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Automation of Stereocompilation

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INTRODUCTION

THE LAST FEW YEARS have seen the effective application of various electronic devices that serve, in one way or another, to improve the stereocompilation operation. Digital computers are being used to perform block adjustments to establish the relationship between a group of models. Digital readout devices are used to digitize the measurements made on conventional instruments, thus making the results of the measurements available in a convenient form for subsequent calculations. Orthophotos are being produced and serve as a convenient means of compiling planimetric detail, or, by serving as a map background, eliminating the requirement for the manual extraction of feature information. Finally, there are now several instruments that make the detailed altitude measurements over the model area automatically.

Although automation of the stereocompilation operation has thus been shown to be feasible, it is a long way from being widely accepted. All of the new instruments require the user organization to change their procedures before they can be used effectively—and the initial investment required is quite high. The U.S. Government mapping agencies are the largest users of such equipments. The Geological Survey has been very active in the development of equipments and techniques for the production and use of orthophotos. The Army and Air Force have sponsored the development of the completely automatic equipments.

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The fully automatic equipments are the most interesting and include the essential features of all of the other equipments—hence they receive the bulk of the attention in this report. The other equipments are reviewed briefly.

STATE-OF-THE-ART

The development of instruments for the production of orthophotos goes back to at least 1936 when Robert Ferber patented his instrument. In the 1950s the Towill Corporation was preparing "Photo-Contour Maps" on a commercial basis, but their process was clumsy and the product quite expensive. The U. S. Geological Survey, largely under Mr. Russell K. Bean, developed the Orthophotoscope and advanced it through a succession of models. In addition, they have been active in the development of techniques such as

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photographic edge enhancement to convert the orthophotos to acceptable map backgrounds. Still more recently, the Europeans have entered the field—Zeiss-Oberkochen with their Giga-Zeiss Orthoprojector, the Zeiss Jena works with the Stereotrigomat and, as recently announced, an OMI unit intended for use with their analytic plotters.

All of these instruments can make orthophotos of excellent quality. However, they all require continuous operator attention to determine the altitude variations throughout the stereo field.

Several devices have been developed that substitute mathematical solutions of the stereo equations for the direct projection analog used in conventional instruments. The Stereotrigomat, reported above, uses a mechanical analog computer, the OMI-Bendix Analytical plotters use a combination of digital-differential analyzer and general purpose computer techniques while the Bunker-Ramo UNAMACE and Automatic Photomapper use general purpose digital computers.

The Stereomat, developed by Hobrough at Hunting Associates Limited in Canada, was the first instrument to follow a stereo surface automatically. The latest version, the B-8 Stereomat offered jointly by Wild and Raytheon, is mounted on a modified Wild B-8 plotter. It can be used as a high-accuracy stereo plotter, as an automatic contouring device, or for combined altitude measurement and orthophoto production.

The Universal Automatic Map Compilation Equipment (UNAMACE) and Automatic Photomapper, developed by The Bunker-Ramo Corporation, are completely new types of instruments. Designed from inception to be automatic, they make altitude measurements over a dense and uniform grid at high accuracy and at a rate that makes them interesting despite the high investment involved. High resolution orthophotos are prepared concurrently with the measurement of altitudes and the detailed results of the measurement are stored in digital form on magnetic tape.

The most recent fully automatic equipment to enter the field is the AS11B/C instrument designed by OMI-Bendix. The unit is essentially an Analytical Plotter modified by adding electronic scanning and correlation circuitry and an orthophoto printout unit.

The UNAMACE, the Photomapper, and the AS11B/C solve the projective relationships on a digital basis and are, therefore, able to handle a wide range of photogrammetric problems.

ABSTRACT: *The compilation of map data from aerial photographs can now be expedited by digital calculation of camera data, by digital readout devices that store the results of stereo measurements, or by the production of orthophotos from which planimetric detail can be traced. In addition, there are now several instruments that measure altitudes and prepare orthophotos automatically. The fully automatic instruments are interesting because of their high speed and the accuracies achieved. The anticipated drastic reduction in the cost of complex electronic packages, including electronic computers, should result in a corresponding reduction in the cost of these equipments making them interesting to a wider group of users.*

THE FUTURE

The demonstrated advantages of automation of the compilation process make it virtually certain that the classical instruments will soon be outmoded—however, there is a considerable question as to the form that the new instruments will take. It is obvious that many potential customers would not be able to make the roughly one million dollar investment required to buy a UNAMACE plus the investment required to house it. Nor is it obvious that such instruments could handle all compilation problems—the compilation of large-scale photography of housing tracts, for example, will not be handled automatically for some time.

But we are just entering the age of electronic computers—their capacity has been climbing and their cost decreasing as the technology advances. Experts speak glibly of the day when every home will have a computer. A wide variety of electronic *components* are now available as off-the-shelf items—not just resistors, capacitors, transistors, as in the past, but components that can handle complete functions such as counting and digital-to-analog conversion. They will not be as cheap as today's small transistor radios, but they will be available for considerably less than in the past. One can say, with a great deal of confidence, that supporting electronics will be used wherever it will simplify the remainder of the equipments.

Looked at in this light, it would seem that projection optics to reconstruct the geometry, as used in first order plotters, is probably not here to stay—the mechanics and optics are just too complex and too limiting in accuracy. The mechanical analog computer is interesting but much too expensive, so it, too, will not persist as a way of handling the projective relationships.

It is, therefore, suggested that the UNAMACE will serve as the prototype for the design of future maximum-accuracy stereo plotters—whether they are completely automatic or entirely manual. The measuring tables will then be simple and the optics trivial. Operation will be effected from a remote station that provides a large, bright stereo display in TV form, eliminating the need for the operator to stay glued to a binocular eye piece, using controls operating through the computer to provide a wide range of adjustment. As a manual instrument, the operator would follow contour lines or features in the conventional manner and the immediate output might be on a coordinatograph or simply as digitally stored data.

A completely automatic instrument would be similar to the above but with the circuitry added to determine the altitude errors and supply them to the computer, thus enabling the instrument to follow profiles automatically.

Orthophotos might be prepared on line, in UNAMACE fashion, or might be prepared on an optical-projection type instrument using altitudes measured in a previous operation. The optical projection would probably be used wherever color orthophotos are desired.

While tomorrow's instruments might be similar to the UNAMACE they would be much smaller. Conventional 9 by 9-inch photography could be handled on considerably smaller tables. A minimum equipment might consist of just two small tables and a control console, with the computer and supporting electronics in the control console. A typewriter and input-output tape unit would fill out the equipment complement.

The minimum system would not permit on-line orthophoto production but these could be produced in a second pass using the stored altitude data, or the orthophotos could be produced on a separate instrument and contour lines added on a coordinatograph.