTATION ON THE KERN DSR

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Abstract

A description of the possible image orientation capabilities on the Kern Digital Stereo Restitution Intrument (DSR), e.g. aerial photogrammetry, close range photography, panoramic photography, SPOT imagery.

1 Introduction

The flexibility of the analytical plotter introduced the possibility of model orientation and accurate measurement of a wide range of stereo imagery.

Conventional analogue photogrammetric instruments could restitute near vertical aerial photography but the more exotic aerial photography such as panoramic and oblique imagery often could not be accommodated in these instruments.

Also, photogrammetric applications are increasingly diverging from that of aerial photogrammetry. Developing sensor technologies and the use of digital computers have made close range photogrammetry, extra-terrestrial sensing and radargrammetry important in their own right.

The important features of the analytical plotter are its ability to restitute images of:

- any focal length.
- metric or non-metric cameras.
- non-perspective geometries.
- extreme rotations.

This paper describes the orientation capabilities of the Kern DSR Digital Stereo Restitution Instrument, with emphasis on the distributed hardware architecture of the instrument and the modularity of the software. The design of the DSR is first reviewed, followed by an outline of Kern orientation software and software developments by users. Finally, some future developments are discussed.

2 Kern DSR distributed hardware

The DSR is a high-precision analytical plotter, distinguished by its distributed architecture. As figure 1 shows, there are three main processors, known as P1, P2 and P3.

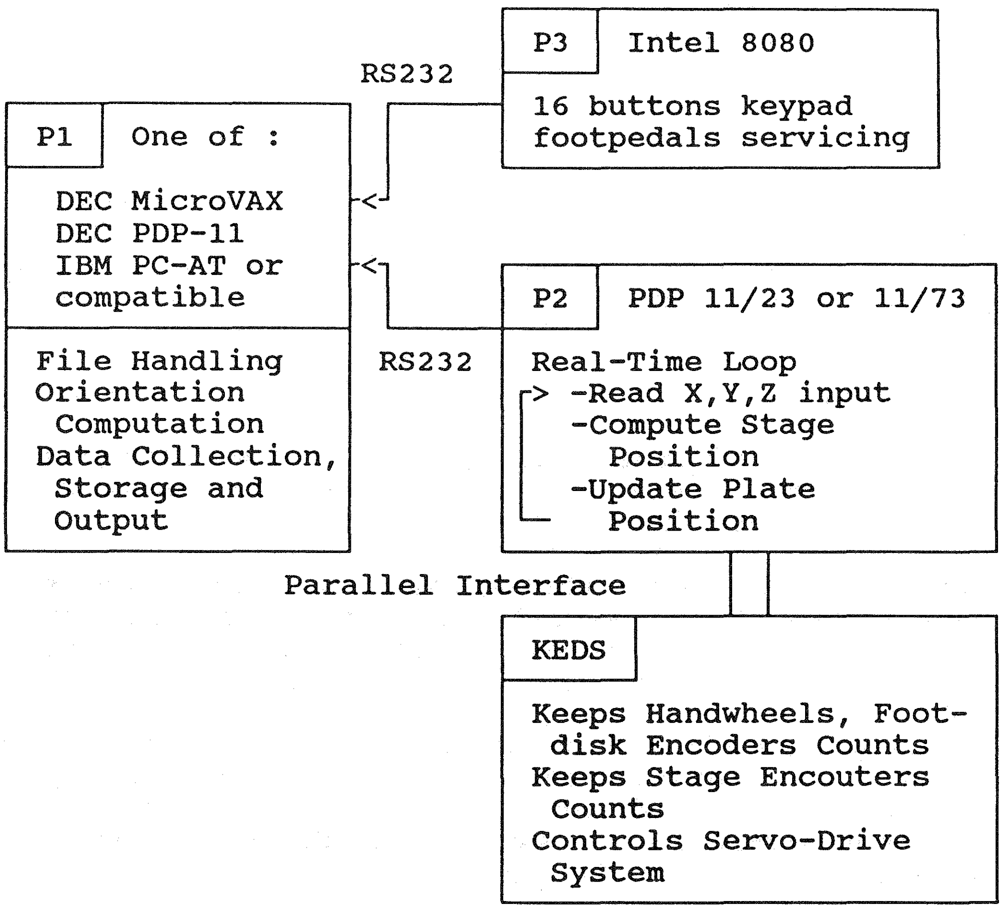

Fig. 1 Kern DSR Architecture

The P1 main processor is a general purpose computer (a DEC microVAX or VAX series machine, an IBM PC-AT compatible, or a DEC PDP 11 series computer). P1 is responsible for file maintenance, model orientation, data collection and output to graphic peripherals.

The plate processor program executing the real-time loop, which maintains the stereo model resides on the processor P2, which is a DEC PDP 11/23 or 11/73 processor.

Communication between P1 and P2 is over a serial line, and P1 downloads orientation parameters and sends commands to move the plates to P2, also request plate positions and other information from P2.

The P3 processor handles footpedal inputs and a 16-buttons keypad. Signals are sent from P3 to P1 using a second serial line. Handwheel and footpedal inputs as well as the servo controls are controlled by the Kern Electronic Drive System (KEDS).

The distributed architecture allows each processor to work efficiently independent of other tasks.

2.1 Kern DSR Modular Software

On the main processor, P1, the orientation software is divided into preparation, measuring and results phases. Kern uses a menu-based approach which helps to clearly define the steps in orientation and allows an operator to understand the various possibilities available in an orientation. Particular care is taken to reduce operator input blunders and to provide online help at each stage of the process.

The plate processor program is downloaded from the main processor, P1, to the plate processor, P2, each time the DSR is switched on. This provides absolute flexibility in defining which program will control the movement of the DSR stages and allows the easy implementation of new features such as other image geometries.

Output data from the orientation systems is stored in ASCII text files, which act as the orientation documentation and are read by other application programs requiring the orientation parameters. Each stage in an orientation has a record of measuring schemes, measurements, control points, residuals, final results and computed orientation parameters.

From a programming aspect, the communication between P1 and P2, is particularly important, and a communication library, the P2 Plate Processor Library, has been developed which may be used in the P1 programs. Some of the routines in this library allow P1 programs to:

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

A second library, the Utilities Library, reads orientation files and allows P1 programs to communicate to P2 using other than the plate or model coordinate systems, e.g. ground, fiducial.

These libraries are available to Kern DSR users to help them develop software for their own DSR.

3 Kern Orientation Software

Software has been developed for the orientation on the DSR of conventional aerial photography, close range photography, SPOT imagery, single model bundles, panoramic imagery and for coorelation-assisted routines. These are discussed after a description of the Plate Processor software.

3.1 DSR Standard Plate Processor

The standard plate processor program which is downloaded to the P2 processor controls the movement of the DSR stages according to the algorithms for perspective geometry.

A correction surface, in the form of a grid, may be downloaded to the plate processor and this allows great flexibility in applying corrections to the images over and above the standard perspective geometry computation. Many types of geometry, distortions and parameters may be taken into account with this correction surface, e.g. panoramic imagery, reseau cameras, additional parameters.

Through the P2 Plate Processor Library, the user may define his own correction surfaces and download these to the plate processor.

The plate processor program is written in Pascal: thus it is very easy to maintain and augment.

3.2 DSR1B operating system

DSR1B is the standard operating system for the Kern DSR and brings the user from an initialisation, definition phase through the measuring procedure to an orientation of perspective imagery taken by a metric camera, aerial photography, close range photography or large format camera images.

Preparatory modules of the system allow the calibration of the instrument's measuring axes, ground control point management and camera measurement. To orient a stereopair, a menu-based series of programs allow the measurement of inner, relative and absolute orientations. Each phase allows the remeasurement, disregarding or inclusion of points, choices of mathematical transformation (for example in inner orientation), and redefinition of measuring schemes. Orientation can be carried out using selected parameters and with initial approximations.

The modules included in the DSR1B are:

- Plate Processor	controls stage movement according to image geometry.
- Instrument Calibration	using a calibrated grid plate.
- Camera Management	for editing and/or creating a file of camera data, e.g. focal length, fiducial coordinates, etc.
- Coordinate Management	for editing and/or creating a file of ground control points.
- Project Definition	defining project parameters e.g., project identification, terrain and flying heights.
- Inner Orientation	model defintion and fiducial measurements.
- Relative Orientation	automatic driving to user defined scheme points. interactive analysis of results.
- Absolute Orientation	automatic driving to ground control points. interactive analysis of results.

3.3 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. This software was developed in cooperation with University College London (UCL) (Gugan, 1987).

SPOT imagery is distinguished by its dynamic geometry, with images being sensed over a nine second period, so that the normal geometric solution cannot be applied.

A plate processor program to handle SPOT geometry was developed by UCL, and this program is downloaded to the P2 plate processor at the start of the SPOT orientation.

During the definition phase, the user may select a subset of the orientation parameters to be solved from those parameters available, according to the availability of ground control. Weights and initial values may be assigned to these chosen parameters.

The inner orientation is carried out using the standard (DSR1B) software. The visible ground points are measured in comparator mode and on each of the stereo SPOT images and the orientation parameters are computed.

Once the parameters of exterior orientation have been found, these are downloaded to P2, using the standard communication library protocol. After orientation, the normal Kern software, for example the DTMCOL package for collecting a DTM, or the MAPS 200 package for map compilation, can be applied.

The modules included in the SPOT orientation are:

- SPOT Plate Processor	controls stage movement according to SPOT image geometry.
- SPOT Project Definition	defining project parameters e.g project identification, constant values, chosen unknowns etc.
- SPOT Orientation	measurement of control points on SPOT imagery computation of parameters.
- SPOT Coordinate Systems	coordinates may be transformed between geocentric, geographical and UTM coordinate systems.

3.4 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 standard plate processor contains the possibility of applying corrections to computed perspective image positions by means of a correction grid, additional parameters for the images may be applied in the real-time loop computation. The project definition and inner orientation are carried out using the standard (DSR1B) software.

After measurement of the control points in the images, the orientation parameters and correction grids are downloaded to the plate processor, P2.

- BUNDLE Orientation	measurement of control points on imagery.
- BUNDLE Computation	computation of orientation elements and additional parameters with automatic error detection.

3.5 DSR Panoramic Orientation

Orientation of panoramic images is carried out using the same software as for the DSR BUNDLE single model bundle orientation. During project definition, the images are defined as being panoramic, and thus corrections for this geometry are applied during the computation of the orientation parameters.

The standard plate processor is used to control the movement of the stage plates for panoramic imagery, with the corrections for the panoramic geometry being applied through the correction surface grid.

3.6 DSR1C operating system

The DSR1C operating system is analogous to the DSR1B operating system outlined above, but which uses retro-fitted CCD cameras to further automate the orientation procedure, and to enhance measuring precision. The system (Lutz, 1988), is used for instrument calibration and for the orientation procedure.

In inner orientation, the fiducial marks are measured by the correlator in a semi-automatic procedure, after automatic detection of the photograph edges, and definition of the fiducial mark form.

In relative and absolute orientation, the operator must first measure chosen points, and parallax measurements are then made with the correlator system.

4 External DSR Orientation Software

The distributed architecture of the DSR, and the ease of programming the plate processor have encouraged programming development by Kern DSR users.

4.1 CRISP Close Range Package

The CRISP package, produced at the University of Graz, Austria, is a close range package which allows measurement on metric and non-metric perspective imagery, measurement of single images or multiple images, arbitrary overlap of images, and the inclusion of extra object space measurements and geometric constraints. The system (Fuchs, Leberl, 1984), uses a modified plate processor program, which determines the object-image transformation on the basis of common rotation parameters, or by a direct linear transformation, or by single image rectification.

This software package is available to other users.

4.2 SMART - Stereo MApping of Radar Tasks

SMART, also produced at the University of Graz, allows measurement from single radar images, or the restitution of stereo pairs. The plate processor is programmed for the geometry of radar imagery. The system (Raggam, Leberl, 1984) orients a model by first approximating the orientation elements of each image, then applies a bundle adjustment to obtain final values. The initial values are found either using space resection, or where no ground control is available, with the attitude and position information of the sensor platform.

4.3 Other user developments

At Imperial Chemical Industries (ICI) in England, orientation parameters generated by the user are directly downloaded to the plate processor. Thus, after completing the Kern inner orientation, the parameters are sent to P2 and the model is oriented.

The Ministry of Transport and Public Works in the Netherlands has developed its own relative orientation procedure using the P2 Plate Processor Library, and integrated this module with the Kern orientation software, resulting in:

- Inner orientation	Kern software
- Relative orientation	User software
- Absolute orientation	Kern software

5 Conclusions

This paper has described the DSR analytical plotter and outlined the wide range of photogrammetric solutions possible with the instrument. The DSR's distributed architecture, seperating processing tasks into clearly defined modules, and the use of a high-level software approach, allow the instrument to be used for the orientation of highly differing image geometries.

With the geometric orientation problem now at a well-defined stage, Kern's future developments are likely to concentrate on systems approaches to photogrammetric orientation. Expert systems can be applied to analyze information about image type and the available coordinate data, and to apply the relevant mathematical model, as well as controlling the location and quantity of measurements needed to meet accuracy specifications.

Computer graphics will also be further integrated into the orientation procedure, both to enhance user interfaces, and for the graphic presentation of results.

References

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Figure 1. Kern DSR system structure.