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Recent Development of Industrial Photogrammetry in Japan

Close-range photogrammetry has been applied to the dynamic measurement of rotating tires, the determination of the subsidence of launching ways, the investigation of marine propeller cavitation, and the measurement of architectural models.

Introduction

The author began to study the application of photogrammetry to industrial projects in 1949. At first, this research was applied mainly to the compilation of topographic maps for dam construction. In the same year, the Indian Mission for Archaeology and History engaged in studying the historical monuments and remains of medieval times in India; the author directed this program. It was continued to 1964 and during this period four study groups were organized. In 1962, the author was engaged in projects relating to the application of photogrammetric techniques to engineering projects. Among these were applications of photogrammetry to automobile models for obtaining body line drawings and for checking the complicated surface of hydraulic turbine runners. The results of this project were presented as a paper at the I.S.P. Congress in 1964. Since then, various achievements have been made in the field of industrial photogrammetry in both software and hardware. In 1966 at the Commission V Symposium during the I.S.P. meeting in Tokyo, the author presented a paper on short-range photogrammetry for objects in motion and this was the first proposal for four-dimensional photogrammetry in the field of industrial photogrammetry. A specially designed stereocamera was developed to deal with objects in motion by shooting continuously at intervals of one and two seconds. The details of these studies were presented at the I.S.P. congress in 1968 as an invited paper. As a result, industrial photogrammetry in Japan has been widely expanded in engineering projects. Various cameras such as the movie camera and the precisely adjusted amateur camera have been developed along with the software which could be applied to the actual engineering works. This paper deals with some recent achievements in Japan.

Examples of Industrial Photogrammetry in Japan

Analytical Short-Range Photogrammetry for the Measurement of a Tire Rotating at High Speed

In conjunction with the increased speed of motor cars due to the construction of super highways, the development of new tires has become an urgent problem. The measurement of tire deformation by the classical method is very difficult to carry out in a laboratory because of the high velocity. The short-range photogrammetric method cannot be replaced by any other conventional method for this purpose. A series of measurements has been developed to accomplish this systematically and automatically from the photography to the taking of measurements of deformation by using a specially designed stereo-camera, comparator, computer, and automatic plotter at the Bridgestone Tire Co. Ltd. with the cooperation of the Sokkisha Co. Ltd., and Hosei University. The flowchart for the measurement operations is shown in Figure 1 and stereophotos in Figure 2. The final mean square of error measurement was ± 0.25mm.

The coordinate data on the plate taken from a SKB-40 stereo-camera, can be transformed to the plate coordinates from the fiducial mark coordinates; six points on the plate can be selected for relative orientation; and absolute orientation can be done from the control points set on the front of the fixed frame. The coordinate data calculated by the computer can be plotted automatically with the online system and the result gives the clear influence area of the inner stress on the tire.

MEASUREMENT OF SUBSIDENCE OF THE LAUNCHING WAYS AT THE MITSUBISHI DOCK

In order to measure the subsidence in the case of launching a heavyweight tanker, the design of the launching ways for ships is very important. The measurement group organized by the Ohbayashi Construction Co. Ltd. is divided into four groups. They are the divisions for phototheodolite, laser, 35-mm movie, and soil pressure (including the measurement of strain gauges at several points). The division for the P30 phototheodolite has a set of five metric cameras which can take a series of photos at time intervals of one second. The shooting time of the five cameras was synchronized by an oscillograph with the launch time of the ship.

As control points, two special pegs were sunk near the centerline of the ship. These were separated from the subsidence of the launching ways by means of special excavations. At the same time, two control points with paper sensitive to the laser beam for measuring the direct subsidence of the launching ways were set, and the fixed points set the laser theodolite rotating the laser beam around the vertical axis. These can be recorded automatically on paper at fixed time intervals. This record also can be synchronized to the time of shooting of the phototheodolite and the starting time of the ship. Accordingly, the resultant data gained by analytical short-range photogrammetry can be easily checked and compared with the data of the laser beam record.

The division of 35-mm movie cameras took a series of stereo-photos from the start of launch to the time the ship slid into the sea. These stereo movie films were used to analyze the behavior of the ship. The data of the strain gauges also were used as a check of the subsidence at the launching ways. These series of measurements were done at the request of the Mitsubishi Heavy Industries Co. Ltd.

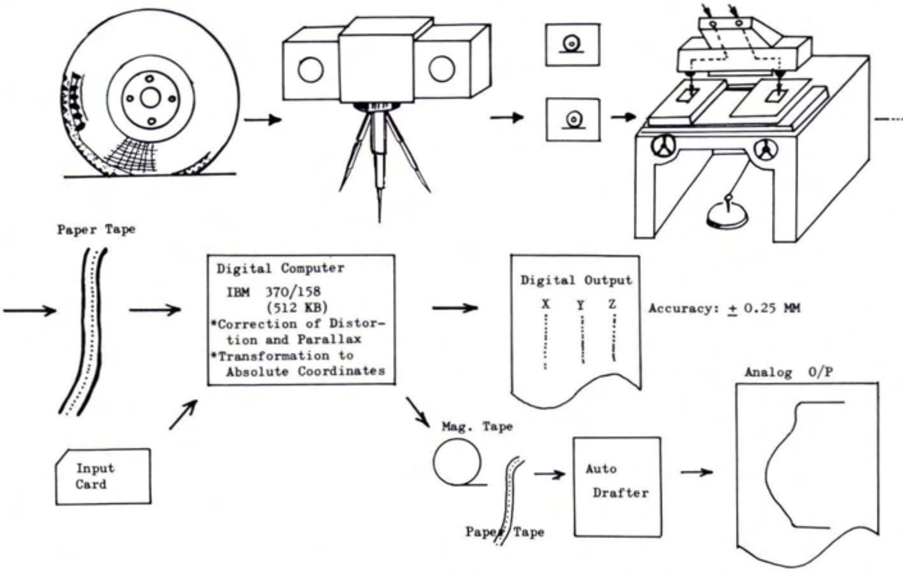

FIG. 1. Analytical short-range photogrammetry for measurement of tires.

MEASUREMENT OF MARINE MODEL PROPELLER CAVITATION IN HULL PRESSURE

Full scale investigations of propeller cavitation are very important in order to check the efficiency of the propeller and to find the cause of vibration and cavitation of the propeller. The thickness of bubbles in the case of the cavitation was measured by comparing the propeller without tank water. The SKB-25 stereocamera was used for taking photos in combination with a strobe light. The propeller at high speed can be photographed in coincidence with the high-speed strobe light. The coordinates on the plate can be transformed by comparing the propeller coordinates without tank water. The mean square error of measurement was ± 0.1 mm.

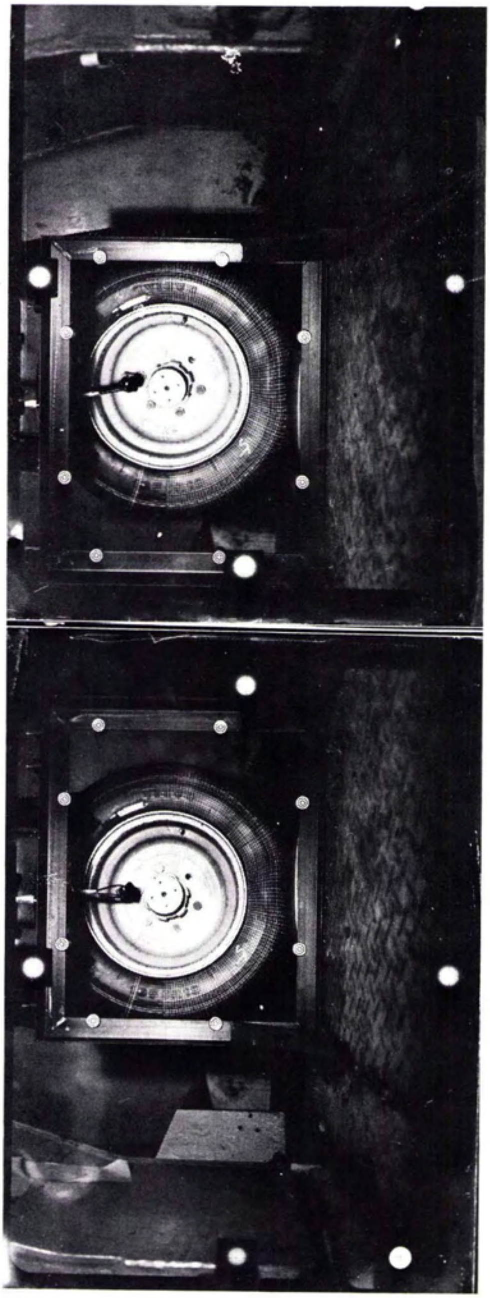

FIG. 2. Stereopair of tire.

PRECISE ANALYTICAL PHOTOGRAMMETRY FOR MEASUREMENT OF THE MODEL

In industrial photogrammetry, precise measurement is sometimes important for design construction with severe criteria. This is combined with the stereo-camera, comparator, and computer and the problems in this case are the distribution and number of control points. Size and marking of control points, geodetic measurement of control points, position and direction of the stereo-camera and its selection, transformation and adjustment of the control points and the check of physical condition of camera and plates, and especially the mathematical formulas for checking the control points are the key factors for this measurement. The inner orientation factors have an important effect upon the result. These must be considered in synthetic ways.

The actual measurement for an architectural model was tried by this analytical means using two SMK-120 stereo-cameras which were used for photographing from the upper side on a specially designed platform. The object was the model of a famous temple, about eight meters by seven meters in cross section and three meters high. The distance between cameras and object was eight meters. The mean square error of measurement was about ± 0.2 mm in plane coordinate and ± 1.5 mm in height.

CONCLUSION

Short-range photogrammetric methods have played an important role in the field of industrial photogrammetry and the results have been most satisfactory. But there are various problems which must be solved if short-range photogrammetry is to be applicable systematically. Since only a few examples have been given, we must perform more research in order to find integrated techniques in considering economical and easily applicable conditions.

ACKNOWLEDGMENTS

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References

1. T. Maruyasu and T. Oshima: "Stereo-camera Designed for Measurement of Objects in Motion", Paper presented at the Commission V Symposium, I.S.P., Tokyo, 1966.
2. T. Oshima: "Studies on Photogrammetric Techniques for Precise Measurement and their Application to the Industrial Field", Paper presented at I.S.P., Tenth Congress, Lisbon, 1964.
3. T. Maruyasu and T. Oshima: "Short-Range Photogrammetry of Objects in Motion", Paper presented at the I.S.P. Eleventh Congress, Lausanne, 1968.
4. T. Oshima: "Photogrammetry of Objects in Motion in Japan: Past, Present and Future", The French Society of Photogrammetry No. 42, p. 65-70.
5. T. Maruyasu, T. Nakano and T. Oshima: International Report of Commission V., I.S.P. Lausanne, July 1968.
6. Japan Society of Photogrammetry: *Precise Photogrammetry for Three Dimensional Measurement* (An interim report for model test) Tokyo, 1969.

Errata

Computational errors occurred in the article, "Bayesian Decision Theory and Remote Sensing," by Thomas J. Jackson and Robert M. Ragan in the September 1975 issue of *Photogrammetric Engineering and Remote Sensing*. Therefore, please correct Tables 6, 7, 8, and 9 on page 1143 to read

Table 6. Expected Opportunity Losses of the Optimal Action Given the Signal

		(1) IS(1)			(2) IS(2)
y_k	a_i	$R_1(y_k)$	y_k	a_i	$R_1(y_k)$
1	2	2.41	1	1	3.33
2	2	5.21	2	2	3.61
3	3	2.94	3	3	0.96
4	4	3.93	4	4	2.82
5	5	5.37	5	5	2.53
6	6	2.19	6	6	1.85

Table 7. Expected Values of the Expected Opportunity Loss

IS(M)	1	2
R_2(IS(M))	3.83	2.19

Table 8. Value of the Information Source

IS(M)	1	2
V(IS(M))	6.47	8.11

Table 9. Decision Rule for Choosing the Information Source

	IF	Choose IS(M)
	C(2)-C(1) > 1.64	
and	C(1) ≤ 6.47	M = 1
	C(2)-C(1) ≤ 1.64	
and	C(2) ≤ 8.11	M = 2
	C(1) > 6.47 and C(2) ≥ 8.11	

Please correct paragraph 6 of page 1143 as follows:

Line 9, 2.23 should be 1.64;

Line 11, \$223,000 should be \$164,000; and

Line 14, \$2230 should be \$1640.

Articles for Next Month

Abraham Anson, Applications of Color and Multispectral Techniques.
Norman L. Fritz, Available Color Aerial Photographic Materials—1975.
A. H. Gerbermann, J. A. Cuellar, and *C. L. Wiegand,* Ground Cover Estimated from Aerial Photographs.
A. K. Gupte and *K. Singh,* Bar Spread Functions for Parabolic Image Motion.
Major John W. Mark, Computer Analysis of Photo Pattern Elements.
S. E. Masry, E. Derenyi, and *B. G. Crawley,* Photo maps from Non-Conventional Imagery.
Lee D. Miller, Robert L. Pearson, and *Compton J. Tucker,* A Mobile Field Spectrometer Laboratory.
Edward F. Puccinelli, Ground Location of Satellite Scanner Data.
Frank A. Scarano and *Gerald A. Brumm,* A Digital Elevation Data Collection System.
Fawwaz T. Ulaby and *Thomas F. Bush,* Monitoring Wheat Growth with Radar.
W. E. Woodcock, Aerial Reconnaissance and Photogrammetry with Small Cameras.