PHOTOGRAMMETRY - A NEW SCIENCE

by
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Photogrammetry as a science is really far from new. With terrestrial photographs as a basis for measurements for obtaining data for surveying and mapping photogrammetry has found numerous applications over a period of many years. However, it is only with the impetus received with the development of aerial photography that photogrammetry has assumed a position of real importance among present day sciences.

Several years ago at the Syracuse meeting of the American Association for the Advancement of Science, an entire half-day's program was devoted to papers on the development of aerial photogrammetry. Discussions were presented of the eminent European contributions in the way of methods and of the construction and operation of instruments as well as discussions of the more meager investigations then being undertaken by American enthusiasts. Since that time the progress in photogrammetry in America has been by leaps and bounds. The recent organization of the American Society of Photogrammetry, accompanying this wide-spread interest in the subject, was inevitable. With confident effort on the part of the officers, who are indeed eminent men in the profession, and with boundless enthusiasm on the part of the membership, the success of the Society was immediate and certain. The recognition at this time of the Society as an affiliate of the American Association for the Advancement of Science marks the admission of photogrammetry to its well merited position among the older established sciences, and for these in turn photogrammetry will doubtless provide considerable stimulation.

Now the development of any new branch of science is always because of demands for it by previously existing branches and by means of the fulfillment of demands made by it upon these other branches. These contributions to and by any new branch of science are always very interesting. In this paper some of these mutual contributions are enumerated without any of the discussion which each one deserves.

To mention specifically some of these topics in connection with the development of the science of aerial photogrammetry, first came the demand for rapid photographic emulsions in order to make aerial photography possible at all. At the same time, it was necessary to construct aerial cameras with a high degree of precision, providing positive devices for holding the plate or film in a definite position at the instant of exposure. It was necessary to produce satisfactory photography at the margins of the photographs using between-the-lens shutters, in order to have an entire photograph exposed from a single point or exposure station. Fine grain emulsions and chemicals were needed to produce photographs upon which precise measurements could be made. All these demands have been fulfilled.

It was thought at first that precise aerial photogrammetry would never be possible except with the use of plates, on account of the shrinkage and irregular distortions to which films were subject. On account of the decided advantage of the films in convenience, it became desirable to produce a film base with either no distortion or at least conformal distortion. Extensive research led to the production of a film base satisfactory for most purposes. On the other hand, as time goes on and as aerial photogrammetry finds additional applications to cadastral surveying and other work demanding more precise measurements, as advocates of the use of plates continue to improve the plate-magazines, as air craft development completely eliminates weight of plates as an obstacle, and as extremely small sizes of aerial photographs seem to gain favor, whether there will not presently be a strong tendency to revert to the plate camera, is a matter of conjecture. Be this as it may, the production of the desired film base constituted a scientific contribution.

The demand for negligible lens distortions has led to the productions of lenses with marvelously minute distortions within the range of the photographs. This is all the more remarkable with the great increase in the angle of exposure.

In fact the demand for wide angle lenses led directly to the development of the multiple lens cameras, which have almost seemed to have superseded the single lens cameras. Multiple lens cameras together with the incidental problems of precise calibration and transformation of wing pictures, have constituted the subject of extensive research and experimentation. A real triumph in this field is doubtless represented by the nine-lens camera constructed by the U. S. Coast and Geodetic Survey under the direction of Lieutenant Reading. Again, with the continued improvement in the wide angle lenses virtually free from distortions, with more stringent demands for precision in the calibration of multiple lens cameras, and with the development of new methods of constructing maps from the photographs, whether there is not now a tendency to revert to the single lens camera is likewise a matter of conjecture.

Certain phases of the work in aerial surveying have demanded rectifying cameras of a highly precise nature. Cameras have been built for removing the effect of tilt from aerial photographs, provided with ingenious devices for preserving the correct relative positions of original plate, screen, and lens, at the same time permitting alterations of scale within certain limits for certain purposes.

This very incomplete list of topics relating only to the production of the photographs themselves, serves to show how one branch of science develops through the aid of others, and how a branch of science progresses by fulfilling the demands of others.

The most interesting phase of photogrammetric work is the production of maps or the obtaining of survey data from the photographs. The methods which have been used might be classified somewhat as follows: (1) Graphical Methods; (2) Stereoscopic Methods; and (3) Special Methods. It is really through these processes that photogrammetry has contributed to other sciences, particularly the sciences of surveying and map-making. It might be said that by means of the applications of these methods of photogrammetry, the engineering profession has been enabled to fulfill the demands made upon it for extensive topographic and planimetric maps by vast projects of national and regional planning and our large scale economic developments.

The graphical methods, the principles of which are described in several modern texts on surveying as "radial plotting", have been used extensively in this country for the production of planimetric maps. The base maps of the entire Tennessee Valley now nearing completion by the Tennessee Valley Authority, the extensive maps by the U. S. Forest Service and by the Soil Conservation Service, etc., all furnish excellent examples of pressing demands for planimetric maps which have been fulfilled by means of the simple graphical methods of photogrammetry.

The stereoscopic methods for the production of complete contour maps, are exemplified in the plotting instruments of European manufacture. The amount of research study and experimentation spent in the construction of these instruments has been enormous. There have resulted the several well-known instruments such as the Zeiss stereoplanigraph, the Zeiss multiplex projector, the Wild autograph, the Hugershoff aerocartograph, the Poivilliers, the Gallus-Ferber, the Nistri instrument, etc. These ingenious devices all embody some of the greatest refinements in optical and mechanical design, and are the result of profound study of the mathematics of projections, stereoscopy, etc. A few of these instruments are now being used successfully in this country for the production of topographic maps. Doubtless one of the most unique photogrammetric instruments is the latest development by Gallus-Ferber in France, the instrument for reproducing from tilted aerial photographs of terrain having topographic relief, photographs virtually free from tilt and virtually free from image displacements caused by topographic relief. The multiplex projector, three of which are in use in this country, one at Wright Field, one at Chattanooga, and one in our own laboratory at Syracuse, constitutes the subject of a paper being presented at this meeting. Tests have proved the merits of topographic maps made by means of all of these instruments. Surely these modern stereoscopic methods of surveying and mapping represent contributions of inestimable value to science in general.

Among the special methods can be mentioned the grid method for constructing planimetric maps from oblique photographs of fairly flat country used extensively by the Canadian government, the method of constructing reconnaissance maps from oblique photographs developed by the American Geographic Society, mathematical calculation of survey data from precise measurements on aerial photographs, and many others. Some of these have involved the invention and design of special measuring and plotting instruments of both monocular and stereoscopic types, such as the comparator for measuring coordinates, the stereo-comparator for measuring parallaxes, the radial triangulator, the photogoniometer, the plotter for oblique photographs developed by Mr. O. M. Miller, and many others. All of these have already found application in many special scientific problems and in many note-worthy projects of exploration and research which represent distinctive contributions to the scientific world.

This very brief outline of some of the phases of the subject seems sufficient to justify the admission of photogrammetry to the realm of recognized sciences.

Now at this point I would like to take this opportunity to mention very briefly to those whose interest lies primarily in the field of photogrammetry, four specific things regarding the science of photogrammetry in the way of suggestions regarding future investigations.

First, we have precipitated outselves into the science of aerial photogrammetry with such suddenness and with such enthusiasm, that, in my opinion, we have rather completely neglected terrestrial photogrammetry. I am inclined to believe that terrestrial photogrammetry should be applied in many types of surveys where at present no use is made of it whatever. It would seem that there are possibilities in this field which well deserve consideration.

Second, although I have mentioned this before at some of these meetings, I wish to direct attention again to the fact that at the 1934 London Congress of the International Federation of Surveyors, the Committee on Instruments and Methods recommended, not the exclusive, but rather the free, use of aerial photogrammetry in the determination of distances and positions of points in cadastral surveying. In view of the thoroughness of much of the European cadastral surveying, this recommendation on the part of well-known authorities on surveying at the congress should carry some weight. Doubtless this application of photogrammetry merits further investigation.

Third, I cannot refrain from mentioning again possibilities in a realm of photogrammetry which has always held for me an intense fascination, namely, the mathematical calculation of survey data from precise measurements on aerial photographs. I hope you will bear with me when I mention again that, despite all the possibilities emanating from stereoscopy and optical and mechanical methods of mapping from the photographs, mathematical calculations from simple linear measurements of the positions of images on photographic plates really exhaust the resources of aerial photogrammetry. Through mathematical calculations every possibility in aerial photogrammetry becomes evident, every resource can be demonstrated, and every limitation and over-elaborate claim can be detected. May I again commend this phase of the subject as a valuable background in photogrammetry?

Fourth and finally, in connection with this topic of analytical methods, I would like to suggest one more feature of photogrammetry about which I am very enthusiastic and which I believe deserves thorough investigation.

Ever since I have had any dealings with aerial photogrammetry I have cherished the thought that we have the cart before the horse with regard to control for aerial photographs. Instead of doing the usual field work of extensive triangulation and traverse to control the mapping from the photographs, we should be using the photographic measurements to produce the results obtained by the triangulation and traverse. It is true that experiments to date in various kinds of aerial triangulation have not exactly borne out this contention, but the method I am about to suggest differs somewhat from any which have been given a thorough test.

Let us suppose that in a strip of photographs overlapping in the usual manner, there are three precisely determined control points in the first photograph. Suppose that a calculation based upon this control is made of the coordinates of the exposure station and the spatial orientation for the first photograph. Next let us suppose that three well defined points are chosen in the overlap of photographs 1 and 2, in such positions that they furnish strong control for photograph 2. If the elevations of these three points are determined on the ground in the field, then measurements of the positions of their images on only photograph 1 are sufficient to calculate precisely their horizontal positions. Then they may be used as control points to calculate the exposure station and spatial orientation for photograph 2. Similarly control points can be determined for photograph 3 by means of elevations determined on the ground and measurements of the positions of their images on only photograph 2. In this manner the entire strip may be controlled with nothing but elevations determined in the field. Theoretically it is possible to dispense with the levelling also, but only at a considerable sacrifice in precision if the control is carried forward through a long strip.

Now in this process the photographic measurements and the calculations are substituted for the usual field traverse and triangulation for determining horizontal positions of control points. Some might argue against the method on the ground that the space calculations for determining the exposure station and the orientation of a photograph require about 6 hours. Even if this were true the method would still represent a considerable saving in time and expense over the customary field methods of determining horizontal positions and computing the traverse or triangulation.

It is to be emphasized that this process is a substitute for the control work or at least for the major portion of it, but not in any sense for the mapping itself which is to be done from the photographs. It reduces the field work necessary for controlling the photographs to the simple determination of elevations, and probably this can even be done in most cases by means of barometers. As for the precision, the determination of horizontal positions from measurements on a single oriented photograph when the elevations of the points in question are known, is very precise, much more so in fact than the usual method of space intersection using rays from two oriented photographs. A precision of about 1 part in 2,500 is doubtless attainable with very little difficulty.

One very interesting feature of such a procedure for obtaining the necessary control data for aerial photographs is that a by-product of the method is the spatial orientation of the photographs. In case the mapping is to be done from the photographs by means of a stereoscopic plotting instrument, the data for orienting the photographs in the instrument would thus be available and much of the instrumental work of orientation would be eliminated. In this connection I might say that in the laboratory at Syracuse we have devised a little method for utilizing these data in the multiplex projector even though the instrument provides no graduated circles on the tip and tilt motions, but the explanation is too long to be presented at this time.

I believe that there are many applications of analytical methods which deserve investigation, but this one in particular appears to be of considerable practical value.

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NEWS NOTE

Affiliation with American Association for the Advancement of Science

The American Association for the Advancement of Science has taken favorable action on an application, filed on behalf of our Society with the approval of the Board of Direction, for affiliation with the Association. This not only adds to the standing and prestige of the Society but also entitles our members to certain privileges.