THE US-2's NON-TOPOGRAPHICAL APPLICATIONS

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Abstract

The US-2 Analytical Stereoplotter System by Helava Associates Inc. is a complete photogrammetric system that is ideal for use in close range photogrammetric and non-topographical applications. The hard and software of the system are described. Software packages, existing and planned, are discussed as applied to the real world for non-topographic application.

Introduction

The US-2 was designed and is manufactured by Helava Associates Inc.; it is a product of ideas of Dr. U. V. Helava, the inventor of the analytical stereoplotter. The analytical stereoplotter is truly a universal photogrammetric instrument capable of solving any photogrammetric related problem. Although the analytical stereoplotter is presently most utilized in topographically related areas, such as by the U.S. Defense Mapping Agency and private firms for acquiring digital data of topography and culture. It is also the ideal system for solving non-topographic related projects. Interest in its use has gained some popular support in the last few years in the aircraft, ship and automobile manufacturing industries.

The US-2 Hardware

The following description of the US-2 is also typical of other analytical stereoplotters. The following five modules are key to any analytical stereoplotters and are the modules most important for economic, effective operation of a system.

Stereoviewer Measurement System

The US-2 consists of a stereoviewer that is precision manufactured. The stereo pair is viewed through binocular optics. These optics can be zoomed concurrently or separately from 6X to 24X. Zoom capability is essential in non-topography applications. The photography moves on stages in X and Y direction. Image rotation is possible through 180° range. Base in, base out capabilities exist. As the photo stages move, measurements are made in one micrometer intervals through use of precision linear encoders. These linear encoders are in closed loop communication with the hand wheels, foot wheel, or XY tablet through a high speed microprocessor which solves the communication problem and performs all of the precise mathematics models required. The design of the stereoviewer is such as mounting of the photographs on the photo stages is simple without the need to aline to marks, etc. The stereoviewer also is enclosed assuring a minimum of interference from dust, etc.

High Speed Microprocessor

The use of the DIGIPRO (digital projector) makes the US-2 unique. This microprocessor in "real time" provides communication in the system and also solves the real time equation necessary to an analytical plotter to perform

most efficiently. The DIGIPRO removes most of the impact required by other systems to reside in the host computer.

US-2

Host Computer

The modularity of the US-2 system allows for various host computers to be used. The host can vary from a small system to a large system. The standard US-2 is equipped with the Digital Equipment Corporation DEC 11/34. The operating system is RSX 11M and operates in a multi-tasking mode. It can solve problems in non-topographic computing while measurements are being made "on line".

Operator Station

The operating station usually consists of a keyboard and CRT which is used by the operator to communicate to the system. Items like operating mode, software selection output parameters, etc., are shown on the CRT. The complete operating system is accessed from this station. Commands required and intercommunication with the computer is in an operator friendly display. The modular design of the US-2 does not limit the operator station by hardware built into the system, but allows selection of a station to meet very specific user requirements.

Printer Output

A teleprinting device is necessary to provide hardcopy verification of data measured on the system. This device can be modified to fit user need. Usually the data shown on the operator station CRT can be duplicated on this printer. Information on model set-up, measurement details, etc., are needed and provided by the printer.

Other Hardware

The modular design of the US-2 allows for many peripherals to be added. Usual additions to the system are various magnetic tape recording devices, floppy disks, Winchesters, interactive CRT's, interfaced with automated drafting machines and to CAD-CAM systems. An important feature of the US-2 is the ability to interface to other hardware. This feature greatly enhances the US-2 capabilities.

SOFTWARE, OPERATING

The system has a complete set of both system and application software. Its software provides (1) on-line support of program and overlay loading into memory from the disk, (2) use of standard peripherals, and (3) the necessary processors to support programming in assembly language (with macro capabilities) and FORTRAN. The processors allow for the production of modular programs and the combination of modules with different source languages. In addition, the necessary support to combine, load, and debug program modules is available. The assembly language and FORTRAN support the standard peripherals with callable drivers.

Depending on the size and computational power of the control computer, the system software provides multi-tasking capability. Since much of the real-time computational load has been taken over by the microcomputer in the control interface, it is now feasible to efficiently control the US-2 while at the same time performing some other tasks. This multi-tasking capability could even be used to simultaneously control more than one stereoviewer on the same host computer.

Standard application software supplied with the system provides for orientation, strip triangulation and adjustment, and stereoplotting from stereopairs of frame photographs as described below. In addition, support programs are supplied to allow means for testing system performance and effectively utilize the full capabilities of the system.

The applications software is able to accommodate effective focal lengths between 25 and 2500 millimeters and virtually unlimited ranges on other photogrammetric parameters with no decrease in computational precision. Provisions are made to correct for atmospheric refraction, earth curvature, lens distortion, film deformation, and principal point offset. In addition, the programs enable the operator to input the display coordinate values directly in UTM or other grid-system ground coordinates, as well as stereomodel coordinates.

The design of the applications software is organized in modular form made up of separate subroutines. Maximum use is made of FORTRAN. Those programs not written in FORTRAN are FORTRAN-callable.

Programs are organized in such a way that no operator action is required to enter a program mode other than to request that mode. The input data is

organized in easily accessed files. An overlay system is used, with the system software automatically controlling overlay loading and execution with no operator intervention required.

Stereoplotting Programs

Standard stereoplotting programs delivered with the system provide the system operations listed in the following. These programs are combined in a software system which provides smooth transition between system operations and are designed to require minimum operator intervention.

Photo/Stage Orientation

This program is used to establish a precise photo-to-stage coordinate transformation based on the measurement of up to nine fiducials. It provides for transformations from a simple intersection computation (to define the photo center and rotation) up through a second order polynominial fit. The program assists the operator in the location of fiducial marks, automatically slewing to their approximate location, and convenient engagement and disengagement of stage motions to permit fast and accurate pointing.

Data Entry and Display

These programs provide for entry and display of data related to the photos, the stereomodel, or control points by the operator from the operator console and/or automatically from memory files.

Past-Point Measurement

This program enables the operator to observe and record coordinates for parallax points, pass points, and control points for use in the relative/absolute orientation computation. It provides automatic slewing to specified points and a fast, convenient method for the operator to remove parallaxes and to record the resulting photo coordinates.

Relative/Absolute Orientation

This program performs an automatic relative or combined relative/absolute orientation based on the gathered parallax points, pass points, and control points. It allows (1) for the computation of either a relative or a combined relative/absolute orientation based on the setting of data items by the operator; (2) for the mixing of parallax points, pass points, and control points in the solution; (3) for the operator to specify which of the orientation parameters he wishes to include in the solution; and (4) for the setting of weights for the orientation parameters and data values used in the solution to influence their relative effects on the solution.

Plotting Table

If a plotting table is used in the system, this program defines the orientation between the plotting table coordinate system and the stereomodel coordinate system thereby establishing the relationship between the ground or other coordinates and the manuscript for plotting.

XY Plotting

This program allows the operator to plot planimetry, contours, or discrete points, operating directly in ground or other coordinates if desired.

Profiling

This program provides terrain or surface profiling with selected direction and spacing. The direction (azimuth) and the spacing between profiles is selectable by the operator, with means provided to assist the operator to determine the azimuth to be plotted. This program allows the recording of data either graphically or digitally, and compilation of digital surface matrices.

Azimuth and Direct Distance

These programs provide for the computation and display of azimuth and direct distance in the active ground (or model) coordinate system.

Digital Plotting

The system is able to plot graphically from stored digital data. This program provides the ability to generate a graphic output for the digital data recorded in the generation of contours, planimetry, straight line plots, or profiles.

Shutdown

The software has the capability of saving all pertinent model information (shutdown data) for future use and the ability to re-enter this shutdown data and re-establish the stereomodel at a later date without requiring any further relative or absolute orientation.

Strip Triangulation Programs

The applications software package includes a complete strip triangulation data collection and adjustment capability. The strip triangulation programs form a stand-alone package performing all the necessary functions and data manipulation with a minimum of operator actions.

Support Programs

In addition to the applications programs described above, the software package includes the following capabilities.

Hardware Diagnostics

Diagnostic routines for determining malfunctions in the central processor, memory, peripherals, servo system, or control interfaces are provided.

Lens Distortion Computation

A program is provided to convert standard camera calibration lens distortion information into values compatible with the lens distortion corrections applied by the real-time software.

Model Set-Up From Strip Adjustment

A program is provided to use the strip adjustment results to calculate shutdown data for each model in the strip. This shutdown data can then be used to establish the stereomodel on the system, without requiring any

relative/absolute orientation, the same way that saved models are re-established on the system. This program utilizes data from strip triangulation directly to form a shutdown file for each model which contains the same shutdown data as is saved in the stereoplotting mode.

Software, Non-Topographic Systems

As you can visualize, the operating software of the US-2 accommodates all the photogrammetric parameters necessary to solve any photography related computations. The software required for non-topographic applications, therefore, is not photogrammetry related but related to specific applications that pertain to making that measurement task more efficient and semi-automatic.

The following non-topographic facilitating programs are operational or in the design phase.

CPL — Circle Placement - When measuring containers for waste disposal, it has been necessary to measure orifice placement to determine design confirmation. Program works for any designed location of measurement needs. On a circle design three orifices are measured and the computer drives measuring mark to location of all orifices. Measurements are refined and tolerance measurements for each are displayed after operator precisely places measuring marks on actual orifice.

GRIDO — Grid Orientation - When remeasuring plate deformations it is very helpful to be able to remeasure at identical points. The Grid Orientation program allows to remeasure those points under computer control. The program remembers points previously measured in relationship to existing control and drives directly to those points for operator intervention. Especially useful program in airframe studies.

SRB — Structure Orientation Bridges - Program is specially designed to gather data related to the U.S. National Bridge Inspection Program. Program allows for digital input of design data which drives measuring mark to critical design location for measurements to verify "as built" and load design computations. Program is also applicable to structual members that are precast and prestressed.

PSS — Profiling for Slope Failure Studies - This program consists of allowing for profiles to be taken of slopes at identical locations for repeated measurement. A substractive procedure is utilized to determine material volume losses. Program works well to determine soil losses on highway backslopes. Works well to monitor earthwork slides.

UST — Underwater Studies - This program computes the necessary corrections for refraction of rays in water. Testing procedures are included to tailor corrections for different types of liquid mediums. All normal measurements can be made with vertical or non-vertical camera stations.

FIS — Forge Studies - Casting of various parts require measurements to assure final casting meets specifications. These castings vary in size from small to large and are of complex shapes. Program measures cast and, using those prechecked measurements, allows the

measuring marks to be driven along critical areas for comparison measurements of cast and casting.

CMV   Computer Machining Verification - Computer controled manufacturing is very prevalent in these times. Checking of tools, parts, etc., from this process is costly and slow by use of coordinate measuring devices. CMV program takes the design tapes and measures in the precise locations in a semi-automatic mode the computer manufacturing process. Since these measurements are on complex figures, program coordinates the location of measurements on several models taken at various angles, etc.

All non-topographic software is modular in design. Separate packages exist for each application, but modules from several packages can be utilized for specific applications. With existing or planned modules we feel we can handle any non-topographic application with the US-2 analytical stereoplotter system.