THE NAZCA LINES AND THEIR DIGITAL ARCHITECTURAL REPRESENTATION

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Abstract. This paper relates to a digital architectural design experience in 2005 for the Nazca Competition. Nazca is an archaeological site situated about 400 kilometers south of Lima, Peru. It is a large desert with gigantic millenary geoglyphs carved on the surface, which can only be seen clearly from above. The Nazca geoglyphs are made up of hundreds of lines, spirals and triangular plazas, as well as zoomorphic figures like birds, fish, spider, etc. The Nazca Competition asked for an observatory-lodge of approximately 1.000m2 with 20 rooms, communal bathrooms, supporting areas and an observatory tower of at least 100 meters. The observatory-lodge was designed using a digital representation technique called "Genetically Constructed Structures". The structure was created using the geometric principle of the affinity of two conic sections: circle and ellipse. The form was produced transforming the circle and the ellipse by performing basic geometric transformations (translation, rotation, reflection and scaling). According to this technique, the sequence of transformations was codified in the form of an alphanumerical string, metaphorically named the "DNA structure". The code was inserted as extended data into the entities which shaped the structure profiles. The algorithms were programmed with AutoLISP language. The "DNA code" allowed the structure to be constructed and deconstructed from any point, generating many different forms, to be studied and compared. One year later, the same 3D model was used to test another digital technology called "musical box" where their geometrical points are captured, read and translated into musical parameters, generating music. In this paper we will present the graphical form of the tower as well as the music associated.

1. The Place.

Nazca is an archeological site situated about 400 kilometers south of Lima, Peru. It is a large desert, 70 x 5 miles, covered with gigantic millenary geoglyphs carved on the surface of the ground. These geoglyphs, characterized by their size, can only be seen clearly and completely from above. The Nazca geoglyphs are made up of hundreds of lines, spirals and triangular plazas, as well as zoomorphic figures like birds, fish, spiders, etc. It is believed to have been drawn during the first millennium AD. The soil presents a peculiar reddish coloration due to the origin of its material: red volcanic riolite rock.
Until now, few investigations have been carried out to attempt to interpret the origin and function of the lines. The first scientific contact with the Nazca lines occurred when the Peruvian archaeologist Toribio Mejía Xesspe

discovered the site in the 1920s. He conjectured that the lines had been excavated by the former inhabitants of the region for ritualistic and religious purposes.

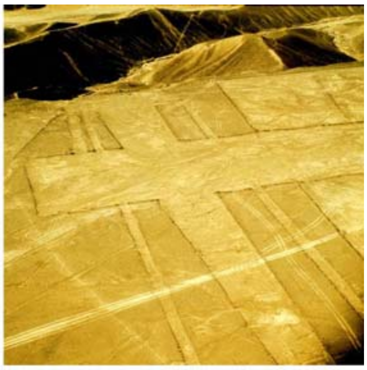

Figure 1. Left: Gigantic representation of a bird.Right: Geoglyphs shaped like embankments or plazas and lines. (Courtesy ofArquitectum International Agency) (Photos: H. Desidare).

The lines can be divided into three categories: a) straight lines with a length of between 30 meters and 9 kilometers, mainly drawn in a radial fashion. The site chosen for the observatory was the central point where the majority of the lines converge. b) Triangular and trapezoidal combinations which contain large empty spaces. These areas have a length of between 200 and 500 meters. Finally, c) the category of zoomorphic figures such as fish, spiders and birds among others. These figures are also of a considerable size.
Among the hypotheses put forward in relation to the function of the lines we can cite: ceremonial paths, sites of death cults, sporting events and images dedicated to fertility. One of the theories, attributed to the researchers Paul Kosoc and Maria Reiche, states that the lines represent a type of agrarian calendar, symbolizing the movement of the stars. In this sense, the figures would be associated with particular stars or planets.

Gerald S. Hawkins, the astrophysicist has presented another thesis. Contrary to Kosoc and Reiche, he concluded that the lines are not related to astronomical events. According to Hawkins, the design of the lines does not present a defined orientation in relation to celestial bodies. In his view, it is more likely that they fulfilled a function in a magical religious ritual, reverting to the idea proposed by Mejia Xesspe.

The Nazca lines also give rise to hypotheses which suggest that they were produced by beings from other planets. Erich v. Däniken, for example, believes that the large open areas marked out by the lines would have served as landing sites for extra-terrestrial spaceships.

In summary, the origin and the meaning of these designs are still unknown. The mystery continues to attract researchers from all over the world to the site. The observatory-lodge would solve the problem of lack of accommodation and facilitate the contemplation of the designs from a privileged position.

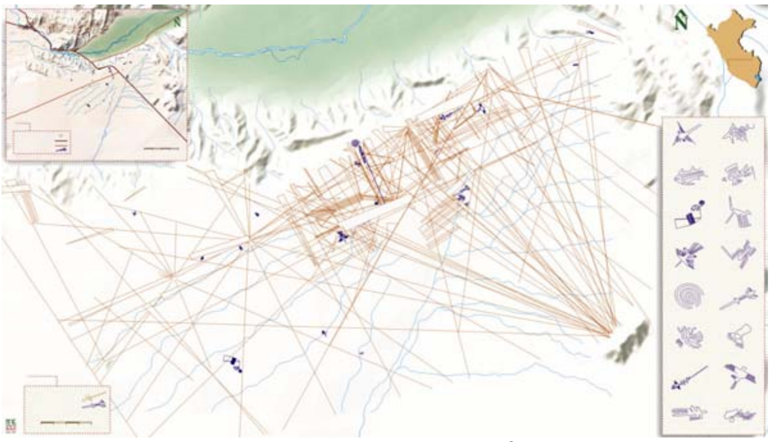

Figure 2. Nazca Site Planandgeoglyphs.(Courtesy of Arquitectum International Agency)

2. The program.

The archaeological site is the destination for many researchers throughout the year. Nevertheless, there is a lack of adequate installations to accommodate demand and at the same time facilitate the research work. The observatory is to be part of the lodge project with an area of 1,250 m2 with 20 rooms, bathrooms, support areas and principally an observatory with a minimum height of 100m to facilitate a panoramic contemplation of the site. We must bear in mind that the size of the area and the dispersed nature of the lines make direct observation difficult. To this must be added the fact that the use of wheeled vehicles on the land has the negative result of destroying the lines and figures.

3. The project

To develop the project we used a digital technique which we created with the intention of maintaining a close link between the graphic representation, formal-symbolic representation of the object and its laws of generation. We called the technique, "Genetically constructed structures ".

The structure was created using the geometric principle of affinity of two conic sections: circle and ellipse. The form was produced transforming the circle and the ellipse by performing basic geometric transformations (translation, rotation, reflection and scaling). According to this technique, the sequence of transformations was codified in the form of an alphanumerical string, metaphorically called "structural DNA". The code was inserted as extended data into the entities which shaped the structures profiles. The algorithms were programmed with AutoLISP language.

In order to design the tower we define two initial shapes, a circle and an ellipse to which we apply a series of basic geometric transformations (translation, rotation, scaling and reflection), the movements were controlled by the principle of geometric affinity. The points highlighted in the transformed figures are the extreme points of the three-dimensional model's profiles. The height of the structural profile is determined as the product between the diameter of the circle and the "characteristic of the affinity", defined as the ratio of the areas of affine figures. (Ricca, 1992) All the rules of transformations are defined by a specific LISP function. The man/machine interface is defined by the keyboard. The keyboard is designated to activate the transformations and label them with the alphanumerical code corresponding to the key which executes the transformation.

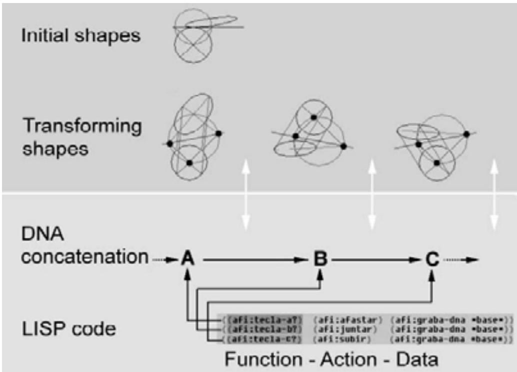

Figure3. Functional structure of the GCS technique.

The alphanumerical chain obtained with the sequence of transformations is called structural DNA. The operations which we define as “Function – Action – Data” are repeated for all and each one of the rules of transformation. Thus, when the symbol which represents the order is joined to the DNA chain it comes to acquire the form of data. The structural sequence of Nazca tower has the following chain:

<V1>111111111111111111111111111111111111111111166611111
11111
1111172222222222222222722222222222222227111111111111111

Generally;
<W> n... where;
<W> is the code of the structural profile.n is the code of applied geometric transformation.

With the aid of this code, the structure can be reconstructed at any moment in the conception work to study other morphological variants. The apparent geometric chaos of the structure follows a rigorous design which permitted the generation of a series of preliminary studies to the final development of the option selected. Once the structure had been defined, horizontal sections were created the height of which corresponded to the height of each floor of the lodge. The sections were adapted to the perimeter defined by the tower base, leaving the planes free between the pillars of the structure which permitted the lodge project to be positioned on its base.
The project sought to emulate the characteristics of the site through a three dimensional elevation of the interlacing of the lines which are traced on the soil. This architectonic gesture was intended to be a tribute to the memory of the people who left their mark on the earth. The ‘genetic structures’ make the generation and formal analysis of the project idea possible. In our opinion, the richness of the conception process proved the importance of enlarging the repertoire of forms of representation (graphic, mathematical and symbolic) during the use of the project’s digital systems, particularly when dealing with the conception stage of the architectonic shape.

Figure 4. The Nazca Tower project. 3D rendering.

In the next item we will explain another representational approach. Following the line of thought initiated by Iannis Xenakis in the second half of the 20th century, we attempted to extend our research to the musical field, relating geometric representation to sound representation; relating architecture, spatial art, to music, temporal art.

4. The sound of the Nazca tower 3D model.

What would the result be of translating a geometric object to a sound object? Would there be a formal concordance between the visual result and its corresponding sound? Guided by these questions, we formalized a system we called "Musical Box", using the following tools; the graphics program AutoCAD, AutoLISP language and the musical composition system Compo-Music. The geometric material to be translated would be three dimensional models, among them, the 3D model of the Nazca tower.

We defined the Box as a virtual system with XYZ axes arranged in modular units which, instead of numerical values, would represent musical parameters.The translation process would begin with the capture of the numerical co-ordinates XYZ of the vertices of a 3D object modeled in AutoCAD. The set of numerical co-ordinates would be transformed into a co-ordinate with the value of a musical parameter according to the syntax required by Compo-Music. The Musical Box is defined by three axes arranged in modules. As we had to put the seven notes of the diatonic scale on an infinite numerical axis we opted to segment it according to the quantity of elements present in the series used. Thus, we would repeat the division of seven parts (C D E F G A B) ad infinitum on axis Y. The procedure of modular division of the axes would be applied in the same way for the durations, heights and dynamics. Our choice sought to imitate the representational form of traditional musical music. In the pentagram, the

horizontal direction is the domain of temporal division and the vertical direction is the domain of scales and the heights of register.
At this point we took an arbitrary decision. As the representation of written music is a notation restricted to the two dimensional plane and architectural objects belong to the three dimensional world we decided to divide the scales (axis Y in the pentagram) into two independent parameters: we maintained the intervals of the scales on axis Y and took the heights of register (eights) onto axis Z. As well as duration and scale, we incorporated a value of intensity into the axes, a parameter which in musical theory is defined as dynamics (piano-forte). In this way, the final configuration of the axes was discovered with the following correspondences:

Axis X = Duration + dynamics.
Axis Y = Scale + dynamics.
Axis Z = Height + dynamics.

The next step to define the space of Musical Box was to transform the cartesian system of real numerical co-ordinates into a modular system of whole number co-ordinates. In order to do this, we extracted the whole part of the coordinate and manipulated it with operations of the modular arithmetic. The modular arithmetic postulates the existence of congruence between two whole numbers in the module m when m is a factor of (a – b), expressed by the formula:

a=b(mod m)

In other words, if a, b and m are whole numbers different to 0, we can say that "a is the congruent of b module m if m divides (a – b) with the remainder equal to 0". Ex.

16 = 4 (mod 12) => (16 – 4) / 12 = 1
52 = 4 (mod 12) => (52 – 4) / 12 = 4

In this way we could find the modular value of any whole number in respect of a defined module and, with this, extract from a list formed in AutoLISP the value corresponding to the nth function.

145 = 5 (mod 7) => (145 – 5) / 7 = 20 (nth 5 ("C" "D" "E" "F" "G" "A" "B")) = A"

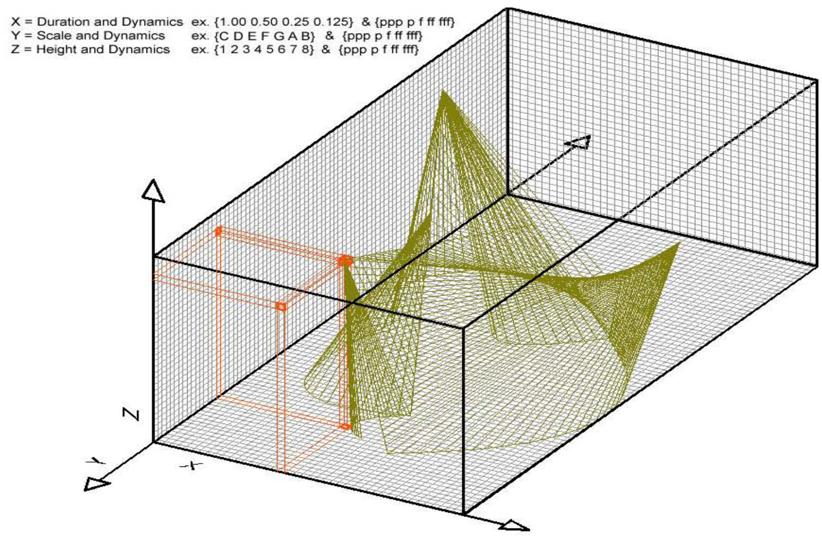

Figure 5. Musical Box configuration and the Philips Pavilion. Xenakis - Le Corbusier.

Once the box had been formalized, we thought about the criteria for the capture and organization of the order of the translation of the points of the 3D model. To this end, we designed some techniques for sweeping and organization with which we can construct a musical narrative coherent with the geometry. Basically, we are working with two techniques.

“Variations on the morphology of model” uses the area of 3DFACES or the longitude of PLINES to form numerical series with the order of capture and translation. As sudden changes of magnitude in the areas produce as a consequence sudden changes in the numerical series of translation, we sought to check if, in this sense, a corresponding variation of the result would be observed in the sound narrative.

Another technique developed was “Variations on schemes of multiples” with which we sought to define a periodic organization of capture. The schemes defined are periodic geometric patterns, the graphic representation of which defines a touch sequence. In the scheme of multiples of three, for example, it can be seen that the multiples in order of appearance in a decreasing sense complete a period in the sixth 3DFACE calculated, starting the geometric pattern again on the seventh face.

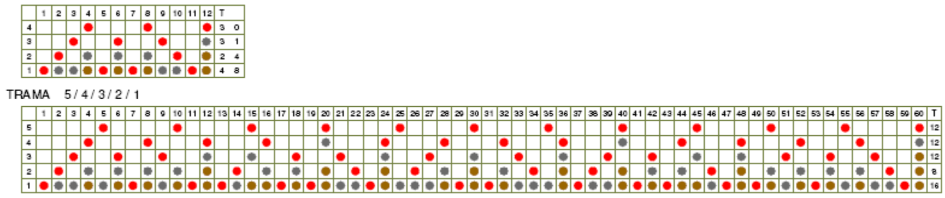

Figure 6. Periodic geometric patterns of "Variations on schemes of multiple" technique.

5. Sound results.

The Nazca01.mp3 and Nazca02.mp3 files attached to this article are some of the sound results corresponding to the translation of the 3D model of Nazca tower project. The audio was compressed using Lame encoder in 96 Kbps stereo compressed rate.

6. Conclusion.

The article has explored two digital representation techniques tested on a concrete architectonic problem. Firstly, we introduced an approach based on the symbolic representation of geometry and its movements. The technique presented was intended to be an alternative to the representational approaches based on the object model. In our case, representation is guided by the generating law of the object, that is, its generating process not its representation as an object already defined.

Secondly, we presented the Musical Box technique which aims to explore the integration and complementing of the senses; in our case the senses of sight and hearing. Thus we proposed a model of digital representation currently in a development phase. The results obtained so far indicate that there is no direct and univocal correlation between the visual shape and the sound shape, as many different sound shapes can be generated from the same geometric shape. However, it still allowed us to imagine applications for the Musical Box. For example, the definition of sound libraries with musical patterns which identify characteristic types of architectural elements; the definition of musical sequences from the morphological characteristics of the architectonic element (variations on the morphology of models); or, the sonification of space through its dimension imagining a narrow space as sharp and a wide space as flat.

These sound events could serve to guide or spatially alert people with visual deficiency. Thus, the next steps in our research will be study the techniques of “sonification” proposed by Delogu, Blum and other researchers.

References

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