RESTITUTION OF STEREO NON-COLINEAR IMAGES

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Abstract: This paper presents a method of restoring space, based upon a pair of non-colinear superwideange images. Images used in this paper were taken with digital camera and use stereospheric projection. Because of the very large field of view of the images, the whole halfspace can be restored.

Key words: perspective, stereospheric projection, restitution,

1. Introduction. It is a well known fact, that single image (no mater how obtained) does not allow to restore any spatial information about the space it represents. For the purpose of restitution of space, it is necessary to work with two images, which are called stereopair. This technique is commonly used in land surveying and cartography to create maps or 3D models of complex surfaces, like elevations of buildings. The restitution itself can be done, no matter what kind of stereopair is used. Traditional images with projection on a flat projection plane (like conventional photography) facilitate the process the restitution significantly, but there is a limitation in the field of view. Images used in this article have very wide field of view (over 180 degrees), thanks to the non-colinear perspective. Thus, such stereopairs are perfect to record interiors and other narrow spaces. Detailed properties of that kind of projection were given in the PhD work of T. Wąsowicz [1].

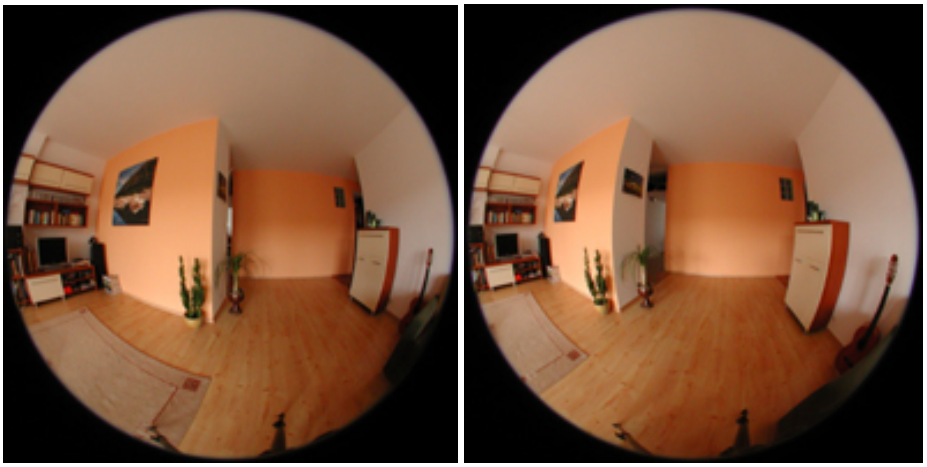

Fig. 1, 2. Above images are a non-colinear stereopair

2. Images. Images used in this paper were taken with vintage digital camera Nikon Coolpix 990, equipped with a 'fish eye' converter FC-E8, also form Nikon. These setup produces round pictures in equidistant projection (arches of constant length on the spherical projection plane correspond to constant length on the image), and the field of view is 185°. It is important to know, that perspectives of straight lines will be recorded as fragments of circles. The properties of equidistant projections simplify greatly graphical construction. More information on this photographic method can be found in the author's work 'Optical realization of stereospheric projection' [2].

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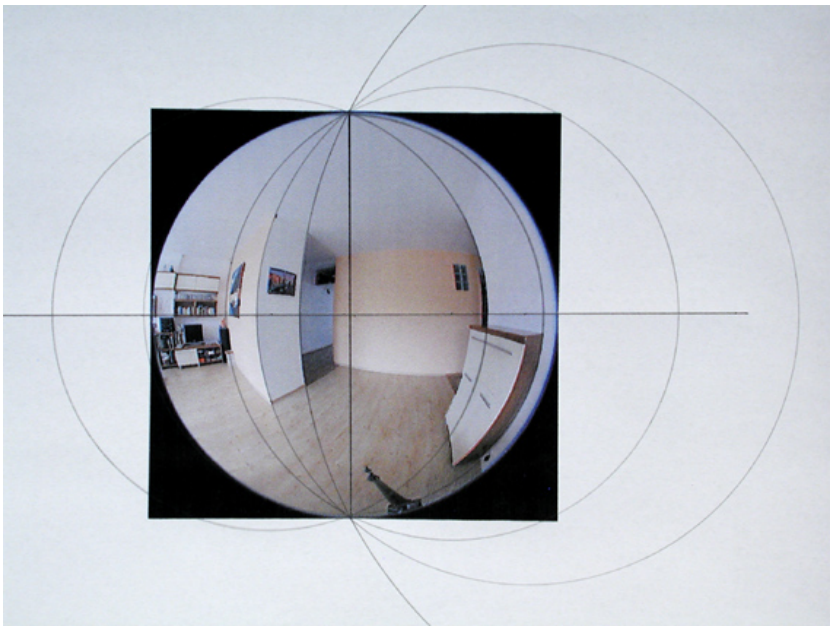

Fig. 3. Perspectives of all straight lines (with the exception of those being parallel to the optical axis) will be recorded as fragments of circles.

3. Restitution. The idea of two-dimensional restitution is based on a very simple geometrical property: to locate a point P in XY-plane (which can be assumed to be the horizont), it is necessary to know two angles φ_1 and φ_2 as well as the linear separation l between both projection centers, as shown on Fig.4 below. The procedure of finding two angles must be done for every single point, which is to be located in space. Points P_1 and P_2 are images of P projected on two spheres, whereas G_1 and G_2 respectively represent the main point of perspective for the left and right image. The method presented below works best, when the following conditions are fulfilled:

- both optical axes are parallel
- they lay in a common horizontal plane

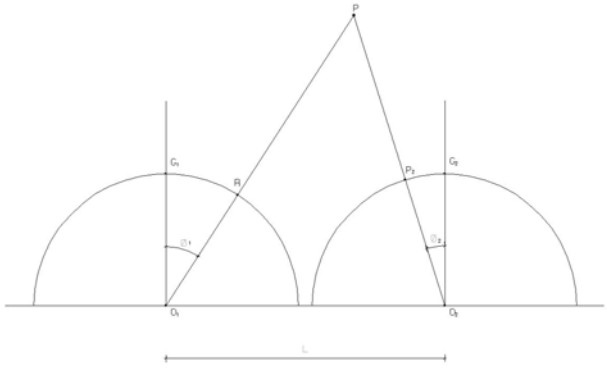

Fig. 4

To determine angles φ on both images, it is necessary to read on the images, where images of vertical edges of walls (fragments of circles) intersect with the horizon. In this case, the position was expressed as r in millimeters of the image, along a "x"-axis, with values growing from 0 to 248 (diameter of image circle in milimeters, as shown on Fig. 5 for the right image).

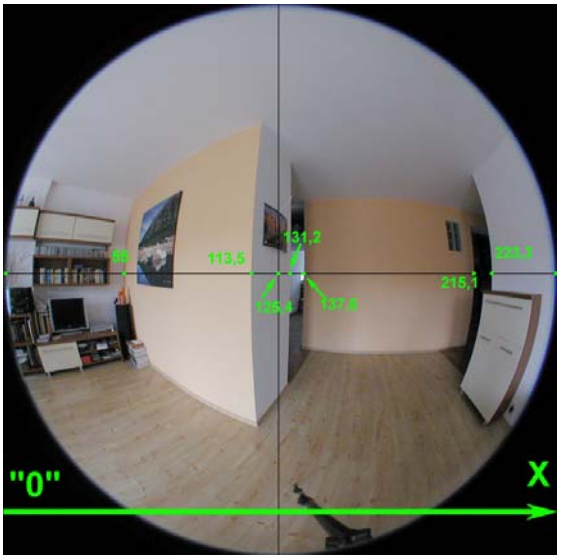

Fig. 5

Then, the coordinate of the central point was figured out to be 125,4 mm. Then, the following formula {1} was used to calculate angles φ_1 and φ_2 on both images:

$$\varphi = \frac{(r - 125{,}4) \times 185}{248}, \qquad \{1\}$$

where: r – as explained above,
125,4 – coordinate of central point
185 – angular field of view for the whole image
248 – diameter of the image in mm.

After a series of calculation, every edge of the walls visible on both perspectives was assigned with a proper φ-value, where a "-" sign indicates an orientation leftward from the main point G_1/G_2. Fig. 6 shows calculated angles for the right image.

Fig. 6

When all angles of φ_1 and φ_2 are known, they can be printed in scale, which will create the XYcross-section of the interior, where the stereopair was taken. X/Y coordinates can also be calculated upon some elementary trigonometric equations. This will require the introduction of orthogonal coordinate system.
The following images – Fig.7 and Fig. 8, show two stages of drawing the XY cross-section of the room

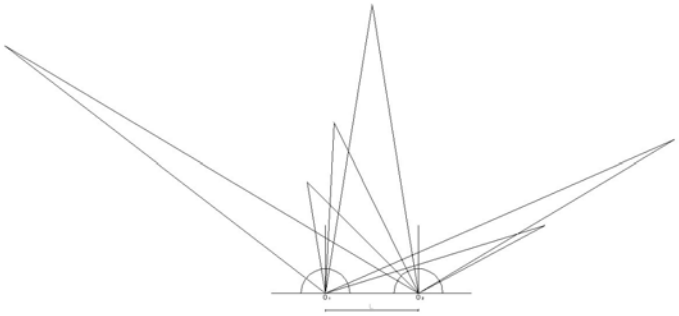

Fig. 7

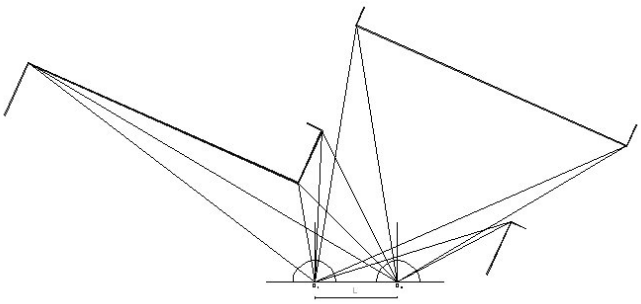

Fig. 8

References:

[1] Wąsowicz T.: *Szerokokątna perspektywa niekolinearna*. Praca doktorska, Wrocław 1996.
[2] Górko M.: *Optical realization of stereographical projection.* "Geometry &Computer" Conference, Ustroń 2007.

RESTYTUCJA STEREOPAR NIEKOLINEARNYCH

W pracy przedstawiono metodę restytucji stereopar niekolinearnych, wykonywanych za pomocą aparatu cyfrowego z nasadką typu "rybie oko". Metoda opiera się na założeniu, że projekcja ma charakter równokątny, oraz wykorzystuje analityczne wyznaczenie wartości kątów dwuściennych między pionową płaszczyzną symetrii obrazu i płaszczyznami zawierającymi poszczególne rozważane krawędzie wnętrza.