Structure Design of Multi-joint Bionic Robot Based on Solidworks

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Abstract. The body structure of the multi joint bionic robot is designed and analyzed. According to the movement form of snake and caterpillar, a multi joint bionic robot is designed and manufactured based on the principle of bionics. Using SolidWorks software to establish the model, there are three parts: head joint, body joint and tail joint. The bionic robot uses 3D technology to be printed and make a physical prototype, and experiment with the prototype. It can imitate the movement of snakes and caterpillars, and realize snake movement, insect movement, turning, curling, lurking and other movements. Through the structural design, processing and manufacturing of the multi joint bionic robot, the movement shape is analyzed and adjusted to make its movement attitude completely similar to the biological shape.

1. Introduction
The multi-joint bionic robot can move freely within a certain range. It can be equipped with cameras, manipulators and other equipment according to different needs, which greatly enhances its intelligence and flexibility. It has now become one of the focuses of robotics research. 3D printing is a new rapid prototyping technology. It is a method of constructing objects through layer-by-layer printing based on computer-generated three-dimensional models and using materials such as plastic or metal. According to the design requirements of the multi joint robot, this paper uses SolidWorks software to model the robot, and makes the entity through 3D printing, which provides the model and experimental platform for the development and research of the multi joint robot.

The design of a multi-joint bionic robot is composed of 8 joints in series, mainly including three parts: head joint, body joint, and tail joint, including one head joint, six body joints and one tail joint. The head, body and tail joints are connected in series to imitate the movements of snakes or caterpillars. Each joint is equipped with a steering gear as the executive component to realize the relative motion between each joint[1].

2. Body joint structure design
The body joints are shown in Figure 1. It is designed with steering gear head connecting locating hole, bearing locating hole, steering gear locating hole and universal wheel locating hole. The body joint has the function of fixing the steering gear and connecting other joints. The steering gear, as an actuator for swinging the joint, is assembled on the positioning hole of the steering gear by fasteners. The fastener fastens the steering gear to the side of the body joint by means of micro screws.
The steering gear assembly is shown in Figure 2. The steering gear head connecting locating hole of the body joint is used to connect the output head of the steering gear, and the connection between the steering head and the body joint is realized through the screw fastening. The bearing positioning hole of the body joint is used for the connection of each body joint. Through the rolling bearing, each body joint can swing through the rolling motion, instead of the friction motion between each joint surface. The body joint is designed with the positioning hole of the steering gear for binding the steering gear, and the steering gear is assembled on the body joint with the fastener. The body joint is designed with a positioning hole of the universal wheel to install the universal wheel. The movement mode between the robot and the ground is ball rolling instead of friction between the robot and the ground[2].

![Figure 1. Body joint structure](image1)

![Figure 2. Assembly drawing of steering gear](image2)
The power output head of the steering gear is connected with the positioning hole of another body joint, and the positioning hole is placed in combination with the bearing to realize the swing output of the power of the steering gear and drive the movement of the next body joint. All body joints are assembled in the same way to realize serial connection[3].

On the one hand, the assembly and transmission of power are realized through the steering gear head connecting locating hole and the steering gear power output head. On the other hand, through the bearing assembly of A and B body joints, the steering gear is assisted to swing. Through the positioning hole of the universal wheel of the body joint, the universal wheel is assembled to realize the winding motion of the joint robot[4].

Two universal wheel positioning holes are designed at the bottom of the body joint. It is used to install miniature universal wheels to reduce the friction between the robot and the ground, so as to realize the control effect of the winding motion easily and flexibly. As shown in Figure 3.

3. Head joint structure design
The head joint design of multi joint robot has bionic characteristics. STM32 controller imitates biological brain, video transmission module imitates biological eyes, human infrared sensor imitates biological senses, and sound sensor imitates biological ears. Therefore, the head joint needs to be placed with an STM32 controller, a video transmission module, a human infrared sensor, a sound sensor, a Bluetooth module, an angle tilt sensor, and a Bluetooth module. Therefore, the head joint is designed with an upper plate structure and a lower plate structure. The upper board structure mainly places related sensors and video transmission modules, and the front and back sides of the upper board can be placed. STM32 controller is mainly placed in the lower board structure, which is placed on the front side of the lower board structure, and has the function of protecting the control core of the whole robot. No circuit is placed on the back side of the lower board structure. The head joint is designed with a rudder frame, which is installed on the rudder frame to realize the head joint's head up and head down motion.

4. Tail joint structure design
The multi-joint robot's tail joint is mainly placed with lithium polymer batteries to provide power for the entire robot. As a result, the tail joint is designed to be hollowed out internally and is dedicated to
the battery. The tail joint is designed with a rudder frame, and the left and right swinging motion of the tail joint is realized by the rudder mounted on the rudder frame.

Figure 4. Head joint structure design  
Figure 5. Tail joint structure design

5. Overall structural design

The overall structure design is shown in Figure 6. The "steering head connection positioning hole" of the body joint is connected to the steering wheel by screws, and at the same time, the steering wheel is fixed to the output shaft of the steering gear by screws, so that the output shaft of the steering gear drives the steering wheel to rotate through gear transmission. The rotation also drives the swing of the body joints, and finally realizes the power transmission of the steering gear[5].

The positioning holes for the bearing of the body joint have two parts: positive and auxiliary parts. The positive positioning hole of the A body joint is connected to the auxiliary positioning hole of the B body joint. A rolling bearing is installed between the two. The rolling motion of the bearing assists the swinging motion of the steering gear, so that the motion of the joints of each body can easily realize the transmission of the meandering motion. Through the design of the positioning holes of the front and auxiliary bearings, the non-friction movement of each body joint is realized, so that the steering gear can easily drive each joint to swing[6-7].

Figure 6. Overall structural design 1

The 3D printed assembly drawing of the overall structure is shown in Figure 7. Use Solidworks software to model the multi joint bionic robot shell, and then input the model into Adams software for simulation, and make the entity through 3D printing. The materials for 3D printed joints are PLA, ABS, etc., considering the machining performance, plasticity, toughness, strong hardness and other
conditions, the PLA material is selected. By setting up 3D printer for printing and using pla materials, 3D printing of robot-driven joints is realized[8].

Figure 7. Overall structural design 2

6. Conclusion
This paper proposes a method for designing and making a multi-joint robot using solidworks and 3D printing technology. The experiments show that the printed shell can meet the rigidity requirements. In the future, the research can further improve its gait, making its running track more beautiful and smooth. With the permission and support of the following conditions, more body joints are added to further fit the winding curve of the turning shape of the multi joint robot, so that its movement process is completely similar to the biological movement mode, so as to adapt to the steps, slopes and other complex terrain.

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