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Bionic Design and Experimental Study for the Space Flexible Webs Capture System

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ABSTRACT In order to make the space flexible webs system have more effective capability of capture, this paper designs a new space debris removal device, which consists of bionic flexible webs, central hub, magnetic mass and rotating mechanism. According to the principle of bionics and institutional design method, which based on the research of spider web structure and capture performance analysis. Firstly, the image processing system of spider web is established, and the spider web image is digitally processed to extract the structure shape of the spider web. According to the structure of spider web, a simplified cobweb-like flexible structure is proposed and a ''cobweb-like'' flexible capture device is designed. Then, the model of flexible web is established based on the finite element method, and the capture effect is compared with the traditional quadrilateral webs. Finally, a ground experiment system of ''cobweb-like'' flexible capture device is designed, and a verification experiment of the capture effect of the flexible webs is carried out. The results show that the bionic design scheme in this paper can fully meet the design requirements for the flexible webs capture system in space and the research provides theoretical and experimental references for the engineering realization of the space flexible webs capture system.

INDEX TERMS Space flexible webs, bionic design, collision analysis, ground test.

I. INTRODUCTION

Compared with rigid structural, flexible webs have the advantages of low cost, light weight and easy deformation, etc. Due to its unique flexible characteristics, flexible webs have been widely used in the engineering field, such as fishing net, police net gun, barricade of unmanned aerial vehicle (UAV) and so on. With the development of aerospace technology, space flexible webs capture system has become a new way of space on-orbit operation due to its high fault tolerance. In the field of removing space debris, it has received widely attention and active research from global scholars.

The space flexible webs capture system is a typical nonlinear dynamic system. The basic workflow of space capture system mainly includes projecting and unfolding the flexible webs, approaching and capturing the targets, closing the web bodies and derailment. The main features of space flexible webs capture system are high universality and high fault tolerance. Current researches on space flexible webs capture system mainly includes several aspects, such as the dynamics modeling and simulation of flexible webs, ground test verification and on-orbit space test verification. In 2001, in order to mitigate the shortage of geosynchronous orbit resources, the European Space Agency (ESA) proposed a project of GOGER to capture a disabled spacecraft by using a space flexible web [1], [2]. In 2012, the rocket of REXUS 12 carried the test device of Suaineadh to verify the feasibility of space flexible webs [3]–[5]. In February 2019, a debris removal satellite of European Union successfully completed the demonstrative experiment and captured the space debris, which verified the feasibility of the space flexible webs to capture space debris [6], and others [7]–[11].

Human beings are the most intelligent creatures on the earth, but many biological structures in nature have already

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surpassed our cognition and discovery. Therefore, this is the meaning of the birth of bionics. Bionics, by simulating the structure, function, and behavior of natural beings, incorporates wonderful biological ideas into scientific research and engineering practice, which improving the development of technology [12]. The spider has survived and reproduced on the earth for hundreds of millions of years, and the spider webs have also evolved into a perfect structure, showing excellent comprehensive mechanical properties [13]–[16]. The spider webs can effectively resist different loading effects and can efficiently capture prey. Donald [17] analyzed the configuration characteristics of spider webs by computer and studied the stress-strain characteristics of the webs. Du *et al.* [18] discovered a new hierarchical structure of spider webs with very high strength, which composed of a polypeptide chain network and silk fibers. Agnarsson [19] studied the biomechanical characteristics of Darwinian spider silk in Madagascar. The research found that the toughness of spider silk will evolve with the environment, thereby reducing the breakup of the spider webs. Lin *et al.* [17] and Frank and Jovan [20] setted up the finite element model of spider webs by softwares of OASYS DYNA and ABAQUS, and analysed the response characteristics of the spider web with impact load. However, the current researches on spider webs mainly focus on the microscopic material properties of spider silk, but ignore the unique mechanical advantages on the macrostructure of spider webs.

Motivated by the published works, this paper takes the spider webs as the research object from the perspective of bionics. By researching the structure of spider web and analyzing its capture performance, a new space flexible webs capture system that composed of cobweb, center hub, magnetic mass, and rotating mechanism is presented. Combined with the structural characteristics of spider webs, this new system has higher structural stability and fault tolerance through static calculation and capture performance analysis.

The main highlights of this article are as follows:

(1) A new bionic design scheme of space flexible webs capture system was proposed based on the biologically inspiration of spider webs;

(2) A ‘‘cobweb-like’’ flexible web with octagonal structure was designed via the idea of morphological bionics, which has stronger structural stability and lower energy dissipation than the traditional flexible web with quadrangular structure;

(3) The ground experiment system of ‘‘cobweb-like’’ flexible webs capture device was designed, which can provide a test platform for verifying the feasibility of the bionic space flexible webs capture system.

The rest of this paper is organized as follows. Section 2 introduces the ‘‘cobweb-like’’ bionic design scheme of the flexible webs capture system. Section 3 creates the dynamics model of single spider silk and the collision model between flexible webs and the target. Section 4 gives the simulation results. Then, Section 5 introduces the ground experiment system of ‘‘cobweb-like’’ flexible webs capture device, and a typical experiment was carried out. Finally, Section 6 gives the conclusions.

II. THE SCHEME OF BIONIC DESIGN

As the excellent hunter in nature, the spider can capture prey in several times heavier than its own weight. The ductility and strength silk is used to build the spiral spider web, which contains the radial lines to guarantee the web body is not easy to break, and the contours to enwind and capture prey. Combined the radial line and contour of silk, the spider web can have super energy dissipation capacity, which will make the prey to rest as soon as possible. Therefore, inspired by the biological inspiration of spider webs, this paper takes its structure as a bionic template to design the space flexible webs capture system.

A. THE SHAPE EXTRACTION OF SPIDER WEBS

As shown in Fig. 1, the spider web mainly consists of the radial silk, catching silk, frame silk and central region, etc. The radial silk is important to stable the web structure, which radiates around the web surface through the central region to fix the catching silk. The stick catching silk is coiled in spiral shape that captures prey. The frame silk is to act as the frame of the web structure, and the shape of web body is determined by the central region [21]. The bionics is an amazing subject that converting the natural phenomenon into a mathematical model by analyzing the biological structure, function and material. According to the engineering requirements, the mathematical model will continue to be optimized into an engineering model with a large number of engineering tests. Based on the current researches of spider webs, this paper analyzes the structure model of spider webs, and extracts its simplified structure model by establishing an image processing system.

In order to get the configuration characteristics of spider web, we develop an image processing system, as shown in Fig. 2. The image processing system mainly includes the

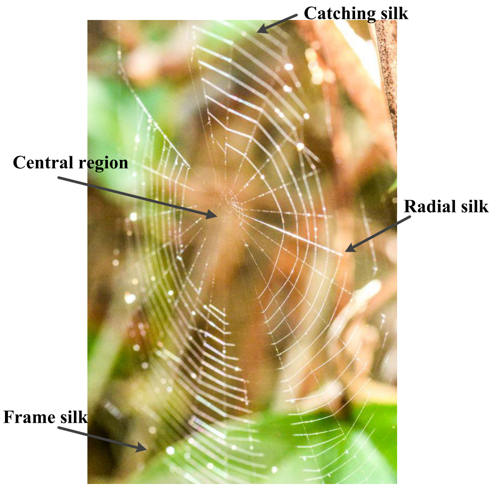

FIGURE 1. The spider web structure.

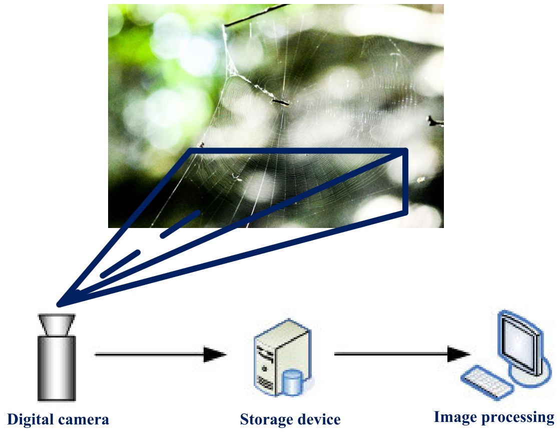

FIGURE 2. The image processing system of spider webs.

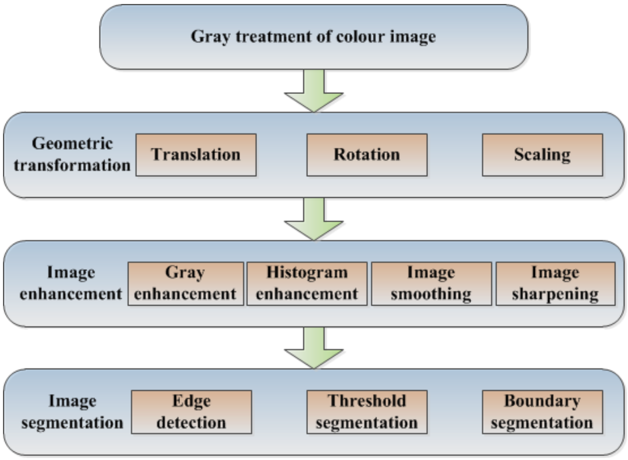

FIGURE 3. The image processing.

target (spider web), digital camera, image storage equipment and image processing equipment, the image processing is shown in Fig. 3.

The inherent vibration characteristic of the flexible webs is reflected by the free perturbation motion. The characteristic of free perturbation motion is reflected by eigenvalues and eigenvectors.

B. BIONIC DESIGN OF THE SPACE FLEXIBLE WEBS CAPTURE SYSTEM

The bionic design steps of the space flexible webs capture system are as follows. First, the geometrical characteristic of spider webs is extracted by the image processing system. Considering the storage and unfolding of the web body, the original suborbicular spider web is improved to the octagonal structure, and the central region has been designed in circular rigid structure, as shown in Fig. 4.

Then, according to the needs of engineering application, the three-dimensional (3D) structure of the space flexible webs capture system is designed by the 3DMAX software. Finally, we design and optimize the internal structure of the capture device, which includes the flexible web, central rigid body, magnetic mass block, variable-speed motor, rotating support, transmission components and other electronic equipment, as shown in Fig. 5.

In detail, the speed regulating motor and the rotating support are installed at the bottom center of the capture device, as shown in Fig. 5. The central rigid body is connected to the variable-speed motor through transmission components. Before working, the flexible web is folded on eight diagonal radial lines, and then coiled to receive in the center of rigid body. There are eight magnetic mass blocks tied on the angular points of the octagon flexible web, which symmetrical adsorbed around the central rigid body under the magnetic forces.

When operating the space flexible webs capture system, the variable-speed motor will drive the central rigid body to rotate through the transmission components. When the rotation speed reaches the predetermined angular velocity, the magnetic mass blocks will drive the web body to rotate and expand by eliminating the magnetism of the central rigid body.

In general, the traditional flexible webs are in quadrangular configuration, as shown in the Fig. 6. Inspired by the bionic design of spider webs, we develop octagonal flexible webs in this paper. With super strength and high tensile, the PBO fiber is adopted as the material of flexible web, so as to improve the stability of the web body and accelerate the energy dissipation after capturing space debris.

III. DYNAMICS MODEL OF FLEXIBLE WEB

A. DYNAMICS MODEL OF SINGLE ROPE

The mechanical analysis of the single rope is conducive to research the dynamics properties of the whole flexible web. A single rope is adopted to describe the dynamics model of the flexible web. As shown in Fig. 7, the both ends of the rope are fixed, its length is $2L$, and the cross-sectional area is A.

As the collision target, a mass element hits the rope with the initial velocity of V_0. The stress-strain relationship of the single rope can be expressed as

$$\sigma = E\varepsilon + B \tag{1}$$

where the different combinations of E and B can be applied to different loading situations.

The displacement of the mass element is y, and the rotation angle of the rope is θ. The relationship between them is expressed as

$$y = L\tan\theta \tag{2}$$

The elongation of the single rope is

$$\Delta = \frac{2L}{\cos\theta} - 2L \tag{3}$$

Therefore, the strain of the rope can be described as

$$\varepsilon = \frac{\Delta}{2L} = \frac{1}{\cos\theta} - 1 \tag{4}$$

The stress description of the rope is

$$\sigma = E\frac{1}{\cos\theta} + B - E \tag{5}$$

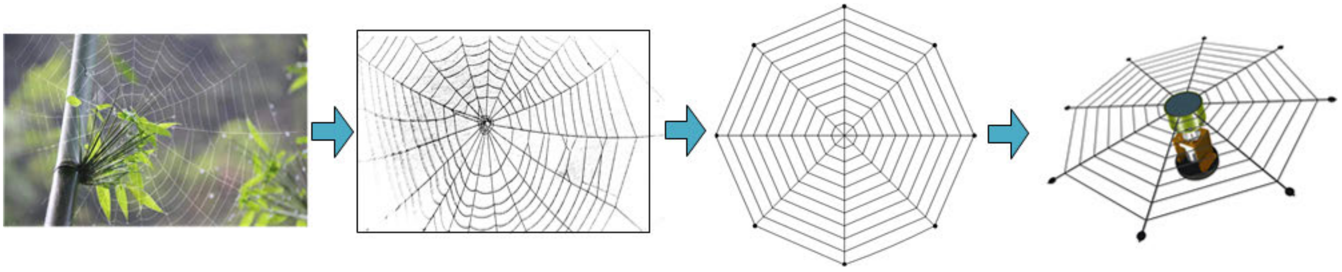

FIGURE 4. **Bionic design process.**

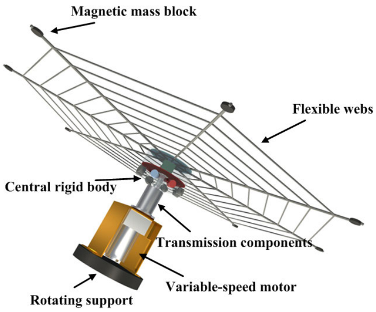

FIGURE 5. **The internal structure of the capture device.**

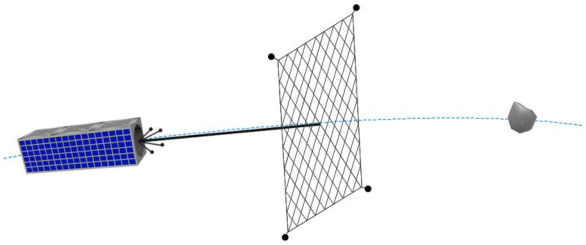

FIGURE 6. **The quadrangular flexible webs.**

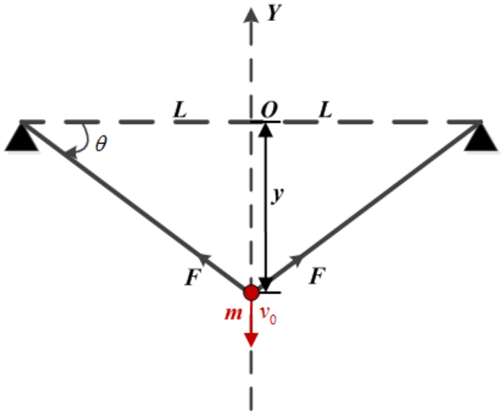

FIGURE 7. **Dynamics model of single rope.**

Ignoring the mass and gravity of the single rope, the dynamics model is as follows

$$-2A\sigma \sin\theta = my'' \tag{6}$$

The system has one degree of freedom, so the dynamics model can be transformed by the variable of θ

$$\theta'' + 2\tan\theta \cdot \theta' = -\frac{A}{mL}(E + s\cos\theta) \cdot \sin 2\theta \tag{7}$$

Define $\theta' = p, p^2 = Y$, the following equation can be deduced as

$$\theta'' = p' = \frac{dp}{d\theta} \cdot \frac{d\theta}{dt} = p \cdot \frac{dp}{d\theta} = \frac{1}{2} \cdot \frac{dY}{d\theta} \tag{8}$$

Therefore, the dynamics model can be converted into a first-order linear differential equation

$$\frac{dY}{d\theta} + 4\tan\theta \cdot Y = -\frac{2A}{mL}(E + s\cos\theta) \cdot \sin 2\theta \tag{9}$$

Then,

$$Y = C_1 \cos^4\theta - \frac{2EA}{mL}\cos^2\theta - \frac{4As}{mL}\cos^3\theta \tag{10}$$

Under the impact on the symmetric midpoint of the single rope, the theoretical solution of above equation is:

$$t = \int \frac{1}{\sqrt{C_1\cos^4\theta - \frac{2EA}{mL}\cos^2\theta - \frac{4As}{mL}\cos^3\theta}} d\theta + C_2 \tag{11}$$

where the constants of C_1 and C_2 are determined by the initial conditions.

B. COLLISION DYNAMICS MODEL OF RIGID-FLEXIBLE COUPLING SYSTEM

This article focuses on the capture ability of the bionic octagon flexible web, and it is a rigid-flexible coupling collision problem. When the flexible web capture system carries out the debris removal mission in space, the target objects are always in irregular configurations. To simplify matters and save time consumption, we simplify the collision targets as rigid cubes. The solution of the collision dynamics model is mainly divided into two steps: detection of collision process and solution of collision force.

1) DETECTION OF COLLISION PROCESS

The flow chart of collision process detection between the flexible web and the targets is shown in Fig. 8, which mainly divided into the following steps.

i. Calculate the position between the detection point and the target

In the collision scenario in this paper, it is necessary to judge whether the test point and the cube are in contact and collision according to the distance between the detection point on the rope and the center point of the cube, as shown

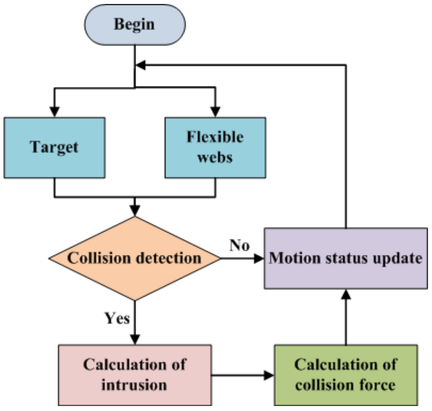

FIGURE 8. **Flow chart of collision process detection.**

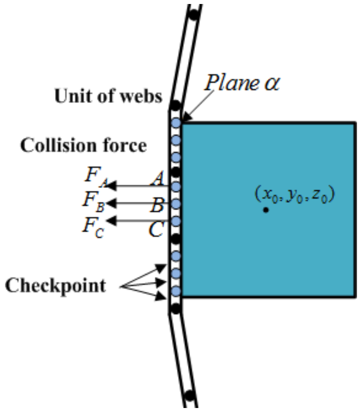

FIGURE 9. **Detection of collision process between the flexible web and the targets.**

in Fig. 9. The position relationship between the detection point and the center of the target body is

$$\begin{cases} |x - x_0| \le \dfrac{L}{2} \\ |y - y_0| \le \dfrac{L}{2} \\ |z - z_0| \le \dfrac{L}{2} \end{cases} \tag{12}$$

where the coordinate of arbitrary detection point on the rope is (x, y, z), the center coordinate of the cube is (x_0, y_0, z_0), the edge length of the cube is L, and the diameter of the rope can be ignored.

i. Calculate the intrusion
ii. Calculate the contact collision force
iii. Update the motion state

2) SOLUTION OF COLLISION FORCES

A equivalent spring damping model is established to simulate the collision force between the flexible webs and target, the model simplifies the contact model into a spring damping system, as shown in Fig. 10, when the collision between A and B happen, the collision force is simulated by spring force, and the energy loss is simulated by a damper during the process of collision.

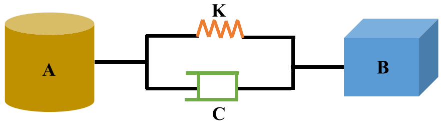

FIGURE 10. **The equivalent spring damping model.**

Based on the Hertz collision theory, the normal contact force $\boldsymbol{F}_i^n$ consists of spring restoring force $\boldsymbol{F}_i^k$ and damping force $\boldsymbol{F}_i^d$, which can be defined as

$$\boldsymbol{F}_i^n = \boldsymbol{F}_i^k + \boldsymbol{F}_i^d = \begin{cases} 0, & |\boldsymbol{\delta}| \ge 0 \\ K_n \delta^{m_1} + c\dfrac{\dot{\delta}}{|\dot{\delta}|}\dot{\delta}^{m_2}\delta^{m_3}, & |\boldsymbol{\delta}| < 0 \end{cases} \tag{13}$$

where K_n is the equivalent contact stiffness, c is the equivalent contact damping coefficient, $\boldsymbol{\delta}$ is the normal penetration depth of the contact point, $\dot{\boldsymbol{\delta}}$ is the normal penetration velocity of the contact point, m_1 and m_2 is the nonlinear contact collision force index, usually m_1 set at 1.5, m_3 is the penetration index of the contact collision.

The K_n is related to the geometric shape and material properties of the colliding object at the colliding point, which can be defined as

$$K_n = \frac{4}{3} \cdot \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-\frac{1}{2}} \cdot \left(\frac{1-\upsilon_1^2}{E_1} + \frac{1-\upsilon_2^2}{E_2}\right)^{-1} \tag{14}$$

where R_1 and R_2 are the curvature radius of the contact point on the two contact surfaces respectively, υ_1 is Poisson's ratio of the webs, υ_2 is Poisson's ratio of the target, E_1 is the elastic modulus of the webs and E_2 is the elastic modulus of the target.

In the collision scene, the collision between the flexible webs and target is contact process between the flexible body rigid body, the target will be wrapped by the webs after collision occur considering the flexible characteristics of the material of webs. Therefore, the radius of curvature of the contact point between two contact surfaces is equal, $R_1 = R_2$. In addition, since the target is rigid, its elastic modulus $E_2 = +\infty$,and the poisson's ratio $\upsilon_2 = 0$. Therefore, (14) can be translated into

$$K_n = \frac{4}{3} \cdot \left(\frac{2}{R_2}\right)^{-\frac{1}{2}} \cdot \left(\frac{1-\upsilon_1^2}{E_1}\right)^{-1} \tag{15}$$

The equivalent contact damping coefficient is related to the recovery coefficient and contact stiffness. The expression is as follows

$$c = \frac{3K_n\left(1-e^2\right)}{4\boldsymbol{v}}\delta^{\alpha} \tag{16}$$

where e is the Newton recovery coefficient, α is the linear damping index, and $\boldsymbol{v}$ is the initial collision velocity.

IV. SIMULATION RESULTS AND ANALYSIS

A. PARAMETER SETTING OF FLEXIBLE WEBS STRUCTURE

In this section, the dynamic characteristics of the traditional quadrilateral flexible webs and the bionic octagon flexible

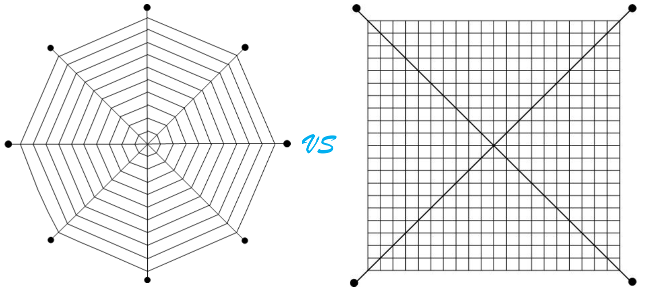

FIGURE 11. Two different space webs configurations.

webs (as shown in the Fig. 11) in the collision process with the target are compared and analyzed. A quadrilateral flexible network with a diameter of 5 m and a bionic octagon flexible network with a diagonal diameter of 5 m are selected to be the simulation object. Except for different shape parameters, the structure parameters of the two webs are the same, as shown in Table 1.

TABLE 1. Simulation parameters and values.

Parameters	Values
Mass of masses/kg	0.5
Sectional area of rope units/m^2	2.73×10^{-5}
Density of webs/ g/cm^3	1.54
Elasticity modulus of webs/Gpa	180
Size of target/m	$1\times1\times1$

B. ANALYSIS OF COLLISION MECHANICAL CHARACTERISTICS

In order to compare and analyze the structural characteristics of the two webs structures, such as the change of internal force and deformation during the process of capturing the target, the endpoints of the webs are fixed to simulate the capture scenario of the target colliding with the webs. The target is a cube shell structure with the side length of 1m and the distance from the surface of web is 1m, the relative velocity between the webs and target is 100 m/s. The remaining simulation parameters are shown in Table 1.

The basic assumptions in the simulation are as follows:

i. Prior to contact and collision, the flexible webs posture remains stable, the speed of each point is identical, and the webs move at a constant speed;
ii. The flexible webs and target experience straight-line motion; the influence of orbital motion is ignored.
iii. The flexible webs are assumed to be stationary while the target moves relative to the webs.

Fig. 12 shows the comparison of the movement between the flexible webs and the target at different times during the collision process. It can be seen from the figure that the collision happen at the simulation time of 0.009s, and the maximum transformation of the webs happen at the time of 0.030s, this two types of webs both can endure high speed strike in simulation. The simulation results fully demonstrate the large deformation, and large displacement of the flexible webs, effectively validate the accuracy of the collision dynamic model and the tensile strength of the flexible webs configuration.

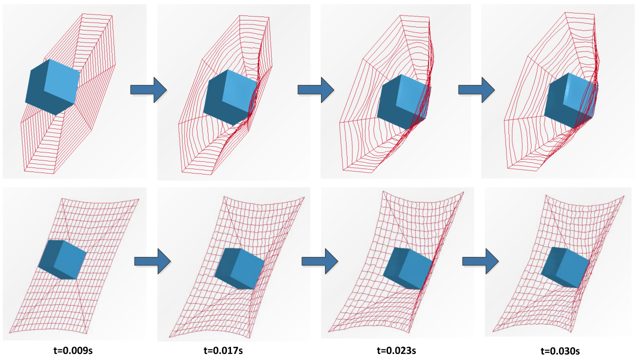

FIGURE 12. The deformation of two web configurations.

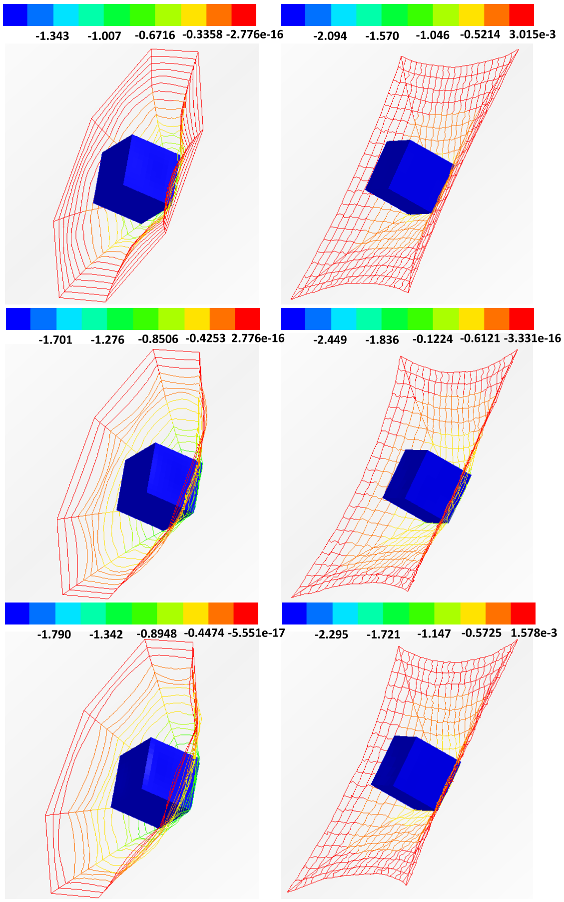

FIGURE 13. The variations in the deformation of the flexible-webs rope segment.

Figs. 13-18 show the simulation results of the collision process calculated based on the finite element method.

Fig. 13 shows the variations in deformation of the flexible-webs rope segment under collision of this two web configurations. It can be seen from the figure that the maximum displacement of the octagon flexible-webs rope segment reaches 1.790 m, while the maximum displacement of the quadrilateral flexible-webs rope segment

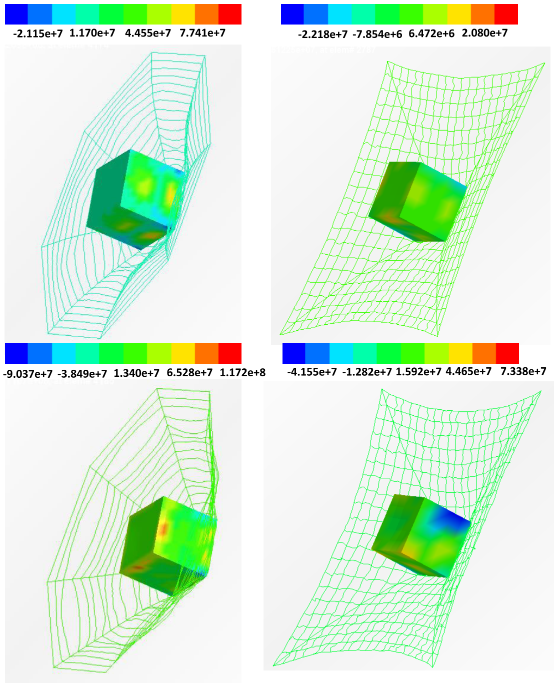

FIGURE 14. The variations of stress in the deformation.

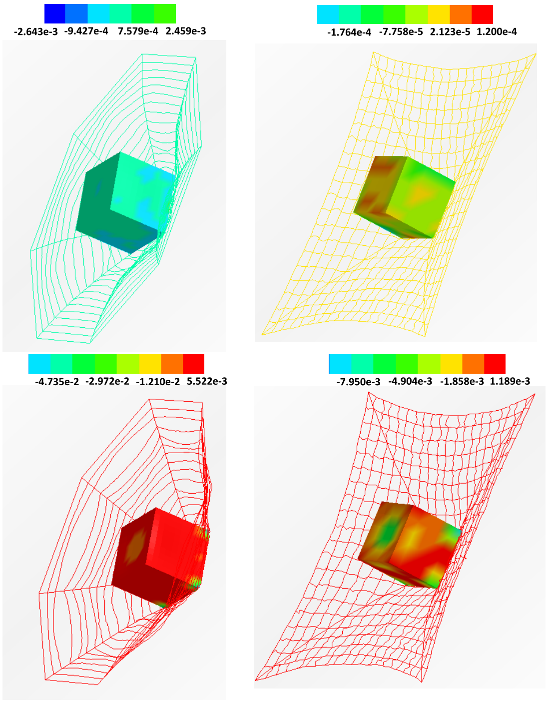

FIGURE 15. The strain in the deformation.

reaches 2.295 m. The analysis shows that in the same collision scenario, the deformation of the octagon flexible-webs rope segment is smaller than that of the quadrilateral flexible-webs, that is, the energy dissipation of the octagon webs structure is better than that of the quadrilateral webs.

Fig. 14 shows the variation comparison of the stress between the two flexible webs and the target in the $-z$ direction during the collision. In the collision scenario of

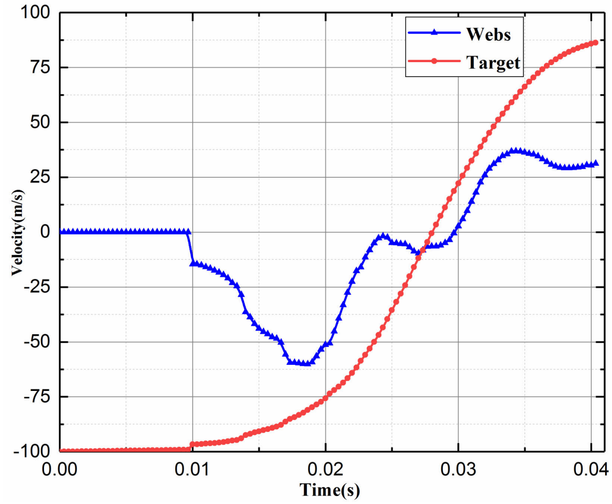

FIGURE 16. The changes of velocity (direction of $-z$).

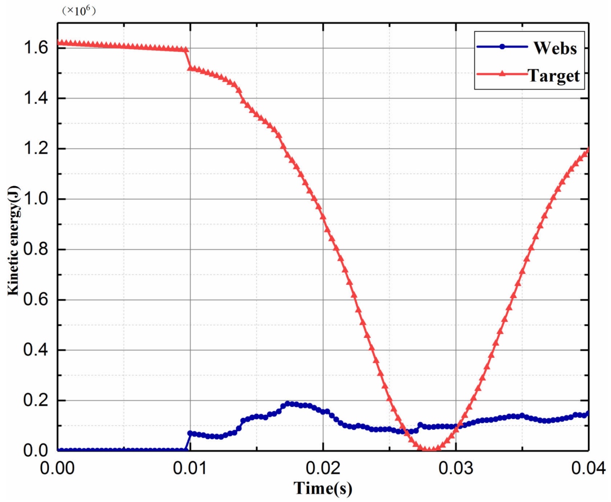

FIGURE 17. The changes of kinetic energy.

octagon flexible webs, the maximal stress of webs increases to 1.340×10^7 Pa, in the collision scenario of quadrilateral flexible webs the maximal stress of webs increases to 1.592×10^7 Pa. It can been seen that the stress level of this two kinds of web structure has no significant difference, namely the tensile strength of two kinds of web structure can both meet the technical requirements.

Fig. 15 shows the variation comparison of the strain between the two flexible webs and the target in the $-z$ direction during the collision. It can be seen from the figure that the maximum strain of the octagon flexible rope segment is 5.522×10^{-3}, while the maximum strain of the quadrilateral flexible rope segment is 1.189×10^{-3}. The analysis shows that in the same collision scenario, the strain of the octagon webs is greater than that of the quadrilateral webs, that is, the deformation and displacement performance of the octagon webs structure is better than that of the quadrilateral webs structure.

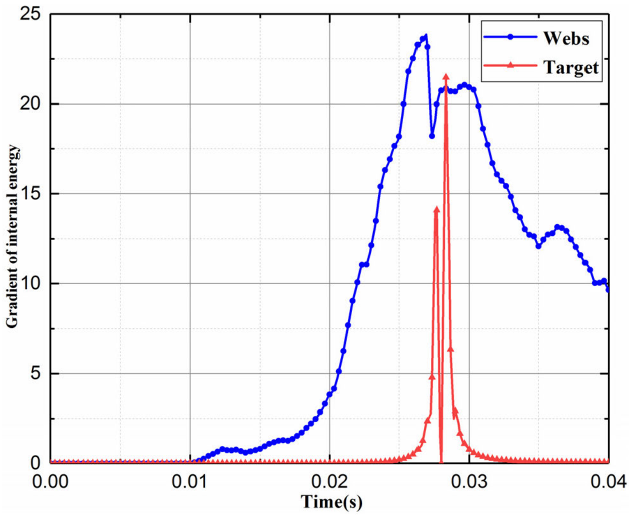

FIGURE 18. The change rate of internal energy.

The following conclusions can be drawn based on these results and analysis: in the collision scenario of this paper, when the flexible network and the target body have contact collision, the change of rope segment deformation and strain of the quadrilateral flexible webs is significantly greater than that of the octagon flexible webs. Therefore, for the space flexible webs capture device, the structure performance of octagonal flexible webs is better than quadrilateral flexible webs with the better dissipation and fault tolerance in the space debris removal task.

Fig. 16 shows the changes of velocity of the octagon flexible webs and target. In the simulation scenario, the initial velocity of the target is 100 m/s, and the net body remains stationary. The velocity remains unchanged within 0.009 s in the simulation time. The collision occurs at 0.009 s, and the target's velocity gradually decreases to 0 after 0.014 s, after which the target bounces back in the webs.

Fig. 17 shows the change of kinetic energy of the octagon flexible webs and target. The variation trend is similar to the velocity. The kinetic energy of target generates invariability at the first 0.009 s, and after the collision happen, the kinetic energy of the target gradually decreases and converts into the elastic potential energy of the flexible network.

Fig. 18 displays the change rate of internal energy between the octagon flexible webs and target. It can be seen from the figure, the change rate of target's internal energy increased sharply after the collision happened, which be due to the kinetic energy of the target quickly converts into the internal energy of webs.

The following conclusions can be drawn based on these results and analysis: the results of simulation fully reflects the dynamic characteristics of the octagon flexible webs such as flexibility, large deformation and large displacement, and fully illustrates the theoretical feasibility of the bionic designing scheme, provides theoretical basis for the next step of the ground test.

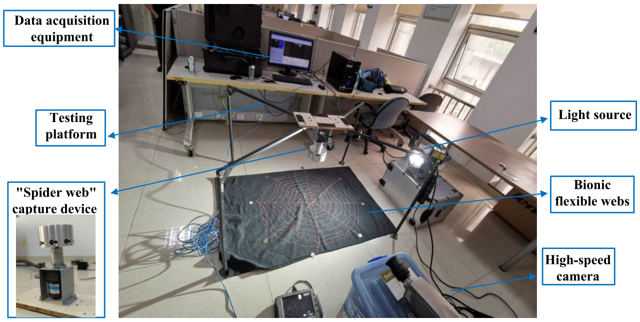

FIGURE 19. The ground test system.

TABLE 2. Material parameters of flexible webs.

Polythene fiber	Tensile strength (Gpa)	Modulus (Gpa)	Density (kg/m^3)	Segment diameter (mm)
	3.1	100	970	0.3

V. SIMULATION RESULTS AND ANALYSIS

In order to verify the feasibility of the bionic designing scheme, this section carries out the ground test research of "cobweb-like" flexible webs capture device. Firstly, the "cobweb-like" flexible capture test device is designed. Then, the testing system of dynamic measurement is established. Finally, the experiment of octagonal flexible webs to capture the target is carried out with the established testing system. During the experiment, the feasibility and effectiveness of the experiment scheme is verified by the motion capture of high-speed camera.

A. DESIGN AND BUILD OF GROUND EXPERIMENT SYSTEM

The ground experiment system of "cobweb-like" flexible webs capture device is shown in Fig. 19. The system mainly includes testing platform, "spider web" capture device, high-speed camera system and so on, which the high speed camera system includes high speed camera, light source and data acquisition equipment. The main components of the "spider web" capture device include flexible webs, magnetic masses, central rigid body, central shaft, transmission components, variable-speed motor and so on.

A small flexible web is used for the ground verification experiment., the webs is the structure of octagon, the diagonal diameter of the webs is 1000 mm, and the diameter of the rope segment is 0.3 mm. The web is woven by polyethylene fiber material, and the material parameters are shown in Table 2. The mass block is made of magnetic iron, and the mass of a single magnetic mass is 5 g.

B. GROUND VERIFICATION TEST OF "COBWEB-LIKE" FLEXIBLE WEBS CAPTURE SYSTEM

The purpose of this experiment is to test the capture effect of the "cobweb-like" flexible webs capture device and to

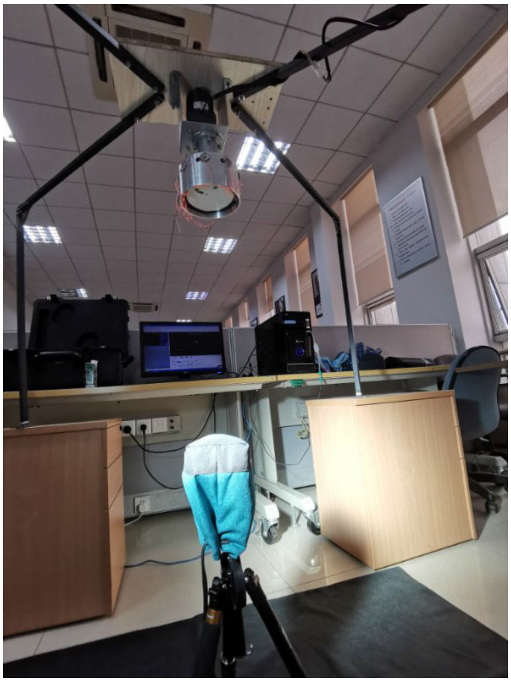

FIGURE 20. Experimental scenario of bionic flexible net capture.

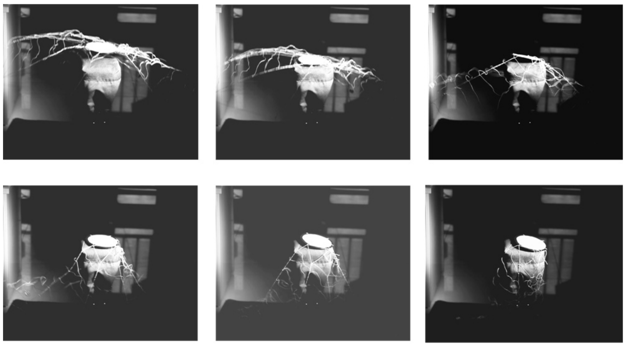

FIGURE 21. The specific internal structure.

verify the collision dynamics model established in section 3.2, the bionic flexible webs capture test scenario is shown in Fig. 20. The dynamic images are captured by high-speed cameras, the shooting frequency is 400 HZ, that is, the camera can obtain 400 frames of sequence images per second. During the collision process between the flexible webs and the target, the typical moment of attitude change of webs is selected for analysis, as shown in Fig. 21. The figure shows that the flexible webs collide with the target body and then the target is packaged by webs, and the state of shell nosing of webs is slightly different on account of the earth's gravity and the weaving error of flexible webs exists in the ground experiment. In general, the experimental results can better verify the accuracy of the collision dynamics model and the feasibility and effectiveness of the bionic design scheme.

VI. CONCLUSION

Aiming at the flexible webs capture mode theory in the space debris removal mission, in order to make the space flexible webs system have more effective capability of capture. According to the bionics principle and the institutional design method, a new space debris removal device is proposed, which consists of bionic flexible webs central hub, magnetic mass and rotating mechanism, based on the research of the spider web structure shape and capture performance analysis. The flexible webs capture device with higher structural stability and fault tolerance which combines the structure characteristics of spider web. The bionic design scheme of the flexible webs capture device is described in detail. The dynamics model is established based on the finite element method, and the capture effect is analyzed compared with the quadrilateral webs. The ground experiment of ''cobweb-like'' flexible webs capture system is designed and the validation experiment of capturing effect is carried out. The results show that the mechanical properties of the bionic octagon flexible webs is significantly better than the quadrilateral webs, with better dissipation performance and tolerance ability. The ground experiment results show that the bionic design of flexible capture device can fully meets the design requirements of space flexible webs capture system. The study in this paper provides theoretical and experimental references for the engineering realization of the space flexible webs capture system.

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