

THE STUDY AND EXPERIMENTS ON PHOTO-
GRAMMETRY OF ANCIENT ARCHITECTURE

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ABSTRACT

The photogrammetric method is used in surveying and drawing the elevation of ancient buildings and the contour map of historic relics. This paper deals with the apparatus and surveying methods used inside and outside the office. It shows that the control points on an ancient building can be measured from one photo station point by triangular levelling. It has proved to be successful in surveying Yue Fei Temple and the control map of his statue. The non-metric camera was used to take the photograph of arts construction location, and the plane picture of enlarged rectification is obtained. Finally, the results, conclusion, experience, precision for field checking and pictures are presented in this paper.

1. INTRODUCTION

China's ancient buildings have a long history. They are distinguished for their traditional style and characteristics. These not only reflect our ancient architects' great achievements in the application of art, literature and calligraphy, but also represent an outstanding creation of our national characteristics in architecture. Being the precious heritage of our country, they must be specially protected and repaired or reconstructed according to their original aspects.

Today, the photogrammetric method is quite an ideal one for surveying and drawing the elevational drawings of ancient buildings and the contour maps of historic relics.

2. THE PHOTOGRAPHY ON THE SPOT AND OTHER FIELD WORK

2.1 Photography

The photography form that is adopted is one that is used in terrestrial photogrammetry. Besides that, it has its special features, for

most of ancient buildings are either situated in forests or surrounded by high buildings. These make it difficult to choose an ideal shooting distance and locate the photocontrols. Therefore, photographic parameters should be carefully chosen to overcome these difficulties.

The best shooting-distance is chosen according to the formula:

$$Y = F(1.5 + x/a)$$

(Y: the shooting distance, x: the size of object, a: the size of picture width, F: the focal distance.)

When pictures are taken, there are such problems as the depth of a scene of the objective lens and the image scale. The metric camera is mainly used to take normal photography and the non-metric cameras (is used) as the subservient hands to take pictures in any direction.

2.2 The locating for control points

The analogue apparatus and the analytical method are the two tools chiefly used for mapping in the photogrammetry of ancient architecture. The number of control points and their precision should be related to the means of indoor handling. Generally, the control points are placed on the four corners of a building. Obvious points and special marks on the building may also be used as the control points. For the sake of convenience for indoor handling, the control points had better be placed on the vertical and horizontal lines of the front side of the building and on the same plane if possible.

Ancient buildings have a long history and a complex structure. To protect them from damage, obvious points on buildings are often taken as the marks. The colour of the marks is chosen according to the different background, so that a striking can be obtained on the images, which is easy for observation and measurement. Generally, black-white, black-yellow and red-white colours are used.

2.3 The surveying for control points

When the ancient building is high and the shooting distance is limited, the oblique photography has to be adopted. Thus, the regular method of common survey cannot be used to survey the coordinates of the photocontrols. In that case, according to the local conditions of the ancient building intersection method or steel ruler which is used to measure the length, is applied to survey four definite characteristic points as the control points. But if the upper part of the ancient building cannot be directly surveyed and the two ground stations cannot be chosen for no more than one suitable spots, the three dimensional coordinates of the photo controls are surveyed in the light of the principle of intersection method and triangulation, using the single station.

3. THE SURVEYING AND DRAWING OF INDOOR WORK

If the structure of the photographic object is complex or the scale of photography is large, it is necessary to take several photopairs. Thus, every part of the building can be perfectly photoed. Meanwhile, it is necessary to set up a net of control points for joining each photopair. If the photographic object is isolated, only one photopair is needed. In order to simplify the photogrammetric work, it is better to adopt the normal photography method. Those important ancient buildings should be photoed as early as possible and the pictures should be put into a technical archive. Whenever needed, they could be taken out quickly to make cartographical survey, generally with stereocartograph. But for some particular objects whose surfaces are plane or similar to that, such as monuments, mural paintings, mosaic bricks and so on, it is better to adopt the rectified mosaicing technique for map-making.

3.1 Mapping elevational drawings of ancient buildings with a rectifier

The Mapping of elevation with a rectifier is mainly suitable for the images on which the front elevation of photographic object is not well concave and convex. Otherwise it should be done by the method of rectification in zones. The rectification of photograph of ancient buildings has its own special features:

- a. The scale of elevation may change according to the required conditions and the range may vary from 1:1 to 1:200.
- b. The precision of rectification demands high accuracy, generally less than 0.3 mm.
- c. The number of rectified points required may be reduced if the systematic property which the outline of the building possesses is taken advantage of. If the image plane is parallel to the architectural plane which is the object of the images, or if their degree of inclination does not exceed the permissible range, it needs only two or three rectified points for rectifying the image.

Through rectification, the original geometric shape can be recovered (such as square shape, rectangular shape, circular shape and other regular shapes). After being recovered, for example, each side of a square on the image is perpendicular and equal in length to its adjacent sides, that is, the deformation of the original geometric shape on the image is eliminated.

3.2 Mapping elevational drawings of ancient buildings with stereocartograph

Generally, Chinese ancient buildings were constructed mostly with wooden material. The spacial overall arrangement has a higher artistic level with national characteristic and local color. The concave and convex on the wall are sharp, because of the good manmade carvings. Therefore

only to use the rectified method will not do. Various stereocartographs should be used to make the elevation in the line form.

If the method of normal photography is adopted and the image plane is approximately parallel to the plane of the object, the stereocartograph can be used for mapping. The degree of the included angle within both planes must not exceed the prescribed limit of appropriate angle of the apparatus chosen (2). The ratio of the length of photogrammetric base to shooting distance is controlled within $1/5$ to $1/15$. The scale of mapping is usually chosen from 1:100 - 1:200 and, if the structure of the building is complex, 1:10 - 1:50. According to the complex degree of the structure, two to four or more control points can be located. The location of control points must be as standard as possible so as to increase the speed of image orientation and raise the precision. Working with this apparatus may take advantage of the elements of exterior orientation which are surveyed in the field as the setting date of the apparatus, and the systematic property which is possessed by the outline of the building and the character of the geometric shape may be used to assist the orientating.

As most of the upper part of the pictures are the sky, the fifth and the sixth points on the image may be much near to the first and the second center points. If this is done according to the usual procedure of mapping, that is, first, the relative orientating, second, the absolute orientating, the precision of relative orientation will be reduced. To make elevations of objects with a universal stereophotoer, we should make full use of the geometric shape of the building and flatten the model while doing relative orientating. Finally, we should check the model scale once more and then do the work of mapping, fair drawing, arranging and decorating.

4. THE EXPERIMENT

In december 1981, the phototheo 19/1318 (a terrestrial phototheodolite) and some common non-metric cameras were combined with each other in use to make photogrammetric experiments on ancient buildings. The buildings selected for the test are Temple Linyin which was built in 326 A.D. and Temple Yue Fei, a national hero in song dynasty. The single image rectified method and the stereophotogrammetric method were adopted for surveying and drawing these two temples. Through rectifying, mapping and drawing, their front elevations were made. The front elevation of temple Yue Fei and the contour map of Yue Fei's statue were also made by means of the stereometerograph. The camera 120 was used for portraying some artistic carvings and industrial arts. The angle of inclination between the image plane and the objective plane would be a little larger than the one when the stereometerograph was used, but it should not exceed the value which the rectifier allowed. In the test, the angle of inclination of one image was 35° , and that of another was 17° and the scales of rectification were 1:20 and 1:10 respectively. Two rectified points and the clear outlines of the building on images

were used for rectifying and the results of the test are shown in figure. The method of mapping the contour map of Yue Fei's statue was the same as the one mentioned above. The contour-interval was 20 mm. The spots elevation was surveyed on the visible parts of the statue. We set red pencil on the apparatus for drawing the dragon and the decorative pattern. The contour width is only 0.15 mm, but the line width of the dragon and the decorative pattern on the contour map is 0.25mm. The principal data of making the contour map are: model scale 1:50 transmission ratio of the apparatus 1:4, image scale: 1:65, final chart scale 1:10. (see figure).

5. EXPERIENCES AND PROPOSITIONS

We have the following appreciations from the experiments of mapping of Temple Linyin, Temple Yue Fei and Yue Fei statue in Hangzhou.

5.1 It is an effective means to make elevations drawings of ancient buildings and contour maps of historic relics with the photogrammetric method (rectifying and stereoplotting). Because the information from these pictures is very rich and is directly perceived by the senses. Moreover, the pictures can be preserved for a long time and can be used whenever needed.

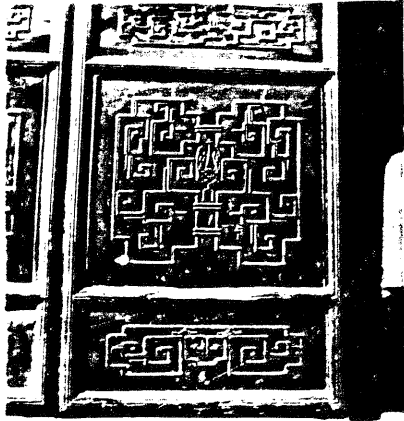
5.2 Usually, the points of interest are being surrounded by some high trees, which may keep out one's sight when photoing the whole sight of a building. As a result, the shooting distance may be limited. Therefore, it is better to use the UMK (a universal terrestrial camera, Zeiss) or the photo 19/1318 together with a regular small camera for the mapping.

5.3 The structure of the ancient building and the industrial arts are complex, so the object contrast is large with the result that the sensitivity of the dry plate and the tolerance are reduced. In order to obtain a clear image of all its parts, it is better to take photos under such conditions as soft sunlight, manmade lights, cloudy weather, and in the morning or afternoon.

5.4 Most patterns of these images are regular, such as a circle, a square, a rectangle, a hexagon and an octagon etc. This character should be made full use of in the work of rectifying and then through fair drawing, arranging and decorating, a drawing of unity of authenticity and artistry can be obtained at last.

5.5 The planimetric map of the ancient building can be obtained by common survey, the chromatic image by color photography and the elevation and contour map by photogrammetry, which is very efficient particularly when applied to complex carved parts. Therefore the photogrammetric method can efficiently provide some reliable, convenient and scientific basis for studying the construction of ancient buildings and restoring them when necessary.

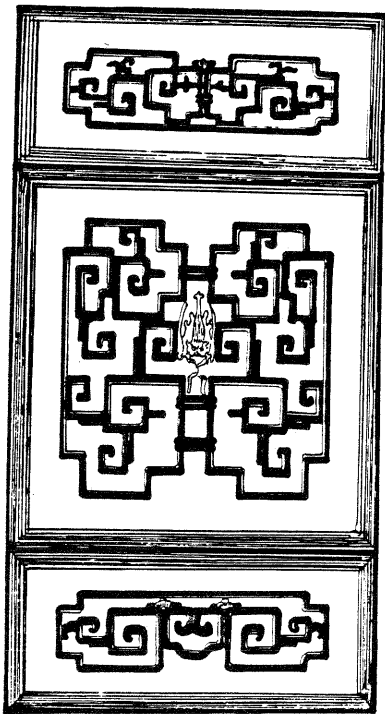
Therefore, departments which are responsible for protecting the historic relics should cooperate with related survey branches to survey and draw the relics and keep the data and drawings obtained in archives for use in the future.



Artistic structure image with camera 120 inclined 17°

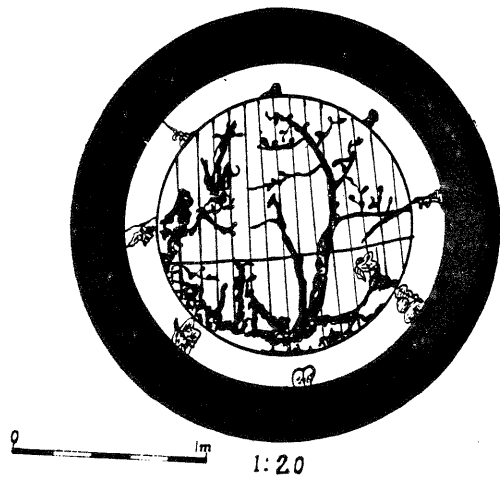


The decorative pattern image with camera 120 inclined 35°



0 50cm 1:10

Rectified line picture taken by camera 120



0 1m 1:20

Rectified line picture taken by camera 120

岳飞塑像等值线图



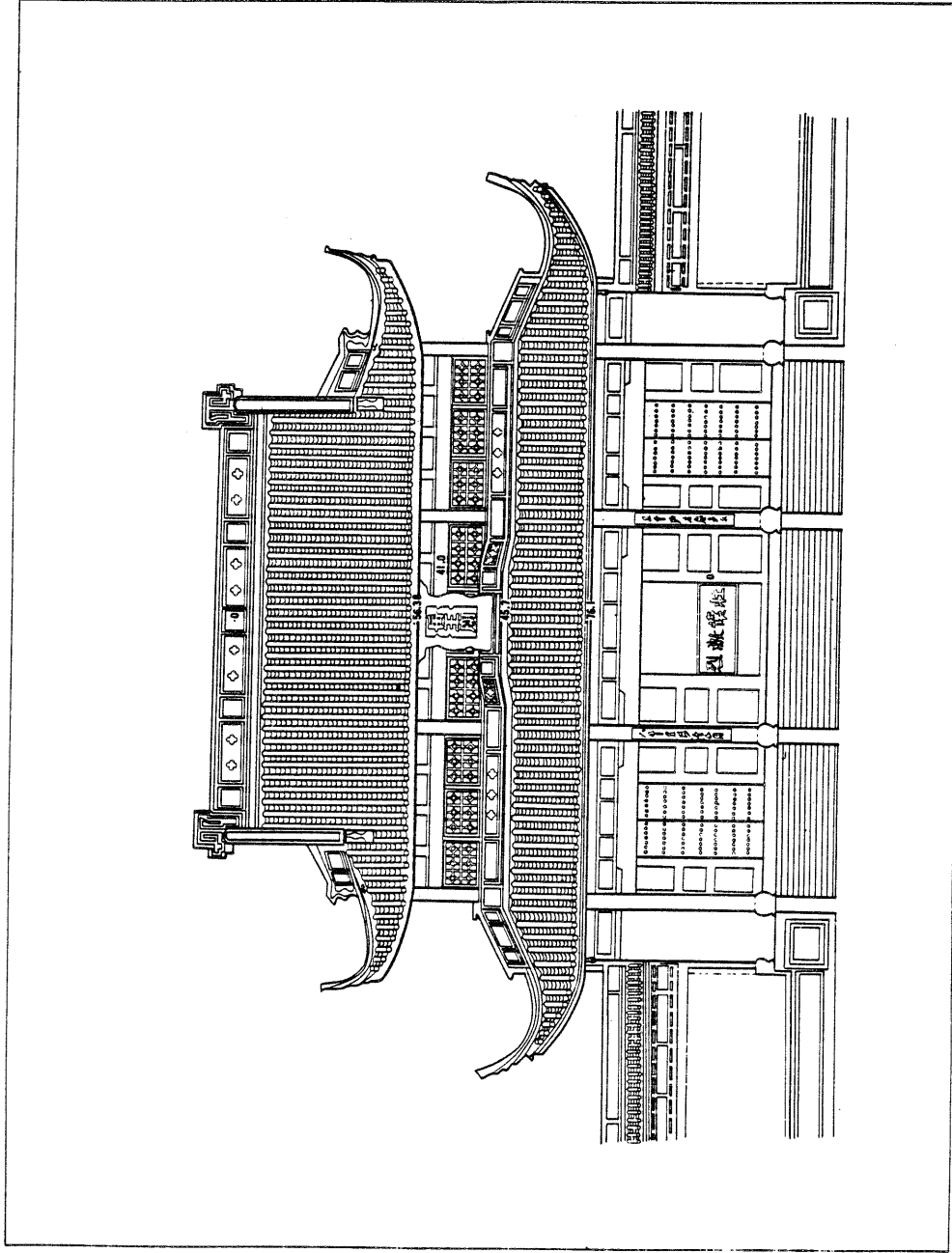
等高距为 2 厘米

原比例尺 1:10

1982 年 5 月测绘

Scale of the original map: 1:10

杭州岳王庙正立面图



1982年5月测绘

原比例尺 1:80

Scale of the original map: 1:80

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