Determination of the Golden Ratio in Selected 16^{th} to Mid - 19^{th} Century Churches of Panay Island, Central Philippines

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Abstract – Using numerical analysis and geometric construction, this study aimed to find out whether the Golden ratio is present in churches constructed during the 16th to mid-19th century in Panay, an island in central Philippines. The study focused on churches that met the criteria set by the National Historical Commission of the Philippines as historically significant namely: Pan-ay Church, Sta. Barbara Church, and Jaro Cathedral. A measuring device, that utilizes a laser, was used to take measurements. The values obtained were used to construct a floor and facade plan then proportionalized to determine their ratios. Ratios within five percent error margin of the Golden ratio were observed which showed that all three churches sampled exhibited the Golden ratio. However, access to historical documents is needed to conclude a purposeful intent of using the Golden ratio in the churches design.

Introduction. – The Spanish occupation of the Philippines lasted for over 300 years, during which the Spaniard colonists introduced many European influences into every facet of Filipino culture. One of these facets is architecture in the Philippines. Throughout the colonial period, the Spaniards oversaw the construction of many notable historic buildings across Luzon and Visayas, such as parks, mansions, and churches. Many of these buildings have been preserved to some degree by the efforts of the National Historical Commission of the Philippines.

In many historic religious buildings of the European world, there occurs an architectural phenomenon where the buildings designer intentionally utilizes the Golden Ratio in the dimensions of certain aspects of the building. Philippine architecture was influenced by the Spanish conquest. Along with the colonization of the Philippines, the Spaniards incorporated some of their culture into the countrys. One aspect of their culture, which was adapted into the archipelagos, was the building of churches as public places of Christian worship The Golden Ratio is a mathematical concept where the ratio between a larger quantity and a smaller quantity is the same as the ratio between the sum of both quantities and the larger quantity. The Golden ratio can be expressed into a line segment divided into two parts such that the ratio between the longer part to the shorter part is the same as the whole segment to the longer part. Studies have found that buildings utilizing the golden ratio subconsciously register as more pleasing to look at for the majority of people compared to buildings without the ratio.In knowing the ratio that occur in the buildings, we may have a basis of preserving our historical structures. This may also lead to finding a new ratio being used in the Philippines.It would also add an extra layer of cultural and historical value of the chosen heritage sites which in turn would help in the preservation efforts that are being allocated to the buildings.

The Spanish occupation of the Philippines lasted for over 300 years, during which the Spaniard colonists introduced many European influences into every facet of Filipino culture. One of these facets is architecture in the Philippines. Throughout the colonial period, the Spaniards oversaw the construction of many notable historic buildings across Luzon and Visayas, such as parks, mansions, and churches. Many of these buildings have been preserved to some degree by the efforts of the National Historical Commission of the Philippines.

Materials and Methods. – The methods are composed of five main parts; Illustration, Procurement, numerical analysis, geometric construction and percent deviation analysis. Buildings that were made during the Spanish colonial rule which was from 16th century until

the end of 19th century. The buildings should also be considered historically significant according to the criteria of the National Historical Commission of the Philippines (NHCP)

Illustration of Diagrams.. Diagrams of the facades and floor plan were drawn. The measurements taken in the next step were put onto these diagrams so the numerical analysis could be conducted accurately.

Procurement of Measurements. Availability of blueprints for the chosen buildings was checked. The chosen buildings had no available blueprints. Manual measurement was done using a laser measuring device and tape measure. The measurements in meters were taken at least three times and then averaged. Since the laser measurement device has an area for error of 1.5 mm, then each measurement obtained should be placed in a range of + 1.5 mm.. A laser measuring device was used to acquire the dimensions of specific parts of the churches facades and floor plans. Dimensions measured were marked on a diagram of the church by the researchers.

Numerical Analysis. The analysis was carried out by dividing a, the greater length, by b, the lesser length, then comparing the value obtained to the golden ratio given by the formula (1)

$$Ratio = a/b \approx 1.61812297 \tag{1}$$

Subsequent calculations follow using the same basic idea of dividing the greater by the lesser.

Geometric Construction. The measurements were inputted into Geogebra graphing software in order to construct a proportionally accurate diagram of the churchs features. Analysis was conducted on the diagrams through Geometrical Construction as described by Salleh where a rectangle with the Golden Ratio was generated and overlaid on the diagram.

Percent Deviation Analysis. The percent deviation was calculated by getting the absolute value of the value obtained by the equation (2)

$$(\frac{DerivedRatio}{GoldenRatio} * 100) - 100 \tag{2}$$

Only ratios that deviated from the Golden Ratio by 5% or less were considered relevant to the studys goal. Materials. A Bosch laser measuring device with a 70m effective range was used to take measurements of the churches features. During the data gathering, a pencil diagram was used to take note of the measurements of specific areas of the structures. Data was analysed through use of scientific calculators, Microsoft Excel spreadsheets, and Geogebra graphing software.

Results. – Numerical data was visually verified through geometric construction on the diagrams.

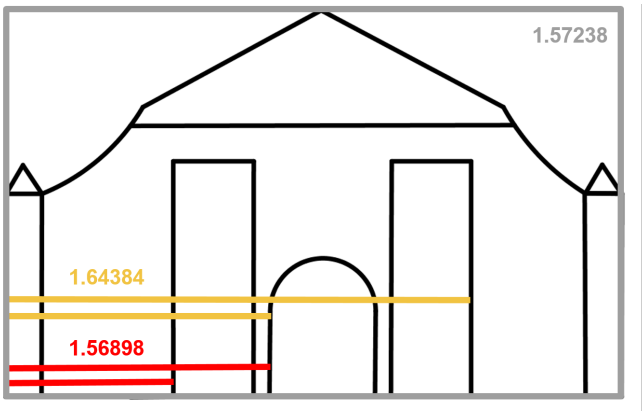

Fig. 1: Golden ratios found on the front facade of Jaro Cathedral

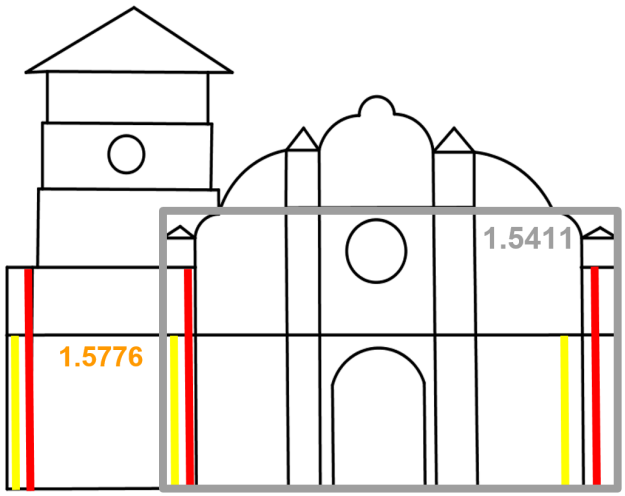

Fig. 2: Golden ratio found on the front facade of Pan-ay Church

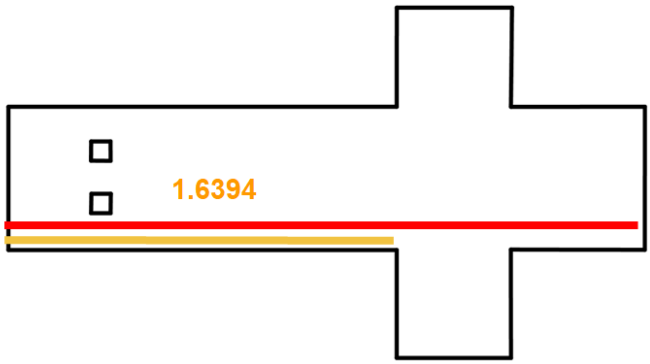

Fig. 3: Golden ratio found on the floor plan of Pan-ay Church

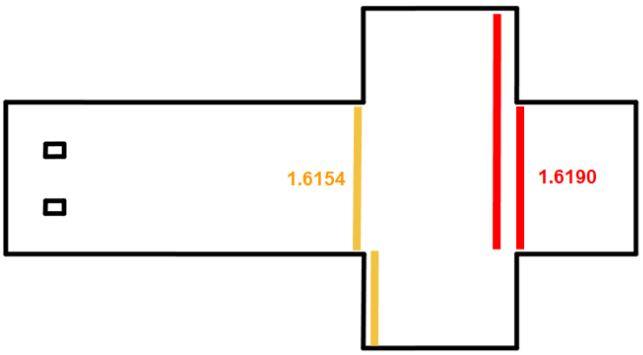

Fig. 4: Golden ratio found on the floor plan of Sta. Barbara Church

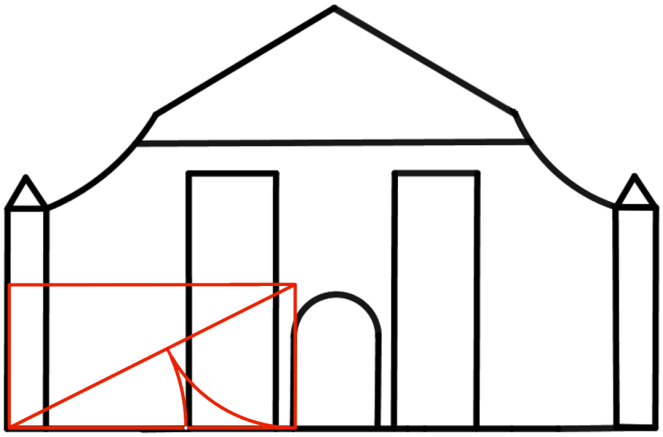

Fig. 5: Geometric construction to verify golden ratio in Jaro Cathedral facade.

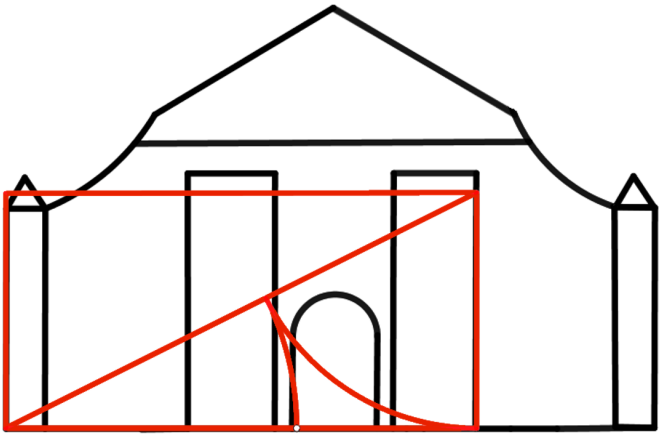

Fig. 6: Geometric construction to verify golden ratio in Jaro Cathedral facade.

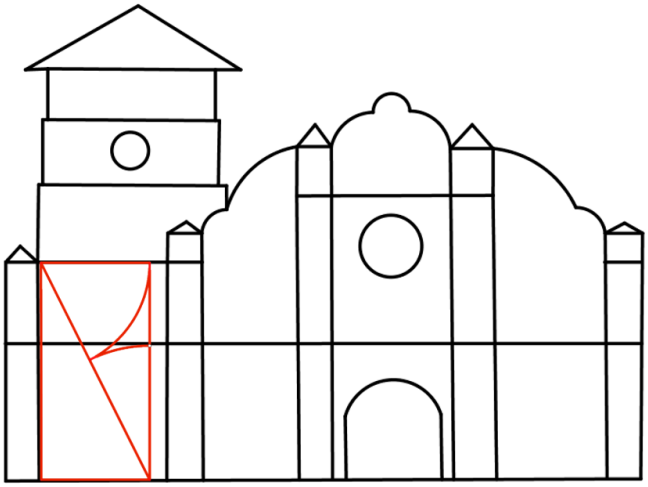

Fig. 7: Geometric construction to verify golden ratio in Pan-ay Church facade.

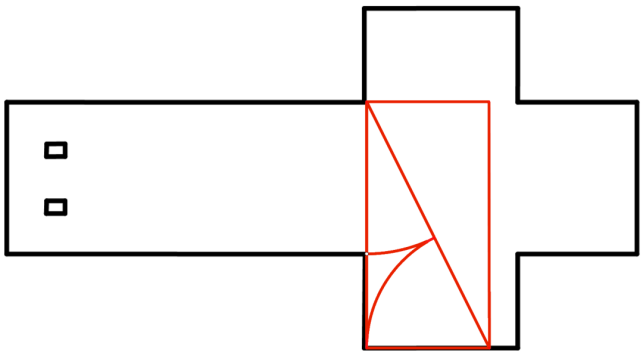

Fig. 8: Geometric construction to verify golden ratio in Sta. Barbara Church floorplan.

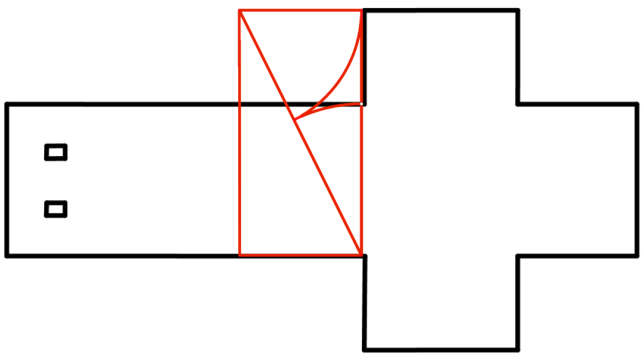

Fig. 9: Geometric construction to verify golden ratio in Sta. Barbara Church floorplan.

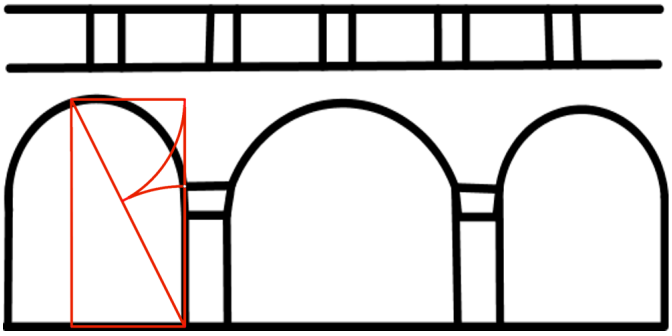

Fig. 10: Geometric construction to verify golden ratio in Sta. Barbara Church arches.

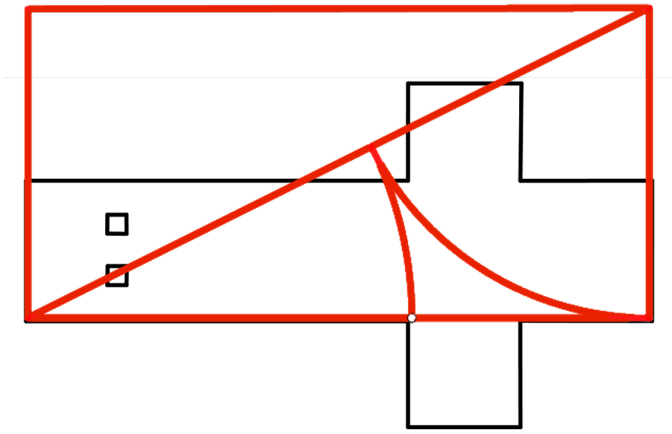

Fig. 11: Geometric construction to verify golden ratio in Pan-ay Church floorplan.

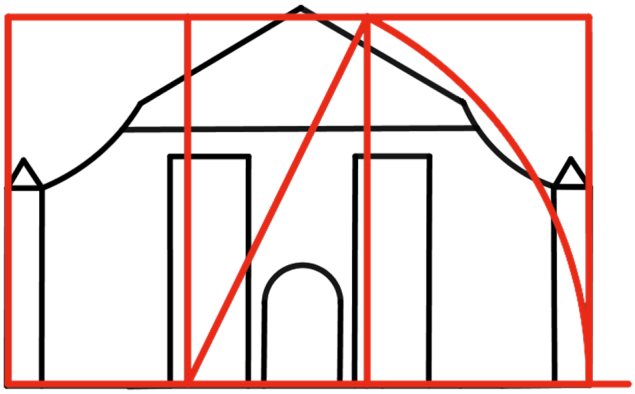

Fig. 12: Geometric construction to verify golden rectangle in Jaro Cathedral facade.

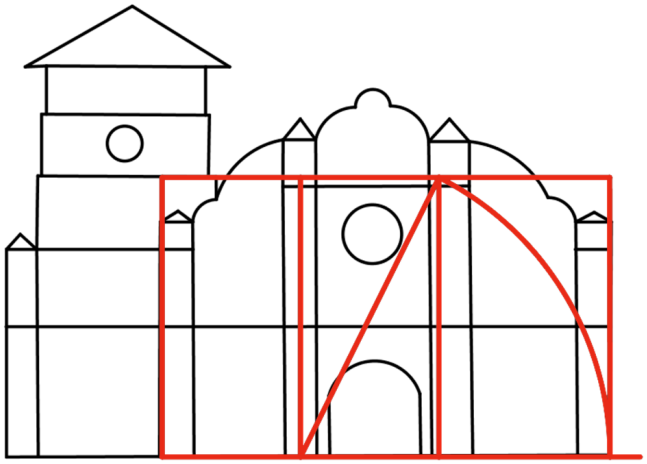

Fig. 13: Geometric construction to verify golden rectangle in Pan-ay Church facade.

Discussion. – The data that was collected showed varying values for the percent deviation with eight being found to be relevant to the Golden ratio. For the front facade of the Jaro Cathedral, the first ratio is denoted by letters A and a in Figure 1. The shorter length is represented by A from the leftmost part of the facade to the left-most of the column to the left of the door. The longer length, represented by B, runs from the leftmost part of the facade to the left of the door. The second ratio has the lengths C and D. The third ratio, unlike the previous two, does not have lengths aligned on one axis. Rather, it is a Golden rectangle with the longer length being the width of the facade F and the shorter length being its height E.

From the front facade of Pan-ay Church, one can observe two significant ratios. The first has lengths represented by letters G and H in Figure 2. Starting from the floor, they measure up to the horizontal section above the door and the horizontal section above that respectively. The second is another Golden rectangle with the width being the facade minus the section including the bell tower, J, and the height being the top of the column second from the floor, I. From Pan-ay Churchs floor plan, we have found one observable ratio. Its lengths were from the door to the other end of the building, K and from the door to where the floor begins to split into the side entrances, L.

The ratios found in Sta. Barbara Church were all within the floorplan as shown in Figure 4. Although three ratios are shown to be significant, two of those can be counted as one. The ratios represented by lengths M and N, and O and P are deemed to be the same ratio. This is because M and P are of the same length and N is merely the sum of lengths O and P. This can be said because both of the side entrances are approximately the same width. The last

ratio was found not exactly within the floorplan, but on an arch inside the church. The longer length of this ratio is the height of the arch R, and the shorter length is the height of a column that is part of the arch itself Q.

In addition, geometrical construction was done to show a more concrete visualization of the golden ratio using the data gathered from the numerical analysis. The geometrical construction was made using the significant ratios found with their P and Q values being used as basis for the initial dimensions of the squares and rectangles needed for the geometrical construction. Figure 5 , Figure 6 , and Figure 12 used the significant ratios from Jaro church. Figure 7, Figure 11 ,and Figure 13 used the significant ratios from Pan-ay church. Figure 8 , Figure 9 , and Figure 10 showed the significant ratios from Sta. Barbara church. The geometric constructions aligned with the location of significant ratios on the diagram of the churches. These constructions confirmed the areas and precision of the ratios that was derived from the numerical analysis.

Conclusion. – Evidence and traces of the Golden ratio can be found in each of the churches which are represented by the highlighted marks on the tables. These ratios are within 5% error deviation from the Golden ratio and have been derived from the floor plans and facades of the churches that were studied. Although the Golden ratio exists in each of the churches, one cannot conclude that it was intentionally incorporated into the entire design of the buildings. This can be said considering that the significant ratios found were either concentrated in one facade or floor plan, or scattered across the building.

* * *

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