Application of Matlab in Teaching of Statics in Theoretical Mechanics Course

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ABSTRACT: Two specific examples of statics illustrate the importance and convenience of introducing the numerical simulation in the theoretical mechanics course teaching. he same results were obtained through analytic method and computation program. We can use these results to testify human calculation. In class, we guide the student to use Matlab to solve problems in the theoretical mechanics computing processes. Not only can they verify the correctness of the traditional operation, they will also lay a solid foundation for the students future design and research work.

KEYWORD: Theoretical Mechanics, Statics, Matlab

1 INTRODUCTION

Matlab is the abbreviation of the Matrix Laboratory. It is a kind of interactive programming language based on matrix calculation. Mainly used for analysis and design of matrix calculating, controlling, and information processing[1]. It is convenient to use, simple and rich in content, operation efficiency, and easy to carry on the secondary development by the user. Compared with other computer languages, it is more suitable to the science and technology professional writing habits and ways of thinking, and greatly improves the efficiency of programming and debugging.

Hu jing discussed how to deal with nonlinear problems in theoretical mechanics[2]. Ao wengang [3] established the visual interface using Matlab in teaching of Theoretical Mechanics. It improves the students' perceptual knowledge in solving mechanical problems. The necessity of training the students to solving the problem by computer is analyzed in the teaching of theoretical mechanics[4], the main problems and causes of realizing the teaching concept are discussed, and the implementation of this teaching concept based on the mobile computing platform is proposed.

The papers above show that the necessity and importance of introducing information technology in teaching of theoretical mechanics course.

Two specific examples of statics illustrate the importance and convenience of introducing the numerical simulation in the theoretical mechanics course teaching[5]. In class, we guide the student to use Matlab to solve problems in the theoretical mechanics computing processes. Not only can they verify the correctness of the traditional operation, they will also lay a solid foundation for the students future design and research work.

2 SIMPLIFY THE COPLANAR ARBITRARY FORCE SYSTEM

A force system is composed by N force. Try to calculate the resultant of forces.

2.1 *Analytic method*

Through simplifying the force system to any point, we get the main vector and the principal moment.

$$\vec{F}_O = \sum_{i=1}^{N} \vec{F}_i \left[F_{Ox}, F_{Oy} \right] \tag{1}$$

$$M_O = \sum_{i=1}^{N} (\vec{r}_i - \vec{r}_o) \times \vec{F}_i = \sum_{i=1}^{N} (x_i - x_o) F_{yi} - (y_i - y_o) F_{xi} \tag{2}$$

$\vec{r}_i$ is the radius vector of action point of $\vec{F}$, and $\vec{r}_o$ is the radius vector of point O.

The main vector and the moment are transferred to T point. Assuming the moment is 0, then the resultant force will be obtained.

Assuming

$$M_t = (\vec{r}_0 - \vec{r}_t) \times \vec{F}_O + M_O = 0 \tag{3}$$

then

$$(r_0 - r_t)\begin{bmatrix} F_{Oy} \\ F_{Ox} \end{bmatrix} = -M_O \tag{4}$$

The point of the resultant force coordinate is

$$r_t = \frac{M_O}{\begin{bmatrix} F_{Oy} \\ F_{Ox} \end{bmatrix}} + r_0 \tag{5}$$

r_t is the radius vector of point T.

2.2 Computation program:

Clear
    N=input('The number of input force=');
    for i=1:N
    i;F(i,:)=input('Component   force   of   F(i)
[Fx(i),Fy(i)]= ');
    r(i,:)=input('Coordinate of one F(i) action point
r(i)=[rx,ry]= ');
    end
    ro=input('Center   of   reduction   coordinate
ro=[xo,yo]=');
    Fo=sum(F)
    for   i=1:N   M(i)=F(i,2)*(r(i,1)-ro(1))-
F(i,1)*(r(i,2)-ro(2));
    end
    Mo=sum(M)
    rt=Mo/[Fo(2);-Fo(1)]+ro
    Result:
    The number of input force=3
    Component force of F(i)
    [Fx(i),Fy(i)]= [2,3]
    Coordinate of one F(i) action point
    r(i)=[rx,ry]= [-1,0]
    Component force of F(i)
    [Fx(i), Fy(i)]= [-4,7]
    Coordinate of one F(i) action point
    r(i)=[rx, ry]= [1,-2]
    Component force of F(i)
    [Fx(i),Fy(i)]= [3,-4]
    Coordinate of one F(i) action point
    r(i)=[rx,ry]= [1,2]
    Center of reduction coordinate
    ro=[xo,yo]=[-1,-1]
    Fo =
    1   6
    Mo =
    -9
    rt =
    -2.5000 -1.0000

The same results were obtained through analytic method and computation program. We use the computation program to testify the correctness of analytic method. And we can also improve our master ability of computation software.

3 THE EQUILIBRIUM OF FORCES

Truss structure was shown in Fig. 1. Try to calculate the normal force of A, B, C.
    Assuming

$$P_1 = 200; \quad P_2 = 100; \quad L_1 = 2; \quad L_2 = \mathrm{sqrt}(2);$$
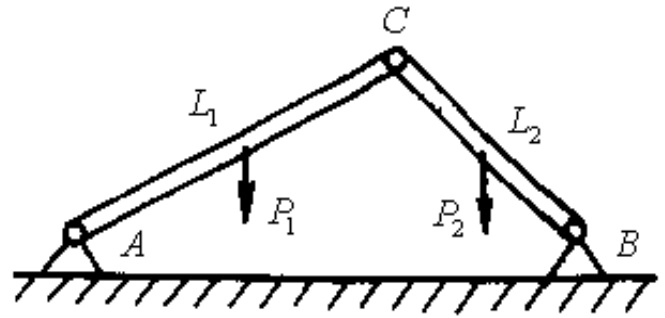
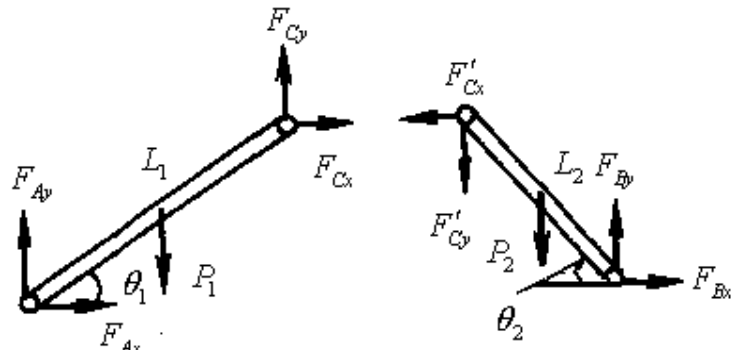$$\theta_1 = 30*pi/180;\ \theta_2 = 45*pi/180;$$

Fig. 1 truss structure

Fig. 2 force analysis

3.1 Analytic method

a. Force analyses were carried on in Fig. 2. From Fig. 2, the equation of equilibrium of the force system was obtained as follows

$$\sum F_x = 0$$

$$F_{Ax} + F_{cx} = 0 \tag{6}$$

$$\sum F_y = 0$$

$$F_{Ay} + F_{Cy} - P_1 = 0 \tag{7}$$

$$\sum M_A = 0$$

$$F_{Cy}L_1\cos\theta_1 - F_{Cx}L_1\sin\theta_1 - \frac{1}{2}P_1L_1\cos\theta_1 = 0 \tag{8}$$

$$\sum F_x = 0$$

$$F_{Bx} - F_{cx}' = 0 \tag{9}$$

$$\sum F_y = 0$$

$$F_{By} - F_{Cy}' - P_2 = 0 \tag{10}$$

$$\sum M_B = 0$$

$$F_{Cy}'L_2\cos\theta_2 + F_{Cx}'L_2\sin\theta_2 + \frac{1}{2}P_2L_2\cos\theta_2 = 0 \tag{11}$$

3.2 *Computation* program:

```
Clear
    P1=200;P2=100;L1=2;L2=sqrt(2);
    theta1=30*pi/180; theta2=45*pi/180;
    % F=[FAx;FAy;FBx;FBy;FCx;FCy]
    A=[1,0,0,0,1,0;0,1,0,0,0,1;0,0,0,0,-
sin(theta1),cos(theta1);0,0,1,0,-1,0;0,0,0,1,0,-
1;0,0,0,0,sin(theta2),cos(theta2)]
    B=[0;P1;P1/2*(theta1);0;P2;-P2/2*(theta2)]
    F=A\B;
    disp('FAx,FAy,FBx,FBy,FCx,FCy')
    disp(F')
Result:
```

A=

1.0000	0	0	0	1.0000	0
0	1.0000	0	0	0	1.0000
0	0	0	0	-0.5000	0.8660
0	0	1.0000	0	-1.0000	0
0	0	0	1.0000	0	-1.0000
0	0	0	0	0.7071	0.7071

B=

```
    0
    200.0000
    52.3599
    0
    100.0000
    -32.2699
```

FAx,	FAy,	FBx,	FBy,	FCx,	FCy
73.5385	181.9975	-73.5385	118.0025	-73.5385	18.0025

The same results were obtained through analytic method and computation program.

4 CONCLUSION

Two specific examples of statics illustrate the importance and convenience of introducing the numerical simulation in the theoretical mechanics course teaching. The same results were obtained through analytic method and computation program.

We can use these results to testify human calculation ability. In class, we guide students to use Matlab to solve problems in theoretical mechanics computing processes. Not only can they verify the correctness of traditional operation, they will lay a solid foundation for students future design and research work.

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