

Design Intention of Scientific Elements in Vitruvian Man

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Abstract: These great works of art, produced during the Renaissance, in this day and age, has never failed to arouse huge debates among people. In order to create more satisfying fine artworks, some artists started to research science and left abundant related remains. As one representative artist, Leonardo da Vinci did many experiments or drew sketches that had relationships with science. Leonardo da Vinci was one of the most representative and influential artists of the Renaissance who had the most extensive knowledge base. He was not only a painter, cartographer, inventor, anatomist, but also a musician and philosopher. His achievements in anatomy were far greater than his achievements in engineering, invention and architecture. The precise sketch of the human body and related notes were stricter and more accurate than previous achievements in this regard, especially *Vitruvian Man* which represented the perfect human body. After the publication of the *Vitruvian man*, the exquisite proportion and harmony displayed have been well-liked by the world and passed down from each generation. Not only that, *Vitruvian Man* has also become one source of inspiration for modern artists and writers. By clearly analyzing this painting through anatomy and geometry, more conclusions could be derived. *Vitruvian man* points out the meaning of the figure itself is often used as the hidden symbol of the basic symmetrical characteristic of the human body's structure, and then as the hidden symbol of the whole universe.

Keywords: geometry, golden ratio, Vitruvian Man

1. Introduction

During the Renaissance, artists and scholars became increasingly interested in classical history, that is, the art and ideas of ancient Greece and Rome. This desire to look backward went hand in hand with a new spirit of inquiry, as new theories about man and nature were developed and new artistic techniques and forms were invented. This is a period of great changes in the status of artists. In the Middle Ages, artists had been considered manual laborers, of low social status. During the 15th and 16th centuries, as artists insisted on the intellectual value of their works, their status in society began to change. One of the most important reasons is that they participate in what we now call "science". Part of the way they study science is through dissecting dead bodies, building machines, making geometrical diagrams, etc. They also read many ancient books on these subjects: Galen, on medicine; Euclid, on geometry, Pliny on natural history and so on. By doing abundant scientific works, in their eyes, artists could complete the works more precisely and they could better comprehend nature or animals through detailed research, especially by drawing human bodies through anatomy.

Accordingly, scientific elements in Renaissance works of art could be considered as a signal of the art in the society during that period, which follows the development of human activities as well. *Vitruvian Man* drawn by Leonardo da Vinci is one of the most famous and studied drawings in the world all the time, which includes many scientific elements. Although there is much scientific knowledge related to the *Vitruvian Man*, there are still several noticeable and representative scientific features. Recent literature research shows that many current concerns are related to geometry or anatomy. The goal of this thesis is to discuss some of those specific scientific features, such as geometry and anatomy in the *Vitruvian man*, through his approaches to drawing, which implies the strictness with which Leonardo da Vinci created this painting.

This paper, precisely, has three main sections. The first section demonstrates the origins of the *Vitruvian Man* that could be traced back hundreds of years, the present situation of this drawing and a brief description of the content of the *Vitruvian Man*. The second section outlines in detail how two main scientific concepts related to this artwork: geometry, which could be separated by two specific parts and anatomy. Those detailed designs of this work imply the goal and the reason for creating the *Vitruvian Man*: the perfect human body and the relationship between man and the universe. The last section of this paper features the conclusions and its limitations, which provides suggestions for further research as well.

2. Leonardo da Vinci's *Vitruvian Man*

Vitruvian Man drawn by Leonardo da Vinci is considered a sample of the perfect human body in the Renaissance. This painting is stored in the Gallerie dell' Accademia in Venice, Italy, and is sometimes displayed [1]. Leonardo da Vinci tries to research the relationship between man and nature through the great combination of mathematics concepts and art forms, which is his goal and inherent in the symbolic significance of the *Vitruvian Man* [2]. This painting includes many rigorous details, which constructs the bridge between art and science.

2.1. Ten Books of Architecture

This painting was inspired by Marcus Vitruvius Pollio, a Roman architect [3]. After winning the war, Caesar Augustus decided to rebuild the seriously damaged city of Rome. He firmly believed that the most stable urban design in the world needs to be harmonious like the perfect human body. Consequently, Marcus Vitruvius Pollio recorded one of his most important contributions in the *Ten Books of Architecture*: the research on the proportion of the perfect human body. His final research results include as the foot is one-sixth of man's height, the height of the body as expressed in a number of feet being limited to six, they held that this was the perfect number, and observed that the cubit consisted of six palms or twenty-four fingers... [4] By doing this, Leonardo da Vinci drew a perfect human body, *Vitruvian Man*, based on Marcus Vitruvius Pollio's conclusion.

2.2. *Vitruvian Man*

In this painting, Leonardo da Vinci draws a triangle and a square with a compass which is tangent to the bottom of the circle on the graph. The person in the painting stands on the square, with his arms extended horizontally and touching the square frame. Precisely, his navel is the center of the circle on the graph, and his lower body is the center of a square. At the bottom of the manuscript, Leonardo da Vinci makes detailed notes to illustrate the painting as well. By extending one's legs to the maximum extent and raising two arms until the middle finger is flush with the top of the head. Also, the center of the crossing of the extended limbs is the navel, not to mention the area between two legs could be seen as an equilateral triangle [5].

3. Science in *Vitruvian Man*

3.1. Geometry

3.1.1. Geometrical Patterns

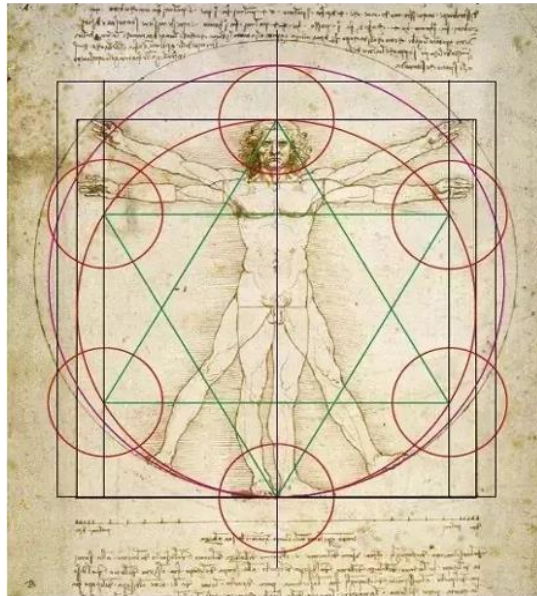


Figure 1: Mathematical Analysis of the Vitruvian Man [8].

Symmetry and harmony are the characteristics of this painting. With the help of connecting lines, circles, triangles, quadrilaterals, pentagons, equilateral triangles, etc could be found obviously in the human body (see Figure 1). According to Figure 2, the sideline on the lower part of this square is circumscribed to the whole circumference. That circumscribed point is also at the middle position of this sideline. This body stands in one range where the square coincides with the circle. Obviously, the vertex of the head is tangent to the upper sidelines of the square, while the tangent point is exactly the midpoint of this sideline. In addition, the two feet of the person are close to this tangent point between the circle and the lower side of the square. His trunk is, precisely, perpendicular to the sides of the square, with the two hands extended 180 degrees. All fingertips of the two hands just separately reach the right and left sides of this square and are perpendicular to them [6]. In this way, the second posture of this human body in this painting has the feet separated at some angles and the sole of the foot that intersects with the circle. In the painting, the man raises his hands to the intersection of the upper edge of the circumference and the square, which reaches the same height as the head. The whole human body, no matter the first posture or the second posture, appears extremely symmetrical both in the circle and square [7]. His first posture includes his body with legs and arms standing straightly, while the second posture demonstrates that the man raising his arms and his legs are separated by a certain distance.

These two postures (see Figure 1) have a sense of movement, such as the movements of gymnasts. To be exact, this posture looks like a person's arms swinging up and down, which is similar to a bird's wings. Those lines of the human body are accurate and simple, the man's face is painted very deep, and the shadows are more eye-catching. The eyes are straight ahead. Besides the contours of the human body, what's more, there are some accurate tangents sketched on the limbs and trunks, while those tangents are sketched on some key parts of the human body: tangents of the trunk are respectively between the genital root, the knee joint, the chest (tangents intersect with two nipples) and the two shoulders. In the posture of extending both hands horizontally, tangent lines are also

drawn on the wrist joints, elbow joints and shoulder joints of both hands. Undoubtedly, those tangents are the perfect dividing lines of the human body so as to demonstrate some characteristics of the regularity of structures of human bodies.

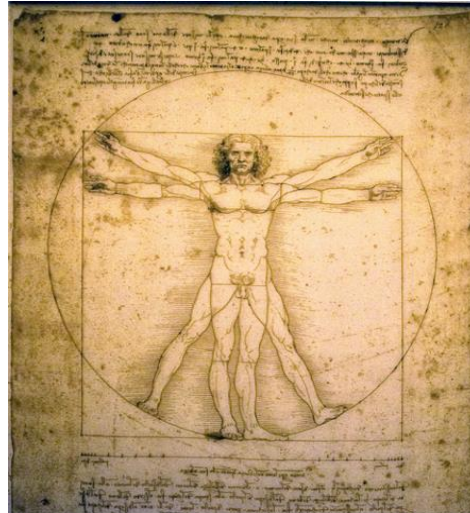


Figure 2: The Vitruvian Man, pen and ink [3].

In conclusion, one of the charming points of this painting is the accurate relationship between abstract geometry and observed physical reality. By analyzing this great painting, although merely a few main parts of the body are painted, the total outline is still beautiful, and the muscles of the body are developed. The human's foot seems to have stepped on the bottom of the square, or the reverse arc.

3.1.2. Golden Section

Vitruvian man is also based on Leonardo da Vinci's most accurate men, the "perfect proportion" that is mathematically called the golden section. As early as the sixth century BC, the ancient Greek mathematician Pythagoras discovered the existence of a harmonious beauty in this state of division. Later, the ancient Greek aesthetician Plato formally called this the law of Golden Section and was always regarded as the best proportion. It was this magical golden divide that became the proportional rule for Leonardo da Vinci's *Vitruvian man*.

When a square with height and side equal to H and a circle with radius R (centred at the navel) is added to the image of the 'Man standing', the ratio H/R comes to $1.70 - 1.72$. This is significantly higher than the $1.64 - 1.65$ range identified in Leonardo's drawing (see the comparison in Figure 3-right), and is substantially greater than the golden ratio value ($\phi = 1.618$). Accordingly, the claims that Leonardo would have used the golden section to determine the dimensions of the square and the circle in circumscribing the man according to Vitruvius's canon is likely to be based on expectations derived from either inaccurate measurements or approximations.

The reason why Leonardo would have not used a value for the H/R ratio closer to ϕ is rooted in the requirement for the fingertips in the raised arms position to be able to touch concurrently the circle and the square, while fulfilling the self-imposed stringent condition that these should be aligned with the crown of the head, as well as ensuring that the fingers retain the capability of contacting the lateral sides of the square in the stand-still posture [6].

The theory underlying Leonardo's drawing is that the "ideal man" (*homo bene figurations*) will fit simultaneously in a circle and a square when the arms are stretched out, so that the middle fingers are aligned with the crown of the head, and the legs are opened to an extent to form an equilateral triangle.

Therefore, in Leonardo's theory, the proportions of the human body are seemingly adjustable parameters, which could perfectly satisfy the conditions shown by the design of the drawing [6].

A scientific interpretation for the right-angle position of the foot in the square of Leonardo's drawing would regard the concurrent angulated posture as a biomechanics requirement for the foot to rotate. The related movements are presented in Figure 3 (left) and represented as a vector diagram in Figure 3 (right), which he may have intuitively used as a concept to account for the discrepancy in the angles swept by the two legs. It can be argued, however, that Leonardo chose the angulated posture of the foot on the right side of the drawing to alleviate the unbalance created by the angular dissymmetry inherent to the opening of the legs, which can be inferred from the observation that the uppermost protrusion of the toes on the two sides has been placed at the same altitude [6].

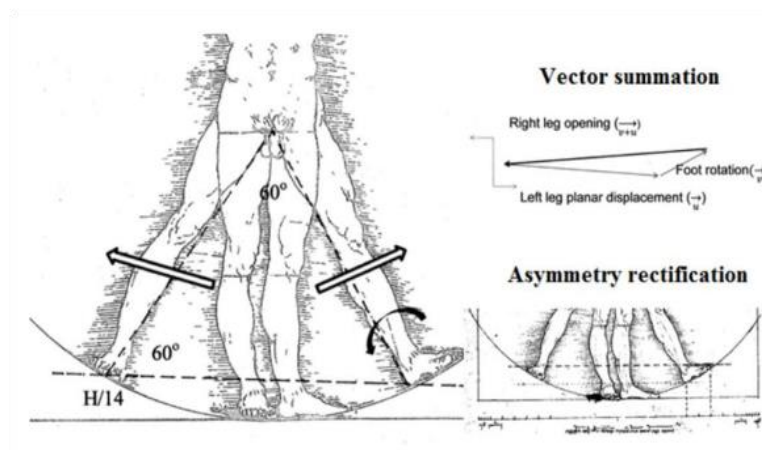


Figure 3: Analysis of the Vitruvian Man [6].

Note: Left: Planar opening of the two legs with angular rotation of the left foot and resulting inclination of the base;
 Right(top): Vectorial representation of the movements of the legs and retardation angle for the planar opening of the left leg relative to the right leg;
 Right(bottom): Alignment of upper contours of toes to redress the asymmetry arising from the difference in the amplitude of the displacement of the two legs.

3.2. Anatomy

In the first Florence period, Leonardo da Vinci began to do anatomical research as the basis of painting. Around 1440, he systematically measured the head, trunk and limbs of bodies. He improved and supplemented the data of Vitruvius on this basis. The first part of the Vitruvian man specifies as a similar meaning [6].

Many manuscripts are pieced together through the bones and simplified limb scale maps of the same period, as well as several drawings of the Vitruvian man drawn by Carlo Urbino of the same generation, showing the process of Leonardo da Vinci and his colleagues' generation artists studying anatomy and human body scale, and finally pointing to his Vitruvian man. Bertley pointed out that the Vitruvian *man* was a summary of Leonardo da Vinci's research results. Leonardo da Vinci put the conclusions of all previous studies on the human body, including harmonious and accurate body proportions [8].

The combination of two positions of the arm and leg in this painting creates distinctively different poses with the help of the same square and circle. Through conveying the concept of motion, Leonardo da Vinci successfully tries to integrate much more than one static principle of proportion. According to this painting, the micro visible compass marks could also show that the human body is based on measured intervals, instead of polygons or the other geometrical figures that were often imposed on similar images [9, 10].

4. Conclusion

By strictly analyzing the geometrical patterns, the golden ratio and Leonardo's previous preparations on anatomy to finish this work, it could be safely concluded that Leonardo greatly devoted his efforts to creating this perfect human body. This drawing seems to be a perfect interpretation of the above abstract symmetry laws of biological geometry, which represents an ideal humanism spirit, praises the dignity, value and rational thinking of individuals, and stands at the intersection of the human and the universe.

The keyword which unites all universe is art—the art of building, cultivating, etc. As a tentative art, by being used in people's daily lives, which makes it much easier to comprehend. Especially from its analytical processes, certain parts of reality and art are absorbed in learning. This greatly shows the definition of what people are and the motivation that moves their lives, not to mention some difficult parts that people are not able to completely understand. All things are forms of art in different ways, for example, accumulated experiences and the art of livings in their differentiated dimensions.

All important points of the universe are inseparable from two things: arithmetic and geometry. Geometry is like a static moment, showing a universal and continuous movement beyond the time limit that is not known to human senses.

The reason why geometry is "mysterious" has been misunderstood by the outside world since ancient times. Some people think that the ancients were not intelligent enough and lacked precise thinking. When they saw geometric figures that could create order by bisecting lines, they thought it was "magic"; some people also think that geometry is related to the worship of blood sacrifice and the architecture of appeasing gods. However, Leonardo da Vinci thought that geometry is the way to study how the universe generates order and maintains it. Therefore, this gives geometry a sense of mystery that is hard to comprehend.

Admittedly, even the analysis of the Vitruvian Man described in this paper has achieved its aims, the author has awareness of its limitations, which may make positive contributions to further research projects. Firstly, some measurements of the perfect human body have demonstrated that the measurement in this drawing is not exactly precise since humans' body structures have changed over the period. Secondly, it would be beneficial to further research to what extent the perfect in Vitruvian Man could be developed by architects in building the church, which is the original goal to design this human body by Vitruvius. This, undoubtedly, could be considered as the starting of future research projects.

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