



## Creating of 3D graphic forms in the RF-3d and Matlab GUI environment

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**Abstract:** The aim of the article is to fundamentally visualize the conceptual approaches and methods for creating, modeling and improvement (modification) of the 3D graphic forms through application of R-functions in the communication and the practical use of the programming environments RF-3d and Matlab GUI.

**Keywords:** graphic forms, modeling, transformation, modification.

### I. Introduction

The 2D graphic primitives are basic building elements (components) for the creation of 3D graphic shapes that can be used in the normal or transformed form. Although it is possible to create the greater part of 3D objects through joining in bars or extruding of 2D shapes, most software packages build three-dimensional objects quickly and conveniently through prepared graphical primitives. The most common 3D graphic forms are: cubes, pyramids, cones, cylinders, a toroid, tubes and serpentine.

Essentially, the graphic primitives have a mathematically perfect external appearance that very accurately shows that 3D shapes are depicted. Using simpler 2D graphical primitives as a basis for creating 3D objects is preferably. The primitives are best suited for building blocks for more complex shapes or for their application as a basis in the three-dimensional graphics. They can be used in a modified form, achieved through transformations and modifications. As with regard to the positioning of these forms in the three-dimensional space, there is a wide variety of embodiments.

The 3D modeling is based on the basic functions of Rvachev [1] that give opportunity for practical visualization of three-dimensional surfaces and models, describing them with an mathematical expression, which in turn makes them easy to use in the construction of each product and their use for visualization of complex mathematical figures.

This article will carry out an attempt to a description of the approach to the transition from 2D to 3D graphical visualization of objects with random or preselected surrounding surfaces. Through the substitution:

$$D = D_0 \pm z^n \quad (1)$$

for symmetrical 3D graphic forms an approach for the most simplified mathematical models will be given.

Each 2D figure described with R-functions, due to the way of describing it through the relationship  $D(x, y) \geq 0$ , is essentially a 3D graphical form. It's enough to make:

$$D(x, y) = f(x, y) = D_0(x, y, z) + z^n \quad (2)$$

$$D_0(x, y, z) = f(x, y) - z^n = 0 \quad (3)$$

or

$$z^n = f(x, y) \quad (4)$$

where  $n$  can be a random number or some function.

### II. Mathematical description of graphical forms by R-functions in the RF-3d environment

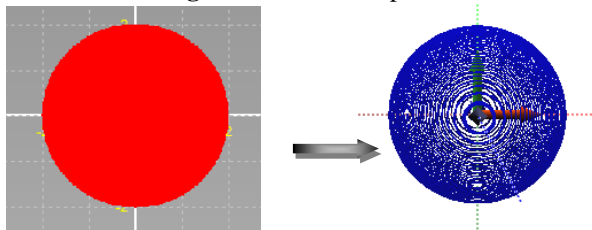
Let's imagine the description of a graphic primitive circle in 2D graphics, and then we can show the transition from 2D to 3D space.

The equations for describing of 2D and 3D are [2]:

- for a circle:  $D = 1 - x^2 - y^2 \geq 0$
- for a sphere:  $D = 1 - x^2 - y^2 - z^2 \geq 0$

Seen from fig. 1 is the existence of another coordinate –  $z$  in the space. Along with this the object – a sphere retains its overall shape from all sides.

Figure 1 Circle and sphere



On this basis and using the expression to describe of a circle:

$$D_0 = 1 - x^2 - y^2 \geq 0, \quad (5)$$

through the substitution:

$$D_0 = D_{01} + z^n \quad (6)$$

follows:

$$D_{01} \rightarrow 1 - x^2 - y^2 - z^n \geq 0 \quad (7)$$

$$D_1 \rightarrow z \geq 0, \quad (8)$$

where  $D_1$  is the plane, which limits  $z$  only in the positive half-plane [3].

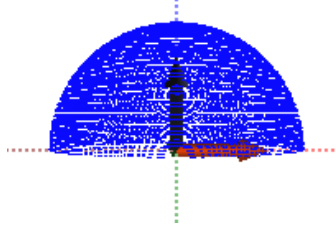
After the processing manipulation of the two expressions (7 and 8) is prepared:

$$D = D_{01} \cap D_1 = \frac{1}{2}(1 - x^2 - y^2 - z^n + z - |1 - x^2 - y^2 - z^n + z|) \geq 0, \quad (9)$$

The graphic display of the area  $D$  is presented at  $X = 0$ ,  $Y$  varies from 0 to 1, and for different values of  $n$  a set of three-dimensional graphic forms is obtained.

When  $n = 2$  a graphic form – hemisphere is prepared, using expression (9), shown in fig. 2.

**Figure 2 Hemisphere**



If the coefficient  $n$  is modified a variety of concave and convex graphic forms can be obtained, as is shown in fig. 3.

**Figure 3 Manipulated hemisphere**



The toroid appears as a stereomerical object with rotational surface, which is described by the rotation of a geometric figure around an axis located in the plane of the figure.

In the particular case, when this figure is a circle, the stereomerical body, obtained by rotating it, is called torus [4].

This graphical form is prepared by using the following mathematical equation:

$$z^2 + (\sqrt{x^2 + y^2} - a)^2 - b^2 \geq 0, \quad (10)$$

where:

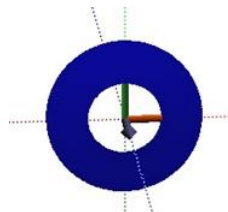
- $a$  is the large radius of the circle;
- $b$  is the small radius.

On the basis of numerous mathematical studies it has been proven that an ideal toroid is obtained in values:  $a = 0,75$  and  $b = 0,0625$ .

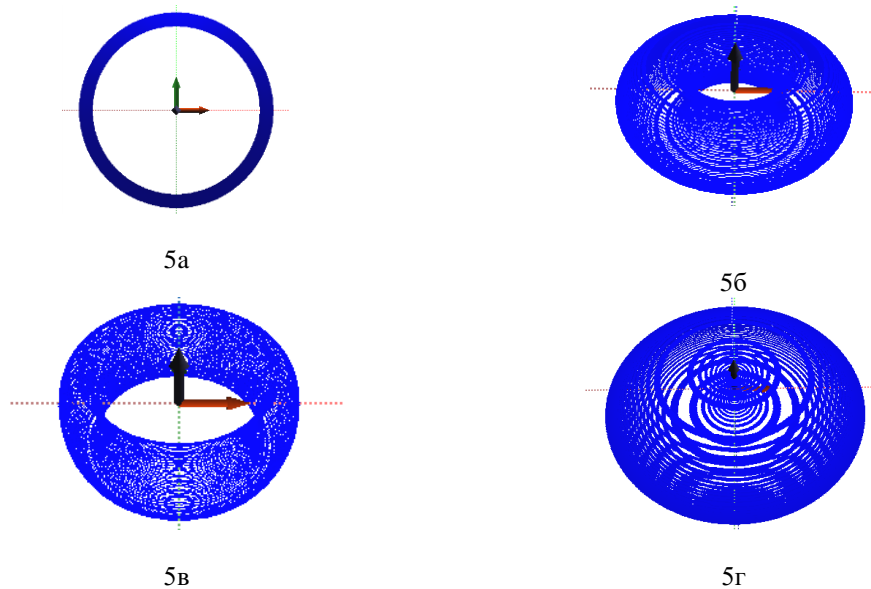
When entering a manipulation factor  $\alpha$ , certain physical processes are clarified, such as putting a screen, variable frequency fluctuations and others. Through means of this factor the impact on a particular physical process can be observed.

In fig. 4 and fig. 5a, b, c and d toroids with and without the presence of manipulation factor  $\alpha$  are shown.

**Figure 4. Toroid without the presence of manipulation factor  $\alpha$**



**Figure 5.** Toroid with manipulation factor  $\alpha$

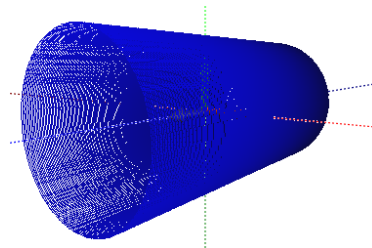


Viewing and obtaining of a graphic primitive – cylinder. The expression through which this graphic form arrived at is:

$$-\frac{\sqrt{x^2+y^2}}{1} + 1 \geq 0 \quad (11)$$

In fig. 6 the type of the graphic primitive in the RF-3D environment is shown.

**Figure 6.** Cylinder

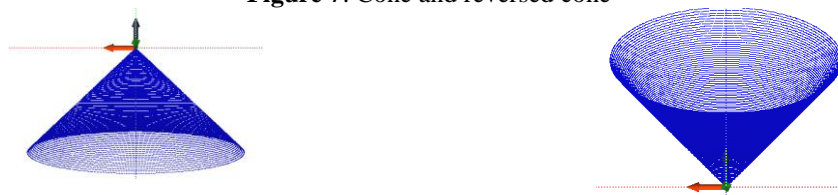


On the basis of this expression for the realization of a graphic primitive – cylinder, a graphic primitive – cone can be prepared by adding of a third coordinate  $z$  [5].

The cone can be subject to the same manipulation employed with other three-dimensional patterns in the modern computer graphic.

In figure 7 a graphical form – cone is shown.

**Figure 7.** Cone and reversed cone



### III. Description of graphical forms by R-functions in the Matlab GUI environment

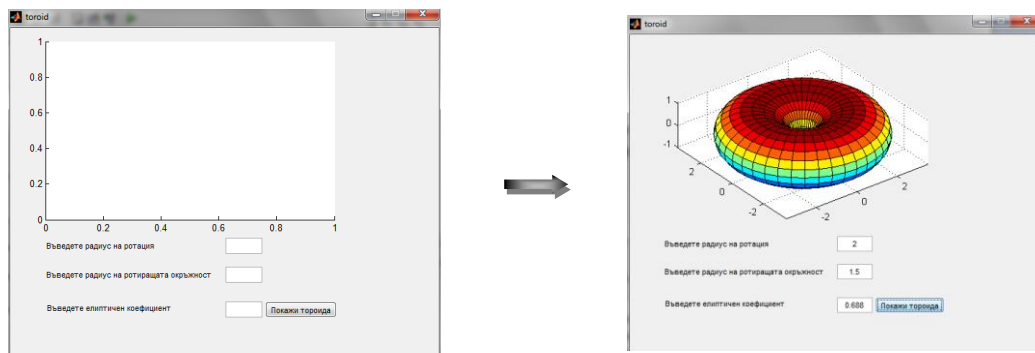
The visualization of the individual graphical primitives in the Matlab GUI environment is shown in fig. 8, fig. 9 and fig. 10.

The source-code for a graphical primitive toroid (fig. 8) is:

```
R = str2num(get(handles.edit1,'string'));
a = str2num(get(handles.edit2,'string'));
alpha = str2num(get(handles.edit3,'string'));
x = nan(41,21); y = nan(41,21); z = nan(41,21);
for j = 1:41
    for i = 1:41
        phi = (i-1)*2*pi/40;
        theta = (j-1)*2*pi/20;
        x(i,j) = cos(phi)*(R+cos(theta)*a);
        y(i,j) = sin(phi)*(R+cos(theta)*a);
        z(i,j) = alpha*sin(theta)*a;
    end
end
surf(x,y,z)
axis equal
```

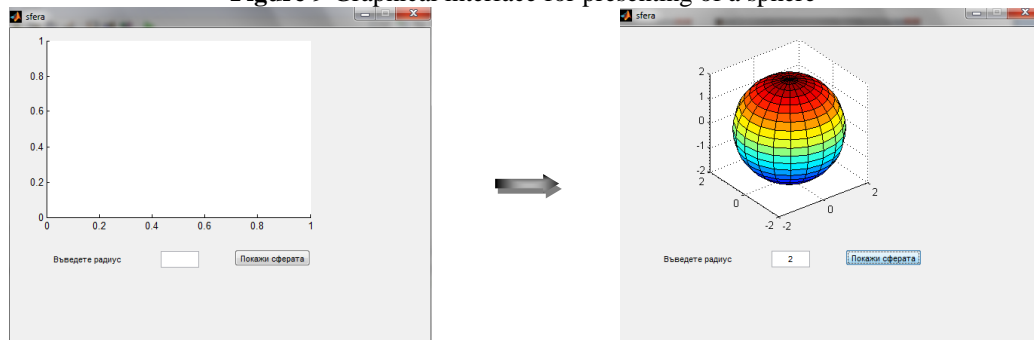
In fig. 8 graphical interface of the application is shown.

**Figure 8** Graphical interface for presenting of a toroid

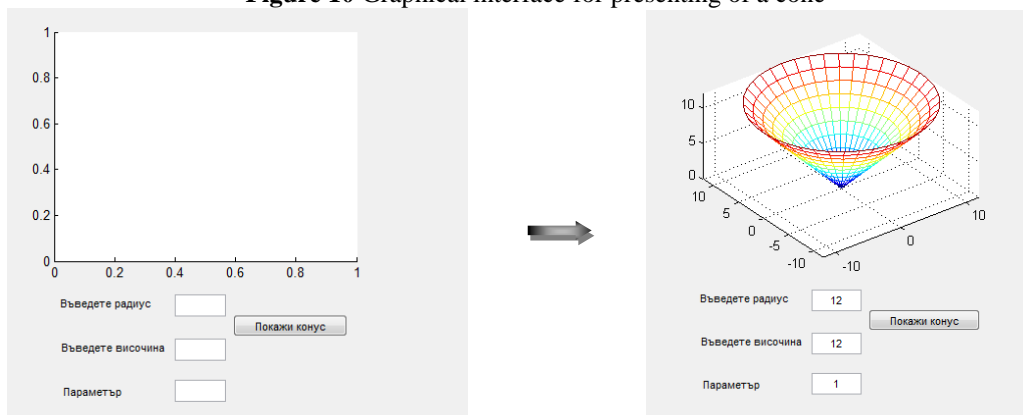


In fig. 9 graphical interface of the application is shown.

**Figure 9** Graphical interface for presenting of a sphere



**Figure 10** Graphical interface for presenting of a cone



## VI. Conclusion

On the basis of R-functions in modern computer communications volumetric graphical primitives of various types and characteristics can be obtained. From this conclusion it follows that there is a wide variety of ways to manipulate the description of 3D volumetric bodies (a pyramid, a hexagon, a star, a torus, a cylinder, a cone, etc.) and their implementation in the Matlab GUI environment.

This article proves that the basic principle for the use of R-functions – obtaining diversity is essential to the practice, i.e. opportunities exist to describe processes with physical nature through the introduction of a third coordinate  $z$ , and the inclusion of additional factors to the basic equations to display various 3D primitives.

The advantages of this method are:

- the possibility of 3D presentation of physical processes;
- from the already implemented graphic primitive various 3D manipulated (modified) bodies can be created. This essentially reveals the great wealth of the developing modern computer graphics in different fields of construction, computer design, electrical engineering, engineering design of objects in various scientific fields;
- the simplicity of the description of a graphic primitive, which is performed with the introduction of a single equation in the program (RF-3d) and the possibility of their visualization in Matlab GUI, where it is necessary to record equations and to introduce parameters.

## References

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