A Study on Mathematical Beauty of the Phra Buddha Chinnarat in the Aspect of Golden Ratio

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Abstract

This research aims to study the mathematical beauty of the Phra Buddha Chinnarat using the golden ratio concept. The image resolution of Phra Buddha Chinnarat in this research is 2,160 x 2,880 pixels, measures the various parts compared to golden ratio variations using Atrise Golden Section software for Windows. The Result found that the various parts are proportional to the golden ratio in many forms such as the golden ratio between two straight lines, a golden spiral, a diagonal of a golden rectangle and a golden triangle. This can be included that the mathematical beauty of the Phra Buddha Chinnarat, which appeals to the viewer, is proportional to the golden ratio in many forms.

Keywords: Phra Buddha Chinnarat, Mathematical Beauty

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาความงามขององค์พระพุทธชินราชในมุมมองเชิงคณิตศาสตร์โดยอาศัยแนวคิดของอัตราส่วนทองคำ ดำเนินการวิจัยโดยศึกษาจากภาพถ่ายที่มีความละเอียดของภาพ 2,160 x 2,880 พิกเซลและทำการวัดส่วนต่างๆเพื่อเปรียบเทียบกับอัตราส่วนทองคำใน รูปแบบต่างๆโดยใช้โปรแกรมสำเร็จรูป Atrise Golden Section สำหรับระบบปฏิบัติการวินโดวส์ ผลการศึกษาพบว่าสัดส่วนต่างๆขององค์พระพุทธชิน ราชที่วัดได้ล้วนสอดคล้องกับอัตราส่วนทองคำในรูปแบบต่างๆ เช่นอัตราส่วนทองคำระหว่างเส้นตรงสองเส้น อัตราส่วนทองคำของเส้นโค้งรูปเกลียว หอย สี่เหลี่ยมทองคำ และสามเหลี่ยมทองคำ เป็นต้น ดังนั้นจึงสรุปได้ว่าความงามในเชิงคณิตศาสตร์ขององค์พระพุทธชินราชที่ทำให้เกิดความ ประทับใจกับผู้ที่พบเห็น มีความสอดคล้องกับอัตราส่วนทองคำในหลากหลายรูปแบบ

คำสำคัญ: พระพุทธชินราช ความงามในเชิงคณิตศาสตร์

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1. Introduction

Mathematics education in Thailand often learns from documents or texts from abroad. Most of the example, information or materials came from overseas. Most of Thai high school students often learn mathematics by focusing or emphasizing on memorizing, calculating or solving problems rather than understanding. Their aim was for the exam or study in the university rather than continuing the knowledge or practical application in real life. Most people tend to understand that mathematics is the science of calculation. Art beauty and religion may, at first, seem to be very differing things from mathematic. Understanding of person's wrong belief that caused by emotion, cannot be converted or measured or compared in numerical format depending on factors such as the different perspectives on the concepts of knowledge. In fact, mathematics is indeed related to everything in life.

The aim of this study is to research and integrate a simple mathematical knowledge to the subject of art including beauty and religion. It suggests that art and beauty scenes can be described using mathematics. Even though it may not be able to explain everything, but some idea to approach or understand the relationship between the beauty of art and mathematics can be obtained. In order to understand this research, the concepts of a golden ratio, Fibonacci sequence, beauty in mathematics and The Phra Buddha Chinnarat are summarized briefly as follows.

The golden ratio, also known as Golden Number, Golden Proportion, Golden Mean, Golden Section, Divine Proportion and Divine Section is an irrational mathematical constant whose value equals to $(1 + \sqrt{5})/2$ or about 1.618…which often encountered when taking the ratios of distance in simple geometric figures, represented by the Greek letter φ (Phi). The study and application of the golden ratio have long been known. The ancient Egyptians used the golden ratio to design Great Pyramids. Phidias, sculptor and Greek mathematicians studied and applied phi to the design of sculptures for the Parthenon. Plato, Greek philosophers, theorized about the golden ratio and believed that it is a key to the scheme of the universe to relate between mass and mathematics. Euclid wrote about phi in "Elements", referred to as dividing a line at the 0.618…, and linked this number to the construction of a pentagram.

It was written by Euclid in "Elements" around 300 B.C., by Luca Pacioli, a contemporary of Leonardo Da Vinci, in "De Divina Proportione" in 1509 by Johannes Kepler around 1600 and by Dan Brown in 2003 in his best-selling novel, "The Da Vinci Code". With the movie release of the "The Da Vinci Code", the quest to know Phi was brought even more into the mainstream of pop culture. (Meisner, 2015)

The golden ratio has been associated with beauty and many things. (Marquardt, 2014). A study by the beauty of the face shapes beautiful person of each era. It was found that facial skeleton is beautiful all the time that is consistent with the Golden Mask. If you study in depth on Phi, you can see that Phi looked like a door to understanding life and the universe. The study of this proportion opened the door to a deeper understanding of beauty, spirituality in life and human history including the universe.

The Fibonacci numbers or Fibonacci sequence was discovered around 1200 AD, named after Italian mathematician Fibonacci. His book, "Liber Abaci", introduced the sequence to Western European mathematics, although the sequence had been described earlier in Indian mathematics. The Fibonacci numbers are the numbers in the following integer sequence: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, … or 1, 1, 2, 3, 5, 8, 13, 21, 34, … and by definition, the first two numbers in the Fibonacci sequence are either 0 and 1, or 1 and 1 and each subsequent number is the sum of the previous two. In mathematical, the F_n of Fibonacci sequence is defined by the recurrence relation $F_n = F_{n-1} + F_{n-2}$.

The Fibonacci numbers are intimately connected with the golden ratio; for example, considering the ratio of two successive numbers in this sequence divide each by the number before it. The ratio seems to approach a particular value, which we call the golden ratio. For example, two numbers 233 and 377 are the member of Fibonacci sequence which is adjacent and the ratio of 377:233 is about 1.618.

The Fibonacci numbers often appeared unexpectedly in mathematics such as a golden rectangle, a golden spiral and a golden triangle. If we have a 1 by 1 square and add a square with side lengths equal to the length with longer rectangle side, then what remains is another golden rectangle. This could go on forever. We can get bigger and bigger golden rectangles, adding off these big squares, as shown in Figure 1.

Figure 1 A golden rectangle.
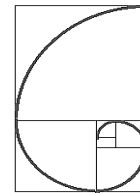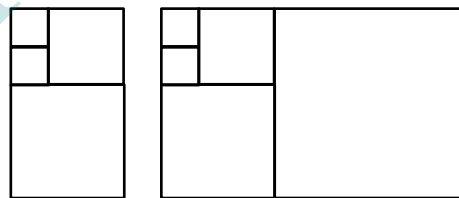
Figure 2
A golden spiral.

Figure 3
A golden triangle.

The golden rectangle has been known since antiquity. It appears in nature and is used by humans in both art and architecture as a rectangular shape that seems right to the eye. From Figure 2, the golden spiral above can be constructed by drawing a spiral curve through the opposite corners of two adjacent squares in the golden rectangle. If you take one point, then a second point one-quarter of a turn away from it, the second point is Phi times farther from the center than the first point. The spiral increases by a factor of Phi. The golden triangle is an isosceles triangle in which the duplicated side is in the golden ratio to the distinct side, as shown in Figure 3.

When we talk about beauty, most people understand that beauty is similar or vary based on individual experience. The ancient Greeks, for their part, were convinced that an explanation of, and definition for, Beauty was as concrete and discoverable as the answer to why the days got shorter in winter or why your toga weighed more after you'd gone swimming in it. Indeed, no less a thinker than Pythagoras, he of hypotenuse fame, logged some impressive early results. In music, Pythagoras showed that the notes of the musical scale were not arbitrary but reflected the tones produced by a lute string -or any string- when its length was subdivided precisely into such simple ratios as 2:1 or 3:2. In architecture and design, similarly, he managed to show that the shapes' people found most pleasing were those whose sides were related by the so-called golden ratio. (Bruno, 2007)

Each person may provide a different definition of beauty depending on the perspective, experience or knowledge that is difficult to explain what beauty is because it recognizes with a soul. However, the beauty of mathematics is significantly larger than that. (James, 2014) Brain scans showing a complex string of numbers and letters in mathematical formulae can evoke the same sense of beauty as artistic masterpieces and music from the greatest composers. Neuroscience cannot tell you what beauty is, but if you find it beautiful where the medial orbitofrontal cortex is likely to be involved, you can find beauty in anything.

Bertrand Russell expressed his sense of mathematical beauty in these words: "Mathematics, rightly viewed, possesses not only truth, but supreme beauty - a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than Man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as poetry." (Russell, 1919)

Most people feel that the beauty of things is abstract but in the aspect of mathematic sometimes are abstract. If we consider about beauty in view of mathematics, it can be classified in many forms such as
- Beauty in the perfect proportion, by the concept of golden ratio.
- Beauty from putting many pieces together to shape a new one, by the concept of tessellation.
-Beauty in theories, methods and results, causes of its systematic, methodical, simple and clear.
- Beauty in the graph that plots a mathematic equation and so on.

The Phra Buddha Chinnarat is a bronze-casted statue, images the posture of subduing mara, widely considered the most important, famous, beautiful and revered Buddha figures in Thailand. The statue's unique feature is framed by a huge halo resembling a flame that signifies the spiritual radiance of the Lord Buddha. It then became an influence on Buddha images in later years. The statue was coated with gold by King Ekatotsarot in 1388.The Phra Buddha Chinnarat has been hailed as an example of the Buddha Sukhothai art which enshrined the cathedral's west side at Wat Phra Si Rattana Mahathat (temple) along the eastern side of the Nan River, Phitsanulok which has been major since the Sukhothai period. However, no evidence was on the year it was built but presumably built during the Dlamini reign (from 1890-1911 BC).

Considering the beauty of Phra Buddha Chinnarat in the aspects of art. The aesthetic appearance of the Buddha is several such as
- Beauty of the curve between left and right relationship and up to the halo, the arch frame lines designed to blend harmoniously with the outer perimeter of the Lord added visual dimension.
- Beauty of the sitting posture in subduing mara posture according to the story of Buddha's life, causing an isosceles triangle. The structure is solid and beautiful which highlights the stability and indicated the path that leads to salvation.
- Beauty is caused by the weight of Buddha sitting on a lotus petal design which lines and shapes created a sense of light and weightlessness.
- The beauty of the colors and objects with a shiny surface in a black background created beauty in the shape and weight including highlighting the Lord's more elegant distinctive look.
- The beauties of the space between the right arm, body and arch frame causing visibility through the rear are clear and not opaque. (Samaporn, 2008)

2. Objective

This research aims to studies on the mathematical beauty of the Phra Buddha Chinnarat using the golden ratio concept.

3. Materials and methods

The Phra Buddha Chinnarat statue is about 2.875 meters in width and 3.50 meters in height. The statue is very important in which the whole country respects. One would not be appropriate to measure from the Lord therefore this research uses the image from Wikipedia (https://th.wikipedia.org/ Buddha) with a resolution of $2,160 \times 2,880$ pixels.

To study mathematical beauty using the golden ratio concept, we use the Atrise Golden Section for Windows to reduce the errors of measurement. This program allows bypass of the routine operations, calculator compilations. We can see and change the harmonious forms and sizes while being directly in the process of working and the precision is also available. The program offers easy methods of achieving sizes with accuracy to the nearest pixel. It uses a principle of building a grid of vertical and horizontal lines, with snap to design. The grid can be easily moved and reformatted into the required size or form which the golden ration is used by default.
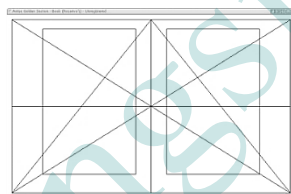
This software provided a variety of form of the golden ratio to compare such as present in Figure 4,5,6 and 7.
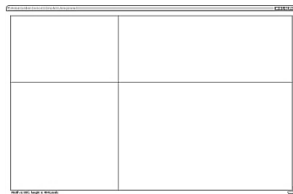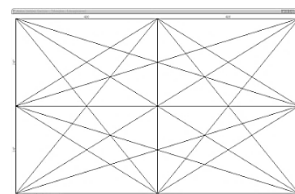

Figure 4 A golden ratio between two straight lines.
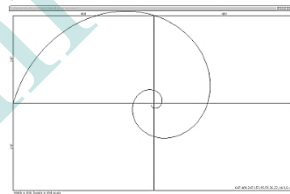
Figure5 A golden spiral (shell-shaped curve).

Figure 6 A diagonal of a golden rectangle.

Figure7 A golden triangle and a diagonal of golden rectangle.

4. Results and Discussion

After we used the Atrise Golden Section to crop and measure the image of the Phra Buddha Chinnarat. We could compare the size of the image with the statue as shown in Table 1.

Table 1 Comparing the size of the image with the Phra Buddha Chinnarat statue.(1 pixel: 0.435 centimeters).

|	Height	Width	Height/Width
The real statue (centimeters)	350.0	287.5	1.217
The real statue (pixels)	804.6	660.9	1.217
The image size measured by program (pixels)	800.0	665.0	1.203
%Error	0.57	0.62	1.150

The Phra Buddha Chinarat's image has measured the length of parts to find the golden ratio using the software. It was found that there were many parts satisfying a golden ratio as follows:
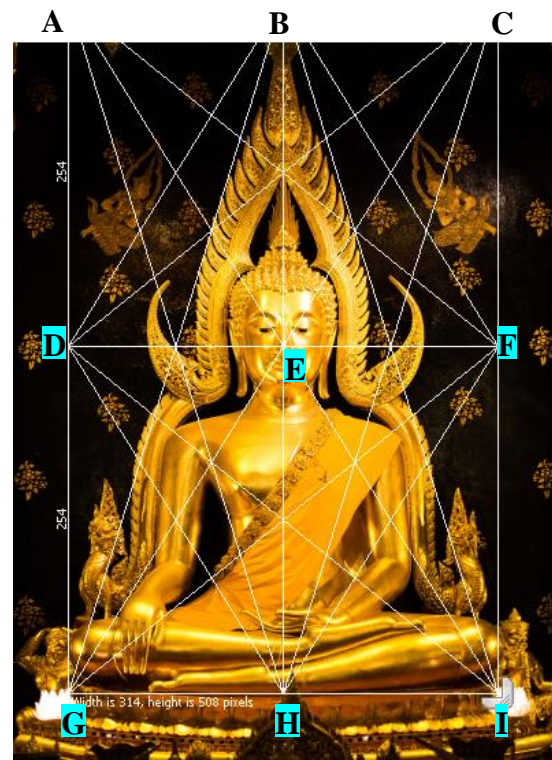

Figure 8 The golden ratio in a vertical line on the Phra Buddha Chinnarat.

Figure 9 The golden ratio in a vertical and horizontal lines on the Phra Buddha Chinnarat.
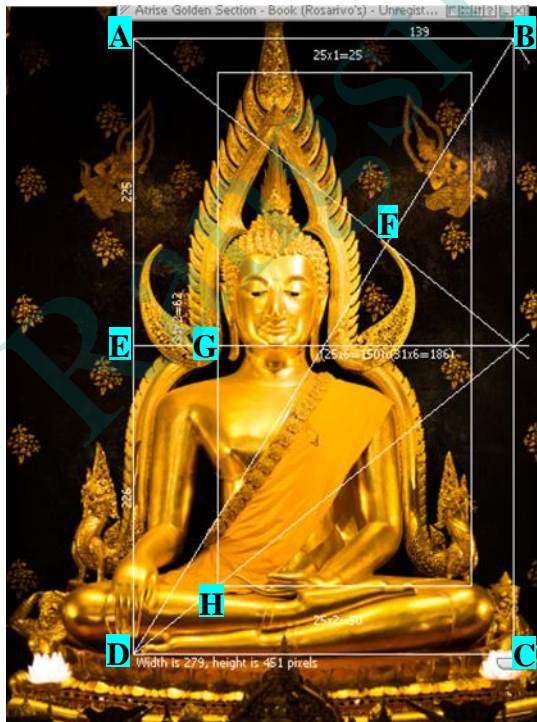
Figure 10 A diagonal of a golden rectangle on the Phra Buddha Chinnarat.

Figure 11 A golden triangle and a diagonal of a golden rectangle on the Phra Buddha Chinnarat.

From Figure 8, in a vertical line, the height CD is the length from top of the flame of halo to top of the head. The height DE is the length from top of the head to the shoulder. The height EF is the length from the shoulder to the base of the Lord. It found that the ratio CD:DE and DE:EF satisfied the golden ratio (1:1.618) and same on AB:BC,BC:CD.

From Figure 9, in a vertical line, the height AB is the length from bottom of the flame of halo to the neck. The height BC is the length from the neck to the base of the Lord. In horizontal line, the width CD is the length from the left knee to the left ear. The width DE is the length between the left ear to the right ear. The width EF is the length from the right ear to the right knee. It was found that the ratio AB:BC,DE:CD,DE:EF and DE:AB satisfied the golden ratio (1:1.618).

From Figure 10, considering a diagonal of a golden rectangle ABCD with the same concept, it was found that ratios DC: CB, DE: DF and GH: DC are about 1: 1.618, which satisfied the golden ratio.

From Figure 11, it is obvious that the triangle BGI is a golden triangle and the Phra Buddha Chinnarat is in the framed triangle fit. In addition, there are many ratios that satisfy a golden ratio such as GI: AG, GI: CI, GH: HE, HI: HE, etc.

Figure 12 A golden spiral on the Phra Buddha Chinnarat.

In addition to the mentioned above, considering about the delicacy of the Phra Buddha Chinnarat statue with a golden spiral. Obviously, there are a lot of golden spiral such as a golden spiral in the face from the eye to the mouth, in arch frame both left and right sides, in the body and in both knees as shown in Figure 12.

5. Discussion

From the past to present, some people believed that the golden ratio is a ratio that was often found in nature. In art, many beautiful things must contain a golden ratio such as the Parthenon in Athens, the Great Pyramid of Giza and the Mona Lisa.

From the above concept, this research aims to study the golden ratio on the beauty of Phra Buddha Chinnarat image in the posture of subduing mara, the most famous, beautiful and revered Buddha sculpture in Thailand. By using software to compare ratios between the arch frame, head, face, shoulder, knee and body of the Phra Buddha Chinnarat, it had shown   satisfaction with the golden ratio in many forms such as the golden ratio between two straight lines, a golden spiral, a diagonal of a golden rectangle and a golden triangle.

Exploration with the golden ratio in this research did not use an equation to proof because the result could obviously be seen on screen by software and the ratio of each line or curves were set to the golden ratio by program default. Although some errors occurred, it was not serious because it was minor and to study the golden ratio concept was to study or apply the trend or approximate ratio that close to the golden ratio to the real life which is not necessarily equal to exactly 1.618.

Therefore, this research integrated all by using the knowledge of mathematics, aesthetic, art, religion, history and technology to offer opportunities to connect understanding of the concepts of the golden ratio and apply to the real world and daily life experience. The golden ratio is a good topic to connect historic and aesthetic elements to a mathematical concept because many artists and architects connected the golden ratio to their works through much of the art history.

6. Conclusion

The Phra Buddha Chinnarat is one of the Thai sculptures that is beautiful in both art and mathematics. In an aspect of art, the Lord is beautiful in the arch frame line, curve, color and shape. In view of mathematics, the Phra Buddha Chinnarat has many parts that satisfy the golden ratio such as the ratio of the face, body shape, arch frame, etc. This makes the Buddha sculpture more delicate and appealing to the viewer.

7. Acknowledgements

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