PROGRESS IN POINT MARKING FOR AERIAL TRIANGULATION

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ABSTRACT:

The choice of cost-effective point marking devices for use in aerotriangulation is greatly limited in both quantity and quality. Accelerating use of Global Positioning Systems for primary ground control is likely to promote an increased use of aerotriangulation for model control. This will create demand for supporting hardware that is both operationally efficient and financially affordable. A modern method of marking scale transfer and tie points for aerial triangulation has recently been developed by Triangulation Marker, Inc. The method allows triangulation data collection on an analytical plotter with a greater ease and precision than is currently possible by any other available means. Increased productivity provides dramatic savings in the total cost of aerial triangulation. A custom-designed laser has been installed on an OMI analytical stereoplotter to provide a capability for simultaneous point marking and measurement. The uniform quality of the mark guarantees excellent measurement repeatability, thus ensuring a superior performance in analog and analytical plotters, comparators and high resolution scanners. This unit can be retrofitted to modern analytical plotters manufactured by the major OEM's, and is equally suitable for a stand-alone instrument.

KEY WORDS: Point Marking, Point Transfer, Aerial Triangulation.

1. INTRODUCTION

Marking of artificial scale transfer and tie points and their subsequent measurement in data collection for aerotriangulation has been in practice for many years. It is an effective strategy in reducing the required amount of conventional, and usually costly ground control. As the most important task in the entire photogrammetric process, it should be done by the most experienced personnel available because carelessness and/or inexperience can produce errors that will affect each subsequent mapping operation.

Point marking and transfer is done stereoscopically and, preferably, with pseudoscopic reference, under variable magnification. Several types of instrument have been introduced to perform this task, ranging from simple, hand-held 'Snap Markers' to the highly sophisticated electro-optical-mechanical devices of recent origin. Most of these have proven much too expensive for the mapping community. In contrast to other areas of photogrammetric instrument design in the past thirty years, private sector industry is restricted to the 'approximate instrument' category for accommodating this most critical mapping task.

Regardless of the sophistication of existing point-marking devices, parallax removal in the immediate area chosen for an artificial point is an iterative series of image magnifications, translations and rotations. There is no measure of the precision of this process which ultimately may affect model set-up and error propagation throughout the entire job. Further, a widely used point transfer device makes no provision for assuring that the emulsion is flat during the critical point marking procedure.

Need for greater efficiency in data collection has been evident but inadequately addressed until now. Addition of a laser to a stereo plotter has proven this method as the best medium for point selection, while simultaneous marking and measurement provides a new plateau of efficiency and cost-effectiveness.

2. BACKGROUND

During the period 1962-1964 the author participated in developing a highly specialized stereocomparator designed and built by Link Group, General Precision in Binghamton, NY. The instrument, known as 'The Automatic Point Marking, Measuring and Recording Instrument' was contracted by USAETL., the US Army Engineer Topographic Laboratory, Fort Belvoir, VA. Prior to delivery the instrument was tested in an aerial triangulation and the results compared with an identical test conducted on a Wild A-7 plotter.

The APMMRI featured twin air-bearing stages whose travels were monitored by Ferranti gratings of one micrometer resolution. Motions were controlled by correlators which maintained the model stereoscopy to a high degree of satisfaction. On occasions, a loss of correlation was encountered in dense trees or areas of sparse detail, e.g. expanses of sand; the stereo model was then restored by the operator. Selected points were marked with a heated die with coordinates sent to a CRT and stored on mag tape. A production version with three plate carriers was ordered: the 'Automatic Point Transfer Instrument'.

Major advances have been made in autocorrelation since those instruments were built and delivered. The technology is now being applied in soft copy to aerotriangulation, including point selection and 'marking' as digital records. That may remain beyond the financial reach of the private sector for some years hence, but, in the interim, this recent point marking and measurement system will be significantly faster and less costly than the traditional classical photogrammetric practice.

Development of the original analytical plotter by Dr.U.V. Helava at the Canada's NRC in 1960 was the basis for all subsequent enhancements, including this development. APMMRI provided only a reference experience to be applied when essential technology had evolved and miniaturized in subsequent years.

A laser point marking instrument was introduced by the former Carl Zeiss Jena, and patented in 1971. This was a stand-alone instrument with an elaborate optical system to direct the laser energy to either or both plates, as desired, and a diaphragm system to protect the operator from any harmful radiation. No measurements were available with the instrument and although it was considered a technical success, it was too expensive for widespread commercial use. When the patent expired in 1988, it was abandoned. The present device bears no resemblance to the Jena instrument other than that a laser is used to mark.

3. LASER CHARACTERISTICS

All lasers consist of the following components:

1. An electrical power supply
2. A pumping device; this may be a high voltage power supply, high output photoflash or lamp
3. A lasing medium: either gas, liquid or solid
4. An optical resonant cavity that encloses the lasing medium, with mirrors at each end, one of which is usually totally reflective while the other may be only partially reflective.

It is not possible to disclose full details of the laser design while patent application is ongoing. However, it can be stated that this particular one ranks among the least exotic of all laser devices. Several characteristics relating to its design and performance benefits will be described hereunder.

3.1 **Design Criteria**

The task began with the establishment of a number of realistic performance objectives which, if met, would improve its chance of success. A few of the objectives required independent feasibility study. For example, the possibility of marking aerial film emulsion through either the glass base plate or a hold-down plate had to be established. Prior point marking had all been done on the exposed surface of the emulsion but this was not considered desirable if means could be devised to ensure film flatness.

Initial research involved power loss measurements at the particular wavelength through glass plates to help establish power requirements of the laser. Other sources of power loss are encountered in any laser application and they vary in relation to the source chracteristics, e.g. mirrors and lenses for which individual absorptions had to be established. All results were incorporated in computer ray-trace analyses to assure optimal system performance. Many ray traces were produced, each reflecting different component arrangements, before a design was chosen.

An additional important design objective was the desire to install the laser on other type plotters since the substantial development costs could only be recovered through sales of a conforming package. Accordingly, visits were made to three different companies where major OEM firms were represented. An equally important design consideration was that the laser package installation would not interfere with the normal plotter operations or require any structural modification to the analytical plotter.

3.2 **Size**

The prototype device measures 200x100x50 mm and is less than one kilogram in weight. Dimensions were initially determined by the available space within the analytical plotter and, though not required, it was fully utilized to ensure operational stability. No element of the instrument's optical system was used by the laser beam, other than the glass plates on each side of the film diapositive. All necessary optics and laser components, with the exception of the power supply, are located in the above package.

3.3 **Notable Features**

All of the forty-odd components in the package are quite small. The resonant cavity or 'pump chamber' shape is obtained by a process first invented in the former USSR, and known in the U.S. as Wire EDM, or Electro Discharge Machining. In this process a part is immersed in an oil bath and cut to shape by an electrically charged, computer controlled wire. It is then polished and coated with silver. Because of its its unique interior shape and finish, it is the most expensive part in the whole laser package.

The pumping device consists of two photo flashlamps which, in most lasers, are the first parts to fail. The lamps are easily replaced but, with an expected life of one million duty cycles (each duty cycle is a marked point) the technology may well be obsolete before the lamps reach the expected service limit.

4. LASER PERFORMANCE

This has been remarkably uneventful in that it has fully met or exceeded all design specifications. An important oversight was our neglect to provide for the usual variations of image density to be marked. This resulted in desired mark characteristics in a uniformly darker grey scale but caused the emulsion in very low density imagery to be fully evaporated in the entire beam diameter, giving a flare effect. This omission is easily remedied by provision of a variable power supply,selectable for image density.

The laser contains no moving parts, but one that is adjustable to permit centering of the mark position in two axes relative to the floating mark. It is both easily performed and rarely required; a check on mark position is always available at any time by firing the laser, measuring a displacement, if any, and correcting it. The laser displayed no drift or other deviation over a period of weeks. Calibration of mark centering is vital for (tie) point transfer and in instruments that collect data simultaneously with firing the laser;this is the preferred method.

The mark is characterized by two concentric circles with respective diameters of 60 and 90 micrometers. The central 'bulls-eye' is a region where emulsion has been evaporated from the base, while the darker annular band between the two circumferences, with a width of 15 micrometers, is an emulsion burn-stain. This pattern is a characteristic three-dimensional Gaussian curve of energy distribution. It is ideal as a pointing target, as coordinate repeatabilities recorded during many hours have firmly established.

5. SYSTEM PERFORMANCE

The laser point marking device has been extensively tested in its intended role as part of a system and the results have been gratifying. Some of these may conflict with the traditional notion of how various tasks that constitute aerial triangulation ought to be performed. There is nothing sacred in the rules as to how certain photogrammetric tasks ought to be performed, and a change should be acceptable on the basis of a fully demonstrable cost effectiveness.

5.1 Preparation

This initial step is mainly organizational. Working with paper prints and a pocket stereoscope, control points are identified and numbered. The locations and numbers of all required scale transfer and tie points are also shown. All of this is essential to proper planning. However, the resolution of prints and magnification of the viewer will rarely combine to reveal the best locations for artificial points. Moreover, the limitations of this process may often mislead one to select points in locations which are too far from correct model orientation positions.

5.2 New Method

Point selection is best performed in the analytical plotter where there is an oriented model and image detail such that there could be multiple locations to choose from that were not visible on the prints. The stereoplotter is, or can be driven to positions of all required points, selections made, marked and recorded. Their positions are then shown on prints. This work sequence is less time-consuming than the processes that currently prevail in most companies. A production rate of three models per hour can be realized by the foregoing procedure with the laser. Additional benefit will accrue to any operator who restitutes the model; he will be unlikely to lament point positions chosen in the stereoplotter, which is frequently the case with current practice.

6. TRADITIONAL BIAS

It is recognized that some professionals will doubt the value of taking an analytical plotter out of an 'income producing' digital mapping job to do aerial triangulation data collection. But a common use of an analytical plotter is measurement of points that were previously marked by a PUG instrument. Such a little extra time is required to mark the points in addition to the measurement, that it will make good economic sense to use the plotter for all the work.

6.1 Management Decisions

As economic conditions are a major consideration in most management decisions, all business sectors are likely to be affected by a clearly changing economy which will demand ever greater efficiency. Hardware that was both 'state of the art' and fully paid for years ago may no longer be productively competitive and will have to be replaced. This decision type is often difficult and is why management must take it. An old practice of marking and separately measuring nine points plus fiducial and control points on all photos is one that should be completely abandoned.

6.2 Conclusion

This development, designated **Trigmark**™, is expected to be well received where triangulation is widely practiced. It will offer advantages over softcopy aerotriangulation for correlation and generation of digital terrain models. In this application, data collection and triangulation would precede scanning of the diapositives. Nine scale transfer points are marked on the central photo of a triplet, while the companion diapositives will each contain six marked points. Thus, full model control would be available for automatic correlation of the two models,and for production of digital terrain data. This technology has yet to reach widespread commercial distribution but is expected to do so. At that time there may be additional applications for this new mapping tool.

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