Optical 3D Anamorphosis in the System of Tetrahedron and Stellated Octahedron

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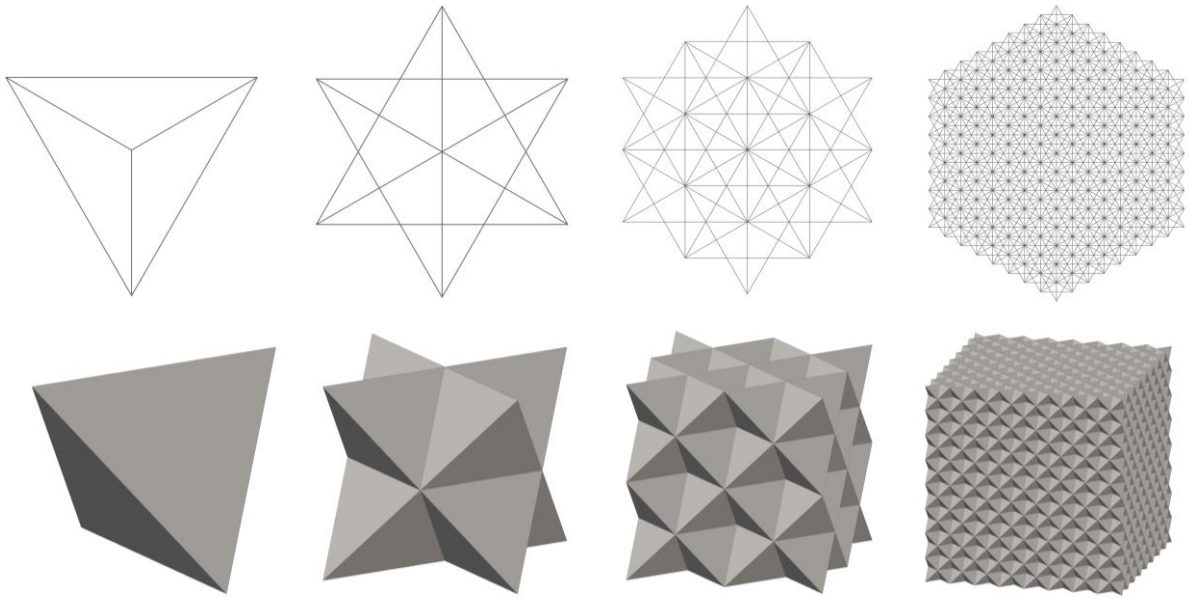
Abstract

This paper presents interdisciplinary research on the topic of 3D optical anamorphoses in the tetrahedron and stellated octahedron system. The results are 3D artworks made of paper which present different images, depending on the viewing angle. The methods of image projection were investigated, as well as the proportion of that image in relation to the number of elements of the object on which it is projected.

The System of Stellated Octahedron as a Geometric Background for Artistic Work

The optical 3D anamorphoses explored in the paper are optical illusions made up of unitary shapes (tetrahedra or stellated octahedra) that contain fragments of specific images understandable only in a certain position. The aim of the research is exploring the possibilities and limitations of presenting images using parallel faces of a polyhedral lattice, as well as their perception by excluding certain number of fields within the composition, see Figure 3. Due to the shape of the stellated octahedron made up of two oppositely oriented tetrahedron, as shown in Figure 1(b), there are fields that are exempted from the image, which is presented in Figure 2. They are shaped as a form of an equilateral triangles, as a result of the cross-section of two tetrahedrons. The final object that is formed is a cube, and the image that is applied is hexagonal as shown in Figure 1(d). The research sought an optimal number of units that would enable better visibility of the image, see Figure 2.



(a) (b) (c) (d)

Figure 1: *The stellated octahedron system forming: (a) starting tetrahedron, (b) stellated octahedron (2 tetrahedrons), (c) repetition of stellated octahedron (16 tetrahedrons), (d) repetition of stellated octahedron (1024 tetrahedrons).*

Figure 2: *Visibility testing, image size ratio and number of stellated octahedra*

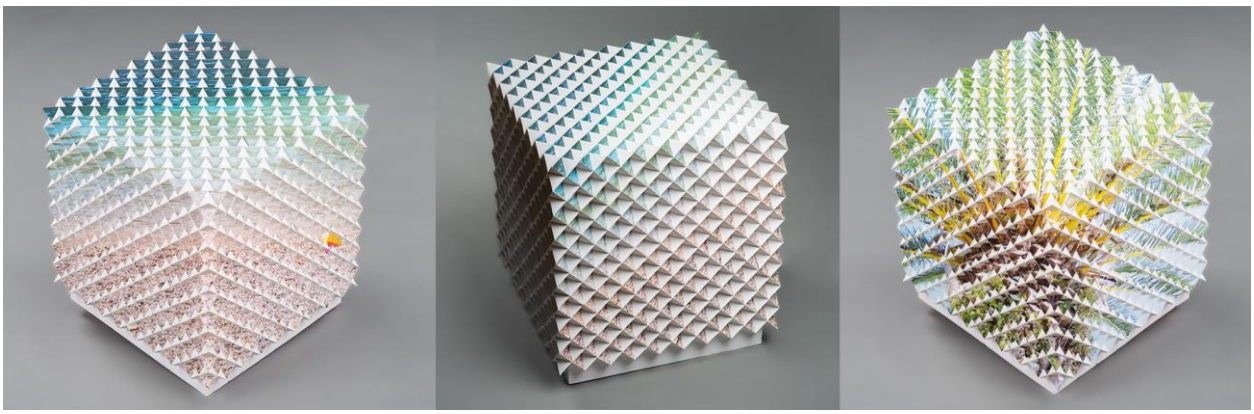
The Artistic Researches

In the technical sense, the first step was to create a network of triangles in AutoCAD, then it was laser cut, and folded and glued by hand. The next step was to apply the images. The first step was the same for all works, but the application of the image in the works differs in methods and techniques.

"Defragmentation"

The work titled *Defragmentation* pictured in Figure 3, is 3D optical anamorphosis displaying two images constructed in a system of stellated octahedron, which is solved by projecting the image by the rays orthogonal to planes [2] which are parallel to each other. The name Defragmentation, a term which originates in the field of computer technology, is chosen symbolically to draw attention to those situations in modern life whereby a person identifies with the machine, dwarfed by the prominent role played by artificial intelligence – not only in the research realm of computer engineering, but also in practice.

This experimental work is 3D model made of paper in which stellated octahedrons form the cube. The number of stellated octahedrons is 9 in height, width and length. In order to restrict the conditions of the experiment, images are projected on a single set of tetrahedrons which are oriented in the same way, thus making the fields exempted from the image uniform - white, so as not to disrupt the composition of the frontally seen image, and to avoid the influence of the visual content from other images. The two images are designed not to interfere with each other.



(a) (b) (c)

Figure 3: *"Defragmentation", 55 x 51 x 51 cm, paper and photography, 2018: (a) sea and the coastline motif, (b) photo from an arbitrary viewing angle, (c) palm trees motif*

Two different photos are selected, one with the sea and the coastline motif which highlights the tonal values and reduced compositional elements, and the other, with the palm trees motif where compositional elements are repeated and have visual vibration and texture effects [1]. See Figure 3(a) and Figure 3(c). For perception of images from a standing position selected size of the cube is optimal, so the viewing angle enables a successful optical illusion.

"The Point"

In the work titled *The Point*, shown in Figure 4, the number of stellated octahedra is 12 in height, width and length, but smaller dimensions than in the previous work, which resulted in a slightly greater distance of the observer from the object. This time the idea was to reduce the color completely and choose a simple motif with a 2D effect. The end result is an achromatic solution, as if to keep the artistic conceptual context. Due to the applied contrast of the painted motif, the shadows (which are created as a consequence of the three-dimensionality of the object) do not significantly affect the visual effect of the applied image – a circle. The perspective method was used to project the image.

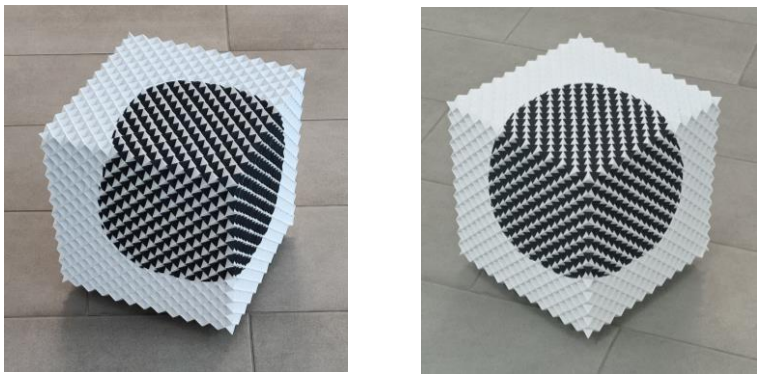
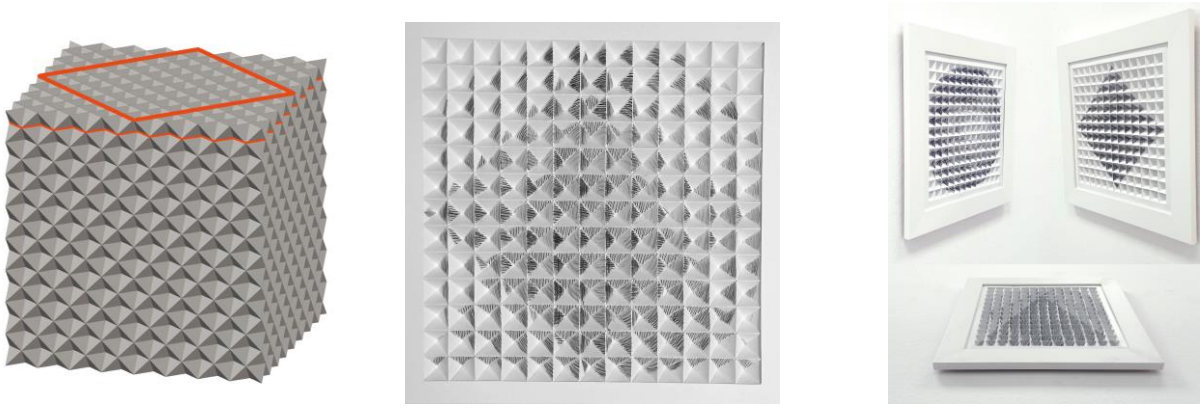


Figure 4: *"The Point", 37 x 35 x 35 cm, acrylic on paper, 2024.*

"The Truth"

In the continuation of the research, one side of the cube was taken as a starting "canvas" shown in Figure 5(a). Because the work was intended to be a relief panel with limited depth, and based on the intended viewing angles, the lattice for this work consists of a square inscribed in the top surface of the original cube, rotated by 45 degrees.



(a) (b) (c)

Figure 5: *"The Truth", 40 x 40 x 1 cm, drawing on paper, 2022: (a) system of tetrahedrons, (b) frontal view, (c) views from three different sides*

This relief allows the application of 4 images, but in this work, 3 images were applied: a triangle, a circle and a square which can be seen on Figure 5(c). The parallel projection method was used to create the image. In the previous two works (cubes), the image was projecting by the rays orthogonal to the parallel triangles. Unlike that, for better visual effect, in this work the image was projected by the rays orthogonal to the plane of the frame square. It was drawn by hand on the created relief.

"In Your Eyes"

The research with relief continued in the context of exploring the introduction of color and visual details in the illustration, see Figure 6. For this reason, the number of image elements has been increased. A circle was taken as a motif and 4 symbols in that shape that are clear and generally known, such as: moon, flower, sun and eye Figure 6(b). These symbols taken as a whole have a personal meaning to the author. The original idea was for the work (relief) to be positioned vertically on the wall. In that case, the upper and lower images would be viewed using mirrors placed on the floor [3] and ceiling. This idea was abandoned due to technical reasons, so the work is placed on a pedestal in a horizontal plane.

(a) (b)

Figure 6: *"In your eyes", 80 x 80 x 1 cm, mixed media, 2023: (a) frontal view, (b) views from four different sides*

Summary and Conclusions

The choice of image content affects its coherency. Eliminating portions of a picture can have a major impact on readability and coherency of the projected image. Pictures with less detail and larger areas of similar colors are more readable and more integrated. Lighting and background significantly affects the perception of the images that are projected on it. This structure allows the application of 8 images, which is a challenge for application in artistic work and would probably imply some kind of mechanization, i.e. rotation of the object or application of mirrors, which will be the goal in some subsequent artistic research.

References

[1] M. Paunović. "Defragmentation." *Bridges Linz 2019 Art Exhibition Catalog*. https://gallery.bridgesmathart.org/exhibitions/2019-bridges-conference/marijana-paunovic

[2] M. Paunović. "Optical Anamorphoses Constructed by the Means of Orthogonal Grids" *Mongeometrija Proceedings*, vol. 2, Vlasina, Serbia, June 20–22, 2014, pp. 257–268.

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