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DEVELOPMENTS IN PHOTOGRAMMETRIC PLOTTING

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1. Introduction

Carl Zeiss, Oberkochen, produces the SEG 6 Standard Rectifier and the Z 2 Orthocomp Orthoprojector for photographic plotting (rectification) of photos. In most applications, the photos to be rectified are aerial survey photos, but terrestrial photography or line drawings can also be rectified or intentionally distorted. The Z 2 Orthocomp Orthoprojector can handle virtually any focal lengths, tilts and differences in elevation. These two instruments have been available for a long time already /1, 3/ and used in the production of photo maps. This paper deals with developments since the last Photogrammetric Week 1983.

2. SEG 6 C Color Rectifier

An approach that some rectifier users have already implemented on their own has been available from Carl Zeiss, Oberkochen, as a standard product for about a year: The SEG 6 Colour Rectifier /5/, a combination of the SEG 6 Standard Rectifier with a colour illumination system made by DURST. The DURST Company is well-known to all professional photographers as the manufacturer of high quality enlargers for all negative sizes up to 25 cm x 25 cm. The illumination system of these units comprise heat resistent dichroic filters which can be power-driven in and out of the ray trace.

The brightness control diaphragm is also power-driven. Several consecutive diffusors ensure uniform illumination, i. e. the color and brightness can be varied continuously. The light loss caused by the diffusors is compensated by a powerful halogen lamp (2000 W).

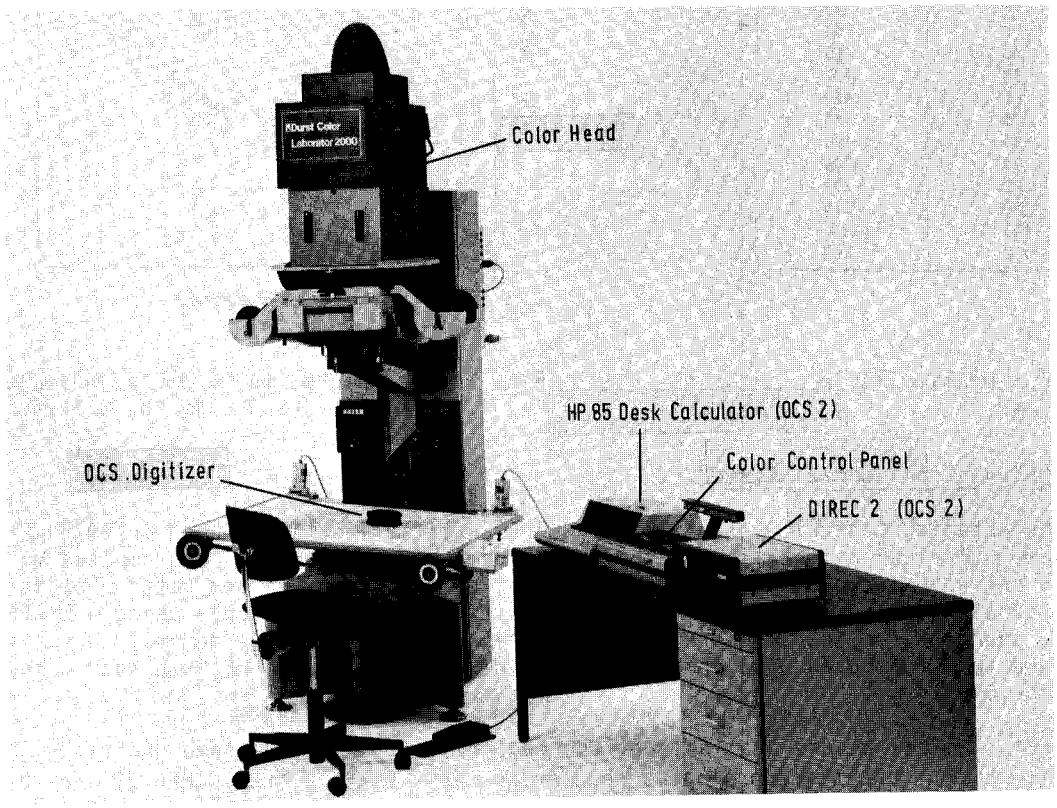

Fig. 1: SEG 6 Color Rectifier with OCS 2 Orientation Control System

As far as the optical adjustment is concerned, the installation of a color illumination system in the SEG 6 presents no problems, but the weight balance has to be optimized for the weight of 40 kg of the color head.

Compared to the previous color attachment for the SEG 6, which required 40 cm x 40 cm color filters to be changed, the new SEG 6 C is very easy to operate. A console installed at desk height serves to set the color and the brightness by means of pushbuttons. The settings for the three colors magenta, cyan and yellow can be read off digital counters as integer values ranging from 0 to 130. This setting range corresponds to the Agfa color densities 0 to 260.

For orienting the SEG, the color filters and the brightness control diaphragm are removed completely from the ray trace upon the touch of a button. After orientation, the preselected densitiy values are set again automatically.

The table illumination of the SEG 6 C (without filters, maximum brightness) is about half that of the SEG 6 with mercury vapor lamp and weak diffusor. The SEG 6 C can therefore also be used for BW work.

It allows the use of variable-gamma emulsions whose density is affected by the color of the light. An example for the Agfa Gevaert GO 210 p film is shown in Fig. 3.

With blue filtering (100 magenta + 130 cyan), a soft gradation with gamma = 0.7 is obtained, while yellow filtering (130 yellow) results in a hard gradation (gamma = 1.7).

Color Density	
Durst	Agfa
0	0
10	20
20	40
30	60
40	80
50	100
60	120
70	140
80	160
90	180
100	200
110	220
120	240
130	260

Fig. 2: Color Density Table of /4/

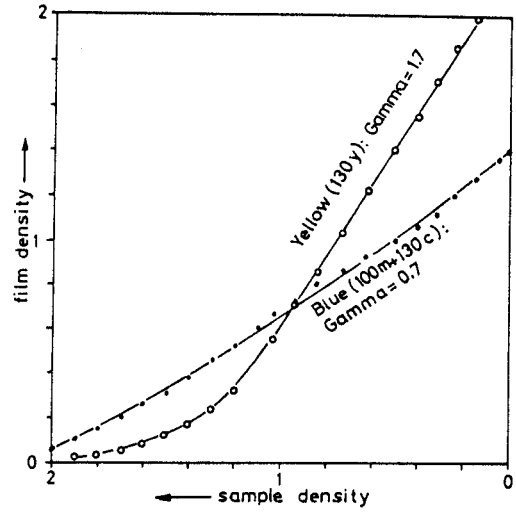

Fig. 3: Variable-gamma GO 210 p film used with the SEG 6 C (f/16, 3.5 sec.)

3. OCS 2 Orientation Control System

The OCS 1 Orientation Control System for the SEG 5 Rectifier was introduced in 1976 /2/. This system allows numerical orientation in the SEG by comparing the nominal coordinates of control points with the actual coordinates of the same control points in the projected photos. The actual coordinates are measured with a special digitizer on the SEG table using a DIREC as coordinates counter. The actual coordinates are then compared with the nominal coordinates and the setting data is computed by a desk computer. The DIREC 1 and the HP 9815 desk computer were used with the OCS 1.

The OCS 2 (Fig. 1) has become available at the beginning of 1985. The same digitizer is used as in the OCS 1 system, but the coordinates counter now is a DIREC 2 or a DIREC 12 and the computer is a HP 85 B. Even though this computer is rather "old" already (available in Germany since 1980), this Hewlett Packard desk computer was selected because its compact design requires little space in the darkroom.

The OCS 2 programs were written by E. Mohr (Stuttgart). The mathematics are essentially those of the OCS 1, but the CRT display facility has been put to use for interactive communication between the programs and the user. Fig. 4 shows a menue offering various application programs.

5 programs performing functions similar to those of the OCS 1 system but having more explicit names are available:

START/CALIBRATION	Digitizer calibration after turn-on.
CONTROL POINT INPUT	Manual control point data entry (number and 3 coordinates) and storage in a cartridge control point file.
CONTROL FROM MAP	Measurement of control points in a map by digitizing the planimetric coordinates and entering the point numbers and elevations. Storage in the cartridge control point file.
SEG ORIENTATION	Control point data reading from the cartridge file, measurement of the control point locations on the SEG table, iterative computation of exterior photo orientation by means of spatial resection, computation of the table inclination and SEG magnification corrections, and output of the residuals and the expected control point offsets, if desired.
DIGITIZE TABLE COORD	Program for using the digitizer independently of the SEG for point-by-point measurement of planimetric coordinates and storage on a cartridge file.

Fig. 5 shows the orientation results as they appear on the HP 85 CRT screen. The new table inclinations ßy, ßx are displayed as they have to be set at the counters (intermediate values for the last digit as decimal fractions).

```
SEG / OCS        START/CALIBRATION

CHOICE OF PROGRAMS
--------------------------------
  k1  START / CALIBRATION
  k2  > CONTROL POINT INPUT
  k3  > CONTROL FROM MAP
  k4  > SEG  ORIENTATION
  k5  > DIGITIZE TABLE COORD.
  k6  CHOICE OF PRINTER        85
  k7  DISPLAY DIREC COUNTERS
```

Fig. 4: OCS 2 CRT Menu

```
RESULT AFTER 4 ITERATIONS:
--------------------------------
SIGMA NAUGHT = +/- 0.06 [mm]
--------------------------------
NEW TABLE INCLINATION:
  LEFT  COUNTER (BETA Y): 053.4
  RIGHT COUNTER (BETA X): 985.3

NEW MAGNIFICATION    (Vo): 1.952
--------------------------------
  k1  PRINT ORIENTATION RESULT
  k2  RESIDUALS OF ADJUSTMENT
  k3  OFF-SET IN RECTIFICATION
  k4  C O N T I N U E
```

Fig. 5

Fig. 6 shows the residuals and offsets as they appear on the CRT screen. The spatial resection residuals are indicative of the precision with which the control points were set at the digitizer. The offsets are computed from the differences in elevation between the control points and the plane used for the rectification process. They are indicative of the errors to be expected from ground unevenness.

```
RESIDUALS AT THE CONTROL POINTS:
! POINT NO ! Vx [mm] ! Vy [mm] !
--------------------------------
!    3164 !   -0.07 !   -0.03 !
!    3183 !    0.01 !   -0.03 !
!    1182 !    0.05 !    0.02 !
!    1342 !   -0.01 !    0.05 !
!    3180 !    0.01 !   -0.01 !
--------------------------------
PRINT: k1                OK >: k4
```

```
OFF-SET IN RECTIFICATION:
! POINT NO ! Dx [mm] ! Dy [mm] !
--------------------------------
!    3164 !   -0.46 !   -1.36 !
!    3183 !    0.71 !   -0.13 !
!    1182 !   -0.77 !   -0.34 !
!    1342 !    0.31 !   -0.34 !
!    3180 !    0.10 !   -0.16 !
--------------------------------
PRINT: k1                OK >: k4
```

Fig. 6: Residuals and Offsets after Orientation

Although the OCS 2 programs have been written in BASIC, they are not slower than the OCS 1 program written in the HP 9815 machine-oriented code. A complete run of the orientation program including control point data reading from a file and measurement of about 4 to 6 control points requires 5 minutes. This is a noticeable gain in time compared to conventional orientation with a map if the terrain is difficult, i. e. when offsets such as the 1 mm offsets in the above example remain even after optimum orientation. Numerical orientation also ensures that the optimum SEG setting will be used.

4. Z 2 ORTHOCOMP Orthoprojector

The programs for the Z 2 ORTHOCOMP were originally written for the RTE 4 B operating system of the Hewlett Packard HP 1000 E and F series minicomputers. As of 1984, the programs have been converted for the RTE A operating system of the more advanced HP 1000 A minicomputers, and a series of improvements and enhancements have been introduced. The first modules of the new software were shown during the 1984 ISPRS Convention in Rio de Janeiro /5/. By now the conversion work is nearing completion. The profile data reading routines have been enhanced by

- a test routine which, for each profile point, checks the ground elevation and the slope to the last point, and issues an error message including the consecutive total and profile point numbers when freely definable elevation and slope values are exceeded;
- a facility for reading profile data from several general files;
- a facility for reading profile data from blocked magnetic tapes:

The last two enhancements now permit the scratch file capacity of 300 profiles with upto 400 points each to be fully used.

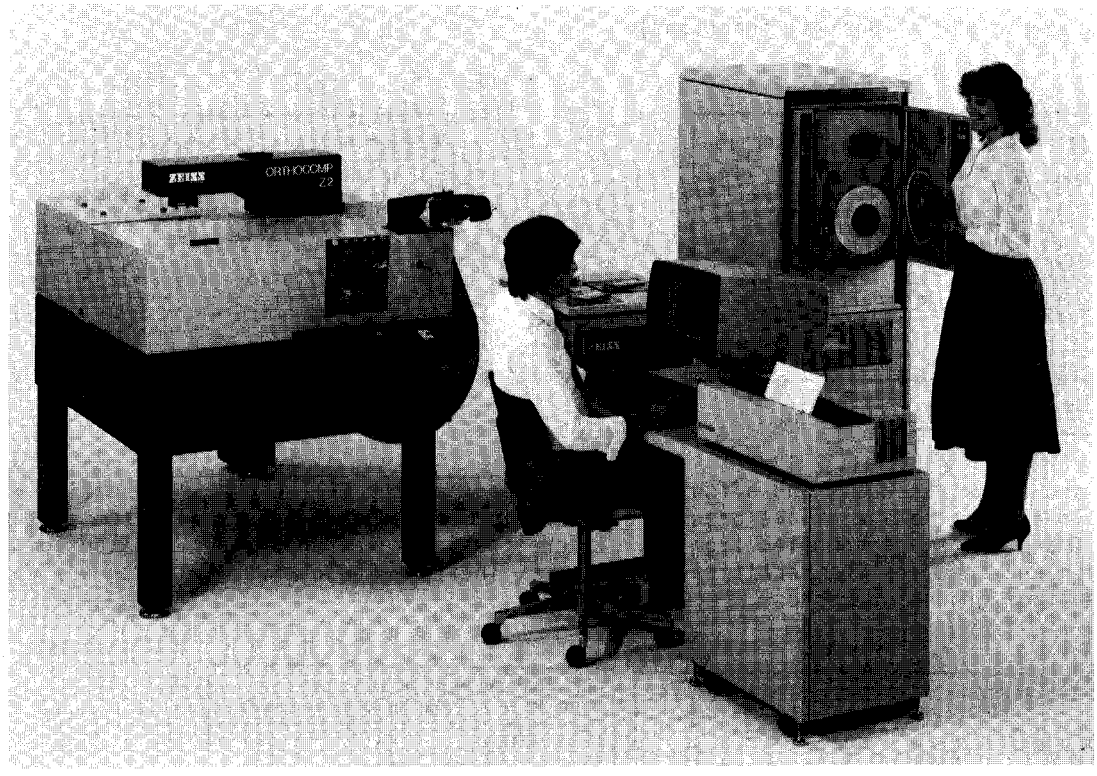

Fig. 7: Z 2 ORTHOCOMP with HP 1000 A Computer

5. HIFI Programs

The HIFI programs written by H. Ebner et al. in Munich have been converted to the RTE A operating system since the last Photogrammetric Week 1983. The programs have also been improved for easy and uniform operator control, and new program branches have been added. These developments have also been included in the RTE 4 B programs.
The software system now offers the following features (see Fig. 8):

Input data:	Elevation data in the form of regular grids, break lines, skeleton lines, single points and contour lines.
Orientation	to a new coordinates system with the HIFI-O program.
Interpolation	of the digital elevation model with the HIFI-P program. The first result is a square-grid model that can be stored directly (only elevation data). By adding the XY data, the data set can be stored as profiles for controlling the Z 2 ORTHOCOMP Orthoprojector.
Stereo orthophoto	profiles can be computed from the digital elevation model with the HIFI-S program.
Perspective views	of the digital elevation model can be computed with the HIFI-3D program. A central perspective is computed for any viewing angle (azimuth and elevation) and put out on a plot file.
Map frames:	The HIFI-G program serves to plot map frames, annotations and coordinates grids. Output is to a plot file.
Point plotting	with a series of different symbols is facilitated by the HIFI-B program. Output is to a plot file.

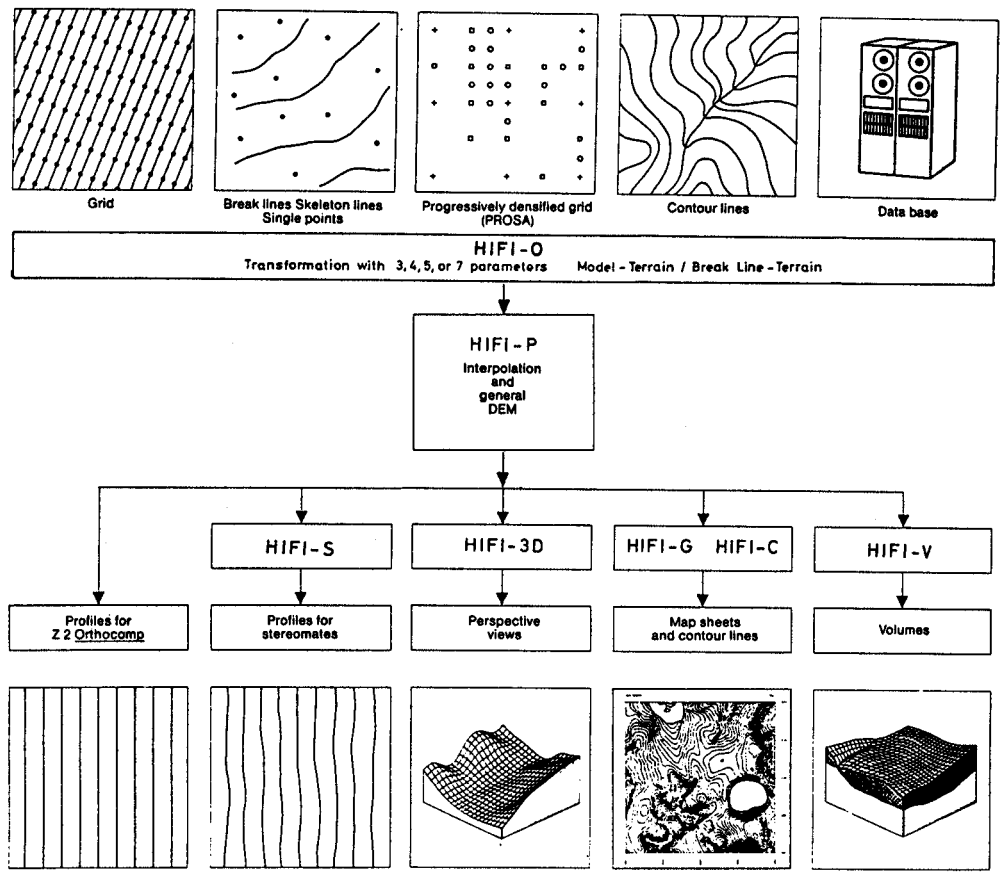

Fig. 8: HIFI Software System Survey

Contour lines: The HIFI-C program for computing contour lines is still one of the main programs in the software system (apart from HIFI-P). Break lines (contour line bends) and skeleton lines (which the contour lines intersect at right angles) are taken into account during contour line computation. The program has been enhanced, e. g. for elevation plotting on curvature-dependent arcs, for the elimination of "bubbles" and the marking of synclines. The contour line data is output to a plot file.

Volumes and differences in elevation between two digital elevation models can be computed with the HIFI-V program. One of the two elevation models can be defined as a horizontal plane. An elevation difference model can be stored in a general file for computing equal elevation difference lines with HIFI-C program for output to a plot file.

Plotting the contour lines (HIFI-C), single point symbols (HIFI-B), map frames (HIFI-G), or perspective views (HIFI-3D) stored in plot files is possible with the HIFI-A program. It enables output on the DZ 7, PLANITAB /6/ and on different Hewlett Packard plotters.

All computer-oriented programs such as HIFI-P, HIFI-C and HIFI-A can be used either in the interactive mode or in the batch mode so that the computer can also be used unattended.

Literature

/1/ H.-K. Meier: Die Entwicklung im photogrammetrischen Instrumentenbau während der letzten 30 Jahre. Zeiss-Mitteilungen 5 (1969), S. 105 - 127

/2/ D. Hobbie: Numerische Einpassung am Entzerrungsgerät SEG 5. Bildmessung und Luftbildwesen 44 (1976) S. 164-168

/3/ H. W. Faust: Z 2 ORTHOCOMP - The Analytical Orthoprojector from Carl Zeiss Bildmessung und Luftbildwesen, 48 (1980), S. 110 - 118

/4/ Firma Durst: Gebrauchsanleitung zum Color Laborator 2000 (1981)

/5/ H. W. Faust: Methods and Instruments for the Production of Photo Maps Bildmessung und Luftbildwesen, 52 (1984). S. 187 - 194

/6/ D. Hobbie: Fortschritte im Instrumentenbau für digitale Kartierung Photogrammetrische Woche Stuttgart, 1985.

Abstract

A brief report is given on improvements and developments related to the instruments for photographic rectification manufactured by Carl Zeiss, Oberkochen: The Standard Rectifier SEG 6 and the ortho projector ORTHOCOMP Z 2.

For the SEG 6 a new color illumination device replaces the color attachment with gelatine filters as used before. This new SEG 6 C uses a color illumination head with dichroic filters manufactured by DURST. Also related to the SEG, new orientation programs OCS 2 have been developed. For the ortho projector ORTHOCOMP Z 2 currently the software is implemented on HP 1000 A mini computers. This new software includes a number of improvements.

The paper also gives a brief review on the HIFI programs and improvements developed since 1983.

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Zusammenfassung

ENTWICKLUNGSSTAND DER PHOTOGRAPHISCHEN AUSWERTUNG

Es wird kurz über die Weiterentwicklung an den Zeiss-Geräten für photographische Entzerrung berichtet, die seit der letzten Photogrammetrischen Woche (1983) durchgeführt wurden. Es handelt sich dabei um Hardware- und Software-Entwicklungen zu dem Entzerrungsgerät SEG 6 und zum Orthoprojektor ORTHOCOMP Z 2. Am Entzerrungsgerät SEG 6 wurde die frühere Einrichtung für Farbarbeiten, die mit Gelatinefiltern arbeitete, ersetzt durch einen Farb-Beleuchtungskopf der Firma Durst mit dichroitischen Farbfiltern. Weiter wurden zum SEG 6 die Orientierungsprogramme OCS-2 neu erstellt. Für den Orthoprojektor ORTHOCOMP Z 2 wird z. Z. die Software auf den Minicomputern der HP-1000 A-Serie implementiert, wobei auch eine Reihe von Verbesserungen eingeführt werden.

Auch über die Weiterentwicklungen an den HIFI-Programmen wird ein kurzer Überblick gegeben.

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