Chapter 20

Geometric analysis of the maloca of indigenous people of the Xingu

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ABSTRACT
A parallel is made between the traditional knowledge applied in the construction of houses for indigenous peoples of the Xingu, and the mathematical theory of the Configuration of the Lines of Curvature and Umbilical Points of the Ellipsoid of three distinct axes by Gaspard Monge.

Keywords: Indigenous Architecture, Vernacular Architecture, Monge's Ellipsoid, Differential Geometry, Curvature Lines

1 INTRODUCTION

In this work, we make a parallel between the mathematical theory of the lines of curvature on the famous Ellipsoid of Monge, and the traditional knowledge of the indigenous peoples of the Xingu. These peoples, in the construction of their collective residence, called maloca, make use of support structures whose designs coincide with what the mathematical theory tells us of curvature lines and umbilical points on an ellipsoid with three distinct axes.

We also emphasize the symbology of the maloca for the peoples of the Xingu, which represents a living animal or man (anthropomorphic).

2 MATERIAL AND METHODS

Bibliographic searches were carried out in books, magazines and internet sites.

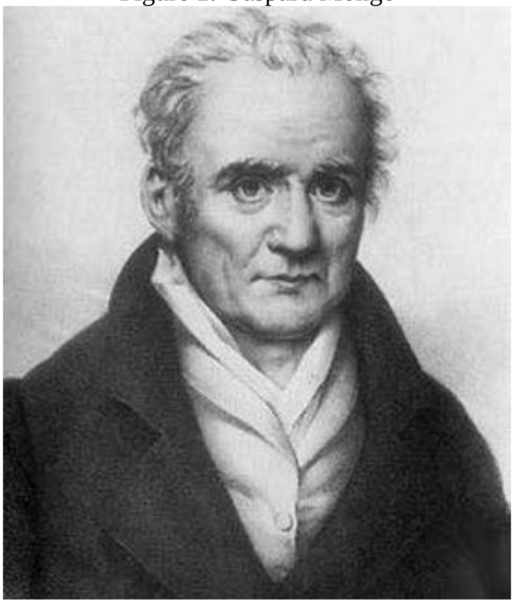
3 RESULTS AND DISCUSSION

Gaspard Monge (1746 – 1818) was a famous French mathematician and engineer, creator of descriptive geometry and one of the fathers of Differential Geometry. Monge was involved in reforming the French education system and founding the Ècole Polytechnique.

According to Ghys (2011)

> “(…) Monge placed considerable emphasis on teaching. He understood that the nation needed a large number of workers, engineers and scientists, and that they needed quality education, especially in mathematics.”

Figure 1: Gaspard Monge

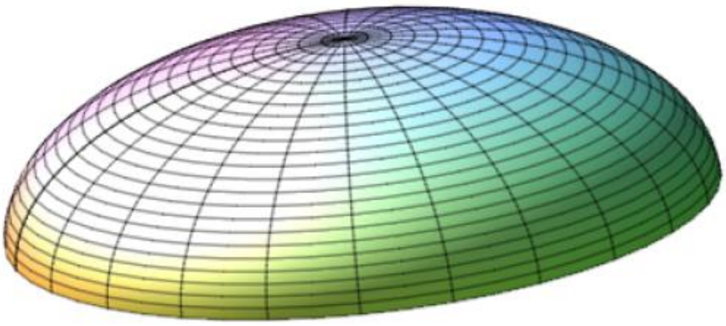


Source: geometriadescritiva.wordpress.com

Among several interesting problems that Monge considered in his life, we can mention the problem of transporting optimal land (GHYS, 2012), and the proposal to build the Parliament building of the French Revolution (SAKAROVITH, 2009).

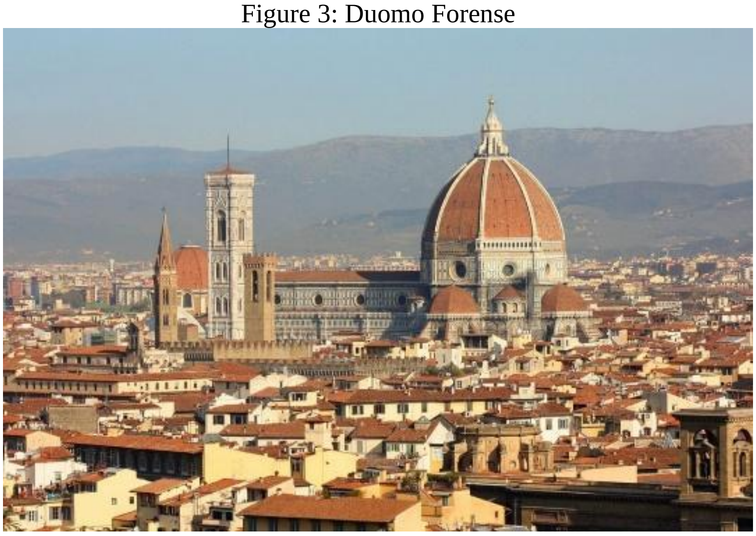
The proposal to build the parliament building of the French Revolution was quite innovative, as it included an ellipsoidal dome in its design. However, unlike those domes of medieval or Renaissance churches (Figure 3), it was not a format modeled by a solid of revolution (Figure 2).

Figure 2: Ellipsoid of Revolution (upper part)



Source: Authors.

Figure 3: Duomo Forense



Source: Wikipedia

Consider the expression.:

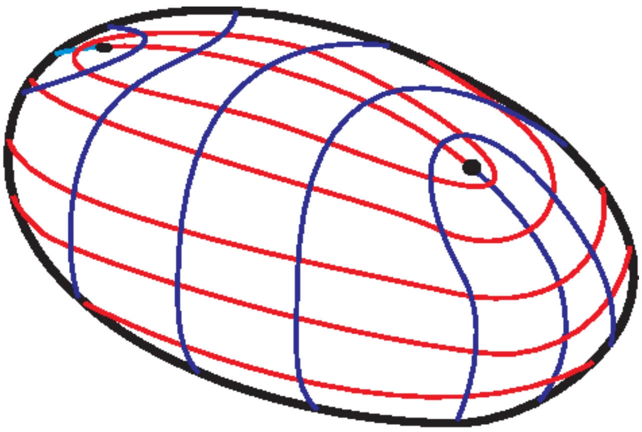
$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$$

where x, y, z are the real variables a,b,c are the parameters..

In the case where a=b=c occurs, we have a sphere.

If the values of the three parameters are all different from each other, we have what we call a Monge Ellipsoid, or Ellipsoid with three distinct axes (Figure 3). In the case where two values are equal and one is different, we have the ellipsoid of revolution (Figure 2).

Figure 5: Monge's ellipsoid, where the curvature lines and two umbilical points at the top can be seen.



Source: SOTOMAYOR, 1993

The illustration above deals with Monge's ellipsoid with the drawing of its curvature lines (blue and red lines).

The concept of curvature lines is central to this text and, intuitively, can be understood as follows: at each location on the surface (except for the black dots) there is a direction in which the surface curves more and one in which it curves less , and the blue and red lines are the drawings that follow these directions. The black points are called umbilicus, because they do not have a direction of greater or lesser curvature, that is, the surface curves equally in all directions around these points. On Monge's ellipsoid there are four umbilical points.

Mathematically, the blue and red lines are determined by solving the Differential Equation of Curvature Lines, which is given by the following expression:

$$det \begin{bmatrix} (v')^2 & -u'v' & (u')^2 \\ E & F & G \\ e & f & g \end{bmatrix} = 0$$

where E,F,G are the coefficients of the first fundamental form of the surface and e,f,g are the coefficients of the second fundamental form of the surface, written on the chart $\alpha(t)=X(u(t),v(t))$ (TENENBLAT, 2008).

In the case of an ellipsoid of revolution, the lines of curvature coincide with those drawn in Figure 2 (meridians and parallels), and there are two umbilical points (the two poles). On the sphere, all points are umbilicus.

Monge used the ellipsoid model with three distinct axes in the design of the dome of the Parliament of the French Revolution (Figures 6 and 7) (SAKAROVITH, 2009).

Figure 6: Construction Project for the Parliament's Ellipsoidal Dome, designed by Monge.

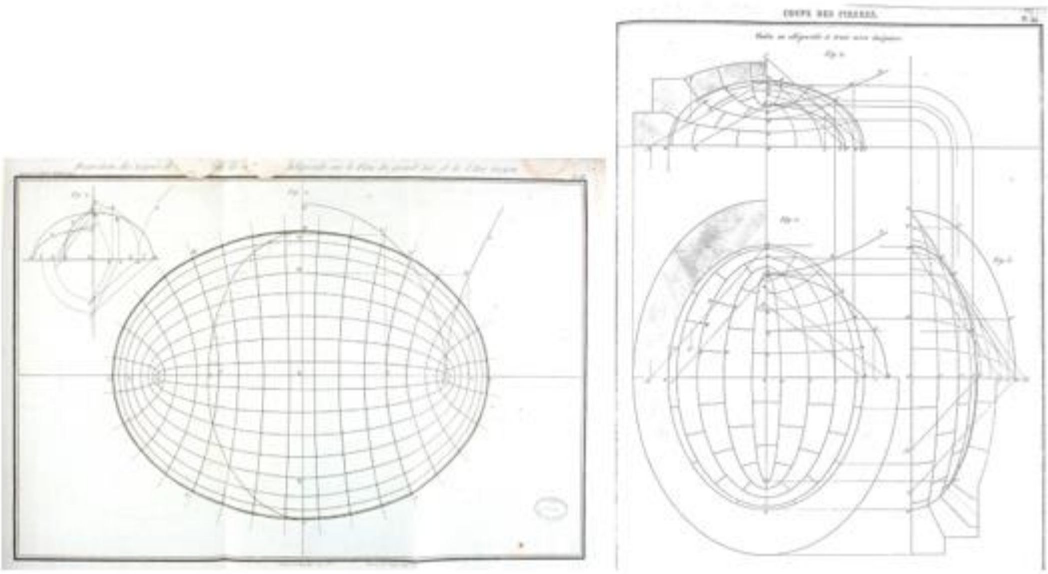
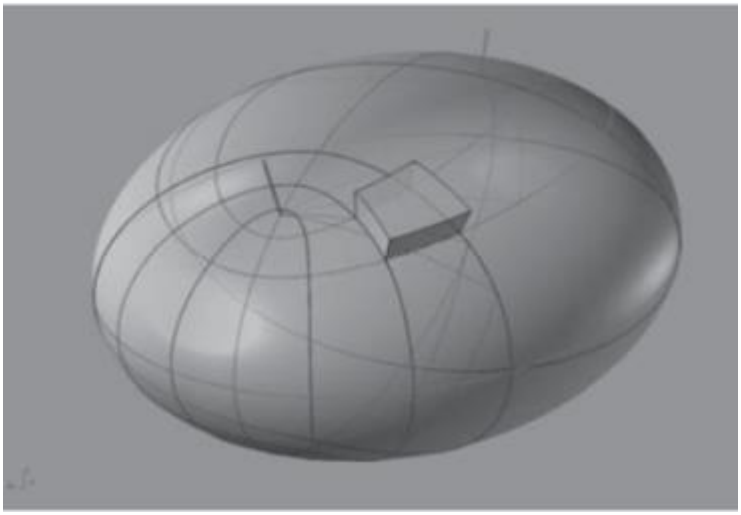


Figure 7: Project for Fitting the Stones of the Parliament Project, by Monge.



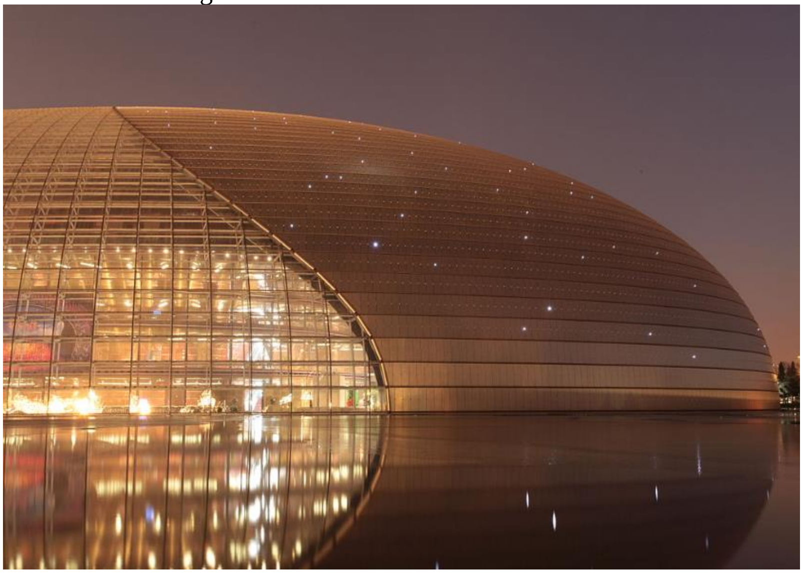
Source: SAKAROVITH, 2009.

The curvature lines are well drawn as lines of fitting of the blocks and so are the umbilical points, as well as the umbilical separatrixes, which are the lines that connect the umbilicals.

Monge's project was not carried out due to technical limitations, but the execution of ellipsoidal domes such as the Great National Theater in Beijing (Figure 8) stand out for their grandeur and ingenuity in structuring large spans. Known as The Egg, the project by French architect Paul Andreu, has a dome 46 meters high and 213 meters wide, structured in more than 18,000 titanium plates interspersed with glass pieces.

Despite the applications of geometry, as well as technologies that aid in the design and construction of huge ellipsoidal domes in Western architecture, indigenous peoples in Brazil have already carried out the construction of collective housing with an ellipsoidal shape (Figure 9) since their ancestry, with a structural conception that resembles the one idealized by Monge in the sec. XVIII.

Figure 8: Great National Theater of China



Source: EVILBISH, 2010.

Figure 9: Three-dimensional model of one of the construction stages of the traditional Kamayurá house, built in the Xingu Indigenous Park.

Source: DIETSZCH, pp. 34-35

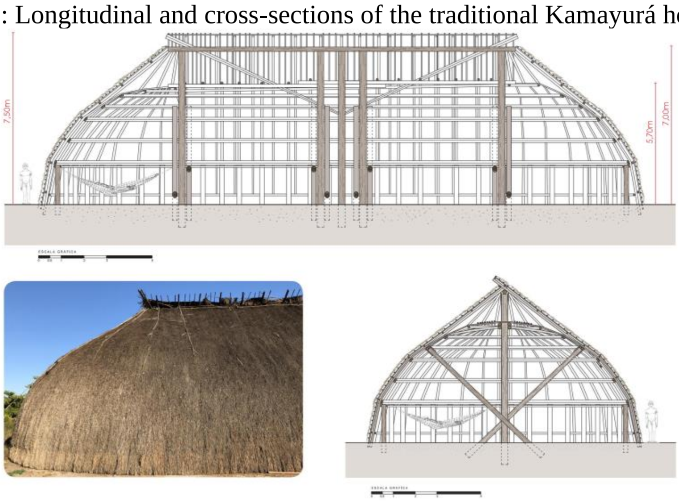
Built in a joint effort by the men of the community, the house begins with the positioning of the masts that are centralized in the structure of about eight meters in height. , pp. 40-41)

When wet, pindoba (matawi) wood has the necessary flexibility to form curved elements without loss of strength. The inner basket is composed of elements such as the 'amyj (grandfather), eikwaryp (ass guide), ipopewyt (armpit), matawi and moti'a'yta (rings). This inner basket connects to the outer basket, which is superimposed on it, which receives the straw, forming the house (DIETSZCH, pp. 34-35).

> "The beams at the top of the masts will receive the weave of pindaíba structural elements in arches (matawi) and in concentric rings (motsi'a'yta and ywayra'ia py'y'ta) that receive the thatch of the roof, not tied, but in bundles simply fitted bent. The moorings between the parts of the structure are carried out through specific knots, such as the "locust chest" (tawarerõa poti'a) and the "monkey's face" (akyky'aroa), explaining the learning through observation of the forest dwellers " (DIETSZCH, pp-.40-41).

The internal structure of the Kamayurá maloca (Figure 10) is very similar to Monge's ellipsoid design, where we can consider the umbilical points located above the support rafters and the umbilical separatrix the rafter that unites them.

Figure 10: Longitudinal and cross-sections of the traditional Kamayurá house.



Source: DIETZSCH, pp. 22-23.

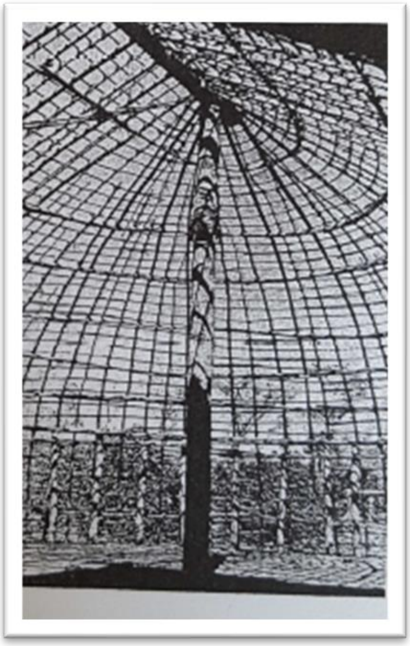
Other peoples of the Xingu also presented the construction of houses with elliptical floor plans. Another case is the Yawalapiti, as seen in the images:

Figure 11: Yawalapiti people, from Xigu, building a maloca.

Source: https://pin.it/6NClAHW

We illustrate, in Figure 12, the interior of the Yawalapiti maloca, where it is possible to verify that the support structure makes a design according to that predicted by Monge in Figure 6, that is, the traditional knowledge of the peoples of the Xingu and the mathematical knowledge de Monge arrive at the same solutions to this constructive problem.

Figure 12: Interior of the maloca of the Yawalapiti Peoples

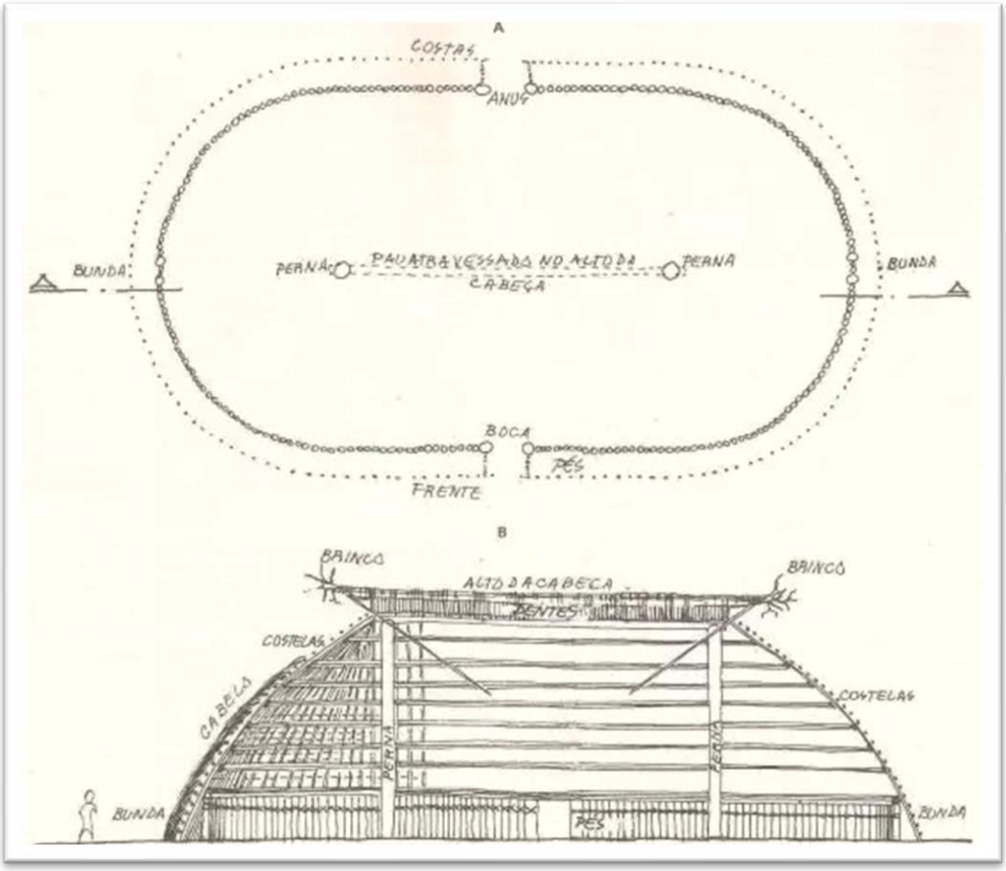


Source: SÁ, 1983

For the indigenous peoples of the Xingu, the maloca is not simply a house, a dwelling where everyone lives, but has the representation of a living being (an animal or a man).

In Figure 13, we can see the illustration of the anthropomorphic house:

Figure 13: Symbology of the maloca – anthropomorphism.



Source: ALMEIDA, 2013

The nomenclature of the structural elements of the Xingu house is associated with the parts of a body, so that the main facade is called 'chest', the rear facade 'back', the upper beam 'top of the head', the horizontal rods 'ribs' and the straw the 'hairs' (SÁ, p.112).

> "Hence, the main pillars of the house – those placed at the central foci of an ellipse – are called the "legs" of the house. The part of the construction corresponding to the upper middle section of the main façade is related to the chest and the opposite sector, in the posterior façade, is considered as the "back" of the house."(ALMEIDA, 1983)

4 CONCLUSION

In this work, we verify points in common, and independently, between the indigenous ancestral knowledge and the European mathematical knowledge of the 20th century. XVIII. Images of the structures of indigenous malocas demonstrate that the elements of this type of traditional collective housing with an ellipsoidal shape coincide with the curvature lines and umbilical points of the Ellipsoid of Monge.

In indigenous symbology, the maloca represents an animal or human being (a living organism), and each mathematical entity of the ellipsoid acquires a meaning in the composition of the collective house.

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