A Space Soft Robot of Multi-joint Ring Structure

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Movable space robots play a very important role in the space exploration tasks that can land on the surface of the planet and execute the task. What is more, the space robots can greatly reduce the cost of the exploration activities, both in money and in manpower. From the start of the last century, the space robots for the exploration activities have been studied. Nowadays, the traditional space robots can be divided into five types—wheel type, crawler type, leg type, wheel-leg type and the other **错误!未找到引用源。**. These traditional space robot are usually assembled by hinges, motors, joints, pistons and other components, resulting in low safety factor and poor reliability in the exploration tasks. While soft robots with large degrees of freedom can solve the problems well[2]. Therefore, we decide to design a soft robot to adapt to complex terrain of space.

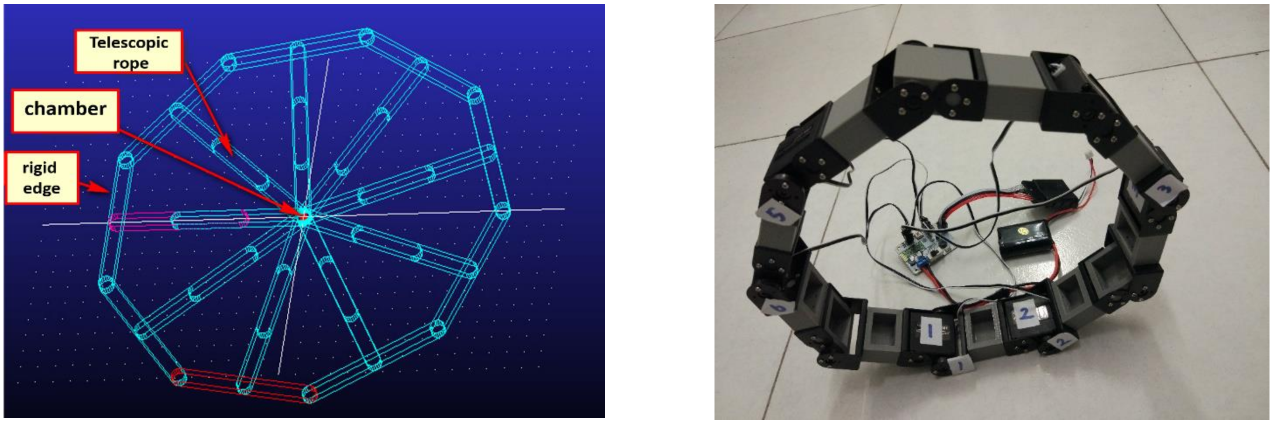

Fig. 1: models and physical models

We propose a simplified model—a multi-joint ring structure. Taking a nine-sided ring structure as an example, the simplified multi-joint ring structure is composed of a chamber of a relatively fixed position, a telescopic elastic rope and a rigid edge. It is a multiple degree of freedom structure and is deformable, in that it shows flexibility in motion performance. We study the kinematics and dynamics of the simplified model. Frist, we discuss its shape by the method of the geometric configuration. It is easy to draw a conclusion that as long as the six angles of the model are known, the shape of the model can be uniquely determined.

We use the method of spatial operator algebra[3] to analyze its motion. Compared to the traditional dynamics algorithm of the multibody system, such as the Newton Euler, Lagrange method, spatial operator algebra has a simple form, high computation efficiency and can reach $O(n)$ algorithm complexity. Then, we use ADAMS for numerical simulation to verify the design. In the simulation process, we set different friction coefficient and angle of inclination to compare the results of simulation with the results of theoretical analysis.

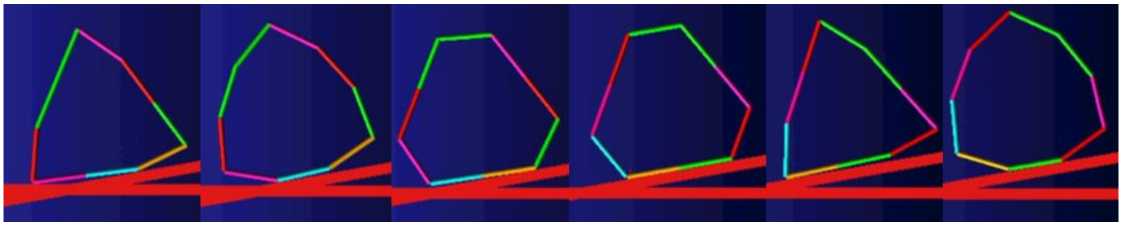

Fig. 2: Numerical simulation in ADAMS

With the result of the theoretical analysis, we design our control strategy. We control the 6 angles of the model to control its shape and motion. One of the control strategies is shown in the figure 3, which can make the model to move forward and climb slowly on a gentle slope under the action of the gravitational force.

At last, we set up an experiment table for physical operation.

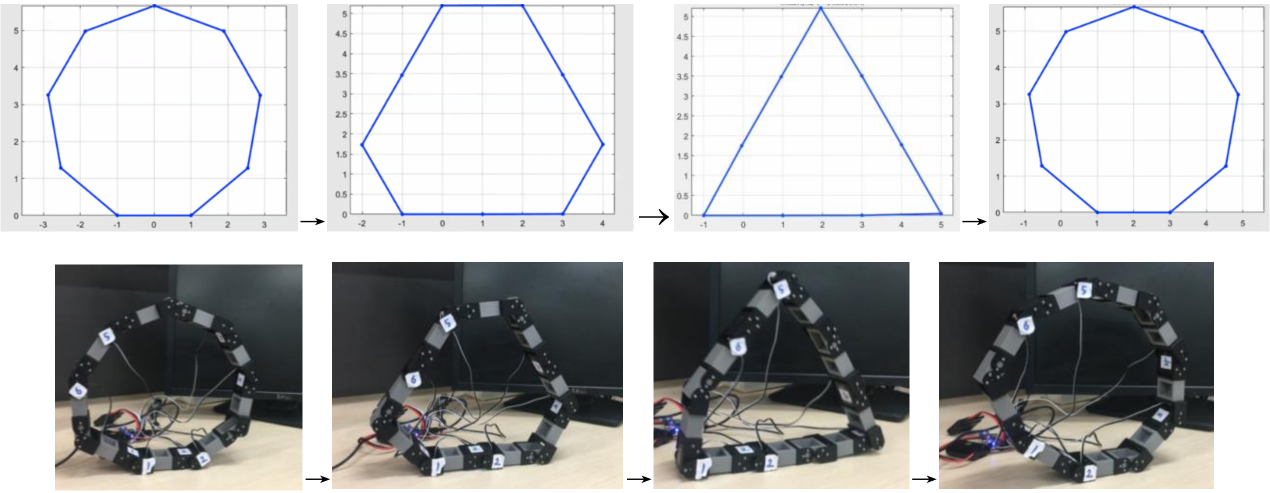

Fig. 3: the control law and experiments

At last, we set up an experiment table for physical operation. Now, the experiments can be carried out by two methods. We can manually control the motion by single-steering-controlled method, which can proves that this model can certainly adapt to complex and unknown terrain. Besides, we can control the motion by action-group-control, which is verified by software. The result of the experiment is basically consistent with the result of simulation and the model could move forward continuously in the ground or a small declivity with this method.

References

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