14th Congress of the International Society of Photogrammetry

Hamburg 1980

Commission V

Presented Paper

USE OF ROENTGEN PHOTOGRAMMETRY IN ARTS

A.N. Cherny

MNIIT, Moscow, USSR

ABSTRACT: This report shows the possibilities of roentgen photogrammetry in the investigations of painting, metal embossing and also in the reproduction of a sculpture shape.

Roentgen photogrammetry, bearing all the basic merits of classic photogrammetry, is used succesfully for solving the roentgenotopometric problems in medicine, industry and other fields. The given work presents the possibilities of roentgen photogrammetry in the investigations of painting, metal embossing, and also in reproduction of sculpture shape.

1. INVESTIGATION OF PAINTING

A. Faber is considered a founder of roentgenologic method of painting investigation. In 1913 he had produced the first roentgenograms of pictures. [1] . He had noticed, in particular, that roentgenography allowed to reproduce the painting inner structures, hidden beneath the outer layer, to find the signs of restoration, to determine the handwriting of an artist, to state the authenticity of a work.

At the same time, the summation of the picture elements (canvas, priming, paint layers) on the roentgen imprint produced definite difficulties in image deciphering.

A stereoroentgenographic survey of pictures had been considered ineffective for a long time because of low thickness of a cloth that makes 2-3 mm together with a canvas.

In 1939 H. Sherwood reported his experience of using stereoroentgenography for the investigation of painting. He mentioned, in particular, that the three- dimensional effect can be enhanced by means of the tube shift increase (i.e., by increasing the survey basis [2] .

R Kozlovski offered a method of microstereoroentgenography, envisaging the thin-layer painting survey at the angle of central rays eintersection of 130. This method had been used for the investigation of the portrait " A Lady with an Ermine" by Leonardo da Vinci.

A stereoscopic exfoliation of the picture allowed to find out a number of new facts, confirming Leonardo da Vinci's authorship [3] .

A method of microstereoroentgenography, envisages the possibility to enhance considerably the thin-layer painting relief, but the realization of this method requires a special roentgenographic support, in which the roentgen tube frame is shifted along the guide, having the form of a circumference arc.

In our work we used the method of stereoroentgenography, envisaging the stereopair production by turning the object around its axis in the plane, perpendicular to the chief ray, by 180 degrees [4] .

This method can be realized by using every standard roentgenographic apparatus in the presence of a simply constructed turning table, on which the survey object is fastened. In essence, the turning table is a tunnel cassette, mounted on the vertical axis, due to which a picture can be turned in the horizontal plane.

A roentgen tube is arranged so that the turning table with a picture is situated at a definite distance from the chief ray. After making the first imprint and shifting the tunnel cassette frame, the table with a picture is turned by 180 , then the picture is roentgenographed for a second time. The survey basis B = 2 S, where S - is the distance from the table axis of rotation to the chief ray. The recieved stereopair answers all the requirings of a survey normal case [5] .

The above-described method was used for the investigation of a XIX century icon, subsequently overpainted. The icon was fixed on the turning table cover with its paint layer directed onto the roentgen cassette entrance port. There was a net of control points - steel balls with diameter of 0,15 mm - on the turning table cover outer side, made of flat ebonite. A field of radiopaque crosses was plotted upon the i inner surface of the ebonite plate, to which the photomaterial emulsion layer was pressed.

Every control point exceeding in relation to the field of crosses was measured by micrometer.

Stereoroentgenography was done on the apparatus TUR-1000 at $f \approx 800$ mm and $B \approx 1000$ mm. The recieved imprints were treated on the stereocomparator.

The elevation between the point of icon structures and the field of crosses was determined according to the following formula:

$$h = \frac{h_0}{\Delta P_0} \Delta P,$$

where: h_o - elevation between the control point and the field of crosses;

ΔP_o - Horizontal parallaxes difference between the control point and the nearest crossing on the field of crosses;

ΔP - Horizontal parallaxes difference between the sought for point and the crossing on the field of crosses.

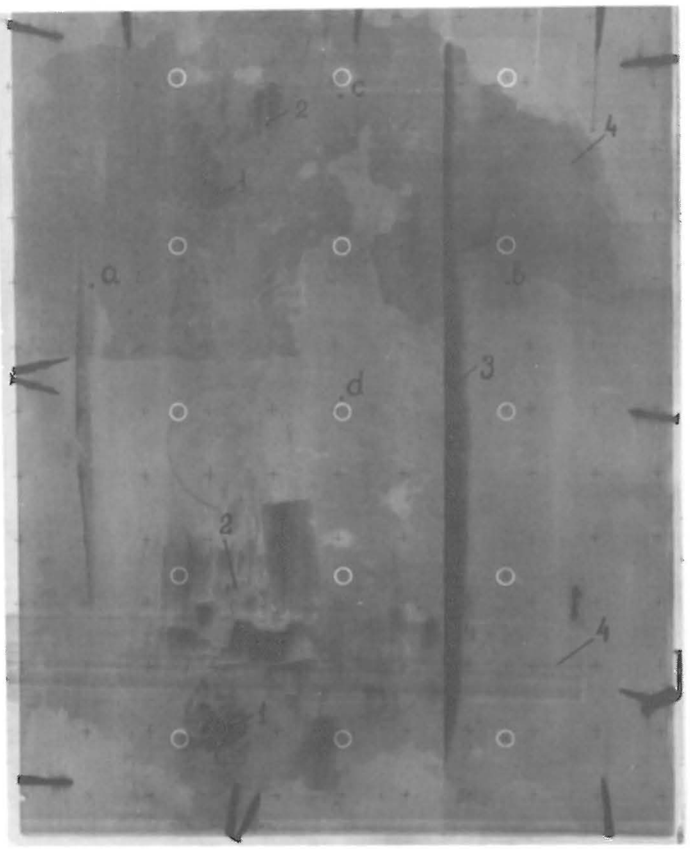


Fig. 1

A stereoscopic analysis allowed to find uot two paint layers (the upper one - partly destroyed), and to reproduce the image of an earlier composition, hidden beneath the outer layer. Besides that, a stereoscopic effect helped to decipher the elements of the icon wooden basis. There were found: defects of wood 1, traces left by a processing tool 2, a vertical crack 3, clamping dowels 4 / Fig. 1 /. Control points are marked with circles on the imprint.

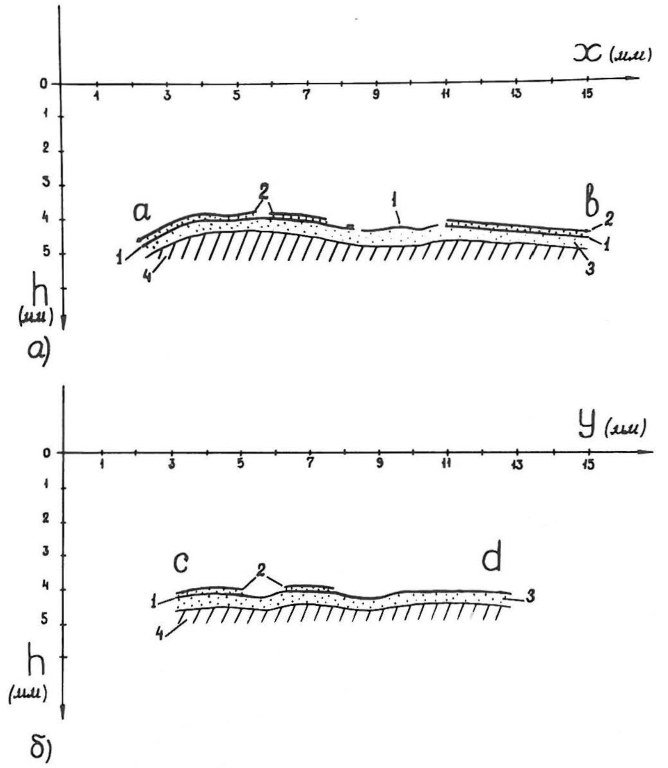


Fig. 2

Fig. 2 demonstrates the icon paint layers profiles between the points ab and cd.

Here: 1,2 - lower and upper paint layers, correspondingly; 3 - a priming layer; 4 - the icon wooden basis.

Thus, the stereoroentgengrammetric method provides the investigator with the valuable additional information. Side by side with the possibility of the inner structure sereoscopic observation, this method allows to make its structural elements topometry: for example, to determine the relief and interposition of paint layers. The photogrammetric data, obtained in numerical and graphical form, are objective. This is extremely important in ancient painting relics investigation, when the authorship of a work can be determined indirectly, for example, from the form and position of paint layers dabs.

2. METAL EMBOSSING INVESTIGATION

Metal embossing is one of the most ancient types of fine arts, having as its basis the mechanic processing of metal with the help of a special tool - a calking chisel.

We pay great attention to the investigation and further improvement of artistic embossing in our modern decorative-applied arts [6] .

Metal embossing roentgenogram reproduces well both large elements of the composition and small strokes of texture. From the first sight the roentgen image of embossing does not differ greatly from its photographic image. But the optical density change on a roentgenogram is not adequate to the half-tintal transitions on the photographic imprint and is the consequence of metal tension under the influence of a calking chisel stroke. That is why the information, containing in the roentgen imprint is extremely important in the aspect of punching forms technics investigation.

Using a single embossing roentgen imprint one can easily get a contour drawing for imitating the original in its natural size. But for this one has to use the orthoroentgenogram, i.e.,the imprint, where the omage points shift, induced by relief, does no exceed the permissible limits.

The roentgenographic support construction envisages the possibility of a camera focal distance chànge within the great limits. That is why the most rayional is to exclude the shift beyond the relief, increasing the survey altitude.

A permissible focal distance value can be determoned according to the following formula (dependence):

$$f = \frac{h}{\Delta r} \quad r$$

where:

h - maximal elevation of embossing extreme points above the photomaterial plane;

r - embossing extreme points moving off from the chief ray;

Δr - permissible value of image points shift

The altitude of embossing relief points can be determined with the help of a stereoroentgenogrammetric method; for recieving the stereopair imprints it is convenient to use also the above mentioned method of an object turning by 180 degrees.

The embossing stereoscopic model reproduces the metal plastic deformation in relief. I contrast to the biologic object model it is monostratal, so the visible picture deciphering does not produce any difficulties. Practically all the image elements are percieved well visually: both those with a sharp altitudes averfall and those with the soft profile. The form of a chasing helps to determine easily the type of a calking chisel.

Embossing relief points can be determined from the control points, using the formula (1) [7] .

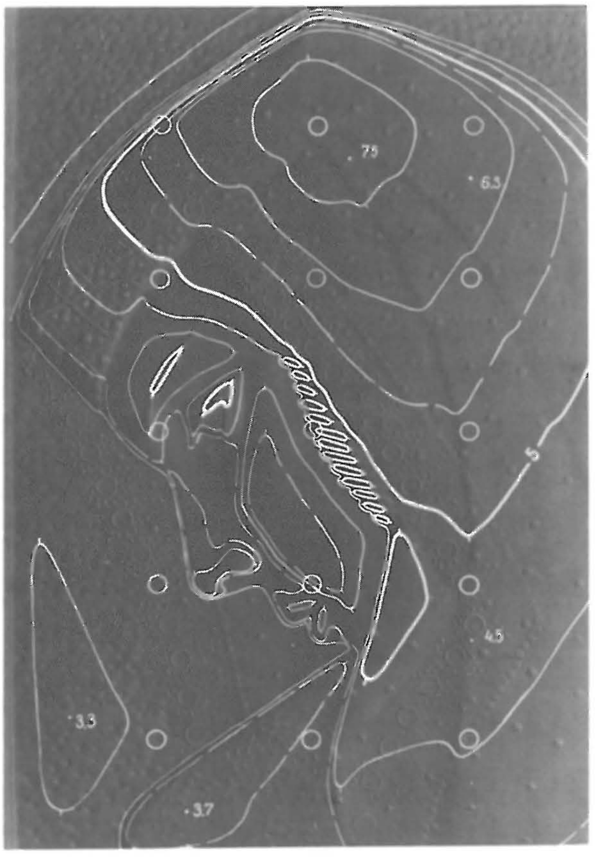


Fig.3

Fig. 3 demonstrates the orthoroentgenoplan of an embossed bas-relief " Kekel ". The relief of the embossing plastic deformation is depicted in horizontals. Entire horizontals are drawn in every one millimeter.

The stereoroentgenogrammetric survey adds considerably to the traditional method of embossing investigation. The obtained model of plastic deformation of an embossed metal allows the investigator to understand deeper the techniques of ancient works of embossing arts making, and also will be useful for teaching the habits of embossing forms chasing and for imitating embossing works.

3. ROENTGENOGRAPHIC SCULPTURE IMITATION

A stereoroentgenogrammetric method is used chiefly with the aim of invisible inner structures of an object topometry. But the penetrating capacity of roentgen irradiation and the possibility of a surface artificial contrasting allow to reproduce the outer shape of an object from roentgen imprints.

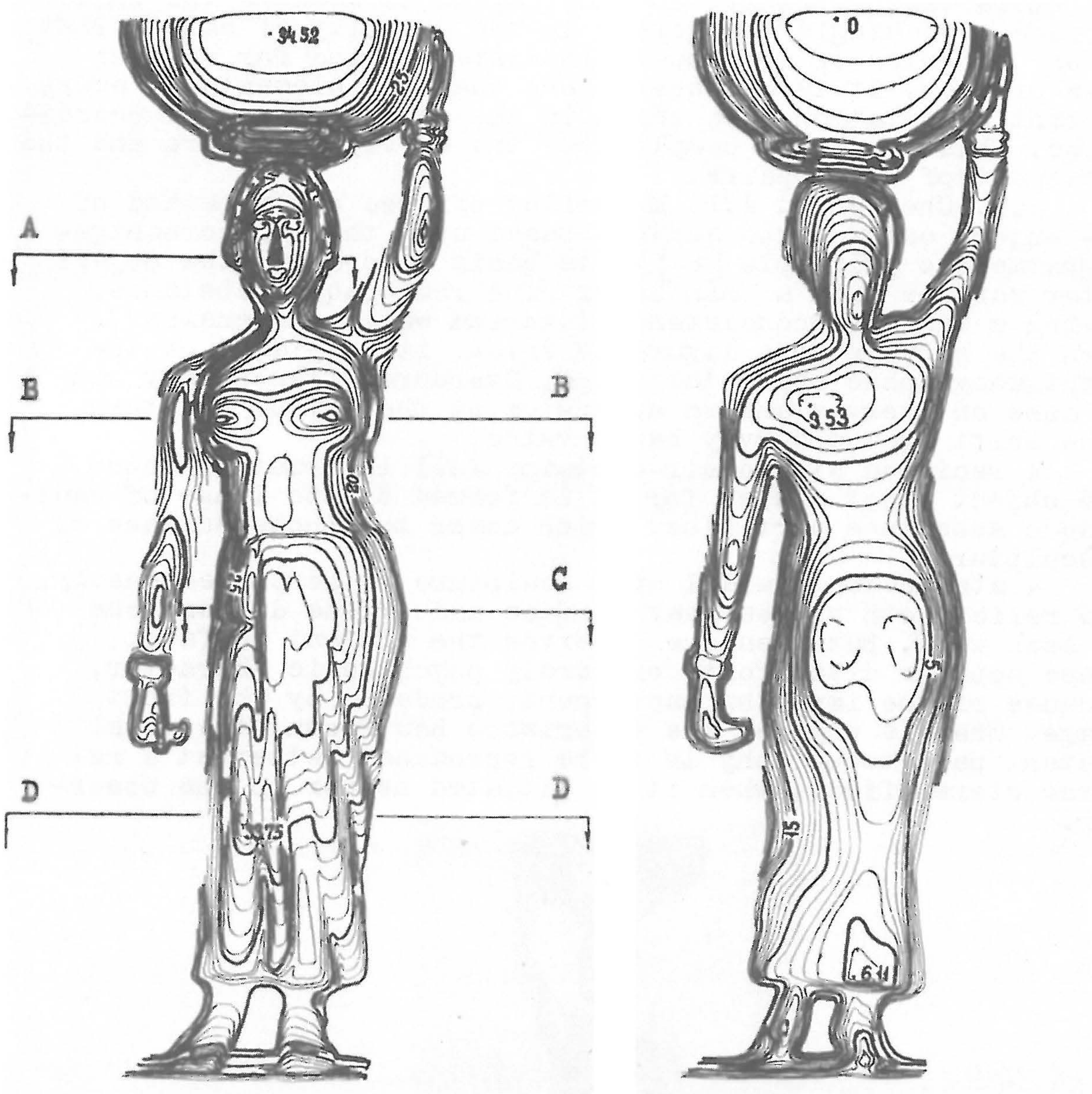
The studying of an object outer shape is usually done in architecture and arts. The survey, done in the electromagnetic waves visible range, does not allow to recieve the whole surface on a single stereopair in the majority of cases. That is why a series of stereopair imprints is used for solving this problem. It is necessary here that the elements of every imprint orientation were known in the common system of coordinates. This condition complicates the survey procedure and the treatment of stereopairs.

A.N. Cherny and A.P. Mikhailov offered a new method of the object outer shape survey, based upon the stereoroentgenogrammetric principle [8]. Its basis is coating the object outer surface with a thin layer of a radiopaque substance, having a discrete consistence (barium water suspension). When the surface of a figure is dried, it is placed on the roentgenographic apparatus stage. Stereoroentgenography can be done on every standard apparatus by the way of roentgen tube shift by the survey basis value.

A recieved stereopair contains full information about the object outer shape, for it is formed by the image of radiopaque substance particles, which cover the whole surface of a sculpture.

A stereoscopic model of a sculpture is percieved easily, the relief both of the near surface and of the distant one is seen well. But when one observes the distant surface, there appaear discomforts of purely psychologic character, because of the impeding background, produced by the front image. That is why, as the experience has shown, the model distant part topography is to be reproduced better at a reverse stereoeffect, when it is situated nearer to the observer.

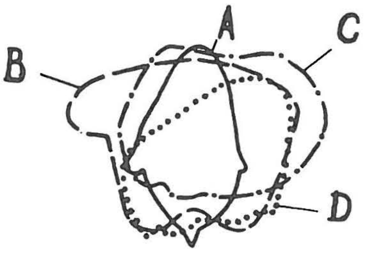
Fig. 4



Scale : 1 cm

Fig.4

Figure 4 depicts the near and distant surfaces relief of a sculpture " A Maid with a Basket". Horizontals are drawn in every 1 mm.



Scale : 1 cm

Fig. 5

Fig. 5 shows the sculpture sections.

For the assesment of the dtermination precision of exceedings between the contrasted surfaces a test object was used, having the form of a cylindric ten-step pyramide, made of organic glass. Test object contrasting and survey was done in the same conditions with a sculpture. In stereoroentgenography the pyramide axis was parallel to the film plane and perpendicular to the basis. A control parameter (a diameter of every pyramide step) was measured twice : before test-object contrasting with a help of a vernier callipers and after contrasting with the help of a testometric method. The evaluation of precision was done from the difference between photogrammetric and direct measurements. As a result, it was recieved a root mean square error 0,4 mm.

Thus, the use of roentgen photogrammetry for the object outer shape determination allows to solve the problem rather precisely and simply. Only one stereopair of a nórmal case, recieved on a standard roentgen apparatus, is needed for this.

R E F E R E N C E S

1. Faber A. - Eine neue Anwendung der Röntgenstralep " Die Umschau", n.12, 1914

2. Sherwood H. - Stereoscopic soft X-ray examinations of parchment antiphonaries- " Technical studies",n. 6,n. 4, 1938

3. Kozlowski R. - Mikrostereoradiographia. Nowa metode badańia dziel sztuki. - " Ochrona zadytków", 9.n.4,1956

4. Черний А.Н. — Авторское свидетельство № 540138. Бюллетень" Открытия, изобретения..", 1976, № 47, с 133

5. Черний А.Н., Проценко Е.М., Музеус Л.А. — Применение стереофотограмметрического метода при рентгенологическом исследовании объектов со слабо выраженным рельефом. Известия вузов " Геодезия и аэрофотосъёмка", 1978, № 3, с. 72-80

6. Флеров А. Чеканка по металлу.-" Художник", 1970, № 11, с. 57

7. Черний А.Н., Проценко Е.М. Применение стереорентгенограмметрического метода для исследования пластической деформации металлов.- Известия вузов " Геодезия и аэрофотосъёмка", 1978, № 6, с. 49-53

8. Черний А.Н., Михайлов А.П. Авторское свидетельство № 626349 Бюллетень " Открытия, изобретения..", 1978, № 36, с. 155