Photogrammetry—A Versatile Measuring Technique

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ABSTRACT: *In recent years, a number of unique studies and projects have utilized photogrammetric principles of measurement, including measurement of volume (such as quantity in stockpiles of ore, cumulus clouds, spherical objects, etc.) and measurement of objects in motion (such as water movement and determination of driver-eye-height). Both currently and in the future, photogrammetry has a tremendous opportunity for use in such fields as medicine, materials, travel, traffic, and space operations. Advancement in such utilization of photogrammetric principles is, however, essentially the responsibility of the photogrammetrist, who can best help the scientist and the engineer to recognize these opportunities and to make use of them.*

INTRODUCTION

THE preparation of topographic maps from aerial photographs constitutes by far the largest proportion of the business associated with photogrammetry. However, there is no reason to limit this important science to so narrow an application, because basically photogrammetry is the determination of size, shape, position, movement, and other metrical properties as determined from photographic measurements.

Since photogrammetry can also be described as the science and art of obtaining reliable measurements from photographs,[1] many people consider that the concept should encompass the interpretation of these measurements until they are converted into a usable form. In this light, there are many who feel that photo interpretation *per se* should be included as a part of photogrammetry.

Certainly now, more than ever, a broader view should be taken of the field of photogrammetric engineering, since there are as yet untapped so many areas in which photogrammetry could prove to be a valuable tool in working out problems for which no method of solution has yet been devised.

This paper has been designed to call attention to some rather diverse and unusual, but quite practical, applications of photogrammetry. Some of the more unique of those reported in PHOTOGRAMMETRIC ENGINEERING during the past five years have been discussed below and are indicative of a growing interest along these lines.

[1] MANUAL OF PHOTOGRAMMETRY, 2d ed. (1952).

MEASUREMENT TO DETERMINE VOLUME

Inventory of Coal Supply (1958).—In certain areas of the United States where large amounts of coal are stored by stock piling, it is necessary to determine periodically the amount of coal on hand. Stereoscopic pairs of photographs, made either from airplanes or from fixed positions above the coal pile, provide the information necessary for determining the volume of coal on hand. The volume so determined, in turn, serves as a measure of fuel available. This same approach has been applied to volume determination for other ores.

Volume Determination of a Basketball (1959).—The use of stereophotogrammetry in volume studies has been reported in this case by a member of the medical profession. This researcher was seeking to determine the accuracy with which volume of an object—in this case a basketball—could be measured via photographs. The investigation was performed as a forerunner to the utilization of photographs in medical research for measuring the volume of the human body. Although a basketball may appear to be an object for which volume would be easily determined, this assumption is not necessarily correct since the ball has slight irregularities and its shape is not a perfect sphere. Thus, such an object could very well serve in a pilot study to evaluate a photogrammetric technique for the solution of a measurement problem.

Cumulus Cloud Photogrammetry (1961).—Authored by a physicist, this article reported the use of cameras fixed on the ground to provide terrestrial stereoscopic photographs of

cumulus clouds. From these photographs, a number of aspects, such as time required for development, motion, and volume of the clouds, could be determined.

Each of these first three articles reported work on the determination of volume. The background of each investigation varied considerably from the others; the objects measured were all different; and a variety of measurements were made, with values ranging from inches to miles. Yet all three experiments utilized measurements based on a stereoscopic pair of photographs in order to determine three-dimensional coordinates of points which would in turn lead to a computation of volume.

MEASUREMENT OF OBJECTS IN MOTION

Water Current and Movement Measurement (1962).—Another illustration of the use of photogrammetry for non-topographic purposes, but involving use of aerial photography, concerned the measurement of water currents and movement of objects on the water by means of time-lapse photography. Although the principles of stereophotogrammetry were employed, the phenomenon to be determined was essentially two-dimensional. The movement of the object, in effect, then added a third dimension.

Measurement of Driver-Eye-Height (1961).—An uncomplicated but unique principle of photogrammetry has been reported by the author, in collaboration with a highway research engineer. In this experiment, statistical information concerning the actual height of drivers' eyes above the roadway surface was determined photogrammetrically. This article is cited as an illustration of measurements from photographs where only one dimension was required, but where indirect methods were also necessary in order to record the data under realistic conditions—in this case, with the cars in motion.

It should be emphasized that the studies and projects discussed here are only examples. *They represent only a very small percentage of the many studies which have been carried out during this five-year period; some have been reported in print, others have not.* Furthermore, the choice of this particular time period was somewhat arbitrary and by no means does it represent the only time during which special applications for photogrammetry have proved valuable.

FUTURE APPLICATIONS OF PHOTOGRAMMETRY

In looking ahead another five years, or for that matter into any future period of time, photogrammetrists should be concerned with trying to estimate not only what kinds of problems are likely to be confronting themselves and other photogrammetrists, but the problems facing the entire scientific and technical universe. Since photogrammetry can help to measure the basic configurations already mentioned—size, shape, position, movement, etc.—the old, time-worn cliché "the sky is the limit" takes on a real meaning in a space-oriented age of today and tomorrow. Other topics and areas in which applications are readily to be found would include medicine, materials, travel, traffic, etc.

MEDICINE

It is sometimes a bit difficult for the engineer to visualize applications of photogrammetry in the area of medicine and medical research. Sponsored research on a broad scale is constantly seeking new methods for determining more accurately various aspects in the progress of a disease. A familiar tool, of course, is the *X*-ray—one which involves both photogrammetry and photographic interpretation. Much time and effort is currently being devoted to the study of cancer and heart disease. Often the medical researcher relies on superficial evidences—those recorded mechanically by *X*-ray or electromagnetic impulses such as in the electrocardiogram—for data on which to base his analyses. Basic research in other areas, such as studies of posture, bone development, weight, height, and age relationships may be accomplished through the use of stereoscopic photogrammetry.

MATERIALS

Ever-increasing complexity in technology requires the utilization of both materials and methods heretofore unknown. Two of the conditions which must be considered in research in this area are the effects of radioactivity and extremely high temperatures. Often, tests involving such phenomena must be conducted by remote systems in order to protect the researcher from intolerable degrees of temperature and radioactivity inherent in such testing. It is possible to photograph materials under test and then to make studies from these photographs where it would have been impossible for a man to handle the material and perform the physical tests to yield the needed data.

A simple example of this type of test involves the stress-strain relation and ultimate strength of metals at high temperatures. If a tensile test is to be performed in which the specimen is above 200–300°F., a man finds it

it difficult or even impossible to handle the specimen; further, there are many types of physical gages that could not be used. If temperatures were even higher, then certain electrical measuring equipment also could not be employed. Yet, as the test was being conducted a series of photographs could be made, and from this record necessary data would be extracted at a later date.

TRAFFIC

As the number of automobiles and the consequent traffic increases, movement of vehicles presents an increasingly difficult problem for the highway engineer. The traffic engineer is also finding it desirable to use photographs (both motion pictures and stills) to record traffic, parking, and land-use problems, as well as in the planning of new and alternate transportation systems.

TRAVEL

Any consideration of traffic problems naturally suggests those of travel, and in today's orientation one thinks also of travel other than on the surface of the earth. Military aircraft travel at supersonic speeds—many creating shock waves known as sonic booms. These shock waves cause multiple-story buildings to vibrate, even to the point of structural damage and the shattering of heavy plate-glass windows. Consideration of the far-reaching effects of sonic booms—particularly since public reaction is strong—would be necessary for a *commercial* flight at supersonic speeds to be acceptable. Such flights would need to be carefully planned in order to bypass heavily populated areas. In the preparation of planned charts and flight patterns for such scheduled flights photogrammetric techniques could prove extremely useful.

Furthermore, in the event that it became advisable to study the effect of shock waves or sonic booms on animals and environmental conditions, photography would be an excellent, well-recognized method for evaluation.

SPACE INVESTIGATIONS

The photogrammetrist faces two challenges in adapting photogrammetry to space investigations: First, he must apply techniques already developed for earth-bound conditions to the measurement of the size, shape, position, movement, etc., of objects in space. Secondly, he must develop recording equipment which will reveal minute detail even when required to transmit the information over relatively large distances.

Photographs are already becoming very nearly indispensable in the study of space projects. Lunar charts prepared from photographs of the Moon which have been made from an Earth station have been the subject of numerous reports. It is well known, for example, that the astronomer frequently uses measurements from spectrograms in order to determine the nature of the light emitted from the stars. In order to utilize man-made satellites, photographs to determine the satellite's position are being taken from the Earth's surface; and, in reverse fashion, photographs of the Earth are being taken from the satellites. It is also logical to assume that photographs taken from man-made and man-controlled satellites will provide the initial means for studying conditions existing on other planets.

CONCLUSION

The photogrammetrist today carries a greater responsibility than he has perhaps ever been faced with before. The advancement of photogrammetry, photo interpretation, and their applications is dependent upon the person best able to use them.[2]

This paper has had as its primary purpose to suggest the broad range of capabilities this important science possesses in the hope that imaginative research will be stimulated in other areas of science and engineering.

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[2] Those individuals who would be interested in using this type of measurement process may find examples of work similar to their own reported in PHOTOGRAMMETRIC ENGINEERING. To aid in library research, a 10-year index covering the period 1948–1958 is available, as well as the individual copies of the magazine.