Reflections on Depictions of Spherical Buildings on the Scale of the Pantheon

This is a brief report concerning the development of present-day photography linked to computer-assisted (EDV, or Electronic Daten Verarbeitung) photographic applications. Attempts to capture building interiors are, as one can see from the attempts of numerous studies of the seventeenth and eighteenth centuries, nothing new. Draftsmen and painters, particularly the Venetian families of the Piranesi and Canaletto, knew many rules to create the first sketch using the camera obscura and how to modify or the “fake” the result to create a lithography or oil painting that appeared almost perfect to the eye of the spectator. The Frenchman Niepce, later Daguerre and the Englishman Talbot, with the help of chemistry, succeeded in transferring the results of the camera obscura directly from the glass plate onto paper, the copper plate or the canvas without an intermediate stage. “Everyman’s drawing machine”, the camera, had been invented.

The fine arts were more than shocked by this process. At first, the artist was seen as helpless against this process of “automation” having, initially, no means by which to counteract this “new competition”. First, the artist aspired to counterattack with new artistic methods; later some adopted the attitude of noli me tangere, or took the opposite course of so-called photo-realism. No matter, the photo became proof of evidence after the nineteenth century, and art slipped into being considered a kind of artistic handicraft.

From a multitude of historic depictions, but also from today’s technical aspect of photography, the suspicion is created that photography can be correctly described as a form of linear perspective in the geometrical sense. However the result, in terms of perception by the human eye, is in many cases, unsatisfactory or even wrong. Without going further into detail, an assessment of a picture concerning urban or spatial themes by an architect is based mainly on drawings and photographs. These illustrations have in common the requirement that they show wide-angle scenes of the object, ideally a total view.

Good examples here are the Veduten (Views) of the Swiss family Merian. These made images of towns available to normal people, and were splendid illustrations of the overall urban situation, as well as being helpful for orienting oneself in the town complex. Based on their high quality of recognition and exactness of detail, they are now extremely valuable records of a certain moment in time. In the trade, these kinds of Veduten are called fish-eye pictures because they display a panorama of almost 360°.

Using photography one can capture almost 110° without distortion. Distorted pictures go up to 180° and in some cases even 360°. As human beings can see up to 180°, and even up to 360°.
by turning the head, and as the world appears, if you will, to be projected around the observer on the inside of a globe, it is understandable that the human being is hardly able to reproduce his surroundings on paper, even with the best of drawing tools: the difficult task is to create an image of the surroundings (three dimensional) on to the plane of a picture (two dimensional). The problem is less a technical one concerning physics limited by the bounds of optical instruments, and more a theoretical one concerning the basics of geometry. It concerns the unsolved general question of how the surface of the visual globe can be accurately presented on a flat surface.

It can be seen that a relationship is hidden behind this formulation that is closely related to other branches of science, particularly with the art of cartography. Renowned scientist J. H. Lambert specified five principles concerning the problem of spherical projection: design; size; distance; straight lines; and co-ordinates of position. In a later text, he refers to the impossibility of achieving all five of these and suggests a compromise: Einige davon besonders vorsetzen, wenn es sich lohnt, derselben vorzüglich Genüge zu leisten (Some priority should be given to allowing the means to meet the end).

In the middle of the eighteenth century Lambert comments on the different types of geographic projection of the surface of the Earth, grouped according to each special use. The cartographical presentation available to us is divided into three types based on their degree of detail: surface area; distances; and directions. This note concerning the field of cartography may suffice to explain the following summary, that the presentation of the surface of a sphere on a flat surface, like the interior surface of the Pantheon, may logically only be achieved by accepting some degree of compromise. The priorities have to be set based on the required aim of the illustration.

The illustration of parts of the visual globe on the flat surface of a picture are similar to cartography. As in a map, the difference of small segments of a spherical surface and a flat representation are minimal, the geometric difference hardly noticeable, but the larger the segments of the spherical surface, the larger the discrepancies between reality and the corresponding horizontal surface. In the architectural representation, the “oversized segment” (“oversized,” in the sense that an unusually large segment of the visual globe is required to see the object completely), means that the urban space, the tower, the cityscape, can only be woven into the scene using noticeable methods of distortion. Three phenomena act to a various degree: splayed lines of perspective, curved illustrations, distorted edges.

Since the beginning of photography, artists have tried to avoid, as far as possible, the visual effects which most disturb the observer. The reason for the irritation caused by these kind of pictures cannot be found in the illustration itself, but in preconceived visual images. The spectator’s eyes create short term perspectives like technical instruments, but the layman rejects as unacceptable, for example, the image of a “leaning tower.” The spectator’s conscious awareness of the physical conditions of objects is so advanced by years of visual training that they condition and even create these “prejudices” of visual reception. The example of the “leaning tower” illustrates how images with “splayed lines of perspective” are considered false, because a house must stand vertical to the ground, and its outer walls must naturally run parallel to each other. If an illustration breaks the rules, counteracts this “prejudice,” the spectator feels that the portrayal of reality is unsatisfactory, if not completely wrong.

A similar feeling prevails with regards to curved illustrations. When a photographer uses a fish-eye lens or similar means such as mirrored dome segments or concave mirrors, the camera...
distorts, cushion-like, all straight edged objects, for example, simple sharp-cornered furniture. The spectator rejects this distortion, as he did the "splayed lines of perspective."

In keeping with the research theme of wide angle perspectives of interiors and cityscapes the issue of distorted edges deserves particular mention, because it is hardly known, and is very important for the present report. A sphere, exactly drawn in perspective according to mathematical laws, appears in two dimensions as a circle only when its centre coincides with the centre of view (of the spectator). It appears as an ellipse when viewed from any other point, and the further away the centre of view is from the center of the sphere, the more elliptical it appears. This is called edge distortion. The elliptical representation of a sphere is perceived as false since the observer identifies this body as being round, because he has experienced it through direct orthogonal observation (perhaps also through touch) and registered it as such in his consciousness.

The spectator distinguishes between direct orthogonal sight within a maximum angle of 9° and the boundary of the visual plane up to 180°. The human being combines both sight processes, so that when the spectator first observes the mathematically exact perspective of a sphere, his eye checks this impression by looking at the edges and then looking directly at again. The eye notices, based on the translated line of vision, that the supposed sphere is really an ellipsoid. The "sphere" first signalled turns out to be false, the impression is corrected, and recognized as a fake by the spectator.

This irritation was first discovered in the Renaissance. It led to the reaction by painters to purposely limit the laws of perspective to the edges of pictures,9 and to depict spheres and similar objects, even heads, orthogonally in their paintings.

Contrary to pure, mathematical, one-point perspective, the so-called "static perspective," is a kind of picture assembly called "dynamic perspective," because the spectator is not intended to look at the picture from a fixed viewpoint, but is actually encouraged10 to look at all details of the illustration, moving across the surface of the picture with his eyes, up and down and side to side. The result is that all details, including the objects on the edges of the composition, can be perfectly interpreted optically and can be observed without irritation.11

From this, it can be deduced that wide-angle illustrations cannot be completed satisfactorily without compression along the picture edges. It would seem to be simple to set up a rule for the composition of the picture giving the appropriate degree of compression along the edges.12 Unfortunately other areas of conflict spring up in this process that put into question the quality of the result, as the elements of a composition react in different ways, particularly with architectural, stereometric and organic elements in the process of compression.

For instance, the picture of a person dressed in a gown of opulent folds may be relatively easy to change, while as the progressive compression of long straight elements in an architectural scene, say of paving, is only possible in very small steps with a great deal of effort. Normal straight lines become curves, which very easily appears distracting.

The space of the Pantheon

The first event of the spring 2002 equinox meeting was the presentation of these large scale pictures (Fig. 1, Fig. 2), one of which had been made during the climb up the dome the previous autumn. Fig. 1 is, in the mathematical sense, a stereometric azimuthal projection. This study, oriented vertically, was made in December 1987. It has been computer corrected with EDV and published several times.

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As a detailed description of the first study has been published elsewhere, only the second study will be described in detail. Research for this image began during the first scientific discussion at the autumn 2001 equinox. All seven original members of the first meeting had climbed up the northern staircase, as part of the meeting program, to the roof of the Pantheon. At the halfway point of the climb about 60 pictures were taken through a shoulder height opening above the string course of the inner surface of the Pantheon. After considerable work, Fig. 2 was completed in the studio using a computer to produce the horizontally oriented interior study.

The view shown in Fig. 2 is different in terms of means of production and in the application of certain procedural rules. First, it is composed of numerous individual pictures; second, it is composed following the rule of dynamic perspective, involving numerous of acts of compression.
The particular difficulty in composing this picture can be explained in brief. Each slight deformity represents a complexity in this survey of the Pantheon, almost impossible to capture geometrically, because within a single picture there exist three individual elements. Each element behaves differently, and does not conform to the others:

1. The flat plane: the rectangular grid of the flooring is arranged linearly based on two vanishing points. For our purpose it is considered perfectly flat. (The very slight curvature of the pavement of circa one Roman foot in height over the entire surface of the floor is irrelevant in this context.)

2. The surface of the cylinder: the wall zones of the sixteen-segment lower hall area up to the springline of the dome is cylindrical, and curves in one direction.
3. The dome: the surface of the 28-segment dome is part of a semi-sphere and curves in two directions.

In other words, the composition consists of the almost insurmountable task of compressing three different types of surfaces—flat, one-sided and two-sided curves—into one picture.

The solution of the combination lies in the overlapping of the joints. Thus, with the help of a perspective wire frame test program, connecting points between the dome and the floor were established, and finally the segments of the cylinder structure were assembled and adjusted.

To start with, the images of the dome were assembled first, because this was less liable to deform in a special bending program, since all of the architectural lines, except the cornice string course, were curved. Additional changes in this direction are less noticeable.

The shape of the curves obeyed the general rules of one-point perspective. All lines of the dome, which are true circles, are depicted as ellipses, since the observation point is outside of the dome. The architectural elements of the cylinder below the dome behave differently. Here all vertical elements are parallel straight lines relating to each other, while the horizontal curves are parabolic, since the observer is placed exactly on the surface of the cylinder.

The circular lines in the back of the altar recesses, hardly visible in the photos; are hyperbolas, since in this case the spectator is inside the surface of the cylinder.

The chequered flooring was the most difficult part of the compression operation. The square design consists in rows of 11 by 11 modules. Based on the slightly eccentric standpoint, related to the north-south axis of the building, the geometric system is displayed in a kind of two-point perspective, the vanishing points placed on the horizon to the left close to the main altar and to the right, well off the picture. The horizon coincides with the string course of the dome, and divides the illustration in the middle into a semi-circle above a half square corresponding to the plan of the building. Due to the side compression a large diagonal angular view is created of almost 150°.

By means of compression a clear representation is achieved of a round building, and the possible impression that the illustration is of an apse or another different form of building is avoided. This means that eleven out sixteen niches are visible, including two that are viewed in section. One can distinguish eighteen of the twenty-eight coffers in the dome, though two of these are only partially visible. Clearly more than half of the flooring is visible. The central module of the pavement grid with its round granite insert and the oculus hovering above are completely visible. Thus, in this photographic illustration of the Pantheon almost three-fifths of the surfaces of the interior are visible.

**Editor's Note**

Notes

1. Carl Zeiss/MF/Distagon fish-eye 30/180° draws curved perspective lines on the surface of a sphere.
2. Seitz 70 panorama camera for 360° draws curved perspective lines on the surface of a cylinder.
3. These facts are maximum values. When the visual field is large, up to 180°, the eye only notices movement and, particularly, the contrast of light to dark. Vision is sharp only at a very small angle, 9° maximum. The active field of vision corresponds to an angle of view of 40°. A picture, constructed in Augenblicke, moments, from single elements of information and remembrances of values gained by eye movements, is created in the brain.
5. Ibid. This would now be in order if the surface of the earth was flat. It is, however, the surface of a sphere and thus does not conform to all the requirements/criteria thus one or the other has to be chosen in preference if this is required to meet the purpose.
6. See, for example, Brockhaus, Konversationslexikon, 1908, p. 1044 for a detailed description of sight habits for static and dynamic perspective.
7. According to the generally uniform “past experience” of the public, architects and town planners since the Renaissance have used marginal deviations from these rules in order to achieve special spatial effects. One special tool is the law of divergent or convergent positioning of a building to strengthen or weaken the feeling of perspective. A standard example is the trapezoid-like placement of buildings on the Piazza del Campidoglio in Rome.
8. The special case of the azimuth projection will be described later in other examples, see also other issues of the Bund Deutscher Baumeister.
9. Using “exact mathematical details,” the analysis is made using the camera obscura, as later the present day camera produces a single vanishing point perspective. The contemporary mathematical algebraic definition of perspective goes back to mathematician Johann Heinrich Lambert, Freye Perspektive, Drell, Gressner, Füsslin, Zurich 1774.
10. The first observation corresponds with true mathematical perspective. At first it causes an irritation to the eye. One assumes that something is wrong at the edge of the picture, as the objects appear too small (compressed). The observer feels subconsciously challenged to check this, moves his eyes, looks closely at the objects at the edge and discovers to his satisfaction that these are correctly displayed. This effect requires the recipient to do something. He must rework the image, be active, see dynamically.
11. As explanation one might observe the magnificent fresco of The School of Athens by Raphael in the Stanza di Segnatura. On the right edge of the painting the master painted Euclid (Bramante) sitting at the table with the group of “natural philosophers”, including himself, and in front of him, Zoroaster and Ptolemy. The latter were given haloes as signs of their importance, circular-shaped heavenly and earthly globes. The fresco displays the conflict between the straight long lines of architecture with their inherent edge distortion,
and the orthogonal group of figures merged into the composition. The choice of space is clever, a kind of cross-shaped platform or stage is extended at the horizon by a Roman bath-like, long, house, divided by a dome. The hall is entered through a kind of triumphal arch. The group of figures, who are grouped around Plato and Aristotele, appear to project from this spatial depth. It is a completely perfect, composed, picture, both perspectively correct and at the same time completely wrong. It is the depiction of a narrative, understood by the spectator by moving the eye and by changing the position, as he moves along the picture at a short distance. The particularly critical edge zone of the architecture, in this case the pavement, is hidden at the lower left and right corners, thus covering up the weaknesses of the illustration.

12. In computer-aided pictorial modification these kind of operations are regulated in continual graduations.

13. A more detailed report of this work was given in the Bund Deutscher Baumeister special edition on the Hamburger Architektursommer 1997. The illustrations in the publication had a size of up to A4 which can be considered as the smallest scale for understanding the material.

14. A first design sketch dated 6 May1986 assumes a standpoint directly opposite from the main altar, above the entrance doors. This meant that the chequered flooring could only be aligned to a single vanishing point perspective, the other strips lying parallel to the plane of the picture.

About the Author

Lambert Rosenbusch born 1940, architect and professor at University of Fine Arts Hamburg, studied philosophy in Frankfurt and architecture in Braunschweig. In addition to teaching at university and giving lectures, especially on the development of architecture up to the present, he has been running an atelier for architecture since 1969. He and his co-workers have realised commissions for buildings in Germany and abroad as well as designs for various products. Moreover, he has participated in many competitions (Reichstagsgebäude Berlin, Germanisches Museum Nürnberg, Museum der Bundesrepublik Deutschland Bonn) and won various awards (Health Assembly Rooms Sylt, Academy of Fine Arts Hamburg, Town Hall Market Hamburg). One of his favourite fields of research is the connection of architectonical space and its representation. In addition, his research interests have extended to theatre (e.g., stage sets), advertising, film, and television. Regarding these topics, Rosenbusch presented his work in national as well as on international exhibitions. He lectures on general questions of the theory of architecture and design as well as on teaching design for the present. He has published papers on various topics, including theory of architecture and design, aspects of teaching design of the present, problems in preservation of historical monuments, construction of buildings in modern times, design, and urban development. He has also worked as a painter (drawings and sketches) and photographer for many years. In 1990, he founded the journal Industrial Design, of which he is editor-in-chief. Visit his webpage at http://www.LambertRosenbusch.de.