The DVP: Design, Operation, and Performance

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ABSTRACT: Evolved as a by-product of what were originally merely educational considerations, the DVP is now a low-cost general-purpose photogrammetric system. As had been stated in Gagnon *et al.* (1990), the general research objective that led to the DVP was the following: to develop software capable of making optimal use of common microcomputer hardware, so that the system would solve the standard photogrammetric problems in a user-friendly and efficient way and even perform tasks beyond the possibilities of conventional photogrammetric instrumentation. This paper completes and updates the general description of the earlier publication and emphasizes the design aspects of the system. The different aspects covered are the structure and sequence of the basic photogrammetric functions; the utility functions and existing or in-development applications; the scanning, storage, and display of images; the editing features and links with current existing graphics software; and accuracy and ergonomic considerations.

INTRODUCTION

BACKGROUND OF DVP DEVELOPMENT

CLASSIFICATION OF EXISTING DIGITAL PHOTOGRAMMETRIC SYSTEMS, with their growing number and diversity, would hardly fit into a simple model. It can be said, however, that at one end of the spectrum are to be found very sophisticated systems, specifically designed to compete with the best analytical plotters. At the other end exist other systems developed to meet, at low cost, particular and simple needs. The commercial softcopy photogrammetric system that the DVP has become belongs to the latter category, considering first its origin and considering also the characteristics that have been preserved.

In fact, the DVP has evolved as a by-product of what were, at first, merely educational considerations and concerns, which were not even oriented at softcopy photogrammetry. Originally, what was sought was a means of improving the learning process related to stereoscopic pointing and accuracy, for students taking an introduction course in photogrammetry. The idea led to the development of a microcomputer-based method, using split-screen imagery examined with a mirror stereoscope, which was presented in Agnard and Gagnon (1988). As is explained in the paper, the method presents many advantages: it is a simple and self-teaching method and it offers practical and efficient ways of dealing with and minimizing the personal factor or equation inherent in the stereoscopic operation.

The new method involved the display of a digitized stereomodel, which led naturally to the idea of going a step further and using it for three-dimensional (3D) measurements. It was felt that the idea deserved investigation: the recent outstanding advances in microcomputer and microcomputer-related technology clearly indicated that, as many photogrammetrists have also realized, with appropriate software, simple and low-cost hardware could have great potential for photogrammetry.

GENERAL OBJECTIVE

These considerations generated the following general research objective: to develop software capable of making optimal use of microcomputer hardware "so that the system would solve the standard photogrammetric problems in a user- friendly and efficient way and even perform tasks... beyond the possibilities of conventional photogrammetric instrumentation" (Gagnon *et al.*, 1990).

The long-term benefits of achieving this objective were, quite clearly, the following:

- an improvement of the existing photogrammetric practice, the new technology being developed to be more cost effective and more operationally efficient; and
- a significant increase in the general accessibility of photogrammetry.

The DVP has been designed to meet the above objective and to go a significant step towards "zero-cost hardware" photogrammetry (Dangermond and Morehouse, 1987). This paper completes and updates the general description presented in the earlier publication and emphasizes the design aspects as well as the recent developments of the system.

PHOTOGRAMMETRIC ASPECTS

SEQUENCE OF BASIC OPERATIONS

In order to achieve the first benefit mentioned as a consequence of the general objective, the software has been structured to make the operations follow the usual steps of interior, relative, and absolute orientations, as illustrated in Figure 1. Photograph coordinates are determined by applying either an orthogonal or an affine (if more than two fiducial marks are observed) transformation to the pixel coordinates stored as a two-dimensional matrix. The relative orientation is solved using the coplanarity condition. It was decided to proceed through the intermediate step of relative orientation instead of going directly to the bundle formation because the procedure was better suited to some specific applications.

Once the relative orientation parameters are known, equations derived from the collinearity condition automatically.

- assure that the measuring marks become locked to the respective corresponding points so that the model is preserved in all displacements; and
- compute model coordinates.

The ground or object coordinates are computed from the model coordinates by application of the similarity transformation based on the Space-M formulation, as described in Blais (1979).

APPLICATIONS AND ACCURACY

Using the transformation parameters of the three orientation steps, the software offers the possibility of the inverse transformation, of going from object coordinates to scanner coordinates. This possibility allows

- superimposition of vectors;
- interactive topometric or COGO computations in the stereomodel, with superimpositioning; and
- displacements at a constant elevation.

This function and the preceding ones provide a flexible basic structure adaptable to various refinements, additions, or developments, as is illustrated in Figure 2, which covers present or in-development applications.

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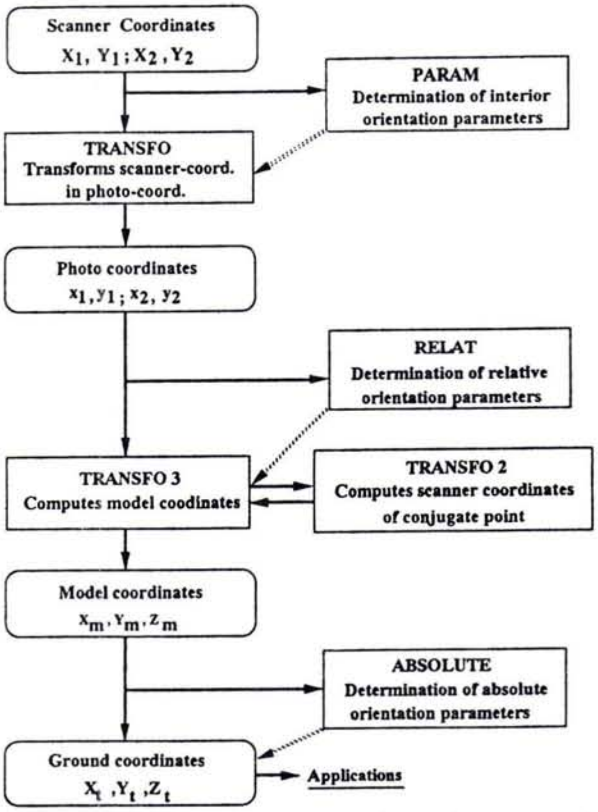

FIG. 1. Structure and sequence of the basic photogrammetric functions of the DVP.

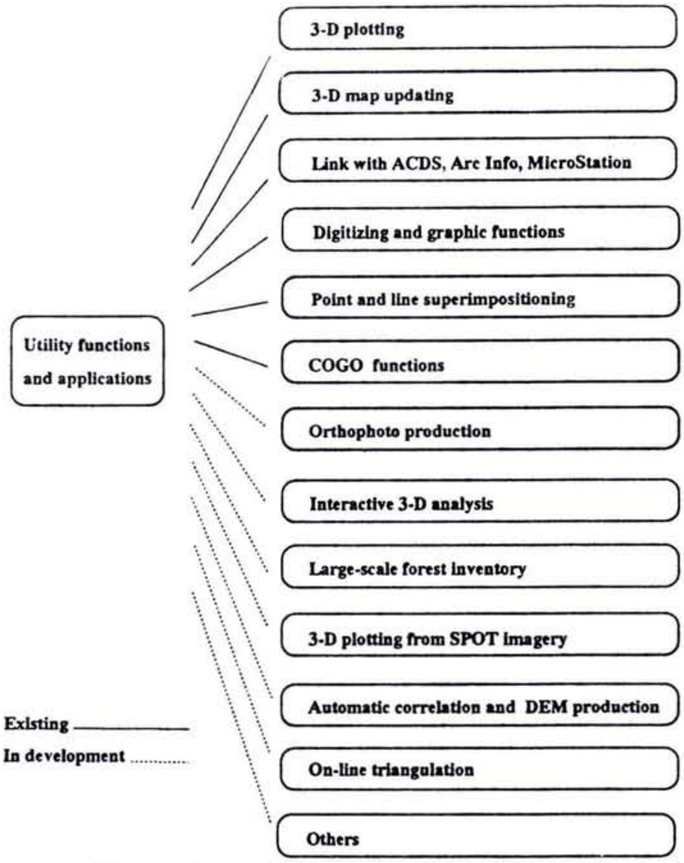

FIG. 2. Utility functions and applications of the DVP.

TABLE 1. ACCURACY OF THE DVP, SCANNING AT 450 DPI.

Model	Scale	RMS on Check Points (micrometres) σ_{xy}	σ_z	Number of Check Points
1	1 : 6000	34	35	14
2	1 : 6000	40	34	17
3	1 : 6000	45	35	12
4	1 : 5000	42	42	33
5	1 : 40,000	50	33	44
Mean		42	36	

For all applications, the accuracy of the product is dependent on the scanning resolution. Different experiments have consistently shown that the accuracy in x and y is of the order of the half-pixel of the scanner output. An example of this is given in Table 1, which shows the accuracies obtained in planimetry (σ_{xy}) and in elevation (σ_z) for five models of scales ranging from 1:5,000 to 1:40,000. To facilitate analysis and comparison, all values are expressed in micrometres at photographic scale. The geometry of all models is the same: standard photography focal length of 152 mm and 60 percent overlap. The photographs have been scanned at 450 DPI, so that the pixel size is 56 µm and the half-pixel expected planimetric accuracy is

$$\sigma_{xy} = (28^2 + 28^2)^{1/2} = 40\ \mu\text{m}$$

For the five models, the relative and absolute orientation have been performed with ten well-distributed points and the number of check points, also well distributed, ranged from 12 to 44.

HARDWARE AND SOFTWARE ASPECTS

SCANNING OF THE PHOTOGRAPHS

Out of the many scanners on the market that can transform photographs into digital data, the two that were used while developing the DVP are:

HP Scanjet:	300 DPI, 16 grey levels, 8½ by 11 inches.
XEROX 7650:	up to 1200 DPI (according to specifications), 256 grey levels, 11 by 17 inches.

The principal technical characteristics considered have been the resolution, the number of grey levels, and the dimension. It was also considered important to choose a scanner that can accept tranparencies. This avoids having to transfer the pug marks from diapositives to paper photographs, which would not be acceptable for standard photogrammetric operation.

The scanner is the only element of the station that includes mechanical parts which could introduce errors. The tests made with the HP and the XEROX equipment reveal that there is no need to calibrate them due to the fact that the measured errors are far under the pixel dimension (an RMS of 38 µm for the HP and of 20 µm for the XEROX).

As previously mentioned, the resolution of the scanner is the characteristic that determines the precision of the measurements in the model. Experiments showing that the accuracy of the measurements is on the order of half-pixel size, it is important to know the actual resolution of the scanner used in order to estimate the precision of the product. The XEROX 7650, even if advertized at 1200 DPI, actually scans with a CCD bar of 5 000 sensors for 11 inches in x which is roughly 450 DPI and the maximum number of steps in y is 600 per inch. So 1200 DPI is obtained by interpolation, and tests performed with the DVP gave almost the same precision for models scanned at 450, 600, or more DPI.

Standard CCD cameras do not provide enough resolution for an entire photograph, even though they can be used for small documents. To scan larger documents, consideration was given to mounting a camera on an old coordinatograph equipped with stepping motors and encoders, but the idea was given up because of the difficulties of getting good mechanical control on the equipment, and of the problems of joining together all the frames of a document, each one potentially including optical distortion and positioning error.

Tests made with 8, 16, 32, and 64 grey levels reveal that there are almost no apparent differences between 32 and 64. Obviously, with 8 and 16 levels the loss of detail is too important and it is difficult to make acceptable orientations and good measurements, which is not the case with 64 levels (Gonzalez and Wintz, 1987). However, it seems that more than 64 grey levels, or even color, could be necessary in disciplines like agriculture and forestry where photointerpretation is closely tied to subtle texture variations. The 256 grey levels produced by the scanner are kept in the file and used to achieve better results when mathematical functions like correlation or interpolation are performed on image data.

Storage of Scanned Photographs

Photograph scanning produces what can be considered huge files in the context of a microcomputer-based station like the DVP. Fortunately the cost per Megabyte keeps decreasing and, depending on one's needs and budget, optical disks, erasable or not, removable disk cartridges, tape streamers, tape drivers, or any high capacity mass storage device can be used to archive the scanned documents. When needed, the two photograph files of a given model can be retrieved and copied on the station hard disk.

It is very important that the system hard disk and disk controller be as fast as possible because it acts, in the DVP, as the main video memory. Use of a disk cache in the system configuration has proved to be very effective in increasing the display speed and it is strongly desirable to use one, as shown in Table 2. Indeed, the solution that gives the best results is to store the photographs in RAM disk if enough memory is available on the computer.

To obtain the fastest speed possible, for display, the data transfer from the disk to the display adapter video memory should be direct without data manipulation. The data structure in the file should match the data structure used by the selected video mode of the adapter. All data transformations, if needed, from the scanning format to the adapter format should be performed once and stored in the files to be used by the photogrammetric software. It can be anticipated that the question of display speed will become much less critical in the near future, because it relates to a facet where technological advances are important.

Table 2. File Size and Display Time.

DPI	File Size (Meg)	Model Display Time (sec.) With cache (1024 Kb)	Model Display Time (sec.) Without cache	Computer AT 80386, 25 MHz HD 130 M, 20 msec.
100	0.7	3.0	29.5	ATI VGA WONDER
450	16	11.9	33.0	(WINDOW 400 by 500)
100	0.7	2.8	37.8	ATI ULTRA (8514)
450	16	15.3	47.0	(WINDOW 512 by 640)

Display of the Photographs

Because of the stated objective of developing a low cost system, it was decided to keep away from high level video graphic adapters and high technology stereoscopic devices using LCD polarizing filters or shutters with special glasses and requiring high frequency monitors capable of 120 non-interlaced frames per second to avoid flicker. So, as with the training device from which the DVP has evolved, stereoscopic vision is acheived with a mirror steroscope mounted in front of the monitor where parts of the left and right photographs forming the stereomodel are displayed on the corresponding halves of the screen. This approach has the disadvantage of dividing by two the observable surface but allows the use of standard analog monitors compatible with inexpensive graphic adapters.

The AT version of the DVP uses the low cost ATI VGA WONDER graphic adapter. With 512K of video memory, this card allows, in extended VGA mode, a resolution of 800 by 600 with a byte per pixel. The color table has 256 entries with 6 bits for each color—red, green, and blue—thus giving the possibility of 64 gray levels. The PS-2 version of the DVP uses the IBM 8514A adapter which, with 1 Megabyte of video memory, gives a resolution of 1024 by 768 pixels with a byte per pixel. The color capabilities are the same as those found on the VGA WONDER. To get acceptable display time, the AT version accesses directly to the registers and to the memory of the ATI adapter card with the drawback that this is not portable to systems using other adapters. The PS-2 version uses the 8514A driver routines so it can be implemented on any system equipped with an 8514A emulator card, as it exists now, even for AT bus systems.

The display of the photographs is made on a ratio of one scanner pixel to one screen pixel. So, depending on the scanning resolution, the viewable part of each photograph, or window, covers smaller or larger areas. When fine details are needed for interpretation, high resolution scanning must be done, so that the area of the photograph shown in each window is small, which may cause a lack of perspective to the operator. The alternative is to decrease the scanning resolution so that a greater object surface can be observed in the window, but then fine interpretation becomes almost impossible. It has been found that, in general, scanning resolutions of 450 and 600 DPI make an acceptable surface- detail working combination with 800 by 600 and 1024 by 768 display resolutions, respectively.

From the 256 entries of the color table, the processing is almost the same on both adapters: the first 64 entries are used for the grey levels (0 to 63), each of the next two 64 entries contain 64 times the same color, thus giving two non-destructive colors that are used to display vectors over the raster images. With appropriate logical operators and/or color table manipulations, it is then possible to erase vectors while keeping the displayed image data or turn off and on vectors or image as needed. The last 64 entries are used for destructive colors that modify the image data and for text display, in the information and dialog window at the bottom of the screen.

The transfer from file to adapter is executed by blocks of bytes, each corresponding to the part of a scanned line to be displayed. With the ATI card, the reduction from 256 grey levels, as contained in the file, to 64 grey levels is performed by a fast assembler routine on each line at it is read. The 8514A adapter driver includes a mix or logical function with the average operator, so that the image is displayed with its 256 levels, then reduced to 64 levels by applying twice the average operator with a black rectangle on the image.

Moving in the Model

Considering the DVP origin and the graphic hardware used, it was never considered that the floating mark should be fixed and the image mobile. It seems natural to move the floating mark in the displayed-model window and to change the window when it is necessary to observe another part of the model. This approach does not involve large video memory with fast roaming functions needs, and it limits disk access to window changes and, as discussed later, to right photograph image adjustments when parallax correction is needed. Besides, it seems that fixed floating mark and mobile image systems, in their present state, may rapidly induce a great eye-strain due to the discontinuity of the displacements by steps of one or more pixels.

Once the relative orientation is completed, the DPV considers, for a given window of the model, that the left photograph displayed part is fixed and that the right photograph displayed part can move vertically to remove the *y* parallax and keep the two cursors making the floating mark on the same horizontal epipolar line. The right image displacement occurs only when the difference between the displayed position and the computed position of the right cursor is over a half- pixel. To reduce right image jumps and to minimize the time the operator has to wait to complete the adjustment, a delay of 0.25 second has been introduced, after the mark movement has stopped, before an adjustment of the needed number of lines is executed. When this parallax correction is performed, the left cursor changes color to notify the operator that it freezes while the retained lines of the right image are moved up or down inside the video memory and while the missing lines are fetched from disk to complete the bottom or the top of the image.

Once the absolute orientation is completed, the floating mark moves at a constant elevation, so that the *x* parallax is constantly computed in order to determine the pixel position in the right image corresponding to a given position in the left one.

To help the operator move in the model, two indexes showing the relative position of the displayed parts of the left and the right photographs are constantly present at the lower right corner of the screen. Each index consists of a grey rectangle with dimensions proportional to the entire corresponding photograph on which stands a white rectangle representing the position and the dimension of the displayed part. When the operator uses the "Window Change" command, a black rectangle following the movements of the cursor on a graphic tablet appears in the index. If the operator accepts the position indicated by the black rectangle, the new part of the photograph is displayed and the white rectangle takes the place of the black one. When the relative orientation is completed, the displayed parts of the left and the right photographs form a stereo pair and the two black rectangles move together to preserve that model. So when a rectangle bumps the limit of a photograph, the other one stops too. It is also possible to disconnect the two rectangle movements as needed. The cursor on the tablet can be used for relative or absolute displacements in the model, as a mouse, if one of the photographs of the model has been placed on the tablet and its position defined by three of its corners at the beginning of the working session.

Within a model window, the floating mark moves along with the tablet cursor, in relative mode, for planimetric displacements. Two speeds are available, one by steps of 10 pixels for fast displacements, one by steps of 1 pixel for fine measurements. One button of the tablet cursor alternatively passes from one speed to the other. The altimetric displacement is controlled by two function keys. A user selectable delay is introduced between each altimetric step to allow control of the floating mark speed on the Z axis. At any time the display window of the model can be recentered on the current planimetric position of the floating mark.

ORIENTATIONS

As previously stated, the orientation process follows the standard three steps of interior, relative, and absolute orientations. At each step, after entering the necessary points and data, if needed, the results of computations are displayed and can be saved on file and/or printed. Review of the control points can be done with automatic recentering on the selected one. New points can be added or old ones excluded before recomputation, until satisfactory results are obtained.

All orientation parameters are saved on file, so the system automatically replaces itself at the latest step reached in the process when a new working session begins.

To help the operator achieve better accuracy, a local zoom function magnifies by two a small window centered on the floating mark. Each interpolated point gets the mean of its neighbors. It is thus possible to observe a point with half-pixel accuracy. This can be useful when the center of a detail counting a pair number of pixels has to be precisely picked. An image autocorrelation function has also been included to facilitate the observation at homologous point pairs, at the relative orientation step.

PLOTTING AND SUPERIMPOSITIONING WITH THE DVP

Working with a microcomputer-based stereoplotter dealing with numerical image data allows the inclusion of many functions that belong to CAD, image processing, or database worlds. So choices had to be made to limit the amount of work to put in the development of the DVP station, even if, at least in theory, a unified tool for photogrammetry, cartography, remote sensing, information systems, etc., could have been designed.

The DVP offers the minimum number of graphic functions needed for plotting. It includes point, line, polygon, and arc generation with snap capabilities on any previously digitized element. Each element receives a code specifying its nature. An "Erase" function allows the removing of existing elements from a graphic elements file. These files are called *XYZ* files and contain graphic elements stored as vectors with the DVP's own header and data structure.

To complete cartographic editing and to perform the drawing of the resulting product, the DVP relies on external graphics software like MicroStation, AutoCad, ACDS, etc. Translators between *XYZ* file format and those required by these software packages are available for both directions. This makes it possible to import data digitized elsewhere and to superimpose it, generally for map updating purposes, in any model that uses the same coordinate system. If the superimposed file contains only planimetric data, an estimated Z can be given to the DVP. Of course, almost every element then seems to float over or under its actual position, but as the information sought is to know the new elements or changes on the ground, the Z misposition is not of great concern.

A totally different approach would be to consider the DVP as a standard analytical plotter linked to another computer running specialized plotting software. Some successful tests in that direction have already been made with Kork software. A more intimate mix of both software packages has also been considered, that could use the DVP display to present the graphic elements digitized by Kork, so the user would see the superimposition of the vectors on the image, as with the actual DVP, but with more powerful plotting functions.

ERGONOMIC CONSIDERATIONS

Since the release of the first beta versions of the DVP, many additions and refinements have been made in order to improve its facility of operation. These additions and refinements affect the menu design, the use of the cursor buttons of the tablet, the use of the function keys, and the display of graphic or text elements. Use of the DVP in a production environment has given the necessary feedback to adjust the software to the users' needs and to the operators' preferences. For instance, two of the tablet cursor buttons were first used for altimetric displacements of the floating mark and the space bar was used to specify a data point when digitizing. Operators have found that combination difficult to handle, so the altimetric control has been relocated on two function keys of the keyboard, and the two buttons of the cursor are now used for data points and end point of elements, respectively, when digitizing.

The cursor has also been studied to remain visible on almost every background. For fine measurements, the cursor is a single-color pixel with a black pixel on each side, forming a small plus sign. Without the black pixels, the color pixel vanishes in high grey levels areas on almost all monitors due to electron beam halo. The cursor for fast displacements is the smaller one, with four color corners at four pixels from the center to increase its visibility. The image between the center and the corners remains visible. Three user- selectable colors are available to insure a good contrast with the background.

All dialog and menu texts are included in a standard ASCII file, so it is easy to translate them into any language to help operators use the station. The DVP adapts itself to new menus provided that each item begins with a different letter.

CONCLUSION

Compared to the preceding descriptions of the DVP (Agnard *et al.*, 1988; Gagnon *et al.*, 1990), this paper gives more in-depth information on the structure, design, and operation of the system, which is quite different from other existing PC-based systems, the best known of these being the DMS (Welch, 1989). It also shows where efforts have been and are still being made to make the system more productive and more user-friendly. The development of the DVP keeps being a great challenge. New ideas for improvement and domains of application emerge almost every day. Color display for forestry and archeological applications or graphic elements display by selected codes are some of them. Another one is having a DVP version running on UNIX. All this shows beyond any doubt the great potential as well as the great flexibility of digital photogrammetry. Some applications might seem incompatible with a microcomputer-based system but many others are already under development or have been realized by other teams: automatic DTM generation, orthophoto construction, numerical aerotriangulation, use of satellite imagery, etc.

It shows also a great potential in extending the day-to-day use of photogrammetry. Low-cost systems like the DVP are affordable and easy of operation, thus allowing many non-photogrammetrists to use a new tool. A consequence of this is that special training and formation will have to be considered, in order to ensure proper use of the new tool. On the other hand, new standards and performance tests should be designed with due consideration for these new users with needs that are not necessarily in terms of accuracy. Other aspects should be considered, like friendliness or ease of operation, lightness, possibility to use portable hardware *in situ*, degree of interactivity between camera operation and photogrammetric processing, etc.

REFERENCES

Agnard, J.-P., and P.A. Gagnon, 1988. L'enseignement du pointé stéréoscopique: une solution nouvelle à un problème permanent. *XVIth Convention, International Society for Photogrammetry and Remote Sensing*. Kyoto, July, 6 p.

Blais, J.A.R., 1979. *Least-Squares Block Adjustment of Stereoscopic Models and Error Analysis*. Doctoral thesis in the Department of Surveying Engineering, UNB. Technical report No. 30001, Division of Surveying Engineering, The University of Calgary.

Boulianne, M., P.A. Gagnon, J.P. Agnard, and C. Nolette, 1990. Large-Scale Map Revision using a PC-based videoplotter. *Proceedings, ISPRS Commission IV Symposium*, Tsukuba, Japan, 15-18 May, pp. 273–279.

Dangermond, J., and S. Morehouse, 1987. Trends in Hardware for Geographic Information Systems. *Proceedings Eighth International Symposium on Computer-Assisted Cartography* (N. Chrisman, editor), Baltimore.

Gagnon, P.A., J.P. Agnard, C. Nolette, and M. Boulianne, 1990. A Microcomputer-Based General Photogrammetric System. *Photogrammetric Engineering & Remote Sensing*, Vol. 56, No. 5, pp. 623–625.

Gonzalez, R.C., and P. Wintz, 1987. *Digital Image Processing, Second Edition*. Addison-Wesley Publishing Co. 503 p.

Welch, R., 1989. Desktop Mapping with Personal Computers. *Photogrammetric Engineering & Remote Sensing*, Vol. 55, No. 11, pp. 1651–1662.

BOOK REVIEW

A Guide to Remote Sensing; Interpreting Images of the Earth by S. A. Drury. Oxford University Press, 200 Madison Ave., New York, NY 10016. viii and 199 p. 138 color images and photographs, 30 black-and-white images and photographs, 25 illustrations. Hardcover: $85.00 [ISBN 0-19-854494-4] Paper: $39.95 [ISBN 0-19-854495-2] (U.S.). 1990.

DRURY'S BOOK PROVIDES THE READER with an organized discussion of why remotely sensed information is critical to future Earth monitoring objectives, resource management practices, and scientific investigations. He provides the reader with ideas about how such information can be interpreted and how the interpretations can be applied to pertinent global environmental issues.

At the beginning of the book, Drury stated, "I did not set out to write a book, but began with the zealous intention of setting up a familiarization course in applied remote sensing... ." He later explains that his purpose is to familiarize individuals with basic principles of remote sensing and given an overview of various aspects of terrestrial environments that can be addressed by examining and analyzing images.

The volume is organized into five chapters, two appendices, a glossary, and an index. The chapters are entitled: The Problem; Getting the Information; Interpreting the Information; Using the Information; and Operational Issues.

Chapter 1 discusses problems around the world as they relate to water, food, natural disasters, physical communications, physical resources, natural environments, and security. The author explains why remote sensing provides valuable information pertinent to many world problems.

Chapter 2 contains a general overview of human perception of electromagnetic energy, radiation and its interaction with matter, sensors used to measure electromagnetic energy, sources of remote sensing information, and display of the information. In this chapter, the author gives a very brief overview of remote sensing principles and techniques. Drury touches on many remote sensing technical components; in about four pages, he discusses such technical issues as line striping, density slicing, false color composites, color look-up tables, contrast stretching, edge detection, filtering, georectification, band intercorrelation, and principal components analysis. After reading this section, I concluded that the author's "whirlwind" approach was designed to acquaint readers with some of the more technical aspects associated with remote sensing, and it was apparent that providing a detailed description of remote sensing technical issues was not the author's objective. This section primarily serves as a quick technical review for the advanced user and will certainly convince novices that there is much about remote sensing that they have yet to learn. Drury also provides an exhaustive list of remote sensing systems; each is briefly described, beginning with instruments deployed in the 1960s and concluding with the High Resolution Imaging Spectrometer (HIRIS), tentatively scheduled for launch on the EOS platform in 1998.

Chapter 3 describes how global environmental phenomena are identifiable from remotely sensed imagery. Drury provides many examples that illustrate the utility of remotely sensed information to study weather systems and aspects of the climate and atmospheric chemistry, ocean features, characteristics unique to landforms of various climatic regions, vegetation communities, human land-use patterns, and the geologic make-up of the continents. Most of Drury's interpretation examples are supported with at least one color figure that was selected to illustrate Earth features with respect to coloration, texture, pattern, tone, shape, juxtaposition, and size.

Chapter 4 discusses how interpreted information can be used to address questions related to water resources, food and fiber, physical resources, communications, disasters, environmental change, and military uses. Notice that the subheadings in Chapter 4 are very similar to those in Chapter 1. In this section, Drury reminds the reader of the environmental issues and describes how remote sensing can be used to address them. He provides numerous examples illustrating the use of remote sensing in a variety of fields to solve a full range of environmental problems. Chapter 4 is also abundantly illustrated with color imagery used to demonstrate interpretation and application concepts described in the text. The author uses color illustrations on nearly every page and he has made an extra effort to use images from many locations around the world. The use of imagery definitely helps the reader conceptualize the lesson being taught, although use of imagery was occasionally less effective, because some illustrations were not labeled, leaving the reader to search the image for the referenced feature.

Chapter 5 addresses practical issues involved in using remote sensing such as cost, data availability, training requirements, political concerns, and the future prospects for the technology.

The chapters are followed by Appendices 1 and 2. Appendix 1, entitled "Training Opportunities," lists world organizations that provide short-term remote sensing training. Universities providing courses in remote sensing were omitted from the list because Drury felt his book would appeal primarily to professionals who would be most interested in part-time or short residential courses. Appendix 2 is entitled "Sources of Images and Further Reading." This appendix contains a list of sources from which imagery can be acquired and also a list of remote sensing textbooks, image atlases, source references, specialist journals, and regular remote sensing symposia. The section lists well-known literature sources in the field; however, several prominent textbooks, symposiums, and professional journals were omitted and one of the listed symposiums is no longer held. The list of references in this appendix is the only place where the author provides the reader with such information; citations are not used within the body, nor at the end of the chapters. Following the appendices is a glossary that contains definitions for 185 terms, and the volume concludes with a four page index.

I found Drury's book to be well organized and informative. The volume will serve as a useful reference to those interested in manual interpretation of raw and transformed remotely sensed information collected from a host of platforms and by many instruments. Although Drury's intended audience is the professional who wishes to use remotely sensed imagery to make environmental observations, academic instructors should consider the book as a good reference, especially if their courses are designed to teach manual interpretation techniques. Although my remote sensing courses emphasize digital image processing and automated classification approaches, I firmly believe that well trained remote sensors are also skilled image interpreters. My review of this book has expanded my understanding of remote sensing applications in other fields. I am pleased to add Drury's volume to my remote sensing book collection.

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OFFICIAL NOTICE TO ALL CERTIFIED PHOTOGRAMMETRISTS

The ASPRS Board of Directors approved an expansion of the Certified Photogrammetrist Program that goes into effect January 1, 1992. After that date, all Certified Photogrammetrists MUST submit an application for recertification as a Photogrammetrist or for certification as a "Certified Mapping Scientist--Remote Sensing," or "Certified Mapping Scientist--GIS/LIS." Recertification is required every five years; fee for recertification application and evaluation is $125 for members of the Society, and $225 for non-members. Those that do not recertify, will be transferred into either an "Inactive" or "Retired" status.

If you were certified between January 1, 1975 and January 1, 1987 (anyone with a certificate number lower than 725), you must comply with this notice.

Each Certified Photogrammetrist will be contacted by Certified Mail, but if you do not receive notice from this Society by April 1, 1992, you should contact the Society directly. If you have any questions, call Chairman Sky Chamard at 502-683-2504, or the ASPRS Office at 301-493-0290.

William D. French, CAE
Secretary, ASPRS