EXPERIENCE MADE WITH WILD OR-1 AVIOPLAN ORTHOPHOTO SYSTEM*

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Abstract

This is a concise description of the operational principles of WILD OR-1. The Technical University, Budapest purchased the instrument two years ago. The experiences of application in various fields are reported. Special attention is paid to the preparation of data input using various types of photogrammetric instruments. Some computer programs have been written at this Institute. These program sets facilitate the interactive use of the SORA software packages.

1982 to 1984 the Technical University, Budapest, in cooperation with ERŐTERV (Power Plant and Mains Planing Bureau) has set up a closed-circuit stereophotogrammetric system. One of its elements is the Wild OR-1 Avioplan system, able to generate dimensionally accurate, correct in key pictorial output. The scheme of generating an orthophoto is illustrated in Figs 1 and 2.

Let us select linear elements in plane XY, which are parallel and equal in length. If these linear elements are produced by the parallel projection of a three-dimensional model, then according to Fig. 1, linear elements varying in length and position as a function of the topographic elevation of the projected terrain correspond to the linear elements in plane XY. The linear elements in the picture corresponding to those in the model, as well as coordinates of their extremities, can be determined from the rules of central projection. From these linear elements of the picture the orthophoto instrument produces the regulated linear elements of the orthophoto (see Fig. 2). For this procedure the picture coordinates of the extremities of the linear elements have to be known. Then the necessary scale of enlargement for each element (to have length "d" in the orthophoto after transformation) and the necessary degree of rotation (to be parallel with the x-axis in the orthophoto) can be computed from the coordinates. From these parameters the OR-1 generates the orthophoto by the optical-mechanical method illustrated in Fig. 3.

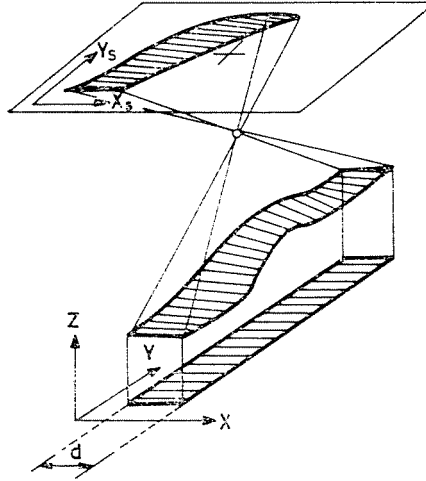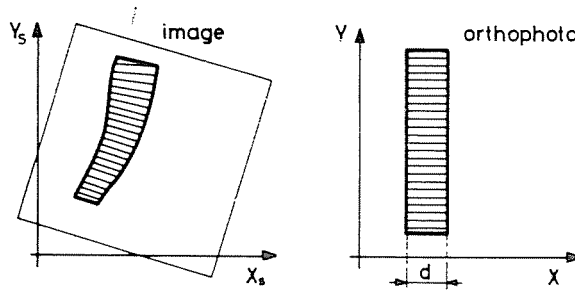The orthophoto system itself is composed of two parts:

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Fig. 1

Fig. 2

One is the operation unit, actually a Helvet-1 type small-scale computer, with 64K CPU capacity, supplied with a console key-board and a magnetic tape drive. The other part is a fully automatic electronically operated projecting instrument comprising optical and mechanical elements. Figure 4 shows the Wild OR-1 Avioplan system (the operation unit in the left side, the projection unit in the right side of the picture).

The computer compatible tape with the picture coordinates will be placed into the magnetic tape unit and the left-side picture of the stereo photo pair put into the projection unit (thus only one picture is used in the actual picture transformation). The system of coordinates of the picture has to be set parallel to that of the projecting unit using the marked three points on the picture. The length of aperture determining the scan-width, the required average en-largement, and other phototechnical quantities is set. In a dark room, the un-
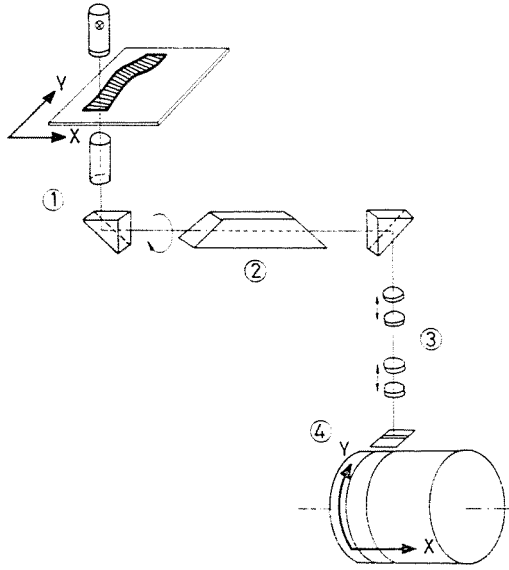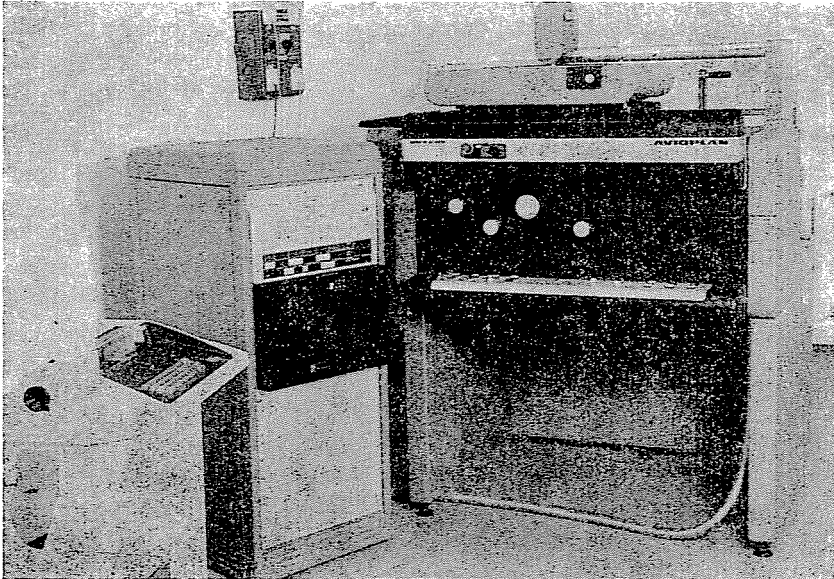
Fig. 3

Fig. 4

exposed photosensitive material is fastened on a cylinder to be placed in a tubular cassette, which after closing is put in the rear part of the instrument. This arrangement makes it possible for the instrument to be operated at light. After completing the manual actions above, the operator sets the instrument going and the further procedure of picture transformation will be fully automatic. The automated picture-transformation procedure controlled by a computer is illustrated in Fig. 3. The optical tube (1) aided by servo-motors stations itself over the centre of the first section in the first strip and projects the picture of the first section into the optical system. The beam will traverse the Dove prism (2) which is also rotated by a servo drive by half of the angle calculated from the picture coordinates. Thus, the projected picture of the section will be parallel to the x-axis. After this, the projected picture of the section will pass through a zoom-lens enlarger (3).

Besides of magnifying at a prefixed scale the enlarger can produce differentiated magnification of each projected section, the resultant of these two kinds of enlargement of each projected section will be the required length d. The rotated and magnified image will be projected through a slit (4) onto the unexposed photosensitive plate fixed on the drum. In course of scanning a strip of the photograph to be rectified, the drum is rotated at a constant speed, thereby it synchronizes the operation of the entire system. After scanning one strip the drum will stop and move in direction X by the width of one strip and start rotating again. The slits are rhomboidal for a photographically even overlap of the strips, thus the overlapping parts are exposed twice while scanning two neighbouring strips.

To ensure the possibility of further multiplications the rectified image is projected on negative film of 970 mm × 780 mm maximum size. The maximum circumferential speed of the rotating drum is 30 mm/s. Magnification can be made to scale 0.27x to 15x continuously. As mentioned before the input of the computer controlling OR-1 consists of the picture coordinates of the extremities of the linear elements. The picture coordinates can be determined in a direct or indirect way depending upon the type of the analytical stereophotogrammetric instrument or of the available three-dimensional information. The direct method can be applied if the Wild B8S analog stereophotogrammetric instrument is completed with an accessory PBK8. The PBK8 shifts the measuring mark at an adjustable speed in directions X and Y by means of a servo-drive The operator has only to care for keeping the measuring mark on the surface of the terrain by manipulating a control wheel. The device is fitted with a transmitter of picture coordinates. The transmitted data of picture coordinates will be stored on a magnetic tape by the controlling-recording unit.

The indirect method is more extended. Besides of using various analog or analytic stereophotogrammetric instruments, data recorded on topographic maps or determined by geodetic methods can be applied for generating an

orthophoto. The indirect method can only be used in the occurrence of: SORA OP software package, a computer with at least 128K CPU capacity, a disk-drive, a magnetic tape drive, a line printer and a card-reader (or terminals or peripherals which can receive the data recorded by stereophotogrammetric instruments, or by digitizing or recording tachimeters). The steps of the working process are as follows:

Terrain profiles are measured by analytical plotters;
or terrain profiles are measured by analog instruments equipped with a profiloscope (else, only contour lines are measured); or
contour lines are digitized from existing maps;
or three-dimensional coordinates of random points on the terrain are measured.
First the SORA OP software package will compute the vertical net representing a digital terrain model from any of the previously described measurement results.
Then the SORA program generates the picture coordinates of the extremities of the linear elements to be adjusted, corresponding to length "d".

It is very important that, in addition to the topographical application above, the OR-1 instrument is capable of transforming a plane surface into any other differently positioned plane. In this operational mode the system works similar to an analog image transformer, except that the OR-1 is free of the limitations concerning the magnification and the angle of inclination of the two planes, which are restricted in case of an analog instrument. The necessary conditions for image transformation are availability of the previously described computer and the SORA PR package. The input of SORA PR program consists of different variations of the parameters determined by the scale of magnification and the relative position of the two planes. In case of one image relatively few input data are needed, so it is needless to apply automated data input; they can be loaded by using a terminal. Before outlining our concrete tasks, the complex photogrammetric-geodetic automated system will be presented (see Fig. 5), since all its elements share the preparation of the input of SORA programs. The function of each element will be presented in explaining the actual applications, remind only that the SORA programs are run on a PDP 11/44 computer using the RSX 11M3200 system. The hardware configuration is as follows:

1 Mbyte CPU
800/1600 bpi magnetic tape drive
80 Mbyte disk drive
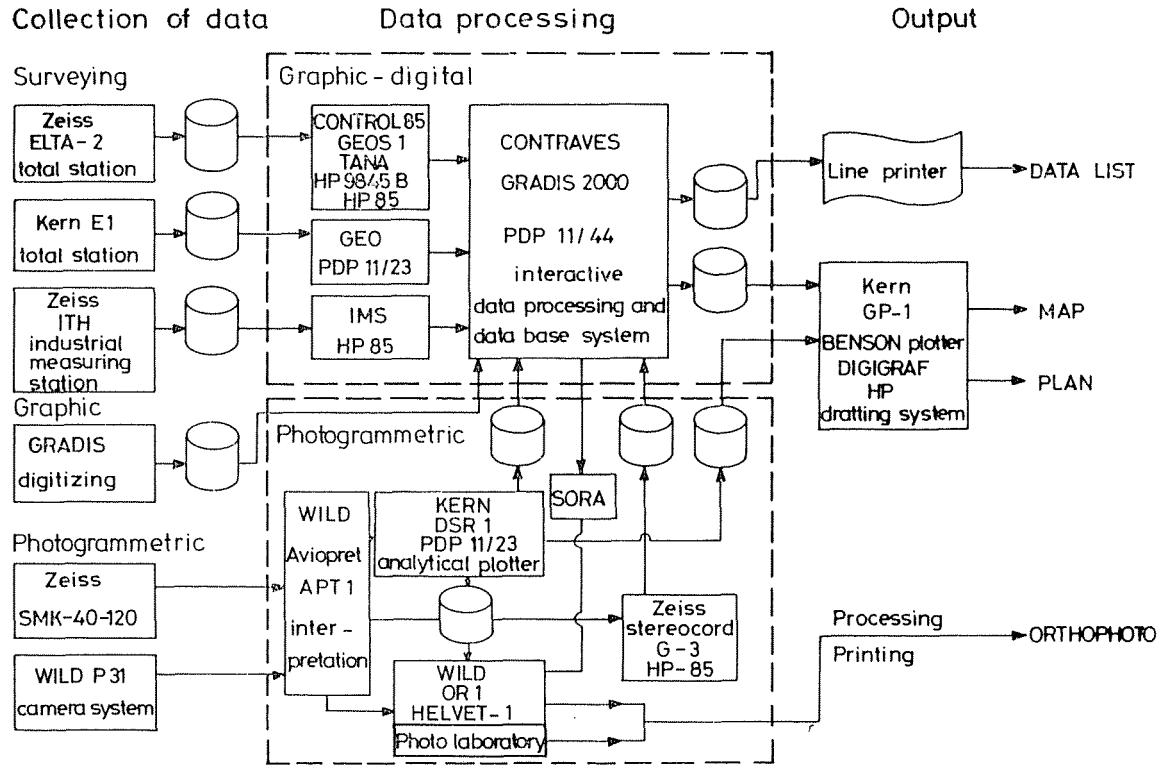1 console
3 video terminals.

Fig. 5

After inserting the SORA PR package, the first application was to generate orthophotos of several wall surfaces in a nuclear power plant under construction. The photos to rectified were made after completion of the construction phase but before installations. They were aimed to supply the technical supervisors with adequate, substantial information about the various wall formations (fitting inlets, openings, etc.) for installation. The photos were made by fixbased SMK-40 twin-cameras. The control marks were measured by a G3 type stereocord instrument while rotating the three-dimensional model in the wall plane. No precise geodetic measurements were necessary. Tape-measure was only used to a better approximate the stand-point coordinates. Later, organizatory considerations induced to determine assembly marks by a DSR-1 analytical plotter to facilitate on-line transfer of outputs to the PDP 11/44 computer. A similar but more complex task was the rectification of photos taken about the so-called localization tower of the nuclear power plant. The photos of the tower 8 m wide, 40 m high and 48 m long of steel and reinforced concrete, hollow inside, were made by a Wild P31 camera. The control marks were measured by geodetic means and densified with photogrammetric methods. Thus, several elements of the complex photogrammetric-geodetic system (ITH, IMS, PDP 11/44, DSR-1, PDP 11/23) took part in the generation of input data (see Fig. 5).

Orthophotos of several building façades were made by applying the SORA PR software package for rectifying photos made with UMK or other ordinary cameras. Experiments are in progress to process the photos of discontinuous (zigzagged) building façades. Among the extraordinary applications, the rectification of photos made on 24 mm × 36 mm films by amateur cameras boarded on model aeroplanes may be mentioned. The generated orthophotos were underlying thematic maps to scales 1 : 1,000 and 1 : 2,000.

Topographical applications of the SORA PR programs resulted in orthophotomaps to scales 1 : 10,000, 1 : 4,000 and 1 : 2,000 generated from a photo to scale 1 : 20,000 of a plain terrain surface. The perforated control marks were determined by aerotriangulation using an analog instrument. The excellent quality of the orthophotomaps to scale 1 : 2,000 generated by tenfold magnification must be emphasized.

The SORA OP software package was inserted about 8 months ago, thus not may orthophotos have yet been generated. The results of the first experiment were the orthophoto maps to scales 1 : 2,000 and 1 : 10,000 of certain areas in Nigeria (magnified to 5x, and 3x). The elevation data were obtained using an analog instrument and recorded on paper tape. Then the elevation data were transferred to a computer compatible tape which was the input media for SORA OP program.

Further achievement of this Institute are: Phtotomaps to scale 1 : 10,000 generated from a photo to scale 1 : 15,000 (a photomosaic using 6 sections); maps to scale 1 : 25,000 rectified from photos to scale 1 : 62,000; finally, the

orthophotomaps to scales 1 : 10,000, 1 : 4,000 and 1 : 2,000 generated from a photo to scale 1 : 20,000 already mentioned in connection with topographic applications of SORA PR programs. By way of experiment, orthophotomaps with enlargement scale 1 : 1 were generated using SORA OP programs.

The above mentioned results well illustrate the wide variety of research performed at this Institute. However, the experimental results are quantitatively fairly modest (not counting orthophotos of wall surfaces) because of the mainly education-oriented profile of our Institute. This is why it is attempted to offer services of data processing to an ever widening circle of those interested and working in related fields. These circumstances and the condition that the original SORA PR program required to input data and initial conditions from a card reader in batch mode, necessitated substantial amount of manual work. In case of inexperienced operators this resulted in a source of errors. It was deemed necessary to develop the SORA IN program package, permitting to apply a menue and masking technique to facilitate the interactive preparation of computation. The program package had two sets, program packages SORA PR and SORA OP. The original SORA OP version B was programmed to allow the use of terminals as input means. The interactive menue-mask technique applied also to SORA OP, however much simplified the operation of the program package. SORA IN allows the experienced user to select only the required steps from the menue, while it prompts a beginner through the whole procedure.

Another interesting software development of input data storage has been formation of geod-files and image-files which facilitate mass-data processing. The geod-file contains the three-dimensional geodetic coordinates of the control points of a certain territory, while the image-file stores the comparator coordinates of control points and frame-marks of each photo.

These files have to be loaded only once, at the beginning of the computation, using a terminal (or transmitted on line from DSR-1). Then, as a preparation to processing, only the serial number of control points need to be referred to. All the other supplementary information will be loaded by the SORA IN program onto the disk file.

It is very advantageous to apply the geod-files and image-files, if several orthophotos to different scales are to be made from the same photo.

The fact, that the data supplying the OR-1 can be produced by various photogrammetric instruments and digitizers made a strong impact on the development of both the hardware and the software. The hardware of such a system must be formed to facilitate the data aquisition from various input means, such as paper tape reader, magnetic tape recorder, floppy and mini-floppy disk drives and cassette tape recorder. Accordingly, the software of the system must be capable to accept any arbitrary format of digital elevation data to be transformed to the required WINPUT formated data set. The above described ar-

rangement is also necessary if the photogrammetric instruments or digitizers are on-line connected to the CPU.

At the Institute, the DSR-1 analytical plotter, the GRADIS 2000 and the FOK-GYEM digitizer are on-line connected and their input data, as well as the off-line recorded CCT or floppy disk information are converted to the required standard format.

In research two, as yet unsolved problems emerged which may have a significant impact on the productivity of the OR-1 system.

The first problem is the montage of orthophotos. Since photos can only be joined by a rather labour-consuming traditional method of composition, the original photographing is to be arranged so as to minimize the orthophoto sections. It would be very beneficial if it were possible to rearrange the operations of OR-1 so as to directly produce an orthophoto from several photos.

The second problem is the automation of the network construction. At present the network is constructed using the GP-1 plotter. Each control point is located by the microscope of the instrument and at the same time its coordinates are input into its central controlling memory. The program adjusts the measured values, records the deviations and then the instrument perforates the points of intersection of the network lines. The merit of this method is to inform of the accuracy of the orthophoto. It has the disadvantage of a limited applicability of system including an intelligent plotter.

It would be very helpful to arrange the OR-1 controls so as to include the network construction in or before, the process of generating the orthophoto.

Finally, the excellent quality of the OR-1 instrument should be emphasized. During its two years of operation only two minor operational problems emerged, almost instantaneously corrected by the ready help of the WILD company.

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