Oldřich Hykš

LINEAR PERSPECTIVE IN PAINTING – A TOOL SUPPORTING GEOMETRIC EDUCATION

Abstract

The paper discusses a motivation for geometric education of students of technical universities and secondary schools, as well as other interested persons. It presents a study material which combines the exposition of basic principles and methods of geometric representations with commentaries and pictorial documentation of the historical development. This approach is based on the analogy between particular phases of perspective knowledge in the history and the gradual development of student's knowledge, which facilitates the study.

Keywords

Linear perspective, painting

1 Introduction

The objective of the contribution is to present a study material *Birth and Applications of Linear Perspective in Painting* [3] which represents a complement to standard lessons on geometry at technical universities and secondary schools. Its principal aim is to motivate students – coming usually without any previous knowledge of geometric projections – for some effort to understand and master the basic principles of linear perspective and methods of its practical applications. At present, in the days of attractive graphical computer programs, many students consider the study of these topics to be purposeless and it is necessary to persuade them of the sense of geometric education and the importance of the knowledge they earn there. For this purpose, the excursion into the history of painting is a convenient tool that can help students to become aware of the importance of geometric methods and of possible consequences of ignorance in this field.

Concurrently, the material was created as an alternative to many of present publications devoted to linear perspective that are usually attractive, contain large colour reproductions, but follow the way of entertaining the reader rather than tasking his mind with a "useless" theory. It tries to remain attractive to motivate a today reader withal teaching him the necessary

foundations and simple methods that enable him the elementary perspective imagery and encourage him to study further. The material is therefore convenient for a wider audience, too, from painters to anyone who just wants to understand the art of painting.

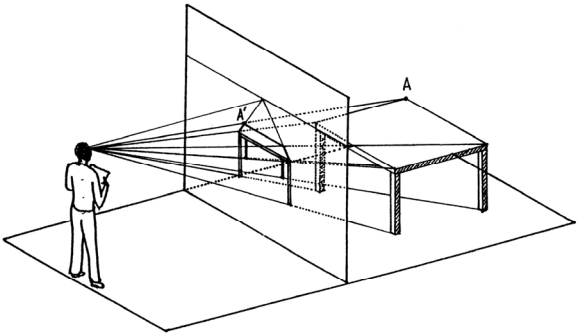
The way based on a historical exposition was chosen. Not only helps this approach to attract and keep the attention of the reader, the development of the society and an individual have many parallels. Particular phases of perspective knowledge in the history correspond to a gradual development of knowledge of a student – and this fact facilitates the study. Particular theoretical pieces of knowledge are put into the historical context, so that the student is gradually getting acquainted with the theory of linear perspective, but his attention is being maintained all the time by a more interesting topic of the development of perspective in painting. After the study of the text, the reader shall not only be familiarized with the history of perspective representations, he shall also understand its basic principles and be able to draw simple perspective pictures.

2 Approach to Motivation and Exposition of Linear Perspective

As it was mentioned above, the approach is based on the analogy between particular phases of the knowledge of the society and the gradual development of the knowledge of a student. The exposition therefore starts with the prehistory and antiquity. In this context it is convenient to emphasize that perspective as a geometric representation that is closest to the perception of the space by the eye and that is today understood by a "common" viewer to be the necessary foundation of painting, is only one of many components of a graphic expression – and not the component that must be used. In most epochs and civilizations, other demands and needs were in the forefront, rather than the realistic depiction of the space. The expression of persons, relations among them and the space in which they are placed can be carried out not only in a realistic way but also in a symbolic or stylized way.

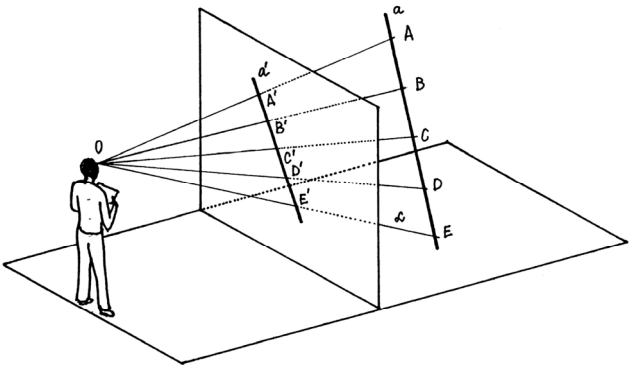
The birth of linear perspective itself is connected to the renaissance epoch. On the basis of an analogy with the historical development, students are motivated for a transition from an intuitive depiction of a reality to an exact representation based on geometric constructions. They are lead to this transition step by step, by the force of the analysis of paintings from various periods of time: from Ambrogio de Bondone (1266 – 1337) called Giotto and his disciple and admirer Ambrogio Lorenzetti (1280 – 1348), up to Filippo Brunelleschi (1377 – 1446) and his continuators.

Giotto's paintings were still based on an intuition and observations, rather than geometric constructions. For our purposes they represent an outstanding stimulus for a discussion of imperfections from the point of view of realistic depiction[1] and the possibilities of their elimination. Lorenzetti's paintings were also based on an intuition; nevertheless, by the imvestigation of his famous painting *Annunciation*, students can discover that all convergence lines have a common vanishing point and they can think about its correctness and the reasons of its convincing effect. This point therefore represents a natural place for the first geometric "intermezzo" explaining the foundations of linear perspective. This explanation starts with the basic principles of the visual sense. Then it is sufficient to imagine that a transparent plane is placed between an eye and the object that we want to represent. The projection ray intersects this plane in one point; provided this point is given the same color and light, it causes the same perception in the eye as the original point of the object. Doing the same with the whole beam of projection rays, we obtain the image in the picture plane that causes the same perception in an eye as the observation of the original three-dimensional object.

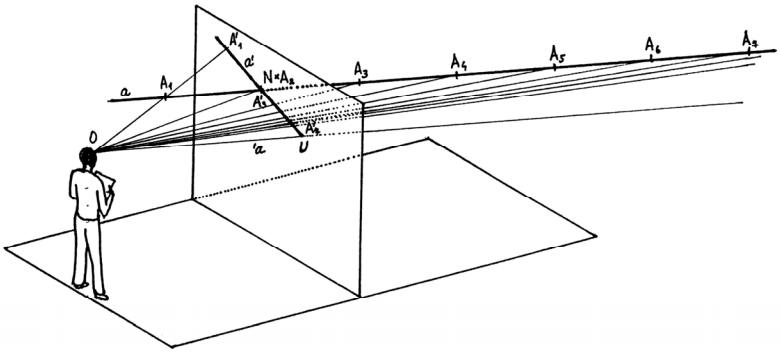


Now the usual notation for the ground plane, picture plane, horizon line, principal distance, etc., is introduced. On the basis of the projection plane α, it is shown that the image of a line a is again a line or a point (when it runs through the centre of projection), which simplifies the constructions: it is sufficient to find the images of two points of the line to obtain its whole image.

[1] For example, in the painting *Exorcism of the Demons*, parallel lines on houses are sometimes represented as parallels, sometimes as intersecting lines converging or even diverging towards a distance; in the painting *Bishop's Dream*, the images of parallel lines of a ceiling intersect in one point, as well as the images of parallel lines of the floor, but these points are different.

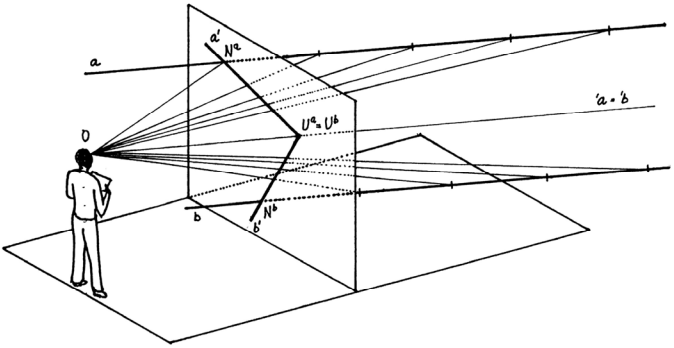


The choice of the *trace point N* of the line as one of these two points is clear. The choice of the second point is illustrated by the following figure.



The exposition proceeds as follows: »Imagine a successive projection of the sequence of points A_1, A_2, ... of the line *a* that move away from the trace point behind the picture plane. Their spacing is constant, but the distance between two successive images is decreasing and the images converge to one point. The angle between the line *a* and the projection lines of particular points is decreasing. When we imagine that the point A_i of the line moves away ad infinitum, its projection line becomes parallel to the line *a*, running through the centre of projection *O*. This line is called *direction line* of the line *a* and it is denoted by the symbol '*a*. The intersection of the picture plane with the projection line of this infinitely distant point is called *vanishing point* and it is denoted by *U*.

On the basis of trace and vanishing points we can construct a projection of any line in the space. Specially, we can construct the projection of a line *b* parallel to *a*:



Their trace points are different, $N^a \not\equiv N^b$, but their vanishing points are equal, $N^a \equiv N^b$, since this is the trace point of their common direction line running through the centre *O*. Thus we come to the conclusion that the projections of parallel lines are the intersecting lines running through one common vanishing point. We can therefore confirm the correctness of Lorenzetti's construction.«

The next important step that students have to do on their way to perspective projection and that must have been done in the history, too, is to find the methods of concrete constructions of perspective projections. Thus we come to Filippo Brunelleschi, who is usually considered to be the discoverer of linear perspective, and to his plans of the cupola of the duomo in Florence where the system of top, front and side views was used. Students are acquainted with the way how Brunelleschi could construct the correct perspective projection of the cupola from these three views.

Then the readers are led throughout the further development to the discovery of direct methods, their improvements and finally to their routine mastering. Here a substantial drawback shall be pointed out, too, namely the fact that the impression of the perspective picture is natural for the viewer standing at one concrete station point only, which is seldom satisfied. A viewer usually walks along a wider canvas, investigating details that are then necessarily distorted. In this context, Leonardo da Vinci touched so-called non-linear perspective at a theoretical level, other authors adjusted their paintings by braking perspective rules around margins to achieve a more natural impression, the limits for an "allowed" view angle were gradually determined.

The historical excursion continues with the paintings where the perspective rules were broken to achieve special artistic impressions, students are acquainted with the styles that abandoned perspective and supplanted it with other tools, as well as with the styles that used perspective for creation of various "playthings" and absurdities. Particular art movements are

discussed together with their approach to the use of perspective. Readers can therefore reach their own opinion of the importance of mastering perspective rules.

3 Conclusion

For descriptive geometry teaching itself, the most important outcome of the discussed material is mastering the methods of perspective constructions, above all the intersection and grid methods. For the last-mentioned one, a computer program was created, which enables students to create and print grids for arbitrary views and hence motivates them for their own creative activities.

With respect to the broad range of the topic and limited extent of this contribution, it was possible to provide only a small illustration of the possible approach to linear perspective teaching. May the kind reader understand it as an invitation to a more detailed look inside the text [2] and its prospective use. Based on the extensive pictorial material from prehistory over the renaissance epoch up to the 20th century, it leads the students to the field of perspective projection, acquaints them with the most widely used construction methods and broadens their historical and cultural horizons.

References

[1] Coleová, A.: *Perspektiva*, Perfekt, Bratislava 1995.

[2] Hykš, O.: *Zrod a užití lineární perspektivy v malířství*, Prague 2004 [*http://euler.fd.cvut.cz/predmety/geometrie/lp_malirstvi/*].

[3] Hykš, O.: *Zrod a užití lineární perspektivy v malířství – motivace výuky geometrie*, in: *Proceedings of the conference Presentation of Mathematics'05*, Liberec, 2005, 8 pp. [to appear].

[4] Kadeřávek, F.: *Perspektiva*, Jan Štenc, Prague 1922.

[5] Kadeřávek, F.; Kepr, B.: *Prostorová perspektiva a reliefy*, ČSAV, Prague 1954.

[6] Kadeřávek, F.: *Úvod do dějin rýsování a zobrazovacích nauk*, ibid.

[7] Parramón, J. M.: *Perspektiva pro výtvarníky*, Svojtka a Vašut, Prague 1955.

[8] Šarounová, A.: *Geometrie a malířství*, in: proceedings *Historie matematiky I*, JČMF, Brno 1994, pp. 191–213.