TOWARDS THE DIGITAL FUTURE

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ABSTRACT

The equipping of the Kern Digital Stereo Restitution Instrument (DSR) with CCD cameras and image processing hardware has allowed the semi-automatic compilation of aerial photographs. This paper describes some applications of digital image processing with the DSR. Many repetitive photogrammetric steps lend themselves to automation, relieving the operator of these monotonous and tiring tasks. For example, the complete production of orthophotos, and the measurement of digital terrain models, can now be carried out fully automatically.

Some tasks, which till now have required skilled operators, have been partially automated. Specifically, instrument calibrations and image orientations are now being carried out in a semi-automatic system.

Further to these possibilities, the equipment can be used for other image processing work, such as the scanning of photographic images.

1. Introduction

The Kern Correlator system together with the Kern DSR15 allows the use of modern image processing techniques for photogrammetric applications. With digital image processing multiple operations can be performed semi- or even fully-automatically, relieving the operator from tiring operations and allowing an increase in productivity and constant precision.

The Kern Correlator consists of hardware and software components, which are combined in a sophisticated way. Due to the modular architecture of the DSR, the Kern Correlator can be easily retro-fitted into every DSR15.

2. Hardware

The hardware consists of standard off-the-shelf components, giving the user a greater degree of reliability and continuity. The hardware system consists of two CCD cameras, optics, a monitor and one image processing board (Fig.1). Optionally, a set of four transputers including an interface board for faster computation is available.
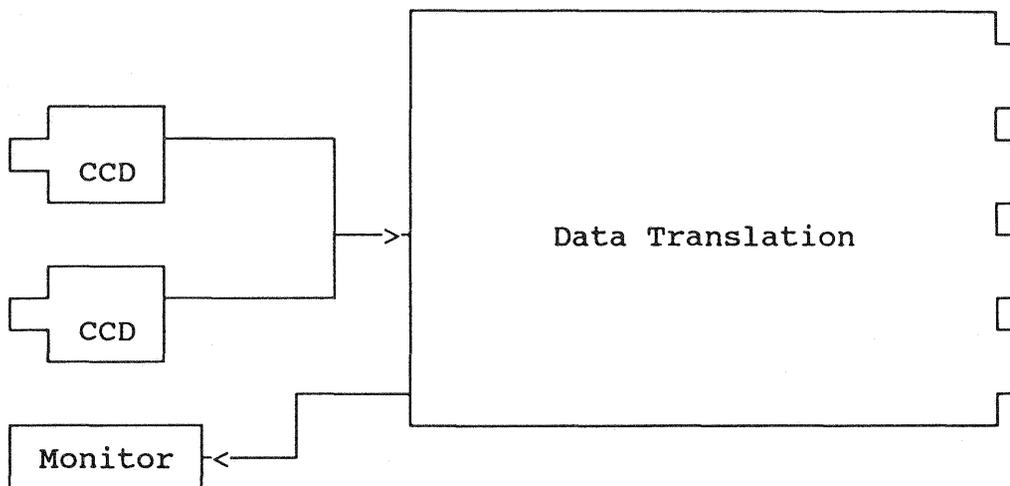
Fig. 1 Kern Correlator block scheme

The CCD cameras used are Philips NXA 1011 and are based on the Valvo-Chip, which has a resolution of 604 x 600 pixels. Using Kern's own optics guarantees minimal distortion and almost no vignetting in the digitized image. The CCD cameras are mounted in the optical path of the DSR15 so they take the same picture as the operator sees in the viewing system.

The image processing board is supplied by Data Translation. Both CCD cameras are connected to this board, which can store two 512 x 512 pixel pictures in its RAM. Additionally, the board has a DMA interface to the host computer and is connected via a Q-bus to the MicroVAX computer.

One big problem in dealing with digital image processing is the high use of CPU resources. To solve this problem Kern uses transputers to do the time critical parts of the algorithms. Due to the nature of digital image processing, many computations can be run in parallel. Therefore transputers are an ideal tool for this type of work, since they are parallel processors, executing concurrently. The transputers are programmed using the OCCAM 2 language and the Transputer Development System (TDS). Since transputers are not special processors, but simply general purpose computers, there are no special restrictions in their use. This enables any time-critical tasks to be programmed on transputers.

3. Software

Like the hardware, the software is designed in a modular way. The software assists normal photogrammetric compilation. The correlator system software has been designed to be as compatible as possible with the standard Kern photogrammetric software.

The software used with the correlator takes over the photogrammetric orientation and allows the automatic measurement of DTMs and generation of orthophotos. It can be used for installation, checking and calibration of the correlator's hardware, as well as being used as a digital scanner.

3.1. Video Installation

The Video Installation Package is used to install, check and calibrate the Kern correlator and consists of three programs.

The first step is to check the functionality of the hardware. This is done with the video test program. With this program all parts of the Kern correlator's hardware are tested, like the CCD cameras, the video board and the monitor.

Next the floating marks have to be centered to the middle of the video coordinate system. This is done with the camera installation program. This work is carried out only during the installation of the CCD cameras.

The last step is the calibration. The video calibration gives the relationship between the video coordinate system and the stage coordinate system. In the procedure a specially designed target is positioned to predefined nominal positions in the video coordinate system and the actual distorted positions are measured. An affine transformation is then computed, relating the stage coordinate system to the video coordinate system. The results are stored in an ASCII file, readable by all programs using the correlator.

3.2. Video Library

The subroutines available in the Video Library enable the development of application programs for digital image processing.

The video library can be used to perform many basic digital image processing functions, such as functions for the acquisition, storage and manipulation of digital images. This library makes full use of all possibilities given by the image processing boards. Besides reading and writing pixels, lines of pixels and areas of pixels to frame buffer or image files, routines for raster graphic primitives are provided. Other routines allow the manipulation of the look up tables.

3.3. DSR1C Operating System

With the DSR1C package a complete orientation can be done under operator control using correlation routines. The operator advises where measurements should be made and the programs do the fine measurements.

One of the programs is used to calibrate the stages of the DSR. After putting in the calibration grid the operator measures the first point of the grid. All other plate points are then measured automatically.

In the case of interior orientation, the operator measures the positions of two fiducial marks. After doing this the program makes the measurements of the rest of the fiducials.

In relative and absolute orientation the operator has to give approximations for each point to be measured. The programs then make the parallax measurements.

3.4. DTM Generation with Correlator (DTMCOR)

Based on the vertical line locus method the correlator is able to measure heights. As well as using the radiometric information the vertical line locus method also uses geometrical constraints and information about the terrain slope to obtain height values.

The user can measure a DTM in a defined window or in a regular rectangle. The regular rectangle is the format the orthophoto program uses as input.

By using various searching techniques a high proportion of points are successfully measured, while points that are unmeasured due to missing structure or lack of contrast are marked in the measurement file. In an additional stage these points can be remeasured by an operator.

The height measurement method is useful not only in topographic situations, but also for close-range photogrammetric environments, for example for industrial measurements or in medical applications.

3.5. Kern Digital Orthophoto System (KDOS)

The Kern Digital Orthophoto System (KDOS) is used to produce purely digital orthophotos. As input it needs the calibration and orientation data and a digital terrain model (DTM). The calibration and orientation data are taken from the files generated by the calibration and orientation routines. The DTM has to be in a readable format for KDOS, and can come from a manual or an automatic measurement, or can be read from a data base. This input data is used to generate a digital orthophoto which is stored as a file on the computer's hard disk. Using digital image processing techniques allows the addition of text, graphical symbols, contour lines and a margin to this digital data. The final product is a digital orthophotomap. A digital recorder generates negatives or printing foils from this data.

Using this equipment reduces orthophoto production costs since all measurement takes place on one machine and because standard

digital image processing routines can be used to manipulate the digital orthophoto.

3.6. Scanning

Additional to its use as a digital stereo restitution instrument, the DSR can be used as a high accuracy scanner. This works like a flat bed scanner using transparent images. The simple relationship between the video coordinate system and the plate coordinate system is one of its advantages. There are also no restrictions in defining the resolution.

4. Conclusion

The Kern DSR15 and the Kern Correlator combines the power of many instruments in one system. Besides the normal digital stereo restitution instrument, it also has the functionality of an orthophoto projector and a scanner. The system can be applied to diverse applications, not only map production, but also medical and industrial applications. This increases the versatility of the instrument and decreases the costs since only one general purpose instrument is needed instead of many special ones. The combination of standard stereo restitution instrument and digital components is a further step in digital photogrammetry. This ability to scan, to store, to manipulate and to display images constitutes a basic image processing system.