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Original Article

Design of a Three-in-One Bionic Chameleon Robot

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Abstract *- This paper takes the chameleon that can change its color according to the environment as the bionic research object, from the leg mechanics, head tongue ejection device, and body colour-changing device, and analyzes the feasibility of robot gait and colour-changing ability, realize the motion control of the robot.*

Keywords *- Bionic robot, Structural design, Simulation verification, Gear mechanism.*

1. Introduction

In order to escape the invasion by natural enemies and approach their prey, to survive in complex environments, except escaping, chameleons can intimidate natural enemies or disguise themselves by changing their skin color. Environmental adaptive behaviors of living organisms have inspired scientists to develop soft drivers and robots with adaptive functions.

However, at present, for chameleon bionic, generally through the analysis of chameleon skin colour-changing mechanism, using thermometric materials to realize its colour-changing function for the hidden intelligent robot (reconnaissance) or invisibility cloak, camouflage, etc., in the military stealth, in the field of camouflage and anti-counterfeiting has potential application value. In addition to the study of its colour-changing function, the chameleon's flexible tongue is also a director of research. The chameleon has a very long, sensitive, sticky tongue, which can quickly shoot out and stick to the prey. The grasping function of the tongue can be used to connect to the end of the robotic arm to grab objects of various shapes, replacing the traditional manipulator.

In summary, based on the principles of bionics, a multi-functional bionic chameleon robot with the characteristics of chameleon gait, tongue grabbing, and body color change has been designed. The bionic chameleon robot is compact in structure, flexible and stable in walking, has a certain grasping function, and can adaptively adjust body color according to the environment.

2. Literature Review

In recent years, quadruped robots have grown rapidly[1-8, 26].

In 2015, the small quadruped robot "XDog", designed by Shanghai University[10], has strong flexibility due to its simplified mechanical structure and can complete complex gait movements such as climbing, crossing obstacles, and walking laterally in experimental environments, and can achieve autonomous adjustment of body balance under the interference of external forces. Yushu company developed the "Laikago" robot[11-12], which is a comprehensive upgrade of the overall size, gait planning, control algorithm, power drive and other aspects based on the X dog quadruped robot, so that it has strong operational stability, and can quickly get up after tipping according to the control algorithm of turning over. Optimization of the control algorithm is a further exploration of the field of motion control of quadruped robots[28]. In 2018, Zhejiang University developed the "Jue Ying", a small, sensitive quadruped robot with a certain weight-bearing capacity that can walk in complex environments such as gravel, grass, ice and snow[14].

In a large number of quadruped robots, a large number of servos or motors are used for better simulation of quadruped dynamics, which greatly increases the difficulty and feasibility of debugging. Reducing the amount of servos or motors makes the ability to cross obstacles significantly weaker. Therefore, it is an important task to reduce the number of servos and motors and, at the same time, ensure the walking ability and obstacle-crossing ability of the quadruped[15-18, 26].

3. Overall Design of the Bionic Chameleon Robot

3.1. Leg Design

Using the chameleon as a prototype, Deng Jun designed a robot with circuit control, structural design, mathematical analysis, gait simulation analysis, and prototype testing. The chameleon robot can crawl flexibly and has broad application prospects in various fields[20].

Referring to the structural design of the quadruped robot[21-24], the structure of the chameleon we designed is different from the previous one, and the main structure is as follows.

The chameleon crawls on land with its claw tips on the ground and its front and rear feet flattened and withdrawn

outwards. The overall structure and walking gait must therefore be considered when designing.

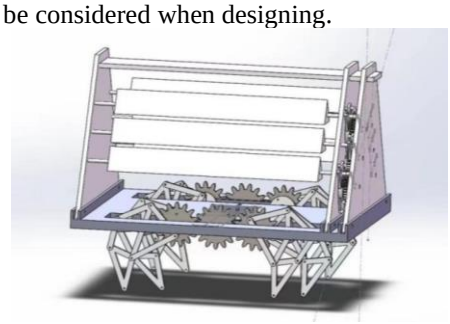

Fig. 1 Mechanical structure of the legs

As shown in Figure 1, suitable for field activities, the foot is designed like the wind mechanical animal's foot design. The mechanical structure part of the leg mainly adopts the gear mechanism, with four feet on the ground each time, ensuring walking stability.

3.2. Tongue Design

The chameleon has a very long and sensitive tongue, twice its own body's length. There are glands on the tip of the tongue which can secrete a lot of mucus. When hunting, the tongue blood vessels quickly congest, and the tongue muscles contract, so the tongue quickly shoots out and sticks to the prey.

Considering the characteristics of the chameleon's tongue: it can be very long and fast, but the travel and speed of the general expansion mechanism will be limited, so the tongue of the chameleon is achieved with the ejection mechanism. By adjusting the ejection component on the position adjustment mechanism and using the reset component to retract the ejected component, a sticky adhesive strip or grabbing claw is connected to the end to achieve quick ejection and retrieval and perform long-distance item grabbing work, as shown in Figure 2.

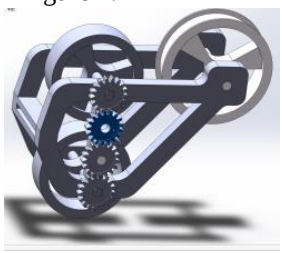

Fig.2 Head, tongue ejection and grasping mechanism

3.3. Colour-Changing Design

Chameleon bionics are basically studied by analyzing the mechanism of chameleon skin color change. For example, a research team at Emory University in the United States has developed a strain-adaptive intelligent hydrogel skin that can be optically triggered by color change. Unlike the previous "artificial camouflage technology", it uses temperature to adjust the color of the bionic chameleon, which can simply realize the function of thermal color change[25].

Different from the previous chameleon color change principle, the whole body of the bionic chameleon is designed based on the body skeleton of the chameleon using the principle of three-side-flipping-billboard. Its shape is designed as close as possible to the real shape of the chameleon. The ribs not only serve as decoration support but also serve as a protective case for the interior parts.

Each side of the body has a different color. After visual recognition, when the bionic mechanical chameleon walks to the corresponding background color, it will flip the color on the body and always keep the same color as the background to realize the colour-changing function of the bionic chameleon.

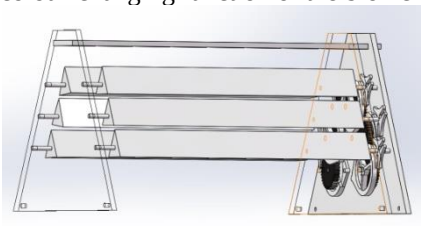

Fig. 3 Discolored structure of the chameleon

4. Simulation Verification

Through motion simulation and analysis by Motion, the product's manufacturing cost can be effectively reduced, and the product development cycle can be shortened effectively. Design analysts can quickly understand the feasibility of the product. After the modelling was completed, the initial simulation was carried out with the help of motion simulation in Solidworks software. Then the leg model was imported into Adams software for an in-depth motion simulation solution to verify the feasibility of the solution.

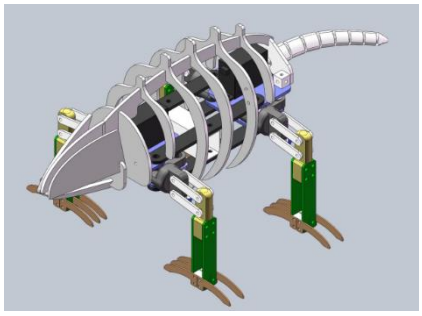

Fig. 4 Simulation validation

1. 5. Conclusion

This paper mainly takes the bionic chameleon robot as the research object. It completes the structural design, 3D modeling and simulation of the mechanical system of the robot according to the actual application requirements and realizes the three-in-one multi-functional bionic.

Acknowledgments

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