Quality Features of a State-of-the-Art, High-Performance Photogrammetric Scanning System: PHODIS SC

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ABSTRACT

The system design of PHODIS SC meets the quality demands made on a state-of-the-art photogrammetric scanner. The hardware is charaterized by the capabilitiy of digitizing uncut original aerial films. Further features include high-precision mechanical guideways, optimum imaging performance of the mirror lens and superior resolution of the CCD line. The high data transfer rate ensures short scanning times. The system is rounded off by a software providing high operating convenience, image processing functions and basic photogrammetric functions.

KURZFASSUNG

Systemdesign von PHODIS SC erfüllt die Qualitätsanforderungen an einen modernen photogrammetrischen Scanner. Die Hardware ist gekennzeichnet von der Möglichkeit, unzerschnittene Originalluftbildfilme zu digitalisieren. Weitere Qualitätsmerkmale sind hochpräzise mechanische Führungen, optimale Abbildungseigenschaften des Spiegelobjektives sowie hohe Auflösung der CCD-Zeile. Die hohe Datenübertragungsrate garantiert kurze Scanzeiten. Einfache Scannerbedienung, Funktionen der Bildverarbeitung und photogrammetrische Grundfunktionen ergänzen softwaremäßig das Systemdesign

1 Introduction

The increasing use of digital photogrammetry leads to a constantly growing demand for scanned aerial photos. Wheras until recently digitized aerial photos were primarily used for orthophoto production, the field of digital applications is now rapidly expanding. In addition to digital stereoplotting, the emphasis is placed today on digital aerotriangulation and matching techniques for DEM generation, to mention only two examples. These latter applications, in particular, make extremely critical demands on the quality of the digital source material, which can only be guaranteed by a high-precision photogrammetric scanner.

PHODIS SC meets the new requirements made on a photogrammetric scanner for the conversion of photos into digital images This includes the scanning of the original photos without any need to cut the film and without any intermediate photographic processes for the generation of original digital images, fully automatic digitization of the images and a high geometric and radiometric accuracy.

PHODIS SC has been fully integrated into the PHODIS photogrammetric image processing system from Carl Zeiss (see Table 1). It uses the same user interface, the same basic modules for image processing and photogrammetric tasks, the same data formats and the same computer platform as the other members of the PHODIS family (Braun, 1996).

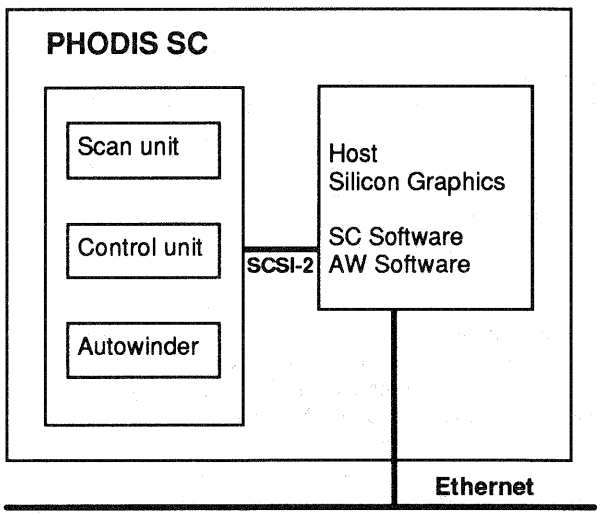
Table 1: PHODIS Product Family

PHODIS Product	Photogrammetric Application
PHODIS SC	Photogrammetric Scan System
PHODIS AT	Automatic Digital Aerotriangulation
PHODIS ST	Digital Stereoplotter
PHODIS TS	Automatic DEM Generation
PHODIS OP	Digital Ortho Projection
PHODIS M	Monoplotting
PHODIS Base	Basic Digital Photogrammetry Tools

PHODIS SC features a modular structure (see Fig. 1)

- the SCAI basic scanner unit, with control unit and Autowinder roll film attachment
- the SC software
- the AW software
- and the PHODIS base software

Fig. 1



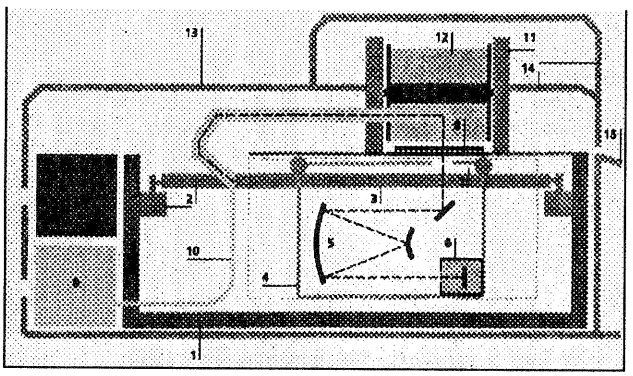
The SCAI scanner unit comprises a high-precision measuring system with a powerful CCD line sensor for monochrome and color digitization, a control unit for controlling the scan cycles and the processing of the CCD data, and the Autowinder for the automatic digitization of complete uncut films. Data transfer to the computer is performed via a SCSI-2 interface. The SC software includes all functions required for scanner control, transfer and management of the image data, basic photogrammetric functions and image manipulation functions. The AW software permits the control of the Autowinder and direct operation from the computer.

2 Hardware

2.1 Basic Instrument

As a precision scanner with a high throughput rate, the SCAI basic instrument makes exacting demands on the optical, mechanical and electronic components used. Its design is determined by the capability of digitizing roll film (see Fig. 2).

Fig. 2 SCAI with Autowinder



1 Cast-iron enclosure
2 Primary guideway and primary carriage with linear encoder (3)
4 Secondary carriage with mirror lens (5) and CCD module (6)
7 Photo stage for scan copy and glass cover plate (8)
9 Lamp module with fibre glass optics (10)
11 Autowinder with film roll (12)
13 Instrument enclosure with cover (14) and control panel (15)
16 Electronics module

The Autowinder (11) is permanently connected with the cast-iron enclosure of the scanner. The copy to be scanned - either film sheets or roll film - is placed on the photo stage (7) where it is held by a glass cover plate (8). This plate can either be lifted up manually for the insertion or removal of individual scan copies, or - if roll film is used - it can be lifted and lowered by motor power. The maximum scannable photo format is 250 mm x 275 mm.

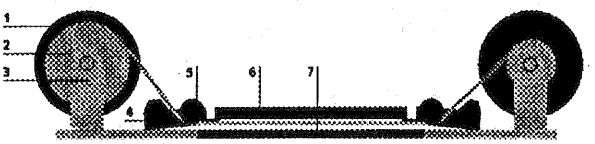
An illumination arm with the lens and CCD module forms the secondary carriage (4) which scans the photo stage in a highly precise, combing movement. The drive and control system of the moving carriage comprises precision guideways, linear encoders and rotary encoders. They ensure the exceptional geometric accuracy of the instrument. The CCD module consists of a tri-linear colour CCD line and permits the three colour channels red, green and blue to be recorded and processed in a single scan cycle. 5632 pixels of the CCD sensor are used, providing a scan swath width of 39.424 mm. This means that a copy with a width of 230 mm can be scanned in 6 swaths. The image section is imaged on the CCD line by a distortion-free and colour-true mirror lens (Mehlo, 1995).

The light source is a lamp module with a stabilized 250 W halogen lamp. The light is conducted to the glass cover plate via a flexible fibre-optic light guide attached to the secondary carriage. The cross-section converter diverges the light before it reaches the scan copy, thus producing diffuse illumination. A prism then deflects the beam path to the mirror lens. The diffuse illumination ensures that any slight scratches or contamination on the photo carrier surface will not - or only to a minor extent - be reproduced in the digital image.

2.2 Autowinder

The great demand for high-quality digital images can be met in an optimum way by the automatic digitization of photo series or complete films. The Autowinder offers the user the possibility of digitizing photos straight from the film roll. It accommodates aerial film up to the standard maximum length of approx. 150 m.

Fig. 3 Autowinder



1 Film reel
2 Film
3 Motorized film drive
4 Motorized lifting device
5 Deflection roller, frame counter
6 Glass cover plate
7 Photo stage

The film is moved in the Autowinder by two motorized reels (see Fig. 3). For scanning, the film is placed on the photo stage. Both the glass cover plate and the film are lifted for film transport. The film is guided by two deflection rollers at a certain distance from the photo stage. For rewinding, the film runs without contact between the lifted cover plate and the photo carrier, and can therefore not be damaged. The electronic frame counter enables automatic positioning to preselected photos. The Autowinder can be interactively controlled either from the SCAI basic unit or using the AW software. The interactive mode of SCAI permits the user loading of the film reels, complete rewinding of the film or single-frame advance, and the definition of the photo length. The maximum rewinding speed is approx. 1 m/s, which means that the complete rewinding process takes less than 3 minutes. The end of the film is automatically recognized from the winding diameters of the film reels, the winding speed is appropriately reduced and the Autowinder is finally stopped. A further confirmation is required for winding the film end off the reel. For single-frame advance or precise positioning of the photo, the transport speed is reduced to approx. 1/3 frame/s. SCAI equipped with the Autowinder is called SCAI-AW.

3 Software

The PHODIS SC software is designed on a modular principle:

- PHODIS Base
- SC software
- AW software

3.1 PHODIS Base

The PHODIS Base software ensures full compatibility of the individual applications in PHODIS (e.g. aerotriangulation,

digital stereoplotter). The digitized image is stored together with the additional information generated in the different applications, e.g. interior and exterior orientation, resolution, image number etc. and thus obtains the far higher status of a photogrammetric digital image. The formats provided for direct processing are TLD (Zeiss format) and TIFF. In addition, tools are available to the user for the conversion of digital images from and into different formats such as Sun Raster, RAW, PostScript, Barco etc. Image processing tools such as image clipping and rotation, radiometric modifications, resampling of the pixel size etc. are also included in the base module.

3.2 SC Software

The SC software is the communication interface with the SCAI scanner. The convenient OSF Motif user interface includes all major steps of the program. The data is managed in a project-oriented structure. All parameters required for this purpose, e.g. directory paths, extensions etc. can be defined by the user to suit his special requirements.

The operation cycle comprises three steps:

- Prescan: overview scan to determine the scan parameters
- Scan: scan parameters and the actual scanning process
- P-Actions: photogrammetric tools

3.2.1 Prescan

The user can call up the Prescan function to predefine the scan parameters, e.g. for a new mission. An overview scan of the complete photo or of a user-defined section is now performed. The resolution of the scanned image is 224 microns. Within one minute, the image is displayed to the user on the screen, and he can check immediately whether the parameters and the section to be scanned have been correctly selected. Histogram displays provide information on whether the radiometric parameters need to be modified. For the interactive definition of the scan area, a rubberband can be activated with the mouse.

3.2.2 Scan Parameters and Scanning Process

The scan parameters are divided into two groups:

- geometric and radiometric scan parameters
- file definition: format and name

The geometric and radiometric scan parameters are combined in a menu. The most important of them are:

- pixel resolution from 7 to 224 microns
- scan area definition (e.g. using the definition from the prescan)
- color or monochrome scan
- scan of a diapositive or negative
- radiometric definition: transmission, density or use of a lookup table (LUT)
- colour corrections
- exposure time
- on-line radiometric image negation.

For radiometric modifications, the user can either employ predefined LUTs or create his own tables using the graphic LUT editor. The predefined LUTs include, for example, gamma corrections, changes in contrast range and brightnes, and permit the user to rapidly define the optimum parameters, especially for scanning negative film.

At the early stage of parameter definition, the disk capacity requirements of the image to be scanned are determined and output as information. All selected parameters are stored in a parameter file and are available to the user at any time.

The file definition permits the selection of the format and naming of the file. The format options are TLD and TIFF. The file name can be either entered directly or generated via a predefined mask. The mask comprises an alphanumeric and a numeric part, which can be automatically incremented or decremented. The entry of the photo number is offered as an option. It permits the unambiguous identification of the images, in particular for digital automatic aerotriangulation (Braun, 1996).

3.2.3 P-Actions

Prior to the actual scanning process, the user defines the photogrammetric actions to be automatically performed after the scan. This includes the generation of image pyramids and automatic interior orientation. Both processes are successively started automatically after the scan and run in the batch mode. After completion of the scanning process, the user therefore obtains photogrammetric digital images which are suitable for direct further processing, e.g. for aerotriangulation or stereoplotting (Schickler, Poth, 1996).

3.3 AW Software

The Autowinder software (AW software) permits the scanning of uncut film in a batch process. Whereas the SC software is used for the definition of all scan parameters, the AW software ensures the communication with the Autowinder. The major functions of the AW software include the definition of parameters

- when a new film is loaded
- for the scan sequence
- for film positioning

After loading the film in SCAI-AW, the user can directly control all further actions via the AW software. The FIN parameter file (Film Information File) stores all film-related parameters which include amongst others

- the current photo position
- the frame numbers of the first and last photo to be scanned
- the film thickness
- the photo length
- the sequence of photos to be scanned

The user can also wind the film forward and backward, and unwind it from the film reel. Precise positioning can be interactively controlled. When scanning in the batch mode, the AW software automatically takes care of precise positioning and checks whether the photo to be scanned is correctly positioned in the scan area.

For the selection of the scan parameters, overview scans can be performed and stored. If the user modifies any parameters

(gamma correction, brightness etc.), the new data is stored for each photo (FIN file) and taken into account in the scanning process. The actual scanning process is an independent cycle, i.e. film transport, film positioning and the scan are run automatically and need not be monitored by an operator.

4 Summary

The PHOCIS SC scanning system processes original photos straight from the film roll. An automatic scanning process converts the complete film or selected photo sequences into digital images and makes them directly available to the applications in digital photogrammetry. Due to the modular design of PHODIS SC, the SCAI scanner can be retrofitted with the Autowinder, permitting its dynamic adaptation to user requirements.

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