# Art and Science in the Renaissance: The Example of Geometric Features in the Work of Leonardo da Vinci

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**Abstract.** During the Renaissance, Leonardo da Vinci was hailed as a master of painting techniques and theories, and had a profound impact on the development of European painting. Studies have shown that the use of geometry is one of the central elements in Leonardo's painting technique. By combining art and science, he used the golden section and perspective to give his works a unique sense of order and beauty. This paper selects three masterpieces by Leonardo da Vinci, *The Last Supper*, *The Annunciation* and *The Mona Lisa*, as the objects of study, and explores in depth the geometric features embodied in these works. Through a detailed analysis of the composition, proportion, and spatial relationships in each artwork, this study reveals the close connection between science and art during the Renaissance. The research reveals that in his creative process, Leonardo employed mathematical principles and demonstrated a profound understanding and observational ability regarding the natural world. This interdisciplinary fusion not only enhanced artistic expression but also reflected the contemporary society's pursuit of an integrated knowledge system.

**Keywords:** Leonardo da Vinci, geometry, perspective.

## 1. Introduction

This study looks at the close links between art and science during the Renaissance, in particular by analysing the geometric features embodied in the works of Leonardo da Vinci, in order to explore the profound cultural transformations of the period. Mathematics played a crucial role in the Renaissance, a revival movement in which art was the main form of expression, and geometry was central to Renaissance artistic expression. This was an important era in the intersection of art and science, representing a dramatic shift in human thought. During this period, the boundaries between artists and scientists were blurred, and Renaissance artists were not only executors of paintings but also scientists and mathematicians, with deep scientific principles and geometric features embedded in many works of art. Through geometry and perspective, they broke the flat limitations of painting and introduced three-dimensional space into the two-dimensional canvas, giving their works realistic visual effects and profound ideological connotations. The Renaissance, as an important stage of cultural transformation in human history, not only reshaped artistic expression, but also laid the foundation for the rise of scientific thinking. This study is therefore important for understanding how art and science interacted with each other and jointly contributed to the process of intellectual development. This paper focuses on the geometric constructions and spatial representations in the works of Leonardo da Vinci, an outstanding representative of the period, and explores how they reflect the understanding and pursuit of the laws of nature at that time. In order to achieve this goal, the research adopts the literature analysis method, which is a systematic search and reading of relevant information and literature, and the advantage of this method is that it can deeply excavate the scientific principles and artistic conception behind Leonardo da Vinci's works, so as to reveal the multi-layered meaning of his works. The ultimate goal of the study is to reveal how Leonardo da Vinci achieved a perfect fusion of art and science through geometric features, and to explore the impact of this fusion on the Renaissance in order to contribute to a more comprehensive understanding of the cultural phenomena of the period. In order to achieve this goal, the study will analyse his representative works and seek to present the richness of the Renaissance by combining the historical context with the theoretical framework.

## 2. Historical Context

The word 'Renaissance' comes from the Italian word *Rinascimento*, meaning "regeneration" or "resurrection". After the long dark ages of the Middle Ages, Italian city-states rose to express new ideas and visions through the revival of ancient Greek and Roman cultural forms. Florence, the home of Leonardo da Vinci, became a center of Renaissance cultural change. The Renaissance art trend is known for its emphasis on naturalism and humanism. Artists gradually moved away from the religious strictures of the Middle Ages to explore the reality of human experience and the representation of the natural world. The Renaissance ignited a renewed interest in classical geometry among scholars, and one of them, Leonardo da Vinci, pored over numerous books on ancient Greek scientific knowledge [1]. The Soviet art critic Sokolov also said of Renaissance painting, "The art of painting had at that time produced masterpieces of genius, and even from the development of this art we shall see that it was to a great extent based on the use of mathematics." [2].

At the same time, the Renaissance witnessed the rise of Humanism, an intellectual movement that emphasised the value and potential of the individual. Drawing on classical texts from ancient Greece and Rome, humanism inspired artists to explore themes beyond the religious subjects that dominated medieval art. This shift fostered a broader exploration of the human experience, including personal portraits, mythological scenes, and depictions of everyday life.

The Renaissance, by reviving the culture of ancient Greece and Rome, fostered the rebirth of humanism and innovative thought, exerting a broad influence across various fields such as science, medicine, and technology. Between the 15th and 16th centuries, numerous creative geniuses emerged. Leonardo da Vinci, amidst the turmoil of war and political instability, absorbed all the influences of his time. Despite the social upheaval, this period remained a flourishing era for artistic and scientific ideas. In this context, Leonardo combined the scientific spirit of ancient Greece with the explorative ethos of the Renaissance, conducting in-depth studies of nature and making remarkable contributions to anatomy, military science, and perspective.

## 3. Leonardo's Mathematical Background

During the Renaissance, Italy was undergoing a cultural and scientific revival. Leonardo da Vinci (1452-1519) was born in Vinci and was deeply influenced by the classical culture and emerging scientific research of the era. In 1469, his father, Ser Piero, became a notary for the chief law-enforcement officer. Leonardo may have moved to Florence and entered the studio of the sculptor and all-round artist, Andrea Verrocchio, at that time or perhaps a little earlier [3]. In Andrea del Verrocchio's studio, Leonardo not only learned painting techniques but was also exposed to maths and science, which were popular then.

Archimedes' geometric principles notably impacted Leonardo da Vinci's scientific and artistic work. Archimedes' studies on circle areas, sphere volumes, and buoyancy underpinned Leonardo's investigations and were instrumental in his application of geometric perspective to achieve enhanced spatial realism in his paintings. He emphasized the importance of mathematics in scientific inquiry, famously stating in his notebooks, "Let no one who is not a mathematician read my principles." [4]. His manuscripts reveal extensive use of geometry in engineering designs, with sketches and schematics demonstrating the practical application of geometric concepts. This interdisciplinary approach highlights Leonardo's deep understanding and innovative use of geometry.

## 4. Analysis of Works

### 4.1. The Last Supper

#### 4.1.1. Geometry and composition

Leonardo's artworks exhibit not only exceptional technical proficiency but also an astute application of geometric shapes and mathematical principles within their compositions. The

integration of geometric forms, such as the golden ratio, in his compositions underscores his profound understanding of geometry and its application in art. He saw composition as the key to unlocking the idea of the work [5].

The golden ratio, also known as the golden section, is a proportion commonly observed in nature and art. Approximately equal to 1:1.618, it is considered one of the most visually harmonious ratios. In *The Last Supper* (Fig. 1), Leonardo employs the golden ratio to structure and organize the composition. The twelve apostles are grouped into four sets of three, arranged symmetrically on either side. The composition integrates both the golden ratio and triangular arrangements, with Judas positioned near the golden ratio point on the canvas (Fig. 2). This spatial organization subtly obscures the visual identification of Judas as the betrayer of Jesus. This approach is particularly intriguing, as it provokes speculation about Judas's identity, thereby infusing the composition with an element of suspense. It also enhances the narrative and dramatic intensity of the scene. Leonardo's application of the golden ratio achieves a natural aesthetic harmony in the visual composition, simultaneously enhancing the emotional expression and thematic emphasis of the work. This not only reflects his mathematical prowess but also demonstrates his profound understanding of the application of geometry in both art and technique.

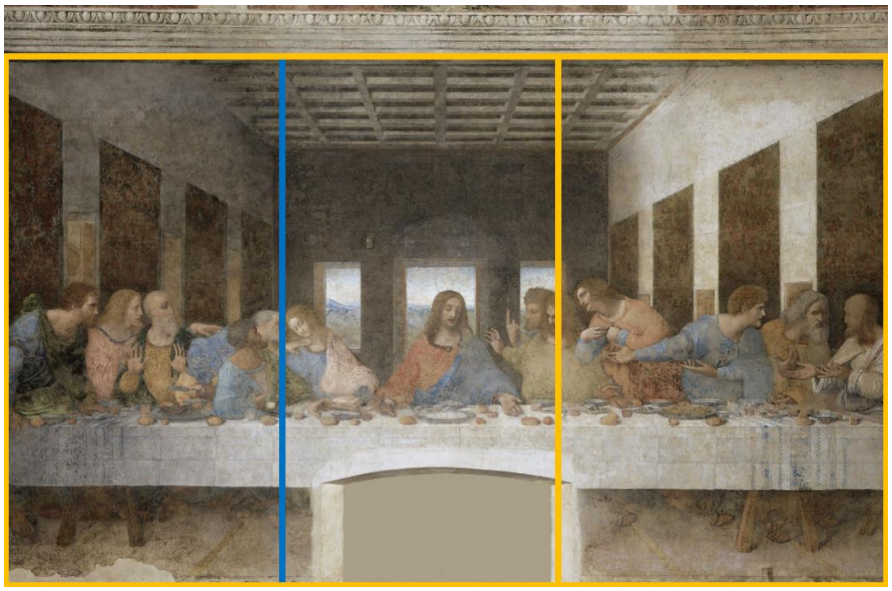

**Fig. 1** Leonardo, *The Last Supper*, 1495-98, mural painting, 4.6 x 8.8 m. Milan, Santa Maria delle Grazie.

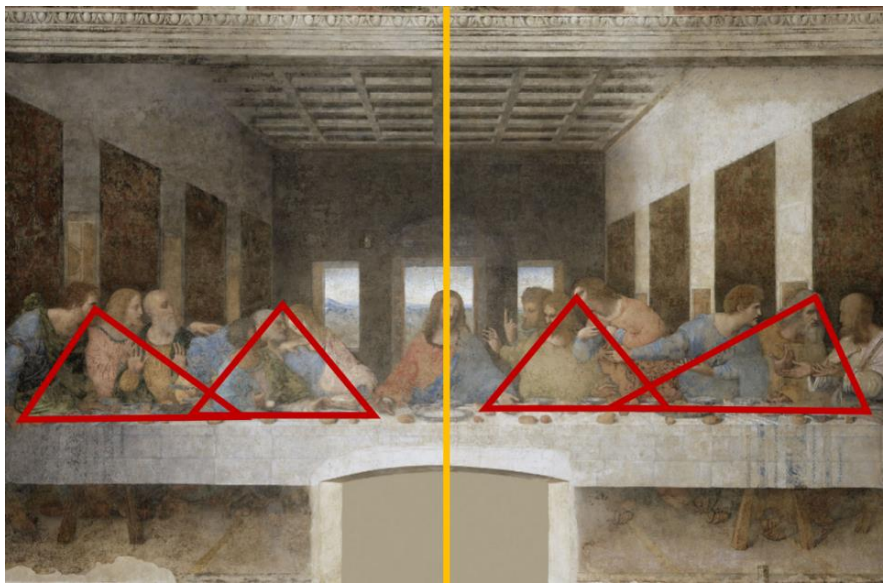

**Fig. 2** Annotated image1

### 4.1.2. The use of perspective

Leonardo's utilization of geometric shapes in his work is evident not only in the application of individual forms but also in the design of the overall spatial composition. He also used the term the law of nature, arguing that the appearance of a natural scene is governed by the laws of nature and that the painter should study and reveal these laws [6]. He employs perspective techniques in his painting, using geometric shapes as the foundation for constructing spatial depth. In *The Last Supper* (Fig. 3), Leonardo utilizes linear perspective to converge all lines of sight on Jesus, positioning Him at the visual centre and thereby directing the viewer's attention. In the composition, three windows are placed behind Jesus, with His outstretched arms forming a pyramid shape, the apex of which aligns with the central window. By employing a focal perspective, all lines of sight are concentrated on Jesus, while the flanking walls further reinforce and highlight the focal point of the perspective.

In *A Treatise on Painting*, Leonardo states: "Color does not change due to the air, but it will appear different to the viewer due to the sense of spatial distance." [7]. Thus, the atmospheric perspective was conceived. The concept of air, as related to perspective, had not been previously addressed in earlier studies of perspective, representing a fundamental conceptual breakthrough [8]. In *The Last Supper*, the depiction of the blue sky and white clouds through the windows employs atmospheric perspective, enhancing the sense of spatial depth. The view of the boundless landscape beyond the windows serves to amplify the perception of space within the composition. The integration of multiple perspectival techniques renders the scene more vivid, presenting a dramatically compelling tableau.

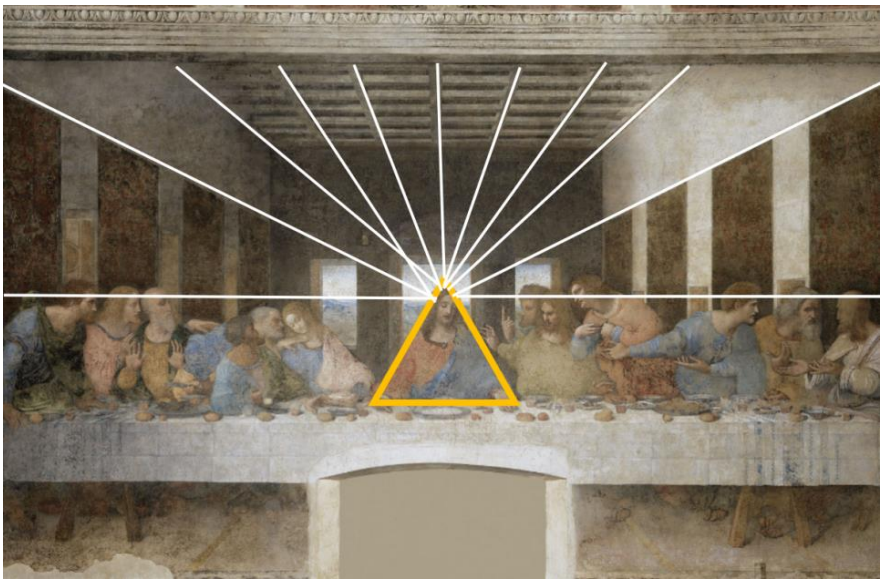

**Fig. 3** Annotated image2

## 4.2. The Annunciation

### 4.2.1. Geometry and composition

In Leonardo's *The Annunciation* (Fig. 4), his use of geometric elements demonstrates a high degree of artistic intelligence, constructing a harmonious and meaningful visual language. The entire work follows the principle of the golden section, forming an organic proportional relationship that subtly guides the viewer's visual experience. In the painting, the layout of the angel and the Virgin Mary presents an invisible diagonal line, a structure that not only strengthens the interaction between the two but also deepens the level of emotional communication.

The angel is located on the left side, with its body slightly leaning forward, its posture and the spreading of its wings forming a dynamic triangular structure, a design that emphasises the sanctity and importance of the angel. The design emphasises the sacredness and importance of the angel. Meanwhile, Mary is on the right side, and the elegant posture of her hands and the position of the desk fall on the golden section line, further attracting the viewer's attention and creating a visual balance and harmony.

**Fig. 4** Leonardo, *The Annunciation*, 1472 c. 90 x 333cm, oil on wood. Florence, The Uffizi Museum.

### 4.2.2. The use of perspective

*The Annunciation* is also a work created in perspective, and Leonardo's skilful use of perspective can be seen in the painting. Through rigorous perspective, he intersects the lines in the picture in a vanishing point in the picture, as can be seen in the work (Fig. 5), the building on the right side of the picture appears very realistic, drawing the bricks, the floor, the windows and even the book in the Virgin's hand with lines, which creates a very typical perspective image, a method by which the picture appears to have a very clear sense of space. In the background of *The Annunciation*, it can be observed that elements such as trees and mountains do not follow the same rules of perspective, but rather employ the technique of air perspective. The colours of the near objects are distinct and separate, gradually adding a hazy blue hue as the objects move deeper into the frame. For example, flowers, trees and buildings far away from the foreground gradually approach the light blue of the sky, especially the farthest mountains, whose silhouette borders are faded and whose colours merge with the sky. This blurring of the contrast between near and far not only makes the characters and things in the near distance seem more real and concrete, but also enhances the infectious power of the picture.

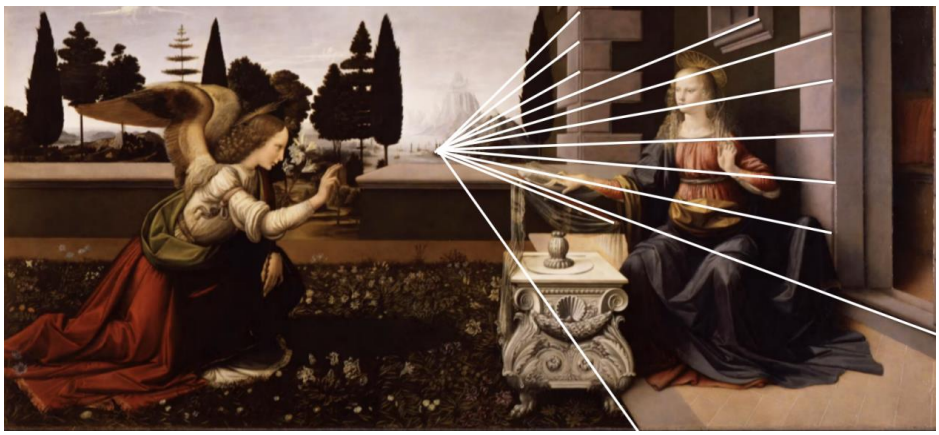

**Fig. 5** Annotated image3

## 4.3. The Mona Lisa

### 4.3.1. Geometry and composition

In terms of geometric compositional layout, *The Mona Lisa* (Fig. 6) adopts the compositional rule of the golden rectangle, in which Leonardo da Vinci broke the constraints of the traditional side view of portraiture. By twisting Mona Lisa's body to a quarter angle, the image not only enhances its dynamism, but at the same time brings the focus up. In addition, the overall composition of the picture presents a pyramidal structure, giving the Mona Lisa a dignified air. This unique geometric compositional technique of static presentation of the inner world of the figure in a dynamic twist demonstrates Leonardo's innovation and profundity.

In analysing Leonardo da Vinci's *The Mona Lisa*, particularly its unique composition in the eye region, one can observe the distinctive application of the golden ratio (Fig. 7). The division between the outer and inner corners of the eyes contributes to a remarkable sense of harmony throughout the overall composition. This design strategy reflects Leonardo's deep understanding of aesthetic principles, he combined mathematics and art, through the application of the golden section, to create a visual balance and harmony, the proportionality of the eyes in the painting makes the image of *The Mona Lisa* both vivid and hierarchical, which not only enhances the mysterious temperament of the character, but also guides the viewer's eyes, naturally focusing on the main body, further enhancing its emotional expression and artistic influence.

**Fig. 6** Leonardo, *The Mona Lisa*, 1503-1519, 79.4 x 53.4cm, oil on wood. Paris, Louvre.

**Fig. 7** Annotated image4

### 4.3.2. The use of perspective

Leonardo's *The Mona Lisa* is not only known for its delicate artistic style and mysterious smile but also profoundly reflects his in-depth exploration and philosophical thinking about nature and science. Kenneth Clark writes of *The Mona Lisa*: "Scientific knowledge, painting skill, fascination with nature, and inner insight all meld together and are so seamlessly balanced that at first we hardly realise they are there." [9]. The tiny curls of hair in the painting are similar to the dynamics of the landscape behind, symbolising the cycle of nature and the continuation of life. Leonardo's use of air perspective and occultation perspective makes the boundaries between the objects in the picture and the background gradually blur, thus creating a harmonious visual effect and enhancing the realism and spatiality of the work. This treatment made mountains, rivers, and the sky merge into one as if the elements of nature were intertwined in his artistic expression. Modern scientific analyses show that Leonardo reproduced the blurring effect of vision through the technique of halo-painting, restoring the blurring of vision itself to the object, as only such a treatment can bring about the true "relief" of the object seen by the eye [10]. This reveals the nature of vision and the mystery of illusion.

## 5. Influence of Leonardo's Geometry on Artistic Expression

During the Renaissance, Leonardo da Vinci profoundly influenced the way art was expressed through geometric principles such as the golden section and perspective. These geometric features not only bestow a sense of harmony upon the work but also enhance the perception of space and depth, rendering the image more lifelike and three-dimensional. The application of the golden ratio

achieves a visual balance among the various elements, while the principles of perspective allow the viewer to experience a natural extension of space during observation. Leonardo's exploration not only promoted technical innovation in artistic creation but also fostered a close connection between art and science. This provided an important theoretical foundation and practical example for future generations of artists. It can therefore be said that Leonardo's geometry is not only a formal embodiment in his artworks but also a profound interpretation of the spirit of the Renaissance, highlighting the infinite possibilities of the intersection of science and art.

## 6. Conclusion

This study reveals Leonardo da Vinci's ability to employ mathematical principles and geometric constructions in his artistic creations. It provides a concise overview of the contextual backdrop of his era and his personal experiences, coupled with an in-depth analysis of the geometric features present in three of his masterpieces. This analysis demonstrates Leonardo's mastery of perspective, proportion, and spatial composition and illustrates his ability to merge scientific methodology with artistic expression. Thus, his works showcase a unique fusion of aesthetics and rationality. Furthermore, it concludes that Leonardo was not only an exceptional artist of the Renaissance but also a pioneer of scientific thought. His works reflect a profound understanding of humanity's relationship with the natural world during that historical period and highlight the significance of nature in artistic expression at that time. This study provides many valuable references for future research in related fields. It not only provides art historians with a new perspective to understand the scientific logic behind artistic creation, but also shows historians of science how art plays a role in scientific discovery and technological progress. Particularly in today's world, interdisciplinary research is increasingly valued. This study emphasises the interactive relationship between art and science, which influences the discourse on the integration of knowledge systems. Therefore, future research should focus more on exploring the intersections between different art forms—such as painting, sculpture, and architecture—and scientific theories, especially concerning how modern technological approaches can re-examine the scientific content inherent in historical artworks. In addition, the works of other Renaissance artists can be further explored to analyse how they incorporated scientific ideas into their respective creations, which will provide a more comprehensive framework for understanding the historical evolution of art and science, and inject new inspirations and methodologies into contemporary art practice.

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