

## GENERATION OF GEOMETRIC ORNAMENTS IN ANCIENT MOSAIC ART

**Abstract:** The paper examines geometrical ornaments from ancient mosaic. We studied the geometric generation by using Computer Aided Graphics for three examples of ancient mosaic: a mosaic of Ancient Corinth, a mosaic of the sacred geometry Flower of Life (exposed in the National Museum of Israel) and a mosaic of fortress Masada - Israel. The technique of drawing ancient mosaic is recomposed using computer aided graphics. A program has been developed that can help draw a petal-type arc (semicircle) of the mosaic that is the Byzantine church of Masada. Based on these mosaics, other variants of aesthetic images in monochrome or black and white and polychrome were drawn, all of which can be materialized in decorative art to embellish various surfaces: walls, floors, pools, fountains, etc.

**Key words:** ornaments, generation, geometric, mosaic, aesthetic.

## INTRODUCTION

The mosaic represents a technique of decorative art, achieved by means of artistic assembly of some small pieces – usually of cubic shape. They are known as “tesserae”, other materials used for mosaic being the marble, ceramics, colored or translucent glass (sometimes with gold insertions), enamel, metal or other rigid monochrome, black/white or polychrome materials, glued together by cement or mortar.

The mosaic represents a form of art, being incontestable one of the most sustainable decorative techniques that survived from antique times until today. The fascinating history of the mosaic finds its roots in the temples from Abra, Mesopotamia, in the second half of the 3rd millennium B.C. At that time it was made of colored pieces, shells and ivory.

The art of mosaic has been continuously developed, as it is still used to decorate surfaces - floors, internal walls, slabs, buildings facades. It is also used in places where the humidity might damage more delicate finishing (baths, pools and fountains). At the beginning of the XX-th century, Gaudy has created ambitious pictorial compositions in the Guell Park, Sagrada Familia Cathedral etc., by using the Art Nouveau style.

The ornamental geometrical motive used by the creators of ancient mosaic provides aesthetic images and rely on the geometric drawings. Simple geometrical shapes can be identified, e.g.: circle, line, curves - arcs or epicyclic arcs, spirals. Today these can be generated by Computer Aided Graphics.

## 2. GEOMETRIC GENERATION FOR A MOSAIC FROM ANCIENT CORINTH

Fig. 1 [1] presents a mosaic that we selected in order to discover its geometric generation. It was discovered in a Roman villa from the ancient Corinth, dated 150-200 A.C. The piece is exposed in the Archaeological Museum, built near the basis of the acropolis Acrocorinth during the period 1931-1932, nearby statues, pottery, sarcophagi and other mosaics, discovered in the archaeological site from the Ancient Corinth.

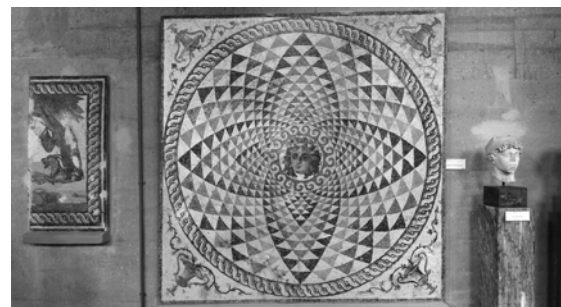


Fig. 1. A mosaic of Ancient Corinth

We will present the stages of generation of this mosaic by using Computer Aided Graphics. It contains a simple ornamental motif and is characterized by a remarkable aesthetic (Fig. 2 and Fig. 3).

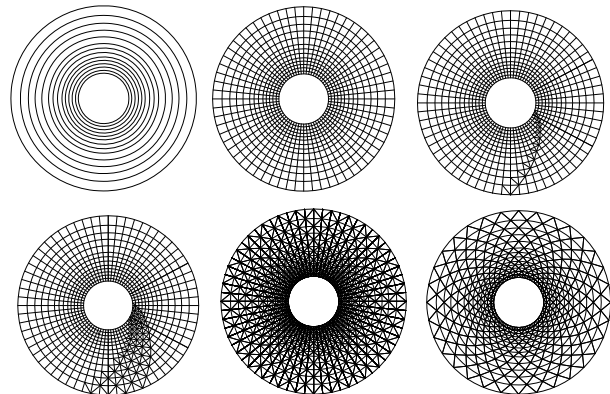


Fig. 2. Stages of generation of geometrical ornament

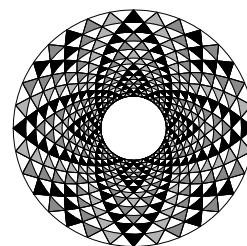
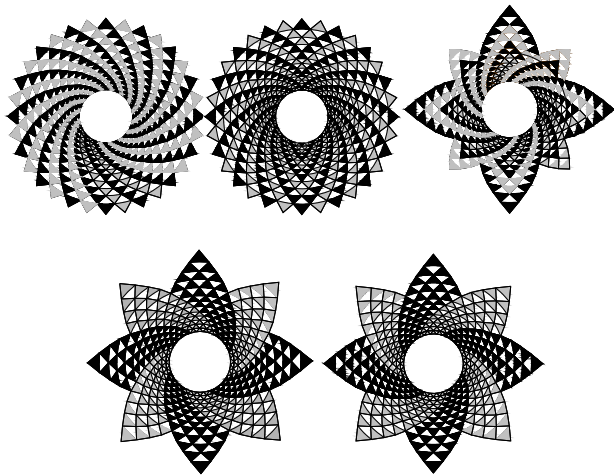


Fig. 3. Cross-hatching of the zones where the pieces of mosaic are to be placed

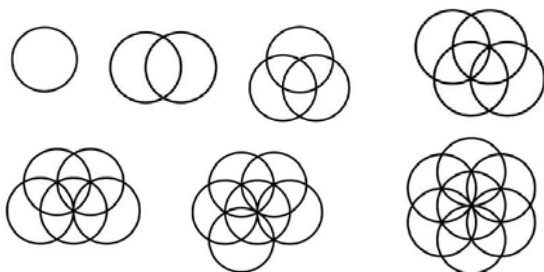
We used this structure of geometrical ornament to achieve other variants, with colors, with a special aesthetic, depicted by Fig. 4.



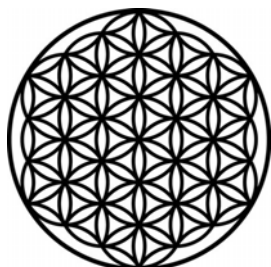
**Fig. 4.** Variants of aesthetic ornaments, created on the basis of the studied mosaic from the Ancient Corinth.

### 3. GEOMETRIC GENERATION FOR THE MOSAIC “FLOWER OF LIFE”

The Sacred Geometry deals with proportions and relations. By using a circular structure in cascade (Fig. 5, [2]) we generated the Flower of Life (Fig. 6 [3]), which represents a symbol of Sacred Geometry, studied by Leonardo da Vinci with respect to its shape and mathematics properties. It can be seen in Egypt, Japan, China, India, Spain, Turkey, Israel, Romania etc.

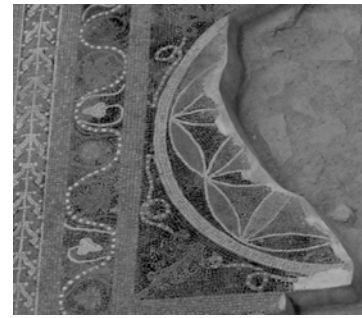


**Fig. 5.** Generation by circular structure in cascade



**Fig. 6.** Flower of Life

Fig. 7 [4] presents this geometrical floral model placed in the reception room from the West Palace of Herod the Great, fortress Masada, Israel, surrounded by pomegranate and fig leaves.



**Fig. 7.** Mosaic “Flower of Life”, placed in the fortress Masada, Israel

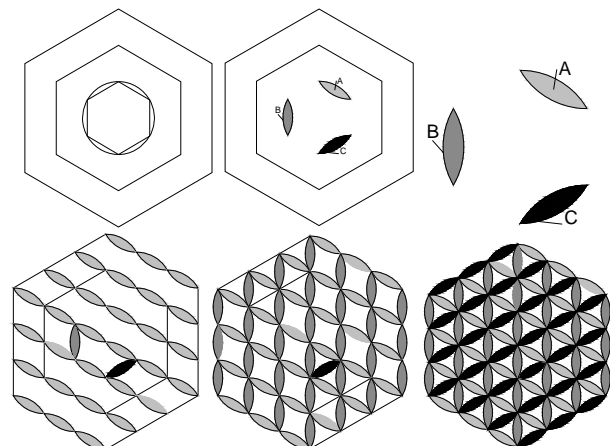
The mosaic from Fig. 8 [4], with a rectangular geometrical shape, contains a representation of the Flower of Life in its center. Today it is exposed the National Museum of Israel, after its recovering from a bathroom belonging to the palace of Herod.



**Fig. 8.** A mosaic of Israel

The Flower of Life has 90 elements, yielded from intersections of circles. They are positioned along 3 concentric hexagons in 3 positions: A, B and C. Firstly the geometry of each individual element is determined. Afterward it is multiplied, depending on the position.

We present in Fig. 9 a variant for the generation by using Computer Aided Graphics of the ornament “Flower of Life” from the studied mosaic, performed in 6 stages.



**Fig. 9.** Generation by using Computer Aided Graphics of the ornament “Flower of Life” with 90 elements.

The generation was developed by using the same procedure for 240 elements (Fig. 10).

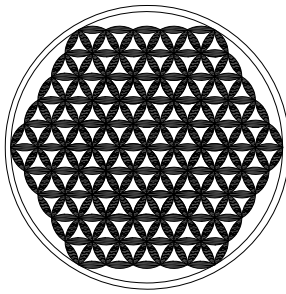


Fig. 10. Generation of the studied ornament with 240 elements.

#### 4. GEOMETRIC GENERATION FOR A FLORAL MOSAIC MASADA

The mosaic from Fig. 11 [5] was placed on the floor of a Byzantine Church from Masada, Israel



Fig. 11. Floral mosaic from Masada, Israel

Fig. 12 [6] presents a detail of the above mentioned mosaic whose geometry will be studied below.



Fig. 12. Detail – mosaic from Masada.

##### 4.1. Technologic details

The mosaic manufacturer traced the external circle and afterward divided it in 12 equal parts (tests can be done by a thread). Then it traced the corresponding radii for the 12 points determined before. Between two radii, he traced the arc tangent to the outer circle and made a stencil with the shape of the obtained petal. Having the radii, he could trace the other petals afterward. Then he glued the colored ceramic plates, including the inside of petals.

From the geometric point of view, the studied mosaic consists in 12 petals, trace between a minimum and respectively a maximum circle. The petals are not strictly delineated. The shape of each petal consists of an arc and two radii (straight lines) traced up to the minimum circle.

The curves used for reproduction which are described below can be arcs of circle or any other type of curves.

##### 4.2. Geometric generation when using an arc of circle (semicircle)

The geometric generation of the curve that we intend to use for the reproduction of a petal from the studied floral ornament is made by using Fig. 13

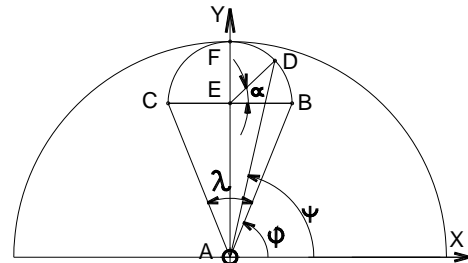


Fig. 13. The generation curve is an arc of circle

The following equations are obtained:

$$\begin{cases} x_D = ED \cdot \cos \alpha = AD \cdot \cos \psi \\ y_D = AE + ED \cdot \sin \alpha = AD \cdot \sin \psi \end{cases} \quad (1)$$

$$\begin{cases} \sin \frac{\lambda}{2} = \frac{EB}{AB} \\ \cos \frac{\lambda}{2} = \frac{AE}{AB} \end{cases} \quad (2)$$

$$\begin{cases} x_C = AB \cdot \cos(\varphi + \lambda) \\ y_C = AB \cdot \sin(\varphi + \lambda) \end{cases} \quad (3)$$

$$AF = AE + EB \quad (4)$$

$$AC = AB \quad (5)$$

We conceived a program which was used to generate Fig. 14, where a traced petal can be seen.



Fig. 14. Tracing a petal

Fig. 15 depicts the variable radii AD.

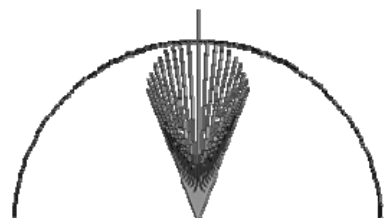


Fig. 15. Tracing a petal from the variable radii AD

The image obtained by means of the Computer Aided Generation presented in Fig. 16, reproduces the studied ornament.

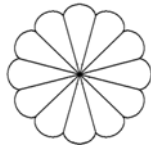


Fig. 16. The floral ornament generated by computer

#### 4.3. Geometric generation when using an epicycloid

The epicycloid is another curve that can be used to approximate the petal.

It is traced by the mechanism from Fig. 17, through the point C, providing that the following relation is obeyed:

$$\alpha = \varphi \cdot \left( 1 + \frac{r_1}{r_2} \right) \quad (7)$$

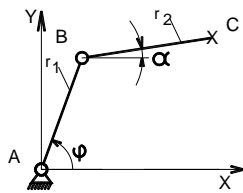


Fig. 17. Mechanism used to trace the curve that reproduces the petal from mosaic

Fig. 18 depicts the resulting petals.

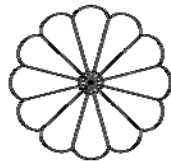


Fig. 18. The resulting petals for  $r_1=110$ ;  $r_2=10$

Both solutions generated by computer are similar to the real mosaic.

#### 4.4. Other variants of aesthetic images built on the base of the model associated to the studied mosaic

By using the above mentioned program we obtained other aesthetic images, Fig. 19.

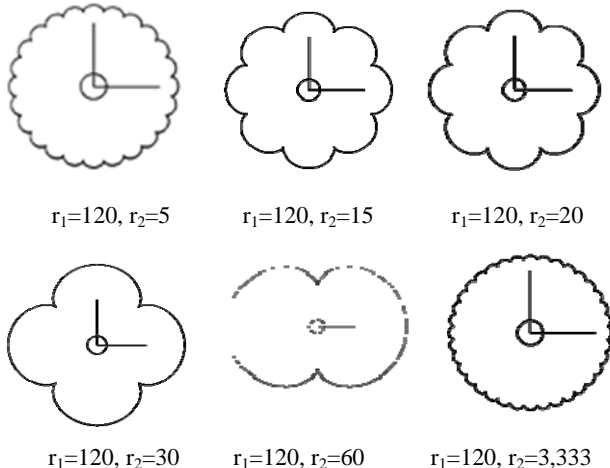


Fig. 19. Variants created for the floral ornament belonging to the mosaic from Masada generated on computer

We could notice that:

- when increasing  $r_2$ , the number of petals decreases;
- the number of petals is given by the ratio  $r_1/r_2$ ;
- for  $r_2=3.333$ , we got a number of petals equal to 36,0036, which is very close to 36 and the errors cannot be revealed by the figure.

#### 5. CONCLUSION

- Due to the talent of creators, the three mosaics selected by us in order to study the geometrical generation - a mosaic of ancient Corinth, Flower of Life, Israel and a mosaic of fortress Masada, provide refined aesthetic images which ennoble the buildings on which they are applied
- We succeeded in identifying the geometrical construction used by artists and we performed the generation of ornaments by using the computer, which provides many advantages
- The curves from the studied geometric ornaments were reproduced and we got computer generated solutions similar to the real mosaic
- The curves used for the reproductions of the mosaic from Masada are arcs of epicycloid or arcs of circle, which are simpler to achieve from the technologic point of view
- This type of generation makes possible the reproduction of an unlimited number of variants, expressed through many shapes
- We have also created other polychrome variants of ornaments based on the structure of the three analyzed examples, which can be used as elements of decorations for walls and floors, having a remarkable aesthetic which provides elegance and brightness to space.

#### REFERENCES

- [1] <http://it.camperistas.com/6227/corinto-antica>, Accessed: 2015-03-01.
- [2] [http://aeqai.com/main/2013/08/geometrically-ordered-design-the-everlasting-fruit/seed\\_of\\_life/](http://aeqai.com/main/2013/08/geometrically-ordered-design-the-everlasting-fruit/seed_of_life/) Accessed: 2015-02-20.
- [3] <http://printablecolouringpages.co.uk/?s=flower+of+life>, Accessed: 2015-02-01.
- [4] <https://floweroflifemystery.wordpress.com/2014/08/29/artifacts/> Accessed: 2015-02-15.
- [5] <http://ellisshuman.blogspot.ro/2013/12/masada-legend-and-truth.html>, Accessed: 2015-02-10.
- [6] <http://en.wikipedia.org/wiki/Mosaic>, Accessed: 2015-01-10.

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