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Geometry of Anamorphic Projections

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Abstract: Anamorphic Projections have been studying by mathematicians, architects and artists since the mid of the fourteenth century. These projections create the distorted image, and the distorted image can be sensed only from one point and with an optical device. The practices and research are still going on in this area. This paper presents the history and geometry behind Anamorphic Projections. For the first time in the history, the word illusion painting in a tale by Zeuxis from Greece was mentioned around 464 BC. Later, Leonardo da Vinci made an illusionary eye in fourteenth century. The practices and the works carried out by various ancient mathematicians, architects and artists and also the contributions of the modern artists are discussed in this paper. The geometry of a regular shape of a square and the distorted images of the square from various positions were also discussed in this paper.

Keywords: Anamorphic Projections, illusion painting, a regular shape, square, convex lens, distortion.

I. INTRODUCTION

The word, Anamorphic comes from Greek. ***Ana*** means again and ***morphe*** means shape. An anamorphic image appears abnormal from all the remaining angles except from the correct viewpoint through an optical device i.e., a convex lens. Once the anamorphosis is realized, they can be read without using any optical devices. There are various ways to create anamorphic drawings using mathematical formulae, projectors, some kind of software and etc. This will create the illusionary effect on different surfaces like on ground, wall, cylindrical, conical shape mirrors and etc.

A. Trompe-l'oeil (Trick of the eye/Deceive the eye)

Trompe-l'oeil, in the form of "forced perspective", was often used in the theatre set design to create the illusion of a much broad space than the actual space of the existing stage, where the actors used to play the drama. An often quoted early example is the Teatro Olimpico in Vicenza, with Vincenzo Scamozzi's seven forced-perspective "*streets*" (1585), which appear to recede into the distance. Greek and Roman artists used to create something three-dimensional, actual work was only two-dimensional by using the technique of tromp-l'oeil (Deceive the eye/Trick of the eye) making the viewer believe that they were seeing a large space or broad street. There was an argument that the anamorphoses were first constructed in Roman times as "accelerated" and "decelerated" perspective, whereby structures such as columns were built with non-standard dimensions in order to appear farther or nearer from an observer than they were in reality.

B. Early Contributions

Zeuxis from ancient Greece was born around 464 BC was often mentioned two rival painters tricking each other with optical illusion paintings in a tale. After a long time the word, optical illusion paintings came into the picture with its new name ***Anamorphic art.*** The art started reaching the people and gaining the popularity in the renaissance period of mid of fourteenth century. The Italian painters of the late Quattro cento such as Andrea Mantegna (1431-1506) and Melozzo da Forlì (1438-1494) started creating illusionistic ceiling paintings, generally in fresco, using perspective projections and techniques such as foreshortening to create the impression of greater space for the viewer below.

C. (Leonardo da Vinci, c. 1485)

Leonardo da Vinci is well known for his paintings. Leonardo's Eye is the first known anamorphic painting by Leonardo Da Vinci and it is a definitive example of perspective anamorphosis, shown in Fig.1.

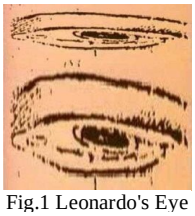

Fig.1 Leonardo's Eye

D. "The Ambassadors" by Hans Holbein the Younger (1536)

"The Ambassadors", art work is the early and most famous example of the drawing using anamorphic projection techniques by Hans Holbein the Younger (1536), shown in Fig.1. In this painting, an unrecognizable object contrasting the rest of the painting which is composed of clearly and precisely rendered elements at the feet of the ambassadors. That floating figure or unrecognizable object in the foreground of the painting is an anamorphic projection of a skull, shown in the corrected form in the right part of the Fig.2 by moving close to the wall at the right side of the image.

Fig.2 "The Ambassadors" by Hans Holbein the Younger (1536)

E. Jean François Niceron (1613-1646)

He was a mathematician and an artist with a passion for investigating perspective. He was from Paris but travelled widely in Europe and was awarded a professorship in Rome. He published his first book on the subject when he was 25 years old ('Thaumaturgus Opticus') and 'La Perspective Curieuse' (The Curious Perspective) got published in 1638. The following figures Fig.3, Fig.4 and Fig.5 are the practices of Jean François Niceron.

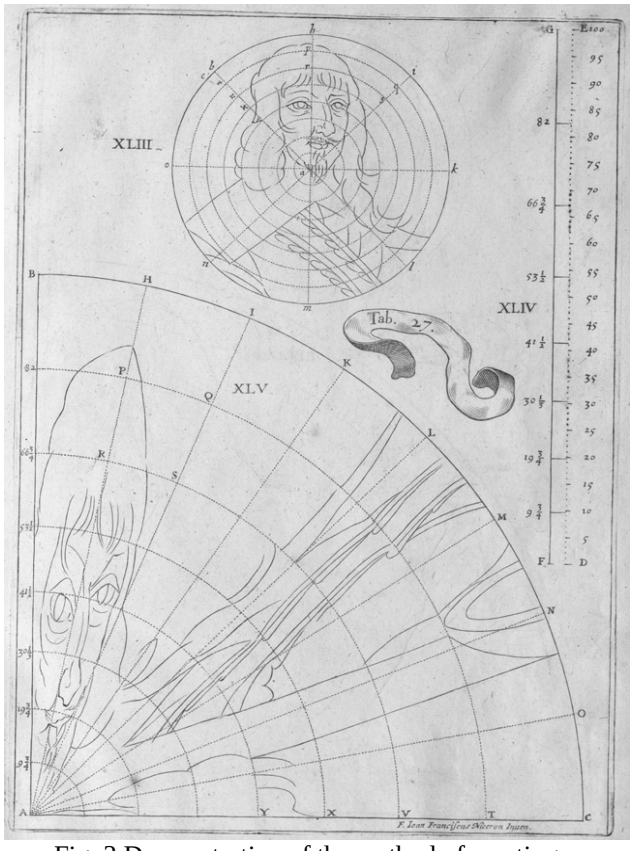

Fig. 3 Demonstration of the method of creating an anamorphic work by J.F. Niceron 1638.

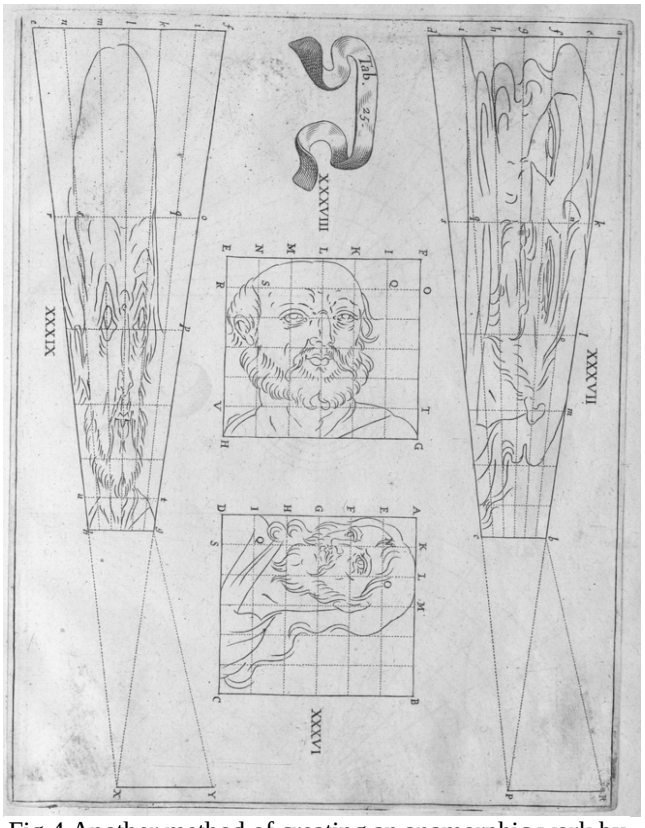

Fig.4 Another method of creating an anamorphic work by J.F. Niceron 1638.

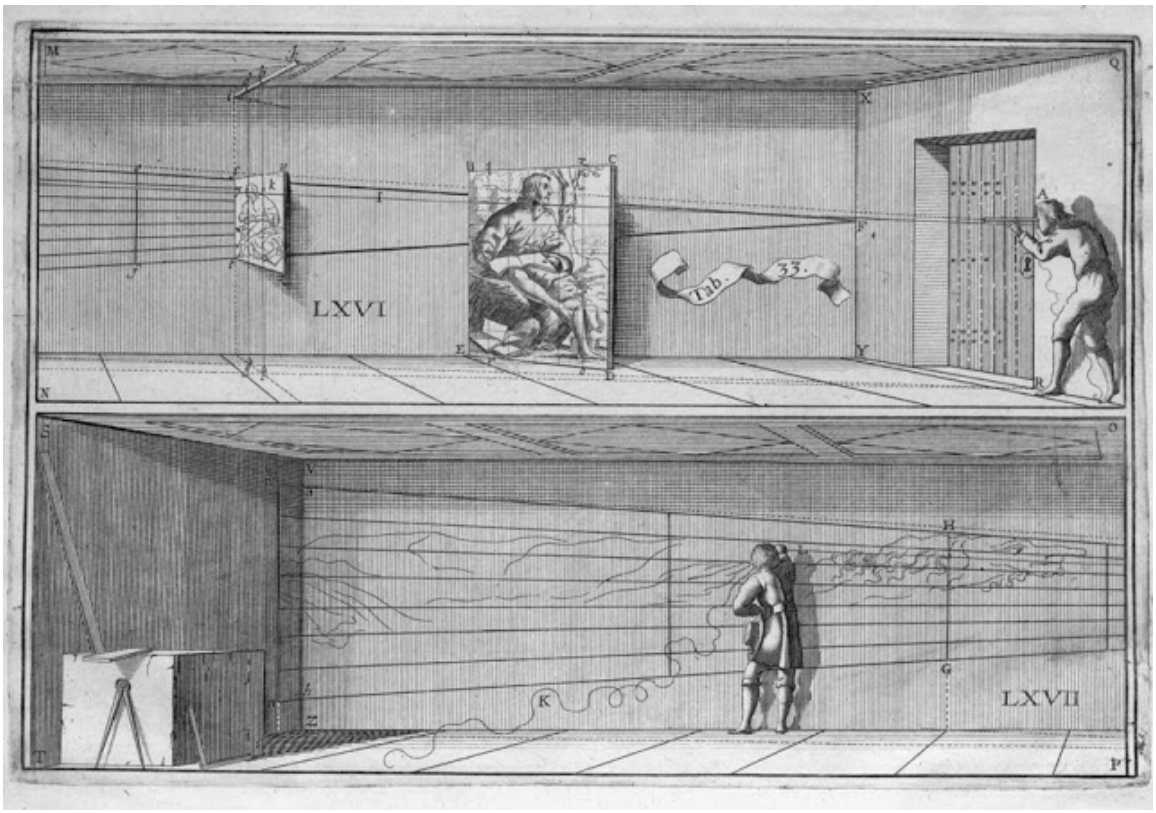

Fig.5 Demonstration of the making an anamorphic work by J.F. Niceron 1638.

Fig.6 The painting on curvature ceiling of the Church of St. Ignazio in Rome by Andrea

F. Andrea Pozzo(1685)

Andrea Pozzo painted an illusion on the dome and vault of the Church of St. Ignazio in Rome, represented the pinnacle of illusion. The ceiling isn't flat actually, that was a curvature and there is only one view point from where the illusion effect is perfect and a dome looks real. Fig.6 shows the painting on the curvature of the ceiling of the Church.

G. Between 18th to 20th Centuries

In 18th and 19th centuries, anamorphic images got more popularity and had come to be used as children's games. In the 20th century some artists like Marcel Duchamp wanted to renew the technique of anamorphosis and reintroduced to the people. Some of Marcel Duchamp's installations are paraphrases of anamorphoses. Salvador Dalí (1944) also interested and utilized the anamorphic technique in his paintings. The illusion behind his art can be sensed only when the painting is placed before a mirrored cylinder. Jan Dibbets (1941) made simple linear art works, the so-called "perspective corrections" are examples of "linear" anamorphoses.

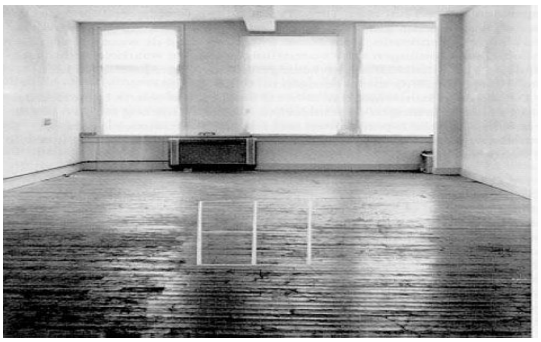

Fig.8 linear anamorphoses by Jan Dibbets

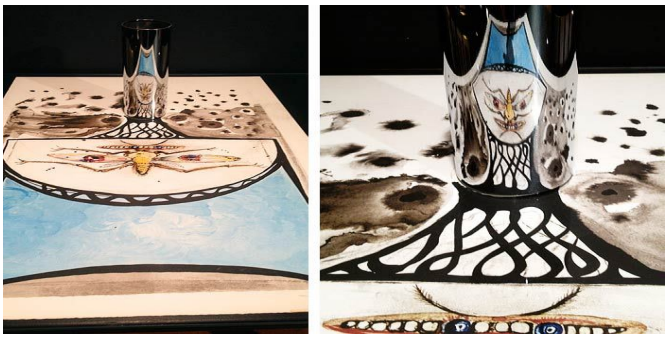

Fig.7 An Anamorphoses by Salvador Dalí

Kurt Wenner from U.S was one of the original modern day Pavement artists who introduced 3d pavement art to the world in the 1980's. He was also an ex NASA engineer combined his knowledge of mathematics with fine art to create spectacular artwork in three dimensional illusion in the streets. Then, Julian Beever, Edgar Mueller, Leom Keer, Nikolaj Arndt, Manfred, Tracy lee Stum and etc. added to the list.

Fig. 9 Anamorphic drawings by the various artists

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H. *Geometry*

A simple regular shape, a square is taken as a reference and seen it from various positions and obtained the distorted view of the square. The square *abcd* is imagined at a place and viewed from a position, which is away from the square at a certain distance and height. When a person's eye position is E, and sees the square from height 5ft from various positions of 1,2,3,4 and 5; the distorted images of the square are obtained in different shapes and shown below. First the position of the person is at 3 and symmetrically sees the square, will give the result of distorted square as trapezium $a^{11}b^{11}c^{11}d^{11}$ shown in Fig.10. If the position of the person changes from 3 to other, how the distortions are going to be formed is investigated.

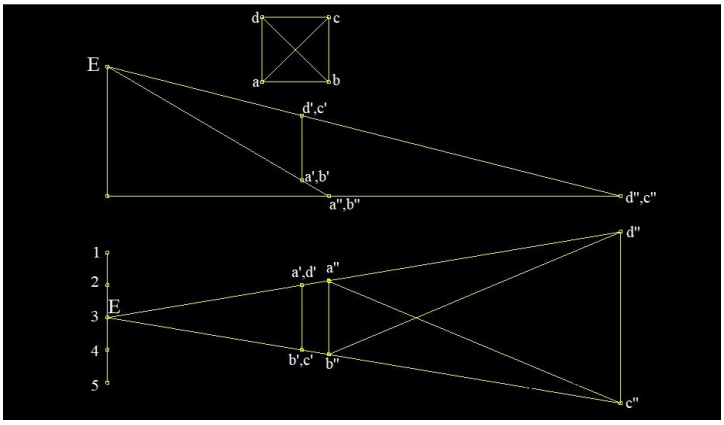

Fig. 10 A view of the square from 3.

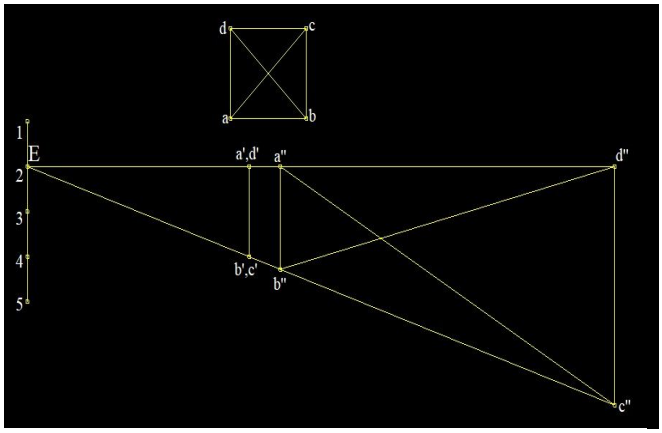

Fig. 11 A view of the square from 2.

The position of the person is at 2 and sees the same square, will produce another distorted image shown in Fig. 11, but not same as the position 3. By changing the position of the person from 2 to 1, 4, and 5, the distorted images will be produced as shown in Fig. 12, 13 and 14 respectively, and not same each other. But if the person sees the distorted images from the position of 1, 2, 3, 4 and 5 through convex lens, will give results as initial $a^1b^1c^1d^1$ in all position respectively. So the distortions of an object from various positions are different, but when seen from the respective positions through convex lens will give the initial view of the object.

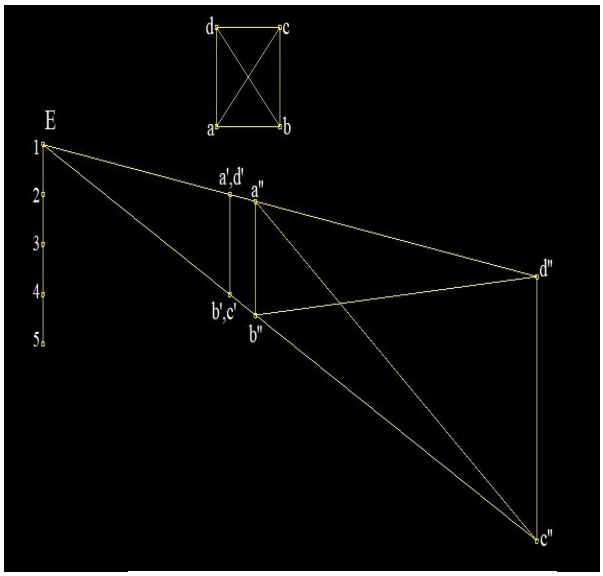

Fig. 12 A view of the square from 1.

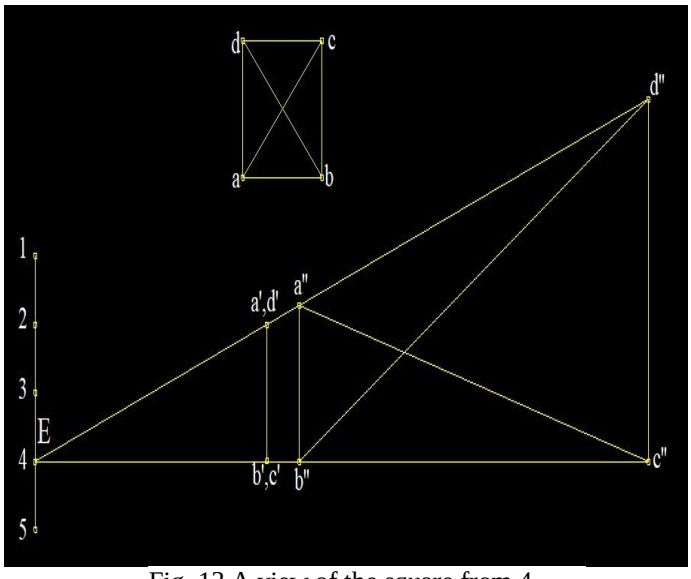

Fig. 13 A view of the square from 4

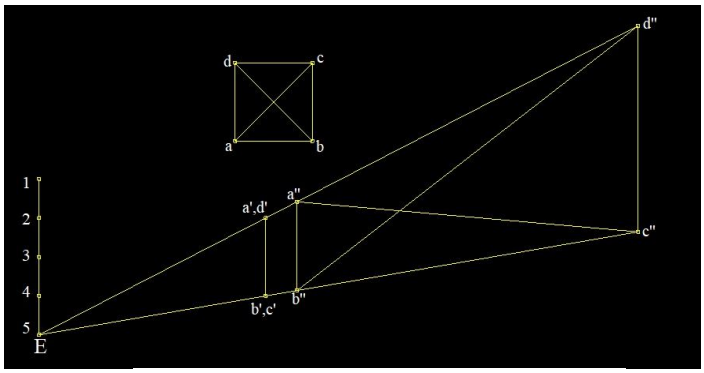

Fig. 14 A view of the square from 5.

II. CONCLUSION

The hierarchy of anamorphic projections from 464BC to till today was briefly presented along with the examples. Taken a regular square as an example, the anamorphic projections' geometry and image distortion from various positions were also presented. The distortions of an object from various positions are different, but when seen from the respective positions through convex lens will give the initial view of the object.

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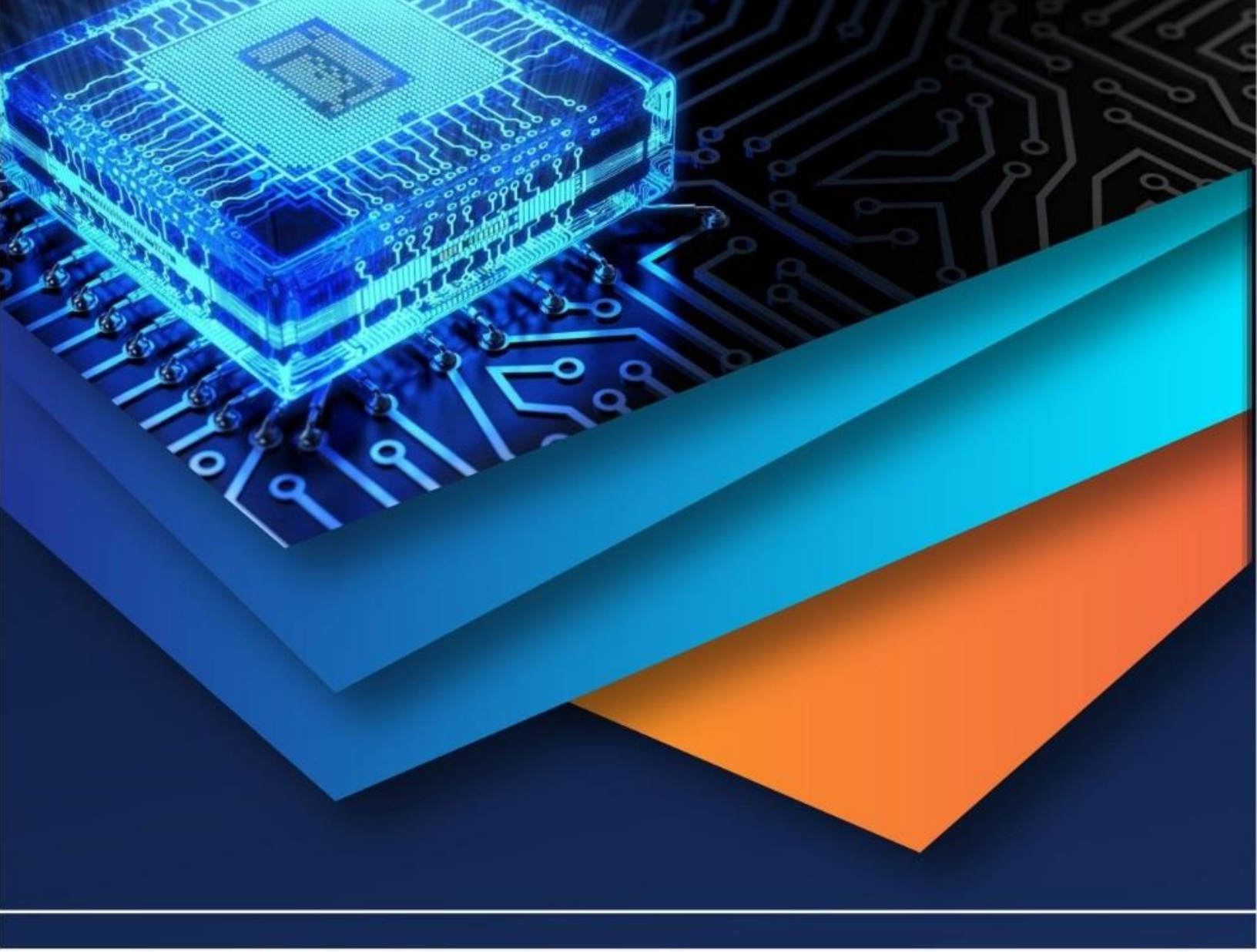

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