Bringing traditional panorama projections from the painter's canvas to the digital realm

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Abstract

A painter has to choose an appropriate projection when envisioning a new three-dimensional map. The projection defines how a terrain is depicted on a canvas. The painter currently has a much wider choice when producing the map with traditional manual means than with digital tools. The reason is that most rendering software does not offer a lot of alternatives to the default central projections.

This article will present a few specialized projections that are generally not implemented in 3D-renderers, but are used for manual production of three-dimensional maps. They can depict particular characteristics of the terrain more clearly and more effectively than standard central projections. The following exemplary projections will be discussed: The progressive projection that combines a steep direction of view for the foreground and a flat direction for the background; the fisheye projection that portrays the terrain in an eye-catching manner; the "rubber projection" that selectively accentuates and arranges particular features of the terrain; and the so called circle section projection that is used for outdoor panels on hilltops.

The projection is a graphical variable that is as important as the texture, the illumination, or the symbols of a three-dimensional map.

Projections for 3D-maps

The projection transfers the terrain onto an image. This process is the same for traditional analog production techniques as for modern computer-based rendering engines. From a geometrical point of view, there isn't any difference between different types of three-dimensional representations either. Whether a representation is called panorama, bird's-eye view, aeroplane map, panoramic map, landscape map, or simply 3D-map, the geometrical definition of the projection remains identical.

The manual production of 3D-maps is very time-consuming. For example, F. Stummvoll writes that he needed 11.000 working hours to generate his very detailed panorama of Austria (Stummvoll 1986). Nowadays, computers can, of course, render three-dimensional views in a comparatively miniscule fraction of time. Besides the considerable time saving, user-friendly software can help us to compare different projections and associated parameters. The projection thus became a graphical design variable that can be easily selected for each individual map. Other examples of design variables for 3D-maps are the color of the terrain, its texture, or the type of clouds in the sky (Häberling 2003).

Camera, ray, image plane and DEM

Graphical user interfaces of rendering software usually use the term “camera” instead of projection. The camera and the attentive eye of a panorama painter proceed the same way. Both use rays of light that start from the painter’s eye or from the camera in a well-defined direction. Each ray intersects the image plane and the terrain. See figure 1 with the central projection as an example, where rays are emitted from point P. A ray intersects the terrain in point A, and the canvas in point A′. The panorama painter now portrays the area around A′ with the color of point A. The renderer does something very similar by assigning the color of point A to the according pixel in the virtual image.

The image is generally a flat piece of paper, or in the digital realm a virtual image plane. Other projection surfaces on uneven physical objects are seldom used and not treated here. Rendering engines use digital elevation models (DEM) to compute 3D-maps.

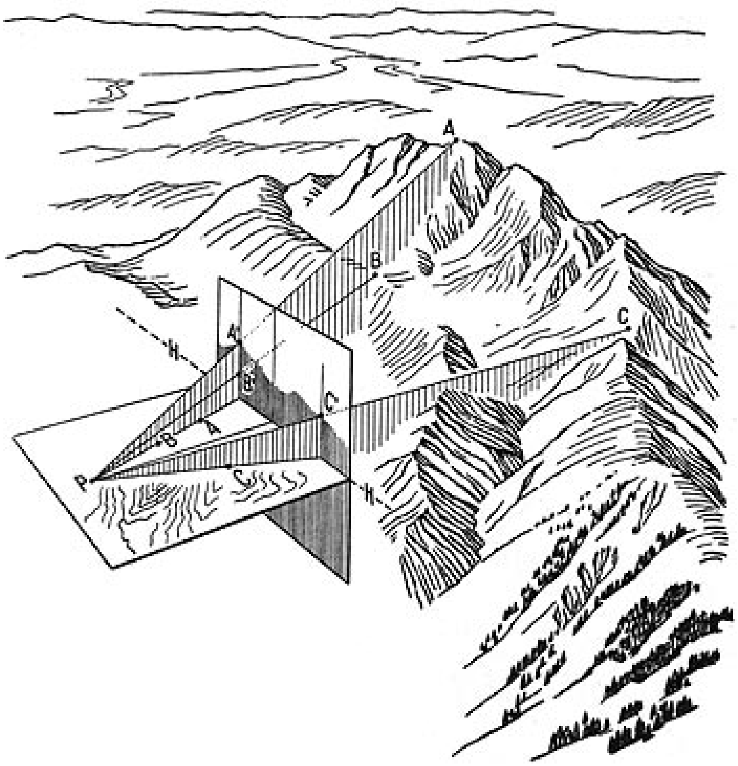

Fig. 1.

Rays intersect the terrain in A, and the image plane in A′. In the case of the central projection the rays are emitted from a focal point P.

Imhof (1963).

The central projection (figure 1) is the most often used projection, since it is similar to the way the human eye or an objective of photographic camera records its environment. The projection on a vertical cylinder, and the orthogonal projection are also commonly used.

Progressive projection

The progressive projection (or progressive perspective) is an interesting enhancement of the central projection (Hölzel 1963). The progressive projection artificially curves the terrain in the foreground downwards, to achieve an improved three-dimensional effect (figure 3). Two alternative ways lead to this result: (1) The digital elevation model can be artificially curved (Patterson 1999); or (2) the renderer combines the characteristics of two cameras. When using the latter technique, the first camera portrays the foreground with a rather steep angle, whereas the second camera targets the horizon of the terrain with a flat angle. The rendering engine linearly interpolates between the parameters of the two cameras (figure 2).

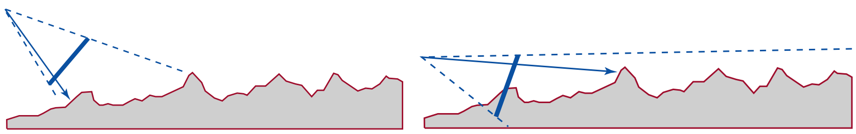

Fig. 2

The progressive projection combines a steep angle for the foreground (left), and a flat angle for the background (right).

Fig. 3.

A three-dimensional view of Lucerne and its surrounding with a progressive projection.

Lucerne, Switzerland, Max Bieder.

Fisheye Projection

The fisheye projection is an eye-catching alternative to other projections. The information on a map using the fisheye projection is possibly harder to seize for an inexperienced reader. However, the fisheye projection is a good means to catch the reader's attention solely by the shape of the image.

The internal geometry of a fisheye camera is rather simple: First, the camera projects the surrounding terrain on a sphere. In a second step, the image on the sphere is projected onto an image plane. Figure 4 schematically shows a so-called angular fisheye. Here, the distance from he center of the image is proportional to the angle from the camera view direction (the vertical line labeled "0").

Figure 4 shows a hemispheric fisheye, i.e. the aperture angle of the camera measures 180 degrees. Any angle can be used, up to a spherical fisheye of 360 degrees.

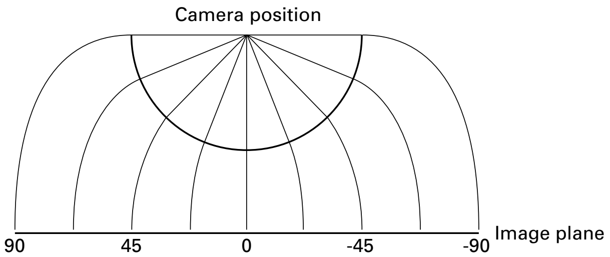

Fig. 4.

Angular fisheye projection.

After Bourke (2001).

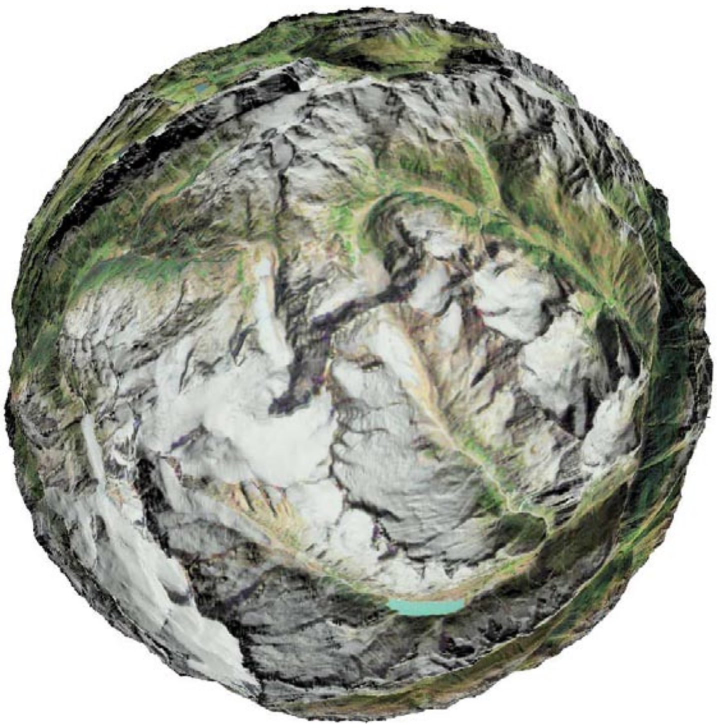

Fig. 5.

Horizontal image plane with fisheye projection.

DEM and satellite image: © swisstopo.

"Rubber projection"

The "rubber projection" aims to portray important features of the terrain in the geometrically "best possible way". It is often based on the progressive projection. With this type of projection, the relative size of mountains depends on their "significance". The painter has to take the decision what the "best possible way" could be and what "significance" a mountain has. These decisions depend on the intended purpose of the map.

For example, in figure 6 the horizontal and vertical dimensions of the central volcano Villarica have been exaggerated, since the volcano is the main attraction of the Chilean tourist town Pucón. Other landforms are rotated, moved, enlarged, or shrunken. It is the cartographer's responsibility to decide which elements merit to be accentuated and which have to shrink to clear a space for others.

To digitally produce this kind of three-dimensional views, the cartographer needs software to interactively enlarge, shrink, rotate, and move sections of the digital elevation model. To the author's knowledge, such a tool does unfortunately not yet exist.

H. C. Berann made this artistic form of three-dimensional depiction widely known (Berann 1989, Patterson 2000). Berann writes about his panoramas in comparison to traditional maps:

"The eye travels through the panorama. Its atmosphere, the wideness of its horizon, its clouds that imply their atmosphere, as well as its natural colors according to the desired season facilitate the viewer the understanding of the landscape, and motivate him to get to know the area." (Berann 1989).

Fig. 6.

Villarica, Pucón, Chile.

Königs (2004).

Königs
Panorama - Atelier Königs / Paderborn
www.panoramakarte.de

Circle section projection

The circle section projection and the circle ring projection received their unusual name by E. Imhof (1963). The circle section projection is mainly used for outdoor maps on hilltops (figure 7 and 8). The circle ring projection is a special case: it displays the full circle, and is rarely used.

The circle section projection produces a particular form of anamorphosis, i.e. an image that must be viewed from a well-defined point. The point of view is the geometric center of the circle segments. If the map also contains the names of the depicted mountain peaks, the reader can easily associate a location on the map with its real world equivalent.

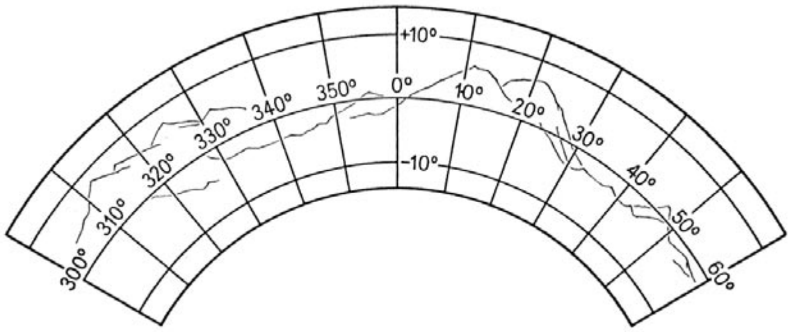

Fig. 7.

Circle section projection.

Imhof (1963).

Fig. 8.

The circle section projection is widely used in China to artistically decorate traditional fans.

Conclusion

Current software for terrain rendering only offers a limited range of projections. This article illustrates a few alternative projections that were popular in the past, but have not been brought to the digital realm. It is the author's hope that future software for the rendering of three-dimensional maps will offer artists a wider variety of specialized projections.

The progressive projection is an important projection, which current rendering engines don't include. Its configuration might be somewhat more demanding than the standard central projection, since the user has to define more parameters (two camera angles of inclination and possibly two camera elevations). An elaborate user interface should however simplify this task.

The fisheye projection and the circle section projection are not used frequently, but they certainly have useful applications. For the computer-based production of 3D-maps using a "rubber projection", user-friendly software will hopefully be developed in the future.

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