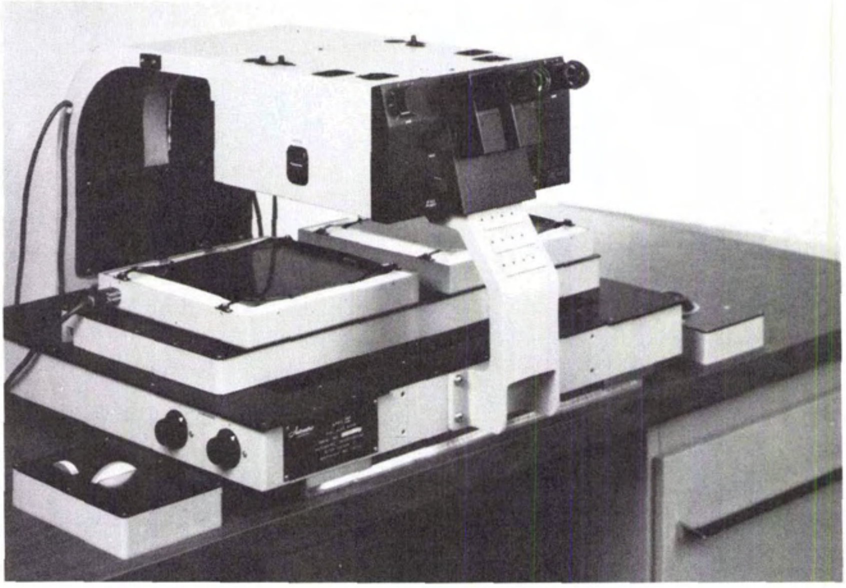

FRONTISPIECE. The APPS-IV Analytical Plotter.

CLIFFORD W. GREVE
Autometric Incorporated
Falls Church, VA 22041

APPS-IV, Improving the Basic Instrument

Improvements which increase the utility of the APPS-IV in many applications are discussed.

(*Abstract on next page*)

APPS-IV

THE APPS-IV is a medium accuracy analytical plotter. Its unique stage-on-stage design lends significant compactness to the instrument, as compared to other units of similar accuracy. The accuracy specification on the stage positions is 10 micrometres after correction using an affine transformation. In actual calibration tests the RMS seldom exceeds 7 micrometres.

The stages are positioned using the combination of a trackball for common stage positioning and x and y thumbwheels for the relative x,y position of the two stages. When automatic stereomodel maintenance is engaged, the x thumbwheel functions as an elevation wheel while the y thumbwheel provides the capability to remove any small residual y parallax. This is accomplished by biasing the y parallax solution.

The APPS-IV's electronic system consists of 13 microprocessors performing servo monitoring functions, communications with the central processor, and maintenance of the stereomodel.

Stereomodel maintenance for all types of imagery can be accomplished without continued communications from the host computer. Once the model parameters have been downloaded to the APPS-IV, the instrument operates independently of the host. Camera systems currently supported by the APPS-IV include frame, focal plane shutter frame, and panoramic. The APPS-IV can take points either on a point-by-point basis or on a distance basis after downloading the sampling interval from the host. The APPS-IV contains a 150-point buffer which protects against the loss of any digitized points should the operator get ahead of the host's data processing programs.

This non-time-critical interface to the host is a unique feature of the APPS-IV, the most obvious benefit to the user being the simplification of the software architecture required in the host.

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ABSTRACT: *The additions and modifications to the original APPS-IV, which make the instrument ideally suited to the interactive interpretation role, are discussed. These features include graphics superposition and the new 3500 stereo optics. In addition, the profiling capability which allows for the generation of digital terrain models with nominal grids in any desired coordinate system is described. Finally, two new mathematical models which accommodate side-looking airborne radar and KA-80-A panoramic photography are discussed.*

The APPS-IV Analytical Plotter, introduced by Autometric in the fall of 1978, is now being actively used in over eight different installations. In-field monitoring of the instrument's performance has proven the APPS' viability in its role of point mensuration, three-dimensional digitizing for entry into graphic information systems, and for performing point transfer into point positioning data bases.

The intent of this paper is to describe enhancements added to the instrument which make the APPS even more valuable to its users. These enhancements enable the APPS to provide more comprehensive data in less time than ever possible in geographic information digitizing, geographic information data base updating, and digital terrain information gathering.

So that the value of these improvements may be fully appreciated, a brief description of the APPS-IV instrument precedes the presentation of the system enhancements.

New Optical System

One of the most significant features of the APPS-IV is its new Optical System. The APPS-IV is currently available with the Model 3500 OEM Zoom Stereoscope as a standard optics. This stereoscope is a 6 to 36 power zoom with high resolution. The high illumination optical system includes image rotation, plus or minus two prism diopter y-phoria correction, as well as an illuminated reticle projector system. The standard reticles offered with the instrument are illuminated dots of 10, 25, 50, and 100 micrometres. Other sizes are available upon special order. The system is capable of a high contrast resolution in excess of 250 line pairs per millimetre at 36 power. A TV camera port which will accept the mounting of a TV camera is now a standard feature. The camera can be mounted to view imagery for training or supervisory inspection purposes.

As another option, the model 3500 may be equipped with one-half power parfocal demagnifiers on the objectives to decrease the zoom range to 3 to 18 power. This range is more suitable for many photointerpretation tasks. The field of view is 30 mm or 180 mm divided by the magnification, whichever is smallest. The field of view doubles when the one-half power demagnifier is installed.

Incorporation of the 3500 stereoscope into the APPS-IV instrument marks a significant advance in the optical quality available today in any compact analytical plotter. This is the first time an analytical plotter's optical quality can be deemed comparable to that of the highest quality light table microscope. The advantage is significant—the analytical plotter now has the ability to perform real-time detailed photointerpretation tasks in the stereomodel during compilation, rendering prior light table tasks ancillary.

Graphics Superposition

Another significant enhancement of the APPS-IV instrument is the incorporation of graphics superposition. Both single and dual optical path superposition are now available. Superposition is accomplished through a second input channel at the objective end of the 3500 stereoscope and can be retrofit on any APPS-IV system with the 3500.

Superposition is accomplished by displaying digitized information on a graphic CRT which is beam split into the optical path of the 3500 stereoscope. The graphic coordinates are transformed into image coordinates as they are downloaded from the host computer to the APPS. An additional microprocessor is added to the APPS electronics card cage for each optical axis equipped for superposition. These microprocessors constantly monitor the APPS stage position and translate the image on the graphics display so that it matches the current stage position. In this manner, the graphics track the stereo model and remain in register with the imagery.

An option with this package is, again, the one-half power demagnifier which essentially doubles the resolution of the graphics display lines. These lines, superimposed on the imagery, yield a higher resolution graphics display than would be possible viewing the CRT one to one with the imagery.

Not only may information currently being digitized be displayed on the superposition screen, but information previously digitized can also be stored. This leads to several unique possibilities. In displaying currently digitized information, the APPS-IV now allows the operator to monitor his digitizing progress without having to look away from the eyepieces. This is mandatory to ensure accuracy of any type of on-line interpretive digitizing such as that used in geologic or land-use interpretation.

When used for recalling information from previous digital data bases, the possibilities for superposition are virtually limitless. The petroleum industry's geologic interpreter can take advantage of the APPS superposition to view lines of magnetic anomalies or seismic survey results superimposed on his imagery. From the anomalies shown by these superimposed lines, he can look for their geologic causes. This important information could point him to geologic features he might not have noticed under normal circumstances. Signal intelligence information can be superimposed over a point positioning data base, enabling a military interpreter to see in real time other intelligence sources which may aid his interpretation.

The advantages offered by superposition also extend to both the military and civilian communities in flight path applications. Proposed flight paths can be superimposed over the imagery along with the position of friendly and enemy radar locations, enroute controls, etc. In the case of stereo superposition, the superimposition of the flight path in both legs of the optical train enables the operator to see the position of the proposed flight path and its elevation relative to the terrain. This flight path to terrain relationship would be immediately evident, providing the operator with a visual test on the terrain avoidance in proposed flight paths.

Another use of the stereo superposition option would be to display a digital terrain model as an array of crosses at the sample points. These crosses would appear to float over the terrain in a photogrammetric model. When the imposed crosses fit the terrain, the operator can be certain that the digital terrain model was compiled without bias. If the crosses do not fit, a bias or compilation error is indicated, and the operator could then use the APPS-IV in interaction with the host computer to digitize the outlines of the anomalous areas. The computer can then be instructed to correct the elevation within those areas and redisplay it for operator verification.

One of the most significant aspects for graphics superposition is its use in map revision. When new photography is acquired, the results of a previously compiled geographic data base can be superimposed over the new imagery. As the operator roams through the imagery, any necessary updates or changes to the map will be evident. If the operator is examining a geographic information system on a host computer which contains an edit capability, the operator can, in real-time, delete features from the data base, digitize the new features which replace them, reverify the data base, and leave the session with a completely updated map ready for cartographic processing. The entire process of generating orthophotos for determination of changes, etc., can be bypassed by using this superposition feature. This upgraded capability has tremendous significance for the mapping community, as it eliminates many of the traditional problems in the determination and detection of changes for updates. Since the geographic information stored as latitude, longitude, and height can be rigorously computed back into line coordinates, the superposition lines exactly overlay the features in the photograph. This eliminates the guesswork usually involved in determining whether a change is actual or simply the result of a relief displacement which has not been accommodated.

Profiling Capability

The final feature of the enhanced APPS-IV is its profiling capability. The APPS-IV microprocessors have been programmed to allow the operator to collect profiles in an evenly spaced grid using any desired coordinate system. These coordinate systems include UTM, local tangent, any state plane system, or geographics.

If an operator wishes to replace points in one row of a digital terrain matrix system, the APPS-IV provides the capability to do so without having to collect another model to be transformed into a coordinate system for pointinterpretation. In short, the APPS-IV can be used to update old digital terrain models or generate new models with minimal panelling and post processing. For instance, in the initial generation of digital terrain models, the profiles can be collected exactly to a join line and then stop. The panelling process is thus simplified to the removal of any biases present at the join line. The operator's concern over what to do about the area of overlap and where to cut one model and begin the next is eliminated. Using APPS programs to move along lines which appear as curves in the model, the operator can profile along a proposed flight path and determine the exact elevation along the path. This APPS-IV enhancement allows available imagery to be used to derive a high resolution digital terrain model in real time, for a specific local area of interest, without having a rely on the rather coarse continental level models provided for general use by government agencies. These continental level digital terrain models are coarse because of the prohibitive costs and time that would have to be expended to produce high resolution digital terrain models over millions of square miles.

Side/Looking Airborne Radar Mathematical Model

The capability to compile from side-looking radar imagery has also been added to the APPS-IV's list of features. This capability is available as an option.

The mathematical model is fully rigorous and supported by alternate firmware in the APPS-IV. This capability is currently operating in an experimental installation and shows great promise as a realistic means of obtaining mapping products from stereo acquisition of SLAR imagery. As with all types of APPS-IV firmware, the interface to the host computer makes no real-time demands upon the host, thereby freeing the host from complete attention to an interrupt structure.

Optical Bar Panoramic Camera Mathematical Model

The KA-80-A optical bar panoramic camera has been modelled, and the software is available in FORTRAN to support the use of this imagery. This addition to the family of mathematical models for the APPS-IV allows users to take advantage of an inexpensive source of high resolution imagery, with considerable coverage over the United States being available. The model is highly accurate and easily used.

Conclusion

The basic APPS-IV instrument, as originally introduced, provided the first inexpensive means to address the analytical plotting needs of the mapping community. The enhancements which have been added in the intervening years have taken the APPS-IV from a basic analytical plotter to an instrument which will interact with the operator to accomplish map compilation, revision, and photointerpretation. All these functions can now be performed in a highly cost-effective manner with minimal operator distractions. Given the capabilities presented above, on-line interpretation and simultaneous compilation are finally feasible.

Forthcoming Articles

Stan Aronoff, Classification Accuracy: A User Approach.
Stan Aronoff, The Map Accuracy Report: A User's View.
P. D. Grumstrup, M. P. Meyer, R. J. Gustafson, and *E. R. Hendrickson,* Aerial Photographic Assessment of Transmission Line Structure Impact on Agricultural Crop Production.
M. L. Imhoff, G. W. Peterson, S. G. Sykes, and *J. R. Irons,* Digital Overlay of Cartographic Information on Landsat MSS Data for Soil Surveys.
L. Daniel Maxim and *Leigh Harrington,* "Scale-Up" Estimators for Aerial Surveys with Size-Dependent Detection.
Atsushi Okamoto, Orientation and Construction of Models. Part IV: Further Considerations in Close-Range Photogrammetry.
Urho A. Rauhala, Array Algebra Estimation in Signal Processing.
Brian J. Turner and *Donald N. Thompson,* Barrier Island Vegetation Mapping Using Digitized Aerial Photography.
J. E. Unruh and *E. M. Mikhail,* Mensuration Tests Using Digital Images.
Mike Wehde, Grid Cell Size in Relation to Errors in Maps and Inventories Produced by Computerized Map Processing.

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Journal Affairs