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The Economical and Technical Aspects of Non - Topographic Photogrammetry

Abstract

In the paper, the review of the economical and technical effects of Non - Topographic applications are presented. The analysis is performed on the basis of informations gathered from Photogrammetrie Institutes and Laboratories of various countries. The final conclusions relative to the advantages of methods of Close-Range Photogrammetry are summarized.

1. Introduction

Working Group of the Commission V has been convoked after the XIIth Congress of the International Society for Photogrammetry in Helsinki, Finland. The tasc of the working Group was gathering information on the cost effectiveness of the close-range photogrammetry.

Initial information on the subject was presented at the Symposium of the Commission V of the I.S.P. in September 1978 in Stockholm, Sweden. The mangement of the Group have come into contact with leading personalities and organisations active in the field of close-range photogrammetry. After the above mentioned Symposium in Stockholm about 50 scientific and industrial organisations have been supplied with questionaries on technical and economical aspects conçering varions applications of non-topographic photogrammetry.

There have been 25 responses on behalf of the photogrammetric organisations on 10 countries.

We take the opportunity to thank all the respondents who have sent us their reply and comments on the questionaries.

The discussion held on matter in Stockholm proved that the sphere of activity of the Group V/2 should not be limited only to a survey of cost and labour savings resulted from photogrammetry.

It was confirmed that a major influence on the effectivenes of photogrammetric projects had other indirect factors which not always should be looked upon in terms of cost and time saving aspects. In some projects it is even not feasible to compare photogrammetric methods with other ones, because photogrammetry is the only possible technique that can be applied.

2. A analysis of various applications of the close-range photogrammetry

Based on the received data here are presented diversified applications of photogrammetry, instrumentation and methods adopted in particular countries.

The report presented does not comprise all aspects connected with the subject of the close-range photogrammetry, but it offers a pattern which can be utilized as a basis for further discussion.

It has been proved by the results of the inguiry /in table 1/ that the photogrammetric methods used in various sphares are identical in spite of different needs and technical possibilites of particular countries. It has to be pointed out that there exists similar technology and instrumentation adopted for solving particular tasks.

Table 1

Country	Scientific or industrial organisations	The types of applications of close-range photogrammetry	The applied methods and equipment
1	2	3	4
Australia	Department of Administrative Services	The Architectural Photogramme-try	Cameras Wild P-31, P-32 Zeiss Topocart, analo-

1	2	3	4
		/plotting of building facades at scales of 1:50 and 1:100/	gical elaboration
	The University of New South Wales	The laboratory and field testing as part of Civil Engineering	Cameras Wild P-32, Zeiss UMK with plate and film, Zeiss Topocart C, analogical and analytical elaboration
	The Broken Hill Propietary Company Limited, Photogrammetric Department New South Wales	The determination of burden shape in blast furnaces and the internal shape of steelmaking vessels	Stereometric cameras Wild C-40 and C-120, autograph Wild B-8, A-10, analogical elaboration
	CSIRO, National Measurement Laboratory	The microstereophotogrammetry /the measurement of the geometry of Rockwell hardness sphero-cone diamond indenters/	Camera-microscope, Zeiss stereometograph with an output on punch cards, analogical and analytical elaboration
	The Hydro-Electric Commission Tasmania	Topographic maps for Civil Engineering Design Overlays indicated fault lines etc. /Engineering Geology/, the checking large fabrications for corretness of manufactures	Cameras Wild C-40, C-120, P-30 Autograph Wild A-7, A-40 PDP II/40 Computer analogical and analytical methods
Canada	Atomic Energy of Canada Limited Chalk River Nuclear Laboratories	The determination of the size and spatial relationships of piping and other process equipment in hazardous nuclear environments	Camera Wild C-40, Zeiss 1818 stereokomparator, Hewlett-Packard 9830-A Calculator
	Department of Photogrammetry Laval University Quebec	The recording of traffic accidents and sites of crimes for the construction of protheses/medical applications/	Stereometric cameras Wild C-40, C-120, Autograph Wild A-40
		Forestry inventories /determination of wood volumes/.	Helicopter-short base system with 2 Hasselblad ca-

1	2	3	4
			meras, Autograph Wild A-7
	Energy, Mines and Resources Canada Science and Technology	The surveying of large open pits, the determination of mined volumes and mass movements The obtaining geological information on spacing and length of joints from steep rock slopes with limited access	Terrestrial and aerial cameras, Zeiss Topocart, Autograph Wild A-8 and B-8, analogical and analytical elaboration
Federal Republic of Germany	Universität Stuttgart, Institut für Anwendungen der Geodäsie im Bauwesen	The permanent final control of bearing surfaces of constructions /neted, caple membranous roofs/ The determination of deformations of sample during the examination of the endurance of materials. The examination of spatial deformations of mechanical constructions	Cameras UMK, Hasellblad MK-70, Non-metric cameras, stereocomparator PSK-2, Autograph A-8, CDC 6600, Cyber 174 and HP 9830 Computers, analogical and analytical methods
		The determination of deformations and displacements of tunels in the coal mine and volume of heapes	Cameras P-31, P-32 stereocomparator Zeiss 1818 automatical coordinatograph camera Zeiss TMK-6, Planimat with Ecomat Computer
Finland	Tampere University of Technology	The determination of the shape size and deformations of different types of objects	Camera Zeiss UMK 1318, Ascorecord and DBA comparators, PDP 11/70 computer, analytical eleboration
	Technical Research Centre of Finland	The control of the blasting of subway tunnels the determination of the shape and size of spatial ship blocks, determination of oil reservois in rock	Zeiss SMK 120 stereoplanigraph /analogical method/ Camera Zeiss TMK, stereocomparator PSK 2, computer HP 2100

1	2	3	4
		the architectural Photogrammetry	Zeiss SMK 120 stereoplanigraph C-5, Hawlett Packard 2100
Israel	Technion Research and Development Foundation Surveying Geodetic Research Station	Calibration of upright oil storage tanks of various capacities, Dynamic mapping of aircraft elements placed in wind tunnel, Mapping submerged models in a hydraulic laboratory. Microtopographic survey of various soil surfaces	Cameras Zeiss TMK, Wild P-30 autograph Wild A-7, stereocomparator Zeiss 1818, Computer IBM 370/168 analogical and analytical methods
Norwegian	The University of Trondheim The Norwegian Institute of Technology Division of Geodesy and Photogrammetry	Ship building industry, Measurement of the smoothing of surfaces /terrain roads/, the mapping of ancient wood carvings, the microphotogrammetry, the underwater aplications	Cameras Wild P-31, Zeiss SMK-120, Hasselblad non-metric, autograph A7 stereocomparator MK-2 analogical and analytical elaboration
	Bloms Surveying Inc.	The control of geometrical shape and volume of tanks and hulls for sforage of liguid, the determination of deformation of ships	Cameras Zeiss UMK, autograph A-7, A-10, Computer HP 9825 A., Drawing machine GT 5000
Poland	State Enterprise "Geoprojekt" Warsaw	The determination of geometry of the construction and their parts /tanks, buildings, prefabricated products, etc/. the determination of the deviation from nominal assumption/cranes/, the determination of the spatial deformations and displacements of the construction and their parts	Cameras Zeiss Photeo 1918, UMK 10, Wild P-31, Stecometr, Computer ODRA 1305 analytical elaboration

1	2	3	4
		caused by diferent external factors	
	Institute of Photogrammetry and Cartography of the Warsaw Technical University	The determination of the statical and dynamical deformations of engineering constractions during their exploitation /railway and suspension bridges, cranes, power line pillars, laboratorial concret sample etc./	Cameras Zeiss Photeo 1918, UMK 1018 Wild P-31, non-metric cameras, film-cameras Pentazet 16 and 35, stecometr, computer ODRA 1204 and 1305, CYBER 70, analytical elaboration
		the control measurement of the products /shape and fitting of cooperated parts of product/,	
		the measurement of technical and natural processes /strains of an aluminium membrane in the process of explosive and the process of shooting off of stones in a stonepit/,	
		the architectural photogrammetry and the documentation of ancient wood carvings and monuments	Cameras UMK 1018, Wild C-120, autograph Wild A-5, Topocart, Stereometrograph analogical methods
		the medical applications	RTG camera, non-metric camera, stecometr, computer ODRA 1204, CYBER.
	Enterprise for Maintenance of Ancient Monuments Warsaw	Architectural photogrammetry /documentation of external and internal elevations, details, monuments etc.	Cameras Zeiss Phototeo 19/1318, UMK 10, Wild C-120, Topocart Stereoautograph, analogical methods
	Photogrammetric Laboratory of Traffic Police and Criminology Department Warsaw	The documentation of traffic accidents	Stereometric cameras Wild C-40, C-120, non-metric cameras and TV-cameras, autograph Wild A-40

1	2	3	4
			analogical elaboration
	Reginal Enterprise for Geodesy and Cartography in Gdańsk	The determination of the trajectory and deformations of the ship during launcking, the measrement of the hydrotechnical models, the determination of the abrasion of steep banks of river, sea and artificial reservoires,	Cameras Zeiss UMK, Phototeo 13/1819, Stecometr, Computer ODRA 1204 analytical elaboration
		The determination of the volume of stocks of coal.	Topocart, stereometrograph analogical elaboration
	The S.Staszic University of Mining and Metallurgy	Architectural Photogrammetry and documentation of ancient wood carvings and monuments	Camera Zeiss UMK, Phototheo 19/1318 Topocart, analogical method
		Industry applications	Stecometr, computer analytical method
	Regional Enterprise for Geodesy in Kraków	Architectural Photogrammetry /documentation of external and internal elevations, details/	Cameras Wild P-31, Zeiss UMK, Phototheo stecometr, Topocart
South Africa	University of Cape Town	X-ray stereophotogrammetry /radiagnosis, location of foreign bodies/	X-ray apparatus, summagraphics digitiser, Tektronix graphic computer system analytical method
		Archeological applications/survey of archeological finds/	cameras UMK, Topocart
		Coastal Engineering /study of strom damage to harbour breakwaters/	F-24 aerial cameras, Zeiss stecometr, H.P and Tektronix computer systems analytical method
		The determination of heights of wild elephants and shape of birds bills	Zeiss UMK cameras mounted in safari vehicle, Linhof Technica camera, stecometr, Topocart, H.P Packard Mini Computer, Tektronix graphic computer

1	2	3	4
			system analogical and analytical method
		Architectural and Engineering applications /study of deformations/	
United Kingdom	National Engineering Laboratory Department of Trade and Industry East Kilbridge Glasgow	Underwater photogrammetry /the examination a damaged off shore platform leg in the North	Non-metric cameras system, stereocomparator analytical elaboration
U.S.A.	New England Medical Center Hospital	The measurement of the ocular fundus optic disc /ophthalmology, Glaucoma/	Donaldson Retinal Camera, Kern RG 22 H.Dell Foster Digitizer, semi analytical method
	Department of the Army Seattle District, Corps of Engineers Seatle, Washington	The monitoring of deformations of an apartment building recent surface slide and an ancient slide area located near a flood control structure and a hydroelectric project	Cameras Wild P-30 BC-4 Ballistic, Zeiss RMK A 15/23 autograph Wild A-7 used as a mono comparator, IBM 379/158 computer analytical elaboration
	University of Washington	X-ray stereophotogrammetry and other applications of close-range photogrammetry	Analytical plotter Balplex PDP-11-34 A Computer analytical and analogical method
	Kelsh Instrument Division /Danko Arlington, Inc./	Kelsh instruments are used in the medical and industrial field in the U.S.A.	Camera Kelsh K-470, sterecamera K-460 and other instruments
	University of Manchester Simon Engineering Laboratories	Medical applications /the registration of shape of body for machinings prothesis/	Moire technics, stereometric cameras, a computerdided system for die design and machining

3. Analysis of technical and economical aspects of various applications

The responses to the enquiry contained besides the informations presented in table 1, remarks concerning advantages and difficulties involved in adaption of the photogrammetric technique.

In the following the cataloqued presentation of technical

and economical aspect is offered with respect to particular projects.

Photogrammetry applied to architecture and maintenance of ancient monuments have been most widely used for some time already and it appears no necessity to sustain its merits.

An applications of photogrammetry for recording of geological cross-sections and determination of terrestial surface by micro-topography makes possible simultane limiting of the fieldwork and getting more information with respect of quantity and quality of the objects examined.

The most applications are included in the industrial photogrammetry.

In hydro-technique photogrammetric methods are applied in the following cases:

1° Laboratory measurements of water wave movement makes possible an elaboration of numerical map of current water surface around the hydro-technical construction model. Precision obtained is 3 to 4 milimeters at the amplitude of waves of a few centimeters.
That only method enables to define a character of wave movement in its different stages and directions and in consequence to define the most optimal shape of the building construction.

2° Measurement of deformation of the buildings constructed at the water steps and embankment of waters - reservoires. The technique has resulted in two - to threefold reduction of the fieldwork in comparison to the standard geodetical measurement. The measurement of deformation of building constructions has been performed with 1:50000 to 1:70000 accuracy in relation to the distance of photogrammetric site. Definition of the changes of natural embankment of the reservoir makes possible to create a map and an unlimited number of cross section with accuracy of $m_x = m_y = \pm 3$ mm at the scale of model and $m_z = \pm 5 \div 8$ cm in the field.

In the ship building industry photogrammetric technique has been applied in the following cases:

1° For determining of the shape of ships and their deformations with the accuracy of 1:40000 in relation to the surface under study. The result has been equivalent to that of the geodetical measurement but much time and field work has been saved.

2° For control of trajectory and ships slope at lounching from the shipyards. That makes possible to characterise the process of ship lounching with 3 second interval. The accuracy of determining the slope is ± 1 .

In the same aera the underwater photogrammetric method is applied. An example can be quoted of measurement of ship's propellers some time after some time of their exploitation and after heavy stroms. The accuracy is 1:1000 relative to the object distance. Similar technique has been used for determination of damage of underwater components of the oil-rigs. In those cases photogrammetric technique proved to be a sole method that could be used.

Another application of photogrammetry is that of defining mined volumes and mass movement in the open pits. Accuracy of measurement has been estimated at about 2 %.

An advantage of that photogrammetric method is the

possibllity of registration of the whole object from a distance wchich is of a great importance because of safety of the working team as well as substantial diminishing of time consumption at the fieldwork measurements.

An application of photogrammetric technique for control of condition of engineering constructions has been primarily adopted for:

1° defining of verbical deformations of slim shaped constructions i, e. chimneys, masts, pillars etc.

2° determination of shapes of spatial constructions and their components with accuracy of measurement ranging from a few to some hundred micrometers in scale of photograph.

An example can be quoted of a final control of flatness of surface of membrane roofs or defining of shape and capacity of oil and gass storage tanks in rocks.

In comparison to other techniques there is a major advantage: a great number of points can be registred as well as time and cost saving and the precision of measurement is ensured.

3° spacial displacements and deformations of the engineering and mechanical constructions can be determined with accuracy of a few micrometers at the scale of the photography. The photogrammetric method permits to record the geometrical state of entire object in arbitrary short time and there is no need to stop an operational activity of the object under control. That is the case both when the object is in fast or slow motion.

Photogrammetric technique can also be applied for control of structure of buildings materials and their deformations during the endurance tests. When microphotography is being used, the accuracy obtained is of 1 micrometer range and the deformations can be determined on the base a major number of points.

A fairly common application of photogrammetry is in criminalogy and primarely in registering data of the traffic accidents. The time saving element is about 50 % in comparison to the classical methods and the precision is unquestionable. The photogrammetric photographs have to be considered as most objective documentation and for archival purposes too. Long after the accident they can be easily restituted.

One of the most recent application of the photogrammetric technique is in medical treatment which opens great possibilities for diagnosis, rehabilitation and production of automatized prothesis. In the latter case the method of photogrammetric registration and in particular in "moire" technique, makes possible getting an accurate description of the shape of a body limb and an exact and fast production of the prothesis. It is of an exceptional importance for diagnostic and rehabilitation purposes that stereophotogrammetry can be used for the spacial reconstruction of human bone structure. Similary the stereophotogrammetric methods can be applied for the measurement of the ocular fundus - optic disc. It permits for early discovery of glaucoma. According to the information received from New England Medical Center Hospital, U.S.A., the time required for measuring of a model of an eye globe is about 20 minutes with about 300 points and three dimensional image is obtained. In those applications the photogrammetry

is a sole method which can be used.

In related field of zoology stereometric technique can be used safely for determination of natural body shape of wild animals living in natural environment. An accuracy is up to ± 2 centimeters. Preservation of some vanishing species of animals adds an importance of these efforts.

A presented review refers mostly to applications of the close - range photogrammetry. But as it is widely known aerial photographs are used too for metrical purposes in the non - topographical photogrammetry. An inventory of forests and wood volumes are measured. According to the Department of Photogrammetry in Laval University, Canada cost saving is up to 1/4 of the conventional methods.

4. Final conclusions

Summing up the economical effect an emphasize should be made that the results cannot be evaluated only in terms of cost effectiveness and time saving. An application of photogrammetry largely depends on the possibilities of particular countries instrumentation, technical abilities of operators and steady or occasional use of photogrammetric methods. In the instances where the occasional photogrammetric method are used the cost effectiveness is difficult to determine due to high cost of the advanced photogrammetric equipment.

There are many problems which concern measuring within various applications adopted by diversified photogrammetric laboratories. Conventional cameras do not fit to the requirements. In particular there is a scarcity of long focal length cameras for precision measurements for industrial purposes. Similarly that is the case with some special stereometric cameras of a very short base length for medical purposes and microphotogrammetry. In spite of it there are unquestionable advantages of the photogrammetric techniques in the above cited and other fields of close - range applications.

The following major advantages can be quoted:

- the saving of time and costs when photogrammetric method are permanent used,
- archival value of the photographs,
- the possibility of the repetition of measurement at any time chosen,
- an impartial registration of an object or an action,
- possibility of a simultane registration of unlimited number of points,
- non - contact measuring system is possible with no interferance with an operational activity of an industrial plant. Safety for personel at measuring process is ensured,
- irregular and constantly changing shapes can be measured within a time period limited at will,
- substantial field work limitation is prevailing.

Finally it has to be emphasized that in quite a lot of cases the photogrammetry is a sole method of measurement that can be applied.