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Application of MATLAB Software in the Teaching of Space Analytical Geometry

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Abstract

In the theory teaching of space analytic geometry in higher mathematics, this paper attempts to integrate MATLAB software experimental teaching with it, through the visualization of analytic geometry figure, enhances the demonstration of space curve, curved surface and other teaching examples, so achieve the teaching purpose of enriching classroom teaching and improving students' hands-on ability.

Keywords

Analytic geometry; MATLAB; space curve and curved surface.

1. Introduction

Space analytic geometry is an important content in higher mathematics, which is a basic tool for solving many practical problems, and it is an important warm-up for studying differential geometry, mechanics, and other scientific technologies, at present, the teaching of analytic geometry is still relatively traditional, the formation and transformation process of many curved surfaces depend on teaching on the blackboard, it is difficult to vividly demonstrate the connection and transformation between curved surface. In allusion to the teaching content characteristics of space analytical geometry, we make up for deficiencies of traditional teaching with powerful calculation function and graphic design demonstration function of MATLAB software, so that students can more accurately grasp the nature of space figures, strengthen intuitive understanding, create opportunities to repeatedly observe the generation of figures, and cultivate students' mathematical thinking of discovering law and exploring results[1,2].

2. Organization of the Text

2.1. Introduction to MATLAB Graphics Function

The graphic processing function of MATLAB is very powerful, it can make complex function problems in higher mathematics draw ideal figures through a few simple commands, so that the functional relationship and figures are tightly integrated, thus making problems of higher mathematics more concrete and vivid. MATLAB is used to assist teaching of analytic geometry; the abstract functions can be intuitively presented with figures, this idea which integrates numbers and figures not only stimulates students' learning interest, but also helps students better understand mathematical formulas.

2.2. Call MATLAB Software to Draw Space Curve

In the teaching of analytic geometry, the space curve is often given by parametric equations or general equations (two simultaneous space curved surfaces), it is very difficult to discriminate its shape and position, the demonstration of MATLAB software is helpful for students to observe and understand at a glance.

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Example 1: draw three-dimensional curve $\begin{cases} x = e^{-t/10}\sin(5t), \\ y = e^{-t/10}\cos(5t), \ t \in [0, 2\pi] \\ \quad z = t, \end{cases}$

The statements of the above figure drawn with MATLAB are as follows:

```
>>xt = @(t) exp(-t/10).*sin(5*t);
yt = @(t) exp(-t/10).*cos(5*t);
zt = @(t) t;
fplot3(xt,yt,zt,[0 2*pi])
xlabel('x');ylabel('y');zlabel('z');
grid on
```

The figure drawn with MATLAB is shown in Fig.1.

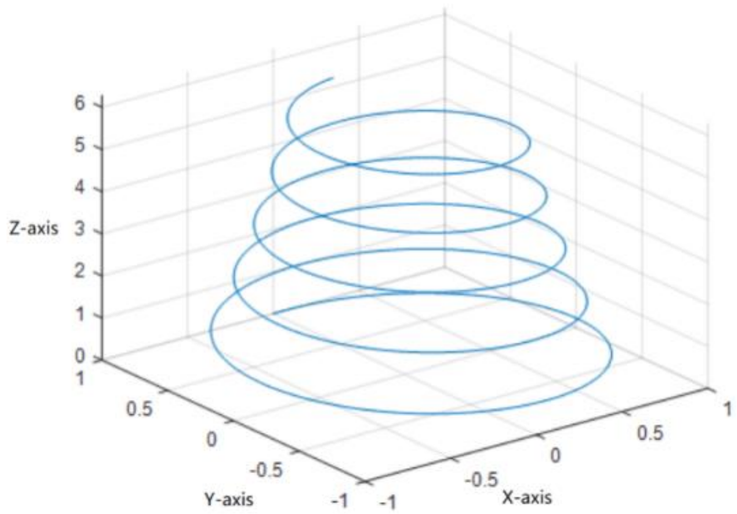

Fig 1. Three-dimensional curve

The parametric equations of many curves and space curve are drawn on one figure, if we want to demonstrate the function figure when the parameters take different values, we can use plot3 to achieve it.

Example 2: space curved surface $z = x\cos y$, each time x take a fixed value, a two-dimensional curve is determined, try to draw a corresponding set of y-z curves when x take different fixed values.

The statements of the above figure drawn with MATLAB are as follows:

```
>>x=-3:0.1:3;
[x,y]=meshgrid(x);
z=x.*cos(y);
plot3(x,y,z)
grid on
```

The figure drawn with MATLAB is shown in Fig.2.

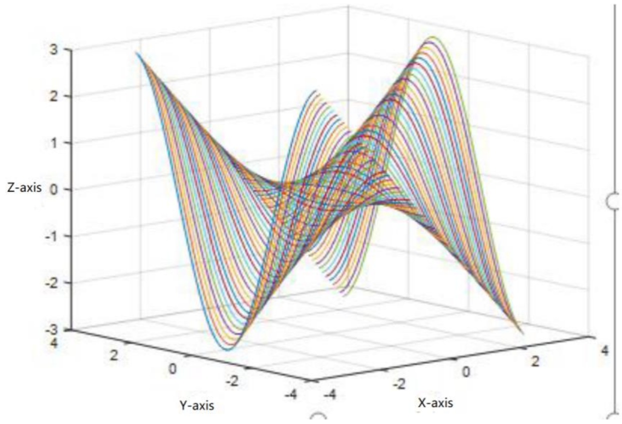

Fig 2. A series of y-z curves

2.3. Call MATLAB Software to Draw Space Curve

When studying problems of space geometry, it is easier to draw the space figures of rotational surfaces, cylinders, and quadric surface, but the intersection shape and the relative positional relationship among them are difficult to achieve, we can call drawing functions of MATLAB software assist teaching, it can not only accurately display the intersection shape, but also easily discriminate its relative position relationship.

2.3.1. Drawing of Common Quadric Surface Figures

Example 3: draw lower half of unit sphere whose center is the origin and the unit sphere whose center is the point (5,4, -1).

The statements of the above figure drawn with MATLAB are as follows:

```
>>[x,y,z] = sphere;
figure
surf(x+5,y+4,z-1)
hold on
p=z>0.5;
z(p)=NaN;
surf(x,y,z)
axis equal
```

The figure drawn with MATLAB is shown in Fig.3.

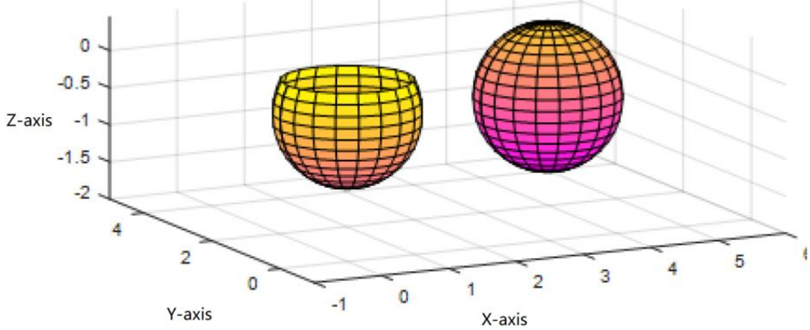

Fig 3. Dimension unit sphere

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Example 4: draw the cylinder where directrix are $x^2+y^2=4$ and $x^2+y^2=1$ respectively, generatrix is parallel to the cylinder of the z axis.

The statements of the above figure drawn with MATLAB are as follows:

```
>>[x,y,z]=cylinder(2,30);
surf (x,y,z)
hold on
[X,Y,Z]=cylinder(1,20);
surf (X,Y,Z)
```

The figure drawn with MATLAB is shown in Fig.4.

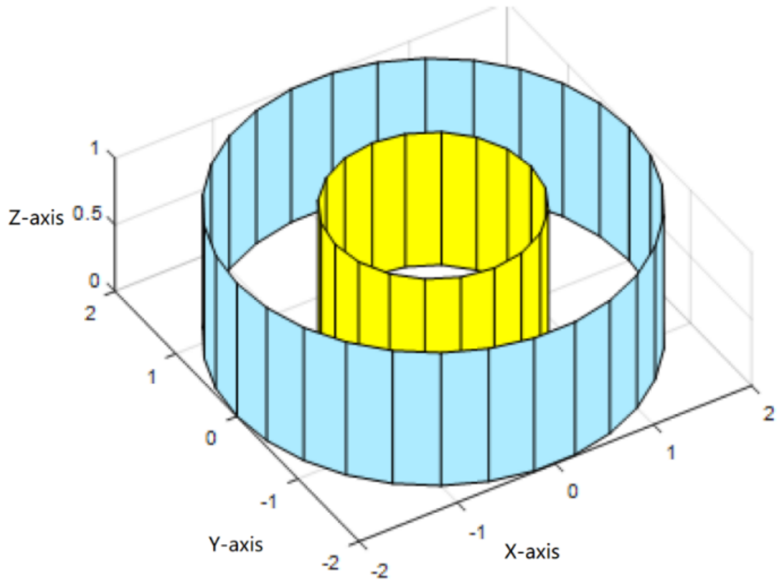

Fig 4. Two cylinders with generatrices parallel to the z-axis

Example 5: draw rotation surface normal obtained after ellipse $x^2+4y^2=4$ rotate around y axis.

The statements of the above figure drawn with MATLAB are as follows:

```
>> y=-1:0.2:1;
x1=sqrt(4-4*y.^2);
[X,Y,Z]=cylinder(x1,20);
surfnorm(X(:,11:21),Y(:,11:21),Z(:,11:21));
hold on
x2=-sqrt(4-4*y.^2);
[X1,Y1,Z1]=cylinder(x2,20);
surfnorm(X1(:,11:21),Y1(:,11:21),Z1(:,11:21));
axis equal
```

The figure drawn with MATLAB is shown in Fig.5.

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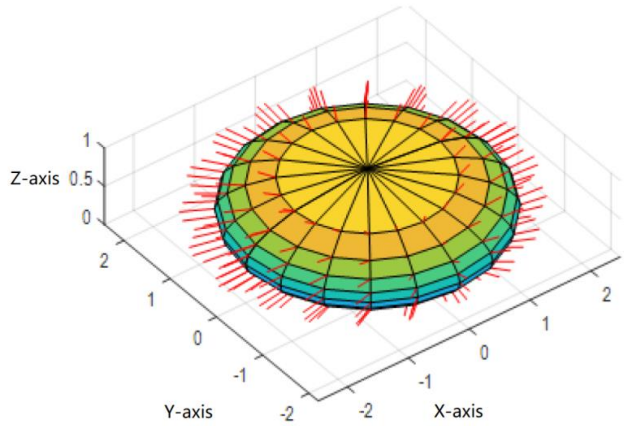

Fig 5. Normal of the ellipsoid of revolution

2.3.2. Draw Quadric Surface Intersection

Example 6: draw two cylindrical figures with equal diameter and meet at right angles.

The statements of the above figure drawn with MATLAB are as follows:

```
>>[x,y,z]= cylinder(1,100);
z=[-1*z(2,:);z(2,:)];
surf (x,y,z)
hold on
surf (y,z,x)
axis equal
```

The figure drawn with MATLAB is shown in Fig.6.

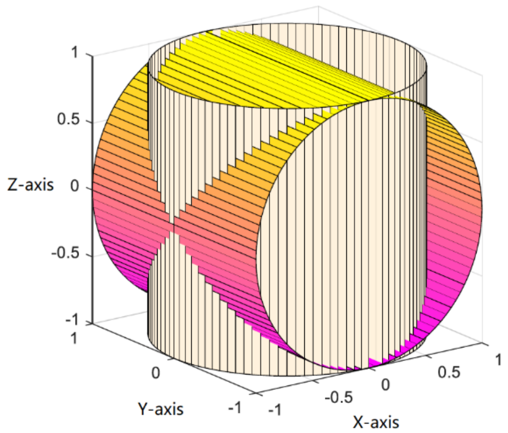

Fig 6. Orthogonal cylinder

Example 7: draw the figure with cone surface $z^2 = x^2 + y^2$ and observe its intersection shape with plane $x=1$ and $z=2-x$.

The statements of the above figure drawn with MATLAB are as follows:

```
>>subplot(2,2,1)
fsurf(@(x,y)sqrt(x.^2+y.^2))
hold on
fsurf(@(x,y)-sqrt(x.^2+y.^2))
hold on
fsurf(@(y,z)1,@(y,z)y,@(y,z)z)
```

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```
axis square
subplot(2,2,2)
fsurf(@(x,y)sqrt(x.^2+y.^2))
hold on
fsurf(@(x,y)-sqrt(x.^2+y.^2))
hold on
fsurf(@(x,y)x,@(x,y)y,@(x,y)-2-x)
axis square
```

The figure drawn with MATLAB is shown in Fig.7 and Fig.8.

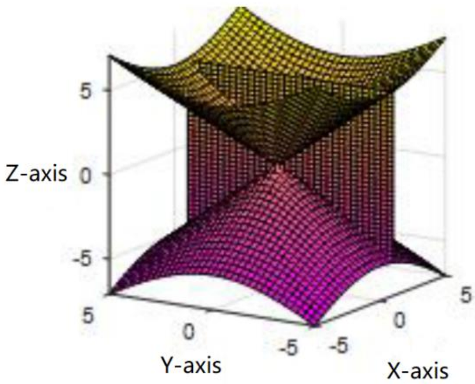

Fig 7. Intersection line of a cone and a plane

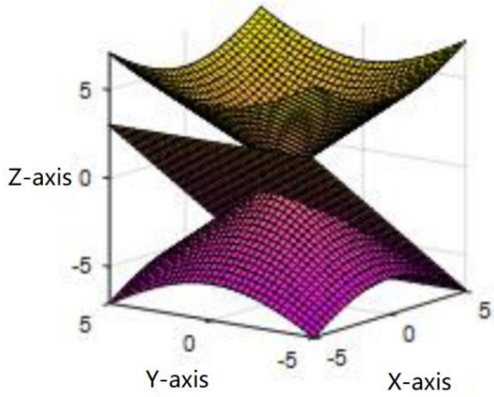

Fig 8. Intersection line of a cone and a plane

2.3.3. Draw Projection Area of Quadric Surface on Coordinate Surface

Example 8: draw the figure with elliptic paraboloid $z=\frac{x^2}{4}+\frac{y^2}{9}$ and observe its projection on each coordinate surface.

The parametric equation of elliptic paraboloid is:

$$\begin{cases} x=2u\sin v, \\ y=3u\cos v,\ (0\le u\le 5, 0\le v\le 2\pi) \\ z=u^2, \end{cases}$$

The statements of the above figure drawn with MATLAB are as follows:

```
>>fsurf(@(u,v)2*u.*sin(v),@(u,v)3*u.*cos(v),@(u,v)u.^2,[0,5,0,2*pi])
hold on
fsurf(@(u,v)0,@(u,v)3*u.*cos(v),@(u,v)u.^2,[0,5,0,2*pi])
hold on
fsurf(@(u,v)2*u.*sin(v),@(u,v)0,@(u,v)u.^2,[0,5,0,2*pi])
hold on
fsurf(@(u,v)2*u.*sin(v),@(u,v)3*u.*cos(v),@(u,v)0,[0,5,0,2*pi])
```

The figure drawn with MATLAB is shown in Fig.9.

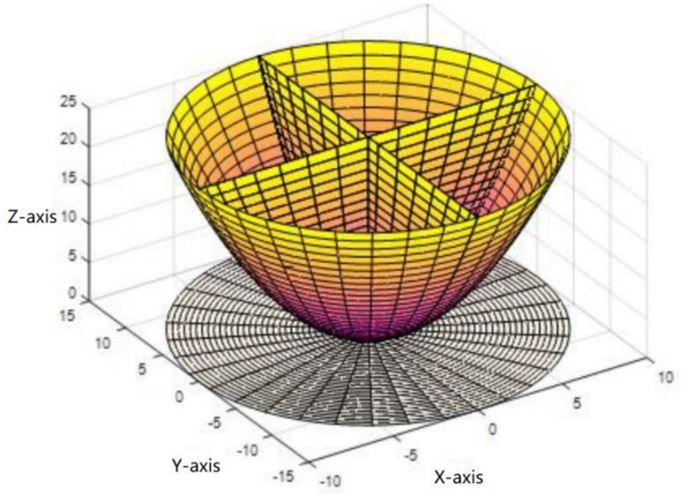

Fig 9. Projection of elliptic paraboloid onto coordinate surface

3. Conclusion

There are many benefits to integrate mathematical experimental courses in space analytic geometry, but we cannot deviate from the original teaching purpose of this course for adding mathematical experiments. Therefore, mathematical experiments are experimental courses that assist students from the angle of students; teachers should pay attention to the following problems when integrating mathematical experiments in space analytical geometry:

(1) In the teaching process of analytical geometry theory, teachers must focus on penetrating the basic ideas and methods of mathematics, reduce unnecessary and detailed demonstrations and complex calculations, and try to avoid adding students' learning burden.

(2) The teaching objects of higher mathematics teaching are freshmen; the program language with high complexity should be avoided in the experimental class, something that is easy to implement should be selected, moreover, students should also avoid over-reliance on the calculation of mathematical software and neglect the study of basic theory and basic operations.

(3) The mathematical experiments are integrated into the course of space analytical geometry; the selected experimental contents should be suitable for students' mastery for software. Generally, the simpler the software, the better, students gradually improve; do not rush for quick results.

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