See the Non-existing but Still Visible

An “unplugged” way to deal with perspective illusions.

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Creation of a geometrical illusion in a staircase will be discussed. This will be done by the classical approach to geometry, by selecting the “punto stabile” point and a 3D structure. This structure, consisting of simple elements, will be projected from observer’s eye over punto stabile onto two vertical walls. As observer walks up the stairs, the perceived illusion will change its shape. The goal of this paper is to show how easy such illusions - once popular in the baroque period - can be created, and how creation of such illusions support further development of spatial imagination. It is important to note, author of the illusion has full control over how such fictive architecture will be seen by an observer. That means, the author will determine all aspects of interior’s perception - a point very important when it comes to the relationship between a person and space.

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INTRODUCTION

In a time, where almost all modern design and modeling steps in the field of architecture are performed by means of computers equipped with advanced software, this is a contribution to the old-fashioned “pencil & paper” technique of creation of a 3D geometric illusion - a forgotten skill nowadays. An imaginary, non-real structure will be created in a staircase of the Building of Civil Engineering at Lodz University of Technology. According to the rules of central projection, this structure will be projected on adjacent walls, where it will be visible to any person walking up the stairs. While being in motion, the observer will experience a slightly different image changes when compared to what would be expected if observed objects would be real. This is always associated with a certain “wow-effect” and shall focus observer’s interest on the phenomena of optical illusion. Especially, if observers are students of faculties like “Architecture” or “Interior Architecture”, where the development of creativity and spatial imagination must be emphasized. The idea itself is of not new ofcourse, the concept of such illusions dates back at least to baroque period and many of such paintings - also called “quadrature” and discussed in works like Górk in 2004 - survived to our time and still fascinate people. Now not so popular as they could be, they deserve being recalled and introduced to all, who shall train his/her creativity and spatial imagination. Further, obtained visual effects will be discussed, where the relations between eye’s path across the staircase and imaginary structure will be shown. This also play a key role in the process of understanding how a perspective and human eye work. With this in mind, an
architect or designer will be able to create more interesting, better objects, interiors nicer to stay in or public spaces influenced by an alternative way - by some fictive elements, being impossible to be done in real world.

**IDEA OF AN ILLUSION**

Human’s two eyes sense of vision lets perceive depth, but what we see and how do we recognize the space around is strongly influenced by former visual experiences. From earliest days, our brain has the ability to save certain patterns. This helps quickly recognize seen objects, without prior precise analyze of them. In the majority of cases this has positive effects on how we recognize our surroundings, however - sometimes this leads to a misinterpretation of what is observed, especially if the ability to see 3D ceases. Creation of any illusion use following property: if spatial relationship of fictive architecture are well made, the image of it on eye’s retina will be the same as from real objects. In other words, rays of light coming to the eye can form the same image regardless of true point’s positions in space. All those rays converge in a common point, the eye of the observer. This point must precisely be defined and its projection on the interior’s floor is called “punto stabile”. Interiors with multiple punto stabile are known and were discussed by Pozzo in 1693. For the presented illusion, punto stabile was chosen for a person at a position just before entering the first step of the stairs. A look slightly overhead will show the illusion, as seen on the Figure 1. It consists of three beams perpendicular to the front wall, fourth beam that’s runs at a right angle to them and seems to support them as well as a small diagonal fifth element - they all form a structure frequently encountered in houses with wooden slabs and roof construction. To make the appearance more attractive, especially when observed in motion, elements of illusion are projected on two different walls.

**PRINCIPLES OF PROJECTION**

Any illusion to be executed in an interior, must be projected onto some surfaces - two walls in this case. This is a 3D task, which might appear complicated in the classical approach to descriptive geometry. However - since both walls are vertical, their projections on a horizontal plane (top view) or vertical plane (side / lateral view) will appear as straight lines. This obvious fact greatly simplifies the process of projection,
The one in the center and the left one will be projected on both frontal and left wall. Similar is true for the long beam - its edges will be projected on both planes. Missing informations about points relationships in space will be gained from another view - projection from above will determine where all key points will be located. In this view - explained on the Figure 3 - eye of the observer and punto stabile occupy the same spot - they are arranged one over another. One can clearly see what foreshortenings will apply for beams perpendicular to the frontal wall. Such top view projection is also best suitable for introducing some computational methods, as an alternative to strictly descriptive geometry methods. A cartesian, orthogonal frame of reference XY must be introduced, the choice of axes position, however can vary, depending on author’s preferences. Two most logical options would be: options “one” Axes X and Y lay in the planes of walls (we can safely assume, there is a right angle between walls) and position of the eye will be described by two coordinates Xe and Ye. Second option would be putting the centre of the frame of reference at eye, and pointing both axes X and Y parallel to corresponding walls, as can be seen on the Figure 4. As coordinates of any given point in the view Xi, Yi can be measured in the view, one can easily write down an equation of a straight line that goes through chosen point and the eye. Having the equation done, it easy to find crossing points with walls. Thus a number of coordinates can be obtained and whey will be the base for the paintwork at the staircase. For flat, vertical walls with a right angle between, both placements of the frame of reference seems to be equally useful. In a general case, however, placing the (0,0) point at observer’s eye will work better if the surrounding walls are not planes (like in a circular room for example, where the shape of a wall be be given by the circle’s equation).

Placing the (0,0) point at observer’s eye also simplifies writing all needed equations for straight lines that go through selected points. Both methods: graphical, based on two drawing only and numerical, based on equations in two dimensional frame
This approach was successfully used in [3], where some elementary trigonometry is used to explain certain properties of Ames Room illusions. Calculation do not introduce any mistakes regarding accuracy of point’s positions, but method based on descriptive methods is much closer to the former “spirit of perspective”, which is of high educational value. There is certainly no better way to practice perspective, as to construct some 3D objects, and a classical drawing clearly emphasize spatial relationships between the observer, objects and surfaces on which this object will be projected.

ILLUSION SEEN AWAY FROM PUNTO STABILE

The most interesting thing about perspective illusions is their behavior when watched not from a point over punto stabile. All the differences between observed perspective of real architecture and fictive architecture force the observer to ask question: “why is it like this?”. When observer observes the illusion form above punto stabile, fictive elements are seen as they should be, without any distortion. Thinks become interesting when observer leaves punto stabile. Let’s say, stays on the higher level as simulated on the Figure 5. In this case, perspective rays used to create the illusion are not the same as watched - two different pencils of rays come into play.

The more the observer moves from punto stabile, the more both pencils of rays differ from each other and distortions of the illusion are more obvious. Construction of the staircase perspective with the illusion, when observed from a very distant point will be shown below. In particular, the construction shows the illusion as seen from the higher floor.

It all starts with a perspective image of the staircase, where both vanishing points V1 (out of image, at left) and V2 as well as the horizon will be recovered. Then, data gained while designing the illusion will be used to introduce all key points on walls. First step is the introduction of all important vertical edges on the frontal wall, which are represented by points P’, R’, S’ and T’ in Figure 3. Heights of all important points were taken from a similar construction, explained on the Figure 4. This lets obtain the view of the rightmost beam. For the middle and left beams, construction of the perspective is much more complicated. It starts the same way on the frontal wall as described.
previously, but at the edge between both walls, the perspective will “break” and rapidly change the way it look from higher level. This is well visible on the Figure 7. Points U’, V’, W’ and Q’ deliver data where to locate corresponding projections on the left wall. At this stage - when all three beams were constructed on walls - a clear confirmation of an error-free construction is possible - all edges, that are parallel to each other run to common vanishing points V3 (low over the floor) and V4 (on the left / bottom, not on image). Both these points can be found on walls and can be used to verify if the paint job has been done without any mistakes. Vanishing points V3 and V4 will represent observer’s eye projections on both walls. When observer moves - its eye will be projected in different spots on walls, possibly not it positions occupied by V3 and V4. How strong the observed illusion will be distorted, can be expressed by the distance between vanishing point and actual projection of observer’s eye. As the eye - at least in theory - can freely move in three different directions, various kind of deformations can be expected.

Following is the construction of the horizontal beam, which is nothing new in terms of geometry, principles mentioned above let obtain projections of visible points and edges on walls, as shown on the Figure 8. Being the largest element and exposed to view, this beam will strongly influence the overall perception of the illusion.

For clarity, straight lines to vanishing points V3 and V4 were left, in the painted work they will obviously be skipped. Last step in the construction process is the addition of the fifth diagonal element, also protruding from the left wall. Of course, some more elements can also be added, but this would be at the costs of good visibility and overall clean appearance. Very interesting must be the first encounter with the illusion - something unexpected and surprising will be watched, and as the observer has to walk across the punto stabile, there will be at least a moment, when the intended perspective will be seen. When
continuing the motion up the stairs, observed perspective will gradually be distorted according to principles mentioned earlier. Even more impressive will be the change in perspective if watched in a reverse sequence - first glimpsed at III floor as shown on Figure 9 - and then followed by eye while walking down. To further reinforce visual effect, some textures, colors and even shadows can be added. To a skilled architect, only his/her imagination will set borders. Below a final view of the distorted illusion is show - a rather strange view, weirdly broken at wall's edge.

**CONCLUSIONS**

Geometrical illusions in interiors are very fine opportunity to play with perspective, develope spatial imagination, creativity and influence the way we see our world. Even if modern computer techniques are more and more advanced and sophisticated, such tasks can easily be done “unplugged”, just based on basic principles of projective geometry. If needed - simple calculations can replace some constructive drawing job or can be done as complementary part of the task. Difficulty of the task will raise if designed illusion would be intended to be painted on surfaces that are not flat. A cylindical wall or a spherical dome immediately come to mind. In such case one has to handle non-collinear perspective, which would be much more time consuming, and where the use of computer could certainly bring some benefits.

**REFERENCES**


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