The Perspective Box and Computer Graphics

Dana Kolářová

Faculty of Architecture, Czech Technical University in Prague; kolarova@fa.cvut.cz

Abstract

I present perspective boxes created by students of the Faculty of Architecture at the Czech Technical University in Prague under the guidance of my colleagues and myself. Inspired by antique perspective cabinets created by Dutch painters in the mid-17th century, we succeeded in our attempt to create similar boxes with the help of modern graphics programs. This resulted in unique models infused with the creative imagination of their creators.

Historical Background

Linear perspective plays an important role in both art and architecture. In the Renaissance period, the first perspective treatise was published and the earliest examples of perspective illusions began to emerge, with perspective boxes being a notable subcategory. The first of these boxes appeared in the mid-17th century, invented by Dutch painters of interiors and architecture. They were popular for a brief period of about 25 years and took the form of wooden cabinets. Only six of these antique Dutch boxes still exist: one in the Museum Bredius in Den Haag, one in the National Gallery in London, Great Britain, three in the National Museum of Denmark in Copenhagen, and one in the Detroit Institute of Art, USA. In them, the interiors of churches and old Dutch houses are illustrated. [3] [4]

Principles of the Perspective Box

A perspective box is an empty box with perspective drawings or paintings decorating its inner walls that create a surprising three-dimensional spatial illusion when observed through a peephole. Each wall of the perspective box represents one projection, resulting in a composite, continuous perspective.

The rules of linear perspective must be followed rigorously:

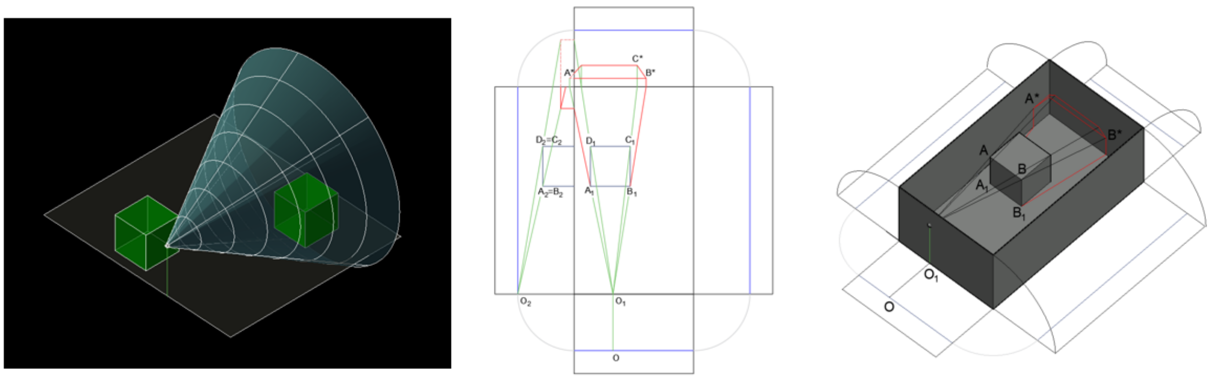
- horizon position: must be at eye-level within the depicted space
- field of vision: the angle of view should range from 60 to 90 degrees
  (this means that the depicted object should be placed within the field of view cone with a specified apex angle, as shown in Figure 1(a))
- distance: a minimum of 20 cm is recommended [1]

The base of a perspective box may take the shape of any polygon. A perspective illusion can be created not only of the interiors, but also exteriors. The space we want to depict is not limited by the shape of the perspective box. Correct scaling is also crucial.

A perspective box can be created either manually or using a computer. With a computer, it can be achieved by producing an anamorphic image in 2D or even 3D. Any graphic program may be used. The shape and size of the future perspective box is chosen, the displayed objects are placed in it, and the position of the eye is set at the correct height of the horizon. Next, projection lines are drawn from the eye through extreme points of the objects, and their intersections with the walls of the box are identified. This can be done in 2D using the multiple view projection. The method is depicted in Figure 1(b). The top vertices of each object need to be displayed in the top view and then in their orthogonal projection onto the corresponding side plane – here, the side view is used. Similarly, the projection center is also displayed, here O_1 and O_2. Next, projection rays are drawn from the selected point and intersections with the walls of the box are identified. Students are familiar with this procedure from the course on Monge projection. A detailed guide is available to them in the electronic course materials. [5]

The other option is to work directly in 3D to determine the intersections of projection lines with the walls of the box. However, it is sometimes challenging to find the correct polyline that defines the projection of the object. After this, the box is unfolded as shown in Figure 1(c), printed and folded into the resulting physical model.

This produces an anamorphic image on the walls of the box, which appears highly distorted when viewed from any position other than the center of projection. However, when the images are viewed through the peephole at the center of projection, the distortion fades and the normal shapes of the objects appear.



(a) (b) (c)

Figure 1: *Construction of Anamorphic image of a cube inside a perspective box, which is shaped as a rectangular cuboid: (a) placement of the object in the field of vision, (b) construction of the projection using top view and side view of the cube, (c) construction using projection rays directly in 3D.*

When constructing an anamorphosis, one can take advantage of the fact that the projection of the object on the wall is the same as its shadow when it is centrally illuminated from the point of the eye

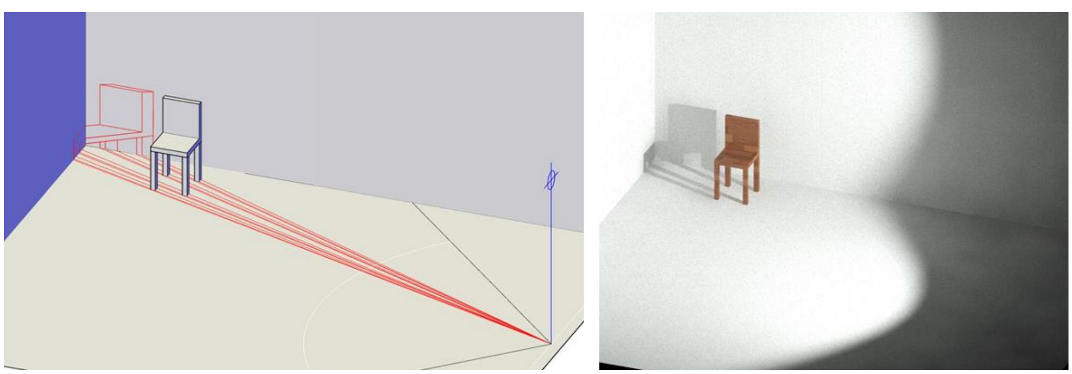


Figure 2: Anamorphic image of chair inside perspective box corresponds its shadow (AutoCAD).

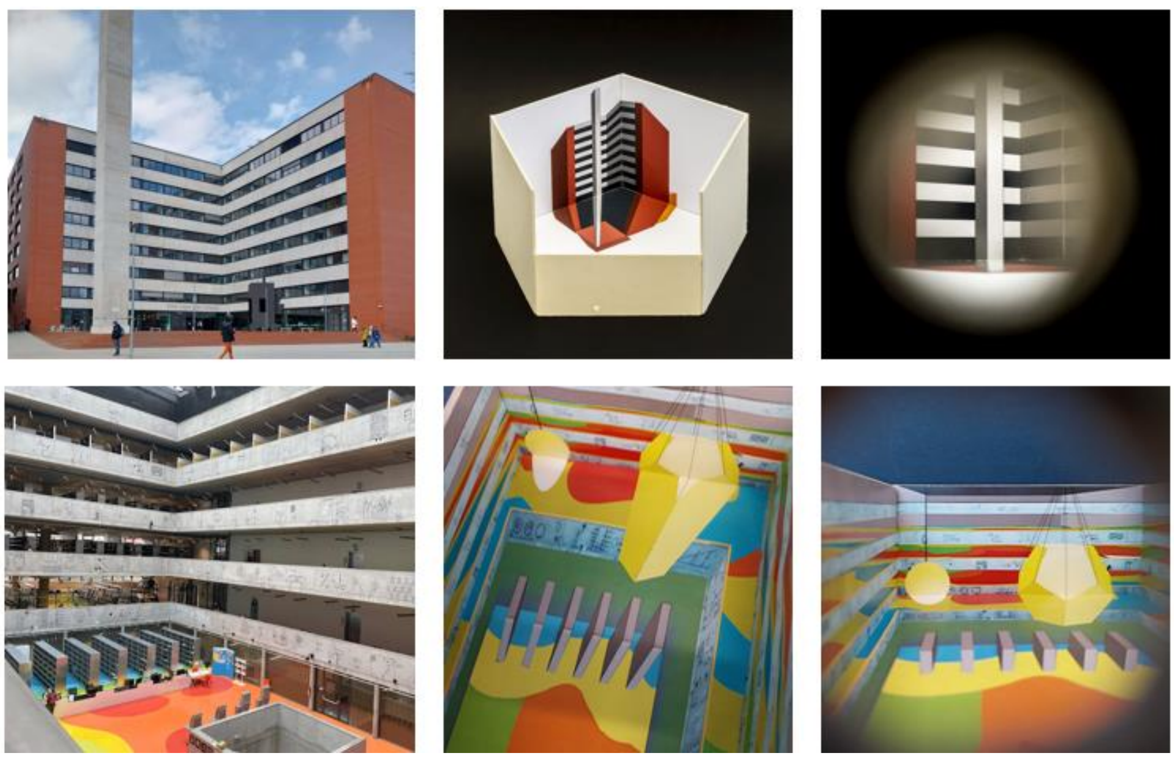
Coursework Projects Produced by Students at the Faculty of Architecture CTU

Working with perspective plays an important role in understanding spatial relationships. Future architects at the Faculty of Architecture at the Czech Technical University in Prague (Czech Republic) take a basic course in descriptive geometry during the winter semester where they learn the rules of spacial representation, i.e. the basics of linear perspective. This is followed by a compulsory advanced course in the summer semester in which they encounter various forms of perspective illusion: for instance, mirroring on a cylindrical surface, relief perspective, or the creation of perspective illusion in a perspective box similar to those created by medieval painters, but enhanced with modern technologies. The topic is met with great enthusiasm from students as it gives them the possibility of variability. Under the professional guidance of our lecturers, remarkable works are created brimming with youthful creative energy and inventiveness.

Initially, students' coursework projects were simple perspective boxes, used for creating an illusion of realistically existing interiors, such as loft apartments, churches, exhibition halls, etc. Later, they placed their own designs in these boxes. For example, modelling the interior of children's playrooms was popular. As time went on, student coursework projects became more elaborate. For example, we experimented with adding mirroring to the vertical walls or to the surface of water, or adding viewpoints to other spaces.

Students choose a space to be depicted (a building or interior of a building), agree with their instructor on the required level of detail, and then construct an anamorphic projection of the unfolded net of a cuboid geometrically (not through calculation). Instructions for this are available in the electronic course materials. Finally, they print their result, removing the construction lines, and glue it into the prepared physical model of a box (usually made from Kapa board). An unfolded net is shown in Figure 4.

The problem with this process lies in the fact that an error in the construction of the projection becomes apparent only in the finished model and is difficult to identify beforehand. Therefore, when creating the projection, it is advisable to gradually assemble the image from smaller constituent parts and continuously check the accuracy of the work. Additionally, if the anamorphic image is incorrectly glued to the walls of the box, the transition between the bottom and side walls becomes visible. This can be prevented only through meticulous attention to detail and precision during final adjustments of the model.



(a) (b) (c)

Figure 3: Examples of coursework projects at the Faculty of Architecture in Prague: (a) photograph of the depicted object (exterior – building of the Faculty of Architecture of CTU in Prague, interior – building of the National Technical Library in Prague), (b) photograph of the anamorphosis of the object inside the box, (c) view into the box through a peephole.

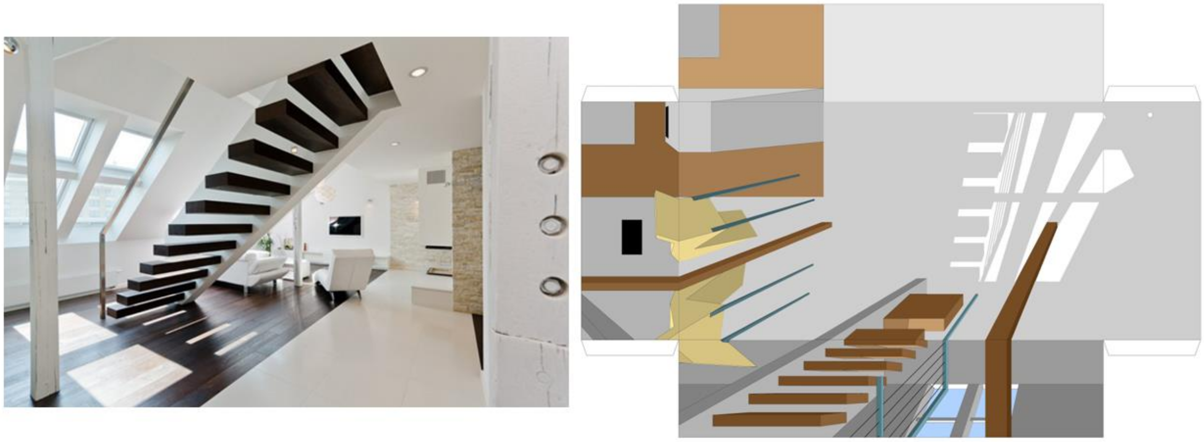


Figure 4: *photograph of an interior in an attic flat in Prague and its anamorphic image in an unfolded net of a perspective box.*

Summary and Conclusions

Working on this project has been a deeply interesting experience. Its enriching, entertaining and creative form led students to understand the rules of linear perspective, allowing them to successfully create a perspective illusion inside a box. The diverse selection of box shapes and objects that can be placed inside allowed students to take an individual approach to the assignment, while also inspiring one another as they worked and explored new approaches. In addition to classic perspective cabinets depicting the interiors of buildings, others can be created with abstract motifs or with large-scale objects, such as a school building. Some students tried to use two peepholes in the manner of the old masters. Furthermore, color processing brings additional possibilities. We have not formally assessed how working on this project has influenced students' performance in other subjects. However, in the yearly student survey, 90 percent of respondents rated this project positively. Overall, I believe that this topic is not yet exhausted, and I look forward to the future models of my students.

Acknowledgements

This work was supported by the Grant of the Faculty of Architecture of the Czech Technical University in Prague, Czech Republic, grant No.15122/105/105501E006.

References

[1] M. Kupčáková. *Základní úlohy deskriptivní geometrie v modelech*, 2nd ed. Prometheus, 2016.

[2] J. Nakamura. "Seeing Outside the Box: Reexamining the Top of Samuel van Hoogstraten's London Perspective Box." *Journal of Historians of Netherlandish Art*, vol. 12, no. 2, 2020, pp. 2-25. https://jhna.org/articles/seeing-outside-the-box-reexamining-the-top-of-samuel-vanhoogstratens-london-perspective-box

[3] J. Spencer."Illusion as ingenuity: Dutch perspective boxes in the Royal Danish Kunstkammer's 'Perspective Chamber." *Journal of the History of Collections,* vol. 30, no 2, 2018, pp. 187-201. https://doi.org/10.1093/jhc/fhx024

[4] A.Verweij."Perspective in a box." *Nexus Network Journal,* vol. 12, no 1, 2010 ,pp 47-62. https://doi.org/10.1007/978-3-0346-0518-2_4

[5] FA ČVUT. "*Perspektivní krabička*." Elektronická skripta. 2012. https://www.fa.cvut.cz/cs/studium/predmety/4962-deskriptivni-geometrie-i/materialy