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Name of authors : Daniel T. N. Liao
Jen-hsing Hsieh

Position/Department : Chinese Society of Photogrammetry, Taipei
100-1 Hoping West Road, Section 2, Taipei,
Taiwan 107, Republic of China.

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Abstract

In recent years, photogrammetry has been greatly used in Taiwan, a province of the Republic of China, for producing orthophoto and line topographic maps, inventorying agricultural and forest resources, classifying land uses, planning city development, assisting civil engineering, etc. Terrestrial photogrammetry is applied to dam construction and traffic accident and industrial studies. The photogrammetric courses in this science have been offered in various colleges and schools. Its most significant achievement is in the production of large-scale orthophoto maps. Thousands of orthophoto base maps of Taiwan have been produced. Photogrammetric control points required for mapping purposes are determined by the analytical block adjustment method.

1. Introduction

In 1930, the year that marked the beginning of photogrammetry in China, an aerial survey team was established in Nanking for the purpose of producing topographic maps from aerial photographs. More aerial survey teams were later organized to conduct cadastral, river and railroad surveys. Photogrammetric courses were taught in the Central Survey School in 1931 and later in the Department of Surveying, Tungchi University.

Rapid economic development in recent years in Taiwan has increased demand for photogrammetric uses in such fields as orthophoto and line topographic map production, agricultural and forestry resource inventorying, land use classification, city planning, civil engineering, etc. Besides, terrestrial photogrammetry has also been applied in the fields of dam construction and traffic accident and industrial studies. The science of photogrammetry has been taught in the Chungcheng Technology College, Chengkung University, the College of Chinese Culture, and other schools in Taiwan.

2. Orthophoto Mapping

Since 1975, thousands of photo base maps of Taiwan have been produced. Photogrammetric control points required for the photo mapping were determined by the analytical block adjustment method. The scales of the photo base maps are 1:5000 for regions up to 1000 meters above sea level and 1:10000 for mountainous regions from 1000 meters sea level and higher where only few agriculture exists and mostly forestry purposes are required.

The orthophoto technique is used to produce base maps in hilly regions while conventional rectification serves to produce those of flat regions. Four Zeiss D-2 Planimat plotters are used for profiling and one GZ-1 Orthoprojector for orthophoto producing in the off-line mode. Photo flights are over the centers of the map sheets. Overlap of the photos is 90%. It makes possible to select the photos which cover the map sheets always completely. Consequently it allows one photo making one map.

The procedure of the photo base mapping is as follows:

Ground control targeting
|
Aerial photography
|
Ground control survey
|
Aerial triangulation
|
Orthophoto producing
|
Field classification
|
Manuscript compilation
|
Editing
|
Drafting
|
Printing

(1) Ground control targeting

Ground targets were placed prior to aerial photography on some 2000 existing triangulation stations of 1st, 2nd and 3rd order accuracy for the purpose of identifying the stations on photographs.

The shape and size of these targets are as follows:

Map scale	Photo scale	Target shape	Target dimensions	
			Central panel	Leg panel
1:5,000	1:17,000	+,Y, T	60 cm x 60 cm	60cmx150cm
1:10,000	1:34,000	+,Y, T	100cm x 100cm	100cmx250cm

Material of white opaque plastic cloth is used to make the targets. The material lasts about 3 to 6 months in the field. However, many targets are disturbed by weather, vegetation, or people before photography. This happened frequently than that expected due to often a long time no good weather for photography and difficulty for maintenance of targets. Therefore, many targets failed to appear on the photographs.

(2) Aerial photography

Aerial photographs required for the mapping were flown by the air crew of Taiwan Forestry Bureau with the following equipment and specifications:

a. Surveying aircrafts: (a) Piper PA-31
(b) Beech King Air 200

b. Camera: Zeiss RMK A 15/23

c. Photo scale: According to the scale and size (about 51 cm x 55 cm) of the maps to be produced, the scales of the aerial photographs taken are:

1:17,000 photo scale for mapping at 1:5,000
1:34,000 photo scale for mapping at 1:10,000

d. Photo overlap: 90% overlap photos were taken. From the 90% overlap photos, that cover the complete map sheets and their 60% overlap neighboring photos were selected for map plotting.

e. Flight lines: According to the configuration of the island of Taiwan and its central mountain range, all photographic strips are flown in north-south direction. To meet the requirement for one photo making one map, all flights pass through the center of the map quadrants within a tolerance of ± 250 meters for photos of 1:17,000 scale as well as ± 500 meters for photos of 1:34,000 scale.

f. Weather for photography: The ideal weather for aerial photography is sunshiny, clear air, free from clouds and haze, the wind velocity and air turbulence at the flight altitude are at a minimum. Experience shows only about 20 days a year in Taiwan where the weather is suitable for photography.

g. Altitude of sun for photography: To avoid the present of long shadows on the photographs, the duration of the day selected for photography is above 30 degrees of the altitude of sun for flat regions as well as 40

degrees for the mountains and cities.

(3) Ground control survey:

In addition to existing triangulation points which are placed with targets prior to aerial photography, more horizontal and vertical photo control points required for aerial triangulation are surveyed with the field survey method after the aerial photography. The horizontal control surveys are mainly performed by the traverse survey method with T-2 theodolites and electron-optical distance measurement equipment. The accuracy of horizontal control is comparable to that of third order triangulation. The vertical control surveys are performed by second order leveling for the flat areas and trigonometric elevation survey for the mountains. The controls are tied to the existing 1st, 2nd or 3rd order basic triangulation stations or 1st order bench marks. An attempt was made to select the location of the control points where the feature images are clear and distinct on the photographs. All control points are pin pricked and ink circled on the face of photographs and a large scale detailed sketch for each point is drawn on the reverse side.

The density and distribution of the ground control points are determined according to the requirements of aerial triangulation. The use of the block adjustment method in aerial triangulation has greatly reduced the volume of ground control survey work. The density and distribution of the horizontal ground controls established is one point per 2-airbase along the perimeter of the aerial triangulation block. The vertical ground control bands are distributed at a density of 5-airbase distance apart in the interior of the block.

(4) Aerial triangulation

Aerial triangulation with block adjustment by independent models is carried out for establishment of the supplementary horizontal and vertical controls required for photo mapping through the geometric relationship of the adjacent aerial photographs. The relating of the geometry of one photograph to an adjacent photograph is accomplished analytically. Six control points per stereoscopic model are established. They are tied to the ground controls mentioned above. The Zeiss PSK-2 Stereocomparator is used for measuring image coordinates of the control points on the film diapositives. The computing program of PAT-M is used for block adjustment by CDC computer. The size of the triangulation block is 200 to 500 models (100 to 250 map sheets) per block.

(5) Orthophoto production

Four Zeiss D-2 Planiment plotters, each equiped with a SG-1 Storage Unit, are used for profile scanning and recording. A Zeiss GZ-1 Orthoprojector equiped with LG-1 Profile Reading Unit is used for orthophoto production. The two stereomodels (three photos) which covering the complete map sheets are selected and succesively oriented in the D-2 planimat for determination of vertical profiles. The orthophotos are produced in the GZ-1 Orthoprojector, following the same pattern as during the scanning of

the stereomodels, by continuous stripwise exposure combined with simultaneous differential variation of magnification. The connection of the second model in the D-2 Planimat plotter usually does not produce visible separation. In mountainous terrain, pronounced slope perpendicular to the direction of the profile gives rise to small step-shaped mismatches. However the mismatches are largely avoided by using a small exposure slit.

The scale ratios between aerial photo, model, orthophoto and map are as follows:

	Aerial photo	Model	Profile storage	Orthophoto	Photo map
Scale 1:	17,000	10,000	50,000	5,000	5,000
Scale 1:	34,000	20,000	100,000	10,000	10,000

To facilitate one photo for one map technique employed in the off-line mode by means of jointless model connection, the numerical orientation method is used for transferring the orientation of the photo to be projected from the D-2 Planimat to the GZ-1 Orthoprojector. The orientation of the models in the D-2 Planimat is made in accordance with the geographic coordinates to allow the safety margin required in addition to the necessary net area to be reduced to a minimum. The orientations of the D-2 Planimat are transferred to the GZ-1 Orthoprojector by scribing checks on the storage plates. Orientations in the GZ-1 are checked by setting the nominal coordinates.

The orthophotos are produced in the following procedure:

a. Selection and preparation of aerial photos:
Aerial photographs actually used for orthophoto mapping are selected with the aid of contact prints of all the photos taken:

(a) Select central photographs which cover the complete map sheets. Mark the approximate map sheet limits on the photographs selected.
(b) Select the additional stereo photographs for profile storage.
(c) Produce the film diapositives to be used in the stereoplotters.
(d) Produce the film diapositives, by Log-E Mark IV Contact printer, of the central photos to be used for orthoprojection.

b. Profile storage with D-2 Planimat and SG-1 Storage Unit:

Insert film diapositives and orient them in D-2 Planimat. To do this, the common diapositive of the first model is always located in the right hand photocarrier. The relative orientation

is obtained by bridging. Absolute orientation is extended by suitable rotation of the models in accordance with geographic coordinates. Then determine the check points and plotting ranges. Couple the SG-1. Scribe the profiles of the first model. Bridge and scribe the second model.

c. Orthophotos are produced in the form of negative with the GZ-1 Orthoprojector by the one photo - one map technique.

(a) Position and orient the central photo in the Gz-1 orthoprojector.

(b) Make numerical check on orientation of the photograph.

(c) Determine working limits and position the film in the GZ-1.

(d) Automatic profile run for orthophotographic exposure and contour plotting simultaneously with HLZ Electronic Contourliner.

(6) Field classification

The orthophotograph is the ideal base for field classification before map compilation. However, in order to speed map production, the normal aerial photo prints, enlarged to the map scale prior to the orthophoto projection, are taken to the field for classification. The photo prints and their transparency overlays are used as the bases for recording the information collected.

Items to be classified in the field are roads, drainages, vegetation, building uses, mines, power and pipe lines, place names, administrative boundaries, etc.

All road networks are field checked. Trails not mapworthy are not checked. All roads are classified according to the specified standards. National, provincial, and county routes are labeled. Road surfaces, widths, bridges, stations, tunnels are noted or symbolized.

The stream courses are delineated where they are obscured on the photographs as in timbered or shadowed areas. The direction of current is indicated with the symbol of arrow.

Landmark buildings such as schools, factories, temples, churches, post offices, government offices, public buildings, etc. are symbolized or named.

Administrative boundaries of the provinces, counties, townships are mapped mainly from those shown on existing land maps.

Names of places and map features are collected. All available sources of name information are consulted - reference works of various kinds, published maps of the area, official records, and especially local residents.

Linear features such as powerlines and pipelines are

shown for their landmark character. Large transmission lines assume such landmark importance that individual steel towers are located and shown.

(7) Cartographic treatment and reproduction of photo base maps

Orthophotos serve as the base for the production of Taiwan base map series. Therefore they are transformed into photo maps by adding the information of contours, spot heights, place names, feature symbols or designations, grids, marginal data, etc.

Two types of photo base maps are reproduced for the users. one is the temporary sheets in small quantity reproduced by contact printer with photographic paper in monochrome (black and white), while the other is the final publication sheets in large quantity printed by offset printing press with ordinary map paper in three colors.

On the monchrome photo maps, roads and drainages are shown in white and legible. Information such as contours, place names, symbols, etc. is overprinted in black on the photo images in order not to distract the map user.

When photo maps are printed in colors, the photo images, contours, spot heights, place names, symbols, grids, marginal data are shown in black, roads in red, and water surface in blue.

In some cases, 1 photo does not cover a complete map sheet, orthophoto mosaics are made by joining orthophoto prints into a complete map.

3. Agricultural and forestry resource inventories being carried out in Taiwan

In 1954, the aerial photographs were first used as the main tool for inventory of the forestry resource and land use in Taiwan. New photographs have been flown later every ten years for revision of the previously inventoried results. Since 1973, both the black and white, and infrared photographs have been used for the following projects satisfactorily:

(1) Identification of the agricultural and forestry types.
(2) Detection of the agricultural and forestry disease.
(3) Prediction of rice, sugar, and other agricultural products.
(4) Detection of agricultural and forestry damage caused by natural disaster.
(5) Inventory of acreage of the cultivated lands.

4. Chinese Society of Photogrammetry, Taipei

The Society is a non-governmental organization established in 1963 and reorganized in August 1978 at Taipei, Taiwan, Republic of China.

The Society is devoted to the development of photogrammetry and related technologies and their applications to land surveys and resource inventorying.

At present, the Society has 199 members, most of them are college graduates in photogrammetry or related fields. These are also personnel employed by various governmental and private survey and mapping agencies such as Agricultural and Forestry Aerial Survey Team, Topographic Map Service, Land Survey, Urban Survey, Road Survey, and related colleges and schools.