SOME RECENT TYPICAL EXAMPLES IN INDUSTRIAL PHOTOGRAMMETRIC APPLICATION WITH CAD TECHNIQUES

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Abstract:

Recently, in addition to remote sensing techniques, the computer-aided Geo-information system(GIS) and computer-aided design(CAD) have been recognized as being very effective and utilized to prepare basic data for decision making in administration and policy control in the field of civil engineering employing the photogrammetric method. This paper describes several typical examples in the field of photogrammetry based on the GIS and CAD systems.

Key Words: Close-Range, CAD,Traffic Accident,Perspective View Calibration,Close-Range,Analytical Graphic Device.

1. 3-D Controlling Techniques using the CAD System for Cenotaph restoration in Hiroshima Peace Memorial Park by Close-Range Photogrammetry

1.1 Outline

The cenotaph built in 1952 in the Hiroshima Memorial Park (atomic bomb site)as a symbol of Hiroshima's prayer for world peace has been damaged by years of outdoor exposure and the city of Hiroshima has decided to rebuild it in granite.

For this restoration, special consideration is needed reviewing the following: In the first place, because of the basic concept of restoration of the existing shape of the cenotaph, the existing shape must be measured accurately and efficiently by means of some non-contact method. To meet these requirements, photogrammetric method was used. In the second place, because the structure will be changed from the present reinforced concrete to granite, the original sectional areas must be modified to compensate for the reduced strength and the shape of the interior wall must be modified. In addition, since the visual exterior wall shape must fully represent the designer's concept, the utilization of the CAD system capable of 3-dimensional representation was decided. The investigation and analysis were executed in accordance with these requirements mentioned above. Here are discussed how the CAD system were used for the restoration of the cenotaph based on the 3-D data by precise close-range photogrammetry.

1.2 Photogrammetry

The close-range photogrammetric technique was used for taking photos with at least 4 to 6 accurately measured control points within a pair of photos. The stereoscopic photographs are processed in a 3-dimensional measuring device called the analytical plotter. The measuring points are recorded and stored in computer. The ground coordinates of the object are obtained on the basis of the photographic coordinates of the object by simple transforming formula.

1.3 Photographing and Measurement

A single photogrammetric camera UMK10/1318 was used and in general the measuring distance is selected between 3 to 10 times of the base line length. A precision analytical plotter of plans was used. The intersection points of each pair of stereoscopic model can be checked by computer. The residual errors of vertical parallax was more or less 1 to 5 microns.

1.4 Application of CAD System

In the series of the cenotaph rebuilding work, a CAD system was utilized for the following purposes:
(1) the numerical data alone obtained from the photograph process is not sufficient to know the 3-dimensional shape fully. Perspective view from any desired viewpoints and other views must be displayed on the screen to allow the designer to easily recognize the 3-dimensional shape and to facilitate correction.
(2) As mentioned earlier, the new cenotaph must have 14cm thicker wall at the middle section for bulging inward than the existing shape. The new wall must have the correct thickness and at the same time, it must be visually satisfactory to the designer.
(3) The quarrying process included in the erection work required the wood patterns and to make them, the numerical data for any desired section is required.

1.5 External Wall Numerical Data Processing

A very good conformance between the external wall numerical data obtained from photograph and the rebuilt cenotaph design specification based on the basic design was ascertained.
As can be seen from the contour map, the existing cenotaph has very well retained the symmetrical shape. On the basis of these two observations, the designer came to the conclusion to use the existing shape of the cenotaph without modification, as the exterior shape of the rebuilt cenotaph.
However, the numerical photogrammetry data consists of height values at randomly selected positions which was defective as the data for 3-dimensional representation of perspective views, etc.
To overcome this shortcoming,therefore, the height at all the intersections of a uniformly spaced grid set on the X-Y plane (10cm interval in X direction and 30cm, in Y direction) were calculated by Lagrange's interpolation.

1.6 Generation of Perspective View

Perspective views are generated on the basis of the grid data for the exterior and interior wall surfaces. To allow the designer to recognize the shape of the object, 3-dimensional shapes are displayed on the graphic display screen with the effective combined use of the existing system possessing ordinary display functions and a newly developed personal computer system adapted to special data processing. For more closer comprehension of the shape, detailed drawing wee plotted on an X-Y plotter at a precision of 0.1mm.
After thorough visual examination from various angles, the designer arrived at the following conclusions:
(1) Interior Wall Surface Shape
The interior wall surface shape formed in accordance with the rebuilt cenotaph basic plan was fully in conformance with the designer's concept and no modification was needed.
(2)Exterior Wall Surface Shape
As a result of the comprehensive observation in combination with the interior wall surface shape and examination, no modification was found necessary.

1.7 Generation of Numerical Data for Erection

In the course of erection, wood patterns must be made before quarrying. For making wood patterns, numerical data are required for the exterior and interior wall surfaces at each grid (30 cm in both X and Y directions) and for the masonry joint surfaces. The photos show numerical photos prepared by the CAD system for the quarrying planning and checking.

1.8 Discussion

To measure the exterior and interior wall surface shapes of the existing cenotaph, the terrestrial photogrammetry was adopted and in rebuilding the cenotaph to determine the modified interior wall surface shape suiting to the concept of the designer, the CAD system was utilized.
The use of Photogrammetry was advantageous in the measurement of the shape of the existing cenotaph, particularly in the following respects:
(1) The 3-dimensional shape of the cenotaph was accurately and precisely measured and numerically represented.
(2) Because of the many visitors during the daytime, the cenotaph was not accessible for measurement. The orientation pints were set and measured during the night and the photographing was executed in early morning and in the evening when visitors were are scarce. The Photogrammetry allowed substantial reduction of site-work time compared with the conventional surveying.
(3) The obtained images on photographic dry plates or film can be stored for later restoration and further reading of 3-dimensional data. Especially with the cenotaph which is a historical monumental object, this feature of data record storage is of special advantages.

The use of the CAD system in the shape determination of the rebuilt cenotaph was advantageous mainly in the following respects:
(1) Isometric projection
The 3-dimensional display, perspective views and the slid models formed on the basis of the grids data as derived from the photogrammetrically obtained exterior shape and arbitrarily determined interior surface curves at the top area allowed easy comprehension and decision of the shape to the designer.
(2) The joint use of a new CAD system based on personal computers with the existing system reduced the expense and time of the process.

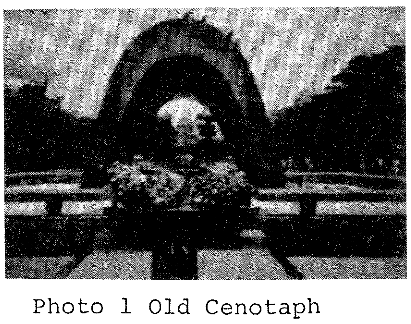


Photo 1 Old Cenotaph

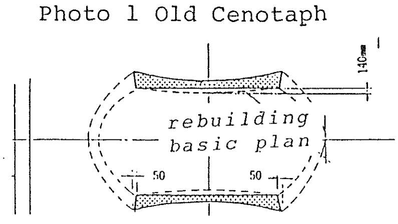


Fig. 2 Cenotaph rebuilding basic plan

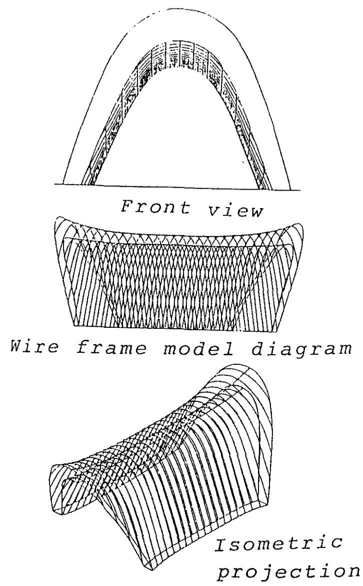


Fig. 2 Graphic image generated by X-Y Plotter

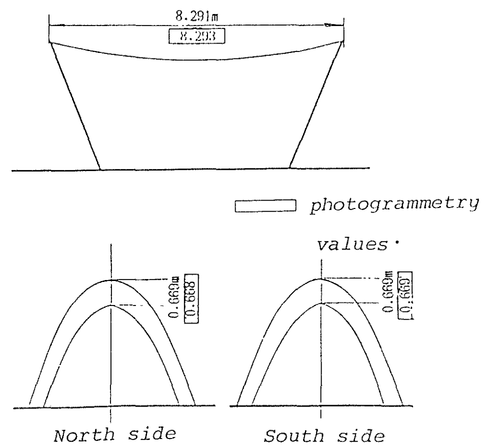
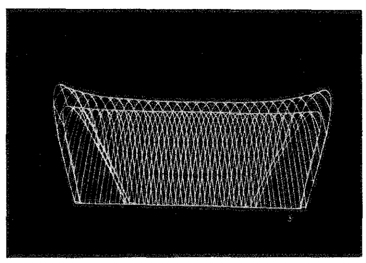
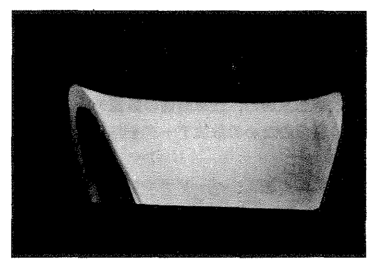


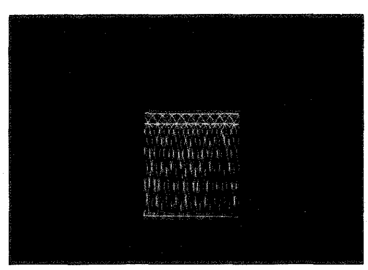
Fig. 3 Comparison of design spec. and photogrammetry data



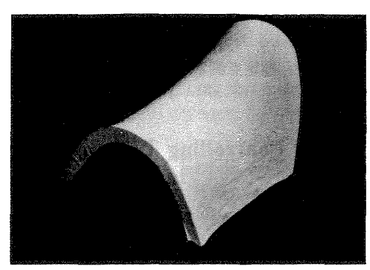
Wireframe model



Solid model



Surfacing of wireframe model



Solid model

Photo 2 Model generated from photogrammetry data

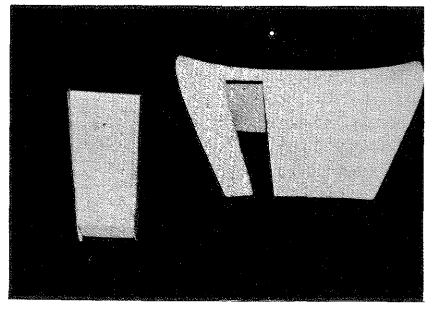


Photo 3 Granite block based on numerical data

2. Traffic Accident Site and Close-Range Photogrammetry

2.1 Introduction

The first technique for measuring traffic sites was adopted in Japan at the police headquarter in Saitama Prefecture, one of 47 administrative divisions in 1967,followed by Kanagawa,Osaka,Hiroshima. In 1971 the national police agency in Japan formally adopted this method and established an organization at each prefecture police headquarters. At the same time, they allocated the necessary funds for the program and offered a training course in Tokyo in Tokyo,twice a year, for leaders in the 47 prefecture. The course continued for about 10 days and included lectures and practical applications.

As of 1987,there were 303 stereo-camera,68 stereo-plotters and several analytical plotters for performing measurements at the traffic sites and also special police cars in which all necessary instruments were set up.The photogrammetric methods proved to be superior to the conventional one, using direct measurements. The positive points using this method are (1) the necessary time for stopping traffic vehicles at accident sites can be reduced drastically, (2) The drivers pay special attention to their driving because of the psychological effect that this very accurate system generates.

Nowadays, the use of photogrammetry is expanding to more and more areas within the police bureau,because the high accuracy of the results. this technique is used not only at traffic accident sites but also at criminal sites, airplane and train accident sites and great fire sites. It has also a special use for estimating car speed from the results of measuring the body strain caused by the auto collisions. Due to the increasing number of accidents, these sites of fatal accidents were mapped photogrammetrically and sent to the court with field survey documents and in the case of slight injury, photos are submitted with this conventional documentation. Frequently, accident sites were mapped beforehand for later use for actual accident reporting.

2.2 Organization and System

At the first stage, the National Police Agency had the initiative to organize police activities, system development and distribution for the national budget. Since the general training course was completed in each prefecture. the technique of measuring at the accident sites had been executed in each prefectural police agency and application programming has been also promoted at several prefecture police headquarters. Therefore, the National Police Agency is now the liaison and planning office of each prefecture and the office to promote new advanced technology and also to carry out training seminars.

The accuracy of the field direct measurements with tapes relies upon personal skill,but the photogrammetric method comparatively does not include personal errors and constantly maintains accurate mapping. As the authors have described here,the time of traffic congestion at an accident site is minimized.

2.3 Stereomicroscope Camera and Plotting Instrument

Stereometric cameras used by the police in Japan are short-base dual cameras which are rigidly fixed at the two ends of a bade-tube. The camera are arranged with parallel axes which are normal to the base-tube. When the clamps holding the base-tube can be rotated and tilted, i.e., he direction of photo-taking can be chosen at will, with the camera axes still remaining normal to the base. Such camera setups are found to be convenient and almost universal for police applications. The camera pointings are equipped with viewfinders provided with cameras. the vehicle, manned by two officers, is fully equipped with photo-taking and photo-processing facilities along with flood-lighting equipment as may be necessary for photo-taking in darkness.

Presently, there are a total 303 cameras being used in police work of which arounf 70 cameras are made by Zeiss, Wild and Sokkisha and about 230 cameras by Asahi Co.Ltd. The distribution of these cameras in the various prefectures depends on their workload. Some examples of such distributions are (as in 1986) Osaka Prefecture, 21;Saitama Pre.,32;kanagawa Pre.,18;Tokyo Metroplitan,8; and Aichi Pre. 13. Most of these cameras have a 120-cm base and are generally used in jobs requiring stereoplotting. For providing additional information and in circumstances requiring very close-range data acquisition and documentation, camera with 20-cm and 40-cm based are also used.

Of the total 68 stereoplotting instruments used by the police in Japan, around 42 were made by Asahi Co. Ltd. with trademark of Asahi-Wild,45;Sokkisha,16; Nikon,4; and Zeiss,3. All of these instruments are capable of yielding three dimensional data of continuous map compilation. Currently, because of the need for a more fully digital type, Pentax Co. developed PAMS(Photogrammetric Analytical Measurement System) and Koei Densi Co. developed PHOCAS(Photogrammetric Coordinate Analizing System). The both use only a metric camera, but also a 35-mm camera specially developed for this schemes.

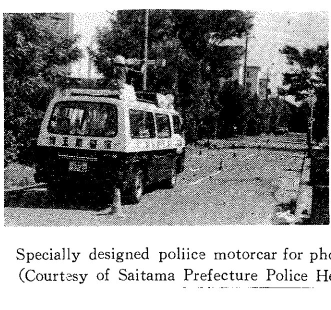


Photo. 1. Specially designed poliice motorcar for photo-taking (Courtesy of Saitama Prefecture Police Headquarters)

2.4 Traffic Accident and Photogrammetry

Unless specially demanded otherwise, all stereo-compilation is carried out at a scale of 1:200 with contouring being optional. The extent of police work in the country can be imagined from the 1986 statistics. That year, of the 579,190 accidents, around 50 %(288,213 accidents) occurred in the areas equipped with stereo-camera. The participation of police wars with stereo-camera were 169,931 in number and a total of 52,647 photo-pairs were taken of which actually 20,487 scenes were mapped with numbering 38.9% off total pairs. These plotted maps are used for the use of various courts. There were invariably submitted with field measurement of various types as deemed necessary for disposal of cases. The photogrammetric operations of the police in Japan, although initially discouraged by the legal profession, now seem to enjoy considerable support from the judiciary department.

Japan is divided into 47 administrative divisions (like states in the U.S.)known prefectures. The total police force in the country is around 220,000 of whom approximately 2,600 are engaged in photogrammetric work. Of these, about 200 are photogrammetric operators, mostly civilians, with roughly 30 percent being uniformed police officers.

2.5 Analysis Results of Mapping

Normally mapping at accident sites at a scale of 1:200 is standard, differ on a case by case basis regarding special jobs, especially for the mapping case for airplane explosion, train collision sites and explosion sites of chemical factories. The mapping accuracy is closely related to the photo-taking conditions, operating instruments and operator's skill. In general, mapping accuracy is normally +0.2mm on the map within the range of 4 to 20 times of base length, that means, +4cm in actual length at a scale of 1:200. In case of an analytical measuring system, accuracy of reading on the plate if_+5um for PAMS and +1um for PHOCAS. Accuracy is related to the control point position and their arrangement, especially mark itself is a big cause of errors. The police Agency made up the marks so that they can be seen and measured easily.

2.6 Conclusion and Remarks

Ten years have passed already since the national project has started. There are big differences in use depending on the prefecture, some are very active and a few prefectures are dull because of knowledge in photogrammetry and training and also camera and plotting machines are very expensive and take time to master. The regular operations take around 0.1% of the total police budget every year in the country. Some cost samples are ¥3.0 million for one stereometric camera with accessories; ¥4.0 million for one special vehicles; and ¥6,000 for 12 glass plates.

The experience that the police in Japan have had, resulted in the raising of the scientific manager power among the police. But in actual works, there are several problems proposed by each prefecture as shown in followings:
(1) Deterioration of the camera and plotting machines.
(2) Lack of good technicians for photo-taking and plotting
(3) Price increase for necessary materials
(4) Photo-taking trouble at snow and raining areas
(5) Careless usage of cameras on the road by policeman
(6) Traffic troubles in the down-town area during photographing because of a shortage of policemen

froThere will be more multiplied applying way increased to solve the trouble related to the police. The PAMS and PHOCAS is ready on the market and more than 10 instruments are used for police work in JAPAN.

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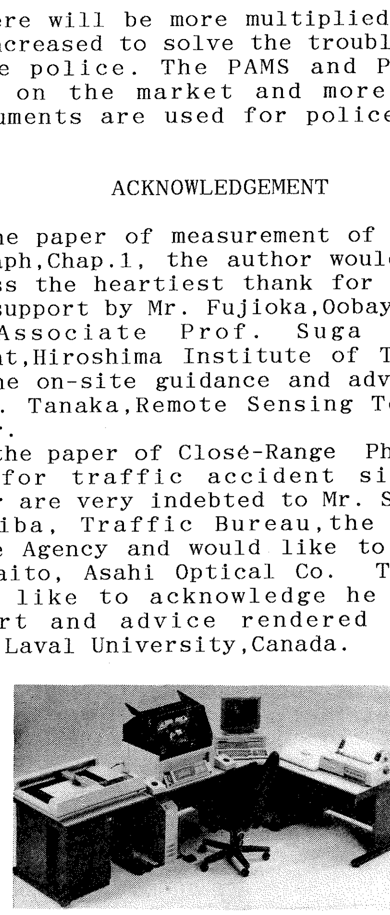

Photo. 2. PAMS (Photogrammetric Analytical Measurement System)

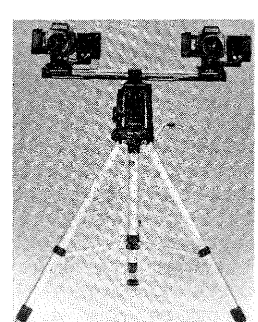

Photo. 3. Specially designed Stereometric Camera (Asahi Pentax PAMS 645)

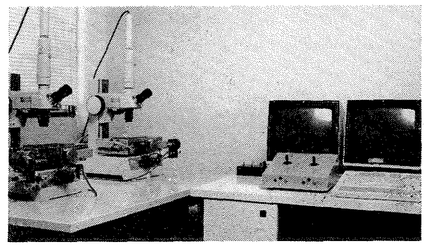

Photo. 4. PHOCAS (Photogrammetrical Coordinate Analizing System)

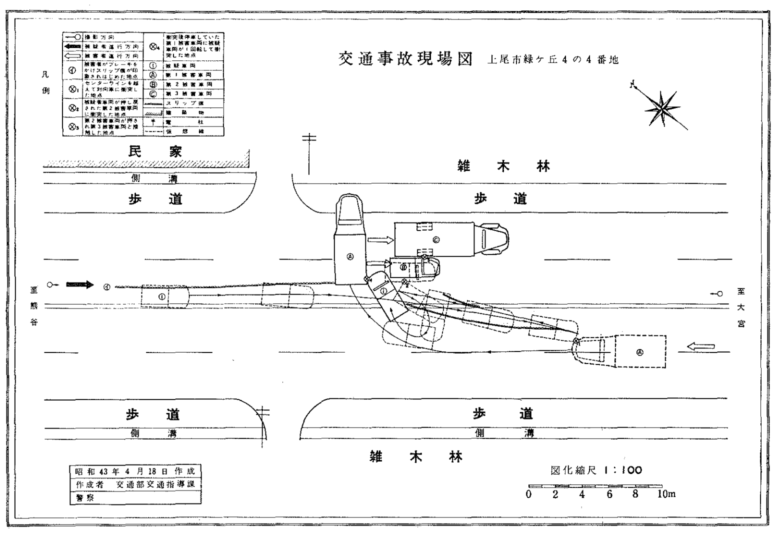

Fig. 1. Mapping at accident site (Courtesy of Saitama Prefecture Police Headquarters)

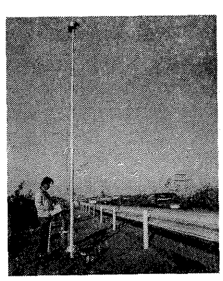

Photo. 5. Specially designed Photo-taking system lifting up to 7.5 m

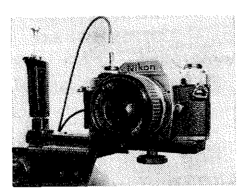

Photo. 6. Nikon FG metric camera

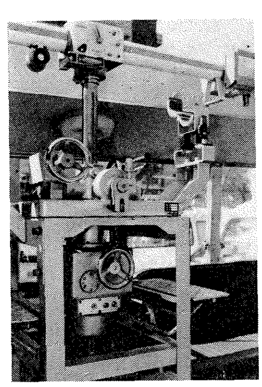

Photo. 7. Mechanism for Raising/lowering a Stereometric Camera in an Accident Disposal Vehicle with Police Department