"Teenage Mutant Ninja Turtles" - A Design of a Bionic Quadrupedal Rescue Robot

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Abstract

"Teenage Mutant Ninja Turtles - Bionic Quadrupedal Rescue Robot is a quadrupedal robot based on the principle of bionics, inspired by the quadrupedal animals in nature. The robot has rescue and life detection capabilities and can perform rescue operations at disaster sites. The design of the robot enables it to operate efficiently and stably in complex environments, and at the same time it has the qualities of bravery and toughness, which are in line with the image of the Teenage Mutant Ninja Turtles. The robot can be used in a wide range of application scenarios, such as earthquake, fire and other disasters, to provide more efficient and safer support for rescue work.

Keywords:Biomimetic Machinery,Artificial Intelligence, Life Detection, Wifi Module

1. Introduction

With the development of society, mankind is faced with more and more natural disasters and man-made accidents, such as earthquakes, fires and mining accidents, which often result in a large number of casualties and property losses, bringing great harm to society. At the scene of these disasters, rescuers often need to risk their lives to enter the danger zone to carry out life detection, environmental exploration, material transportation, etc. Constrained by the number of rescuers, capacity, equipment, time and other factors, it is difficult to achieve high efficiency, safety and comprehensiveness [1].

To solve this problem, a bionic quadruped rescue robot called "Teenage Mutant Ninja Turtle" has been developed. The animated image of "Teenage Mutant Ninja Turtles" is a brave, invincible and courageous little turtle, and the rescue robot designed by the team has the same qualities of bravery and toughness, "Teenage Mutant Ninja Turtles" animated image is a brave, invincible and courageous little turtle, and the rescue robot designed by the team has the same qualities of bravery and toughness essence of the spirit, and therefore the name of this rescue robot for the "Teenage Mutant Ninja Turtles". The legs of "Ninja Turtle" use eight servos as joint actuators, and the legs can be replaced with wheel-type, bionic foot-type, negative pressure suction cup-type and three kinds of modularized structures to cope with different working scenarios, such as flat, rugged,vertical and muddy.It is equipped with acoustic obstacle avoidance system with superb obstacle-crossing ability.It is also equipped with 4G infrared transmission for working in dark environments and entering collapsed pits for life detection and environmental exploration [2].

The rest of this article is organized as follows. Part II describes the modules used in the hardware system design. Part III describes the design of the bionic mobile joint. Part IV builds the model and tests to determine the foot structure. Part V summarises the main points of the paper [3], [4].

2. The Hardware System Design

In terms of hardware design, the Teenage Mutant Ninja Turtles Bionic Quadrupedal Rescue Robot has been carefully PCB-drawn, including the design and layout of several key modules, to ensure the stable and efficient operation of the robot. The design of the PCB board is shown in Fig. 1.

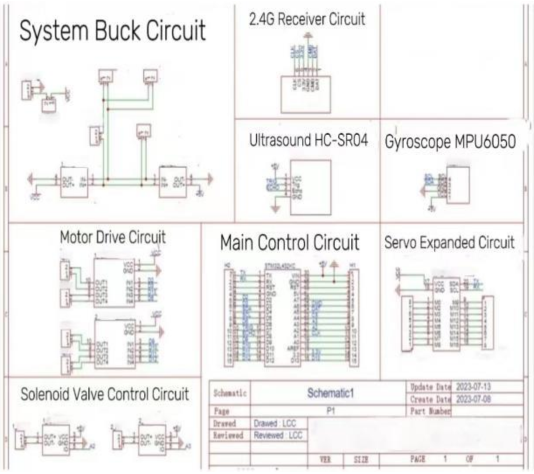

Fig. 1 The design of the PCB board

2.1 Circuit module section

Buck modules are an important part of power management, used to reduce the input voltage to a suitable operating voltage for each electronic component, helping to ensure system stability and power efficiency.

2.2 Motor drive module

Used to control the robot's motors, using PWM to control the speed and direction of the motors.

2.3 Bluetooth module

Enables the robot to communicate with external devices over Bluetooth, providing a convenient way for remote control and data transfer.

2.4 Ultrasonic sensors

Measures distance by sending and receiving ultrasonic signals for obstacle detection, navigation and localisation, providing robots with environmental awareness.

2.5 Wi-Fi wireless mapping module

Using the Wi-Fi wireless mapping module, the robot can transmit real-time images and video streams to remote devices, providing powerful support for teleoperation and environmental exploration [5].

The hardware design is shown in Fig. 2.

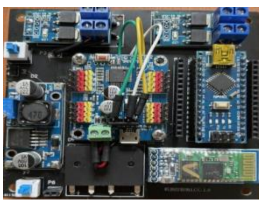

Fig. 2 Hardware design Hardware design

3. Design of bionic mobile joints

The parts design drawing is shown in Fig. 3. Detailed descriptions of functions and uses are shown in Table 1.

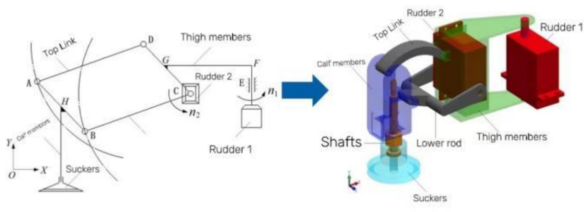

Fig. 3 Component design drawing

Table 1 Functions and uses

	Functions and Uses
Connecting rod	Transmission elements for connecting different joints and actuators to ensure coordinated movement of the robot's limbs
bear	Used to provide a rotational connection that allows the robot's joints to rotate freely without excessive friction
Servo 1	Used to control the swinging motion of the thighs
Servo 2	For controlling the elevation movement of the lower leg
shafts	Allows the robot to control the attachment and release of suction cups by varying air pressure, thus enabling the ability to climb and attach to different surfaces
suction pad	Uses a vacuum or pneumatic system to create a suction force to enure that the robot is firmly attached to the target surface.

A sophisticated system has been designed for Teenage Mutant Ninja Turtles Bionic Quadrupedal Rescue Robot in Pneumatic Adsorption System. The system has a strong adsorption and climbing function and ensures strong adsorption by negative vacuum -55KPa. The suction cups can withstand wall loads from 1.25kg to 1.7kg, allowing the robot to safely support its own weight and other additional loads. The design of the pneumatic adsorption system is complex and requires consideration of material selection, airflow control, negative pressure generation and other factors to ensure that the robot performs reliably in a variety of environments. Such systems are not only used in bionic robots, but are also widely used in industrial automation, glass suction handling, and handling equipment [6]. The pneumatic adsorption system is shown in Fig. 4.

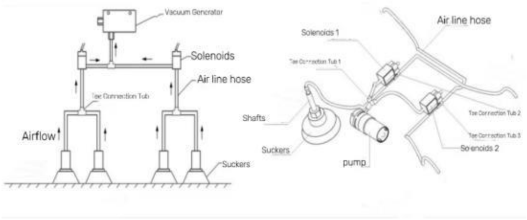

Fig. 4 Pneumatic adsorption system

4.Modelling and Testing

4.1 Multi-body dynamics modelling

In the mechanism dynamics simulation, a multi-body dynamics model is adopted, focusing on the kinematic mechanism of the robot leg, and the swinging of the thigh joint, the lifting and lowering of the calf joint, and the linkage between the thigh joint and the calf joint are simulated and analyzed, respectively [7]. And the model diagram is shown in Fig. 5.

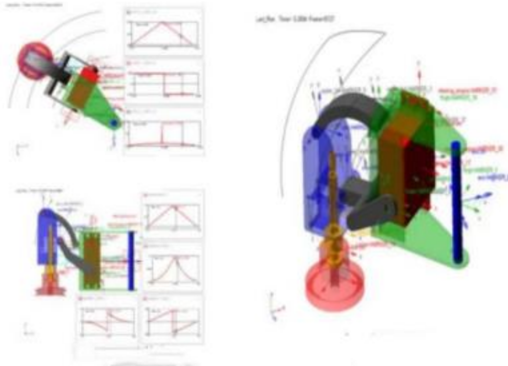

Fig. 5 Multi-body dynamics model

4.2 Stress and deformation maps

The structure of the Teenage Mutant Ninja Turtles (TMNT) bionic quadrupedal rescue robot was studied in depth in a finite element static analysis to evaluate its performance under different workloads and environmental conditions. This analysis includes the generation of stress and deformation maps, as shown in Fig. 6.

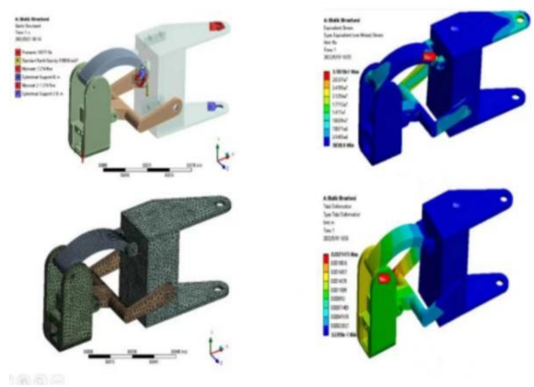

Fig. 6 Stress and deformation cloud diagrams

Stress distributions also help to ensure that the robot does not suffer from material fatigue or damage during operation; deformation clouds show how the robot's structure deforms under different loads. They are presented through colour coding or arrows to visualise the change in shape of the robot under stress.

5.System testing and results

Continuous optimizations and upgrades are performed to ensure good product performance. Through continuous product iterations, system testing and results are closely monitored to validate and improve the effectiveness of each iteration round. Over the course of the program's continuous development, five generations of products have been witnessed with significant progress and improvements.Firstly, the first generation of the product identified a quadrupedal structural solution with a four-link structure, which significantly enhanced the airframe's manoeuvrability. However, this was only the beginning [8]. The first generation is shown in Fig. 7.

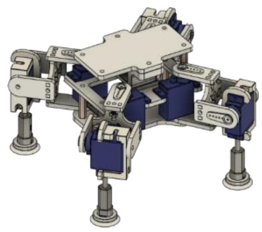

Fig. 7 First generation products

Subsequently, the introduction of the second generation of the robot brought significant improvements with the adoption of a high torque servo, MG996, to make the robot more agile and the introduction of modularly designed legs to improve ease of maintenance. The second generation is shown in Fig. 8.

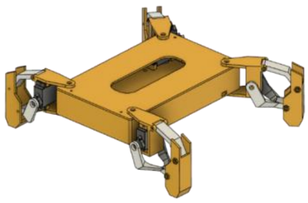

Fig. 8 Second-generation products

The third generation product further extends the function by adding tail and head structure, introducing automatic obstacle avoidance function and wireless mapping technology to make the robot more intelligent and adaptable to different environments. The third generation product is shown in Fig. 9.

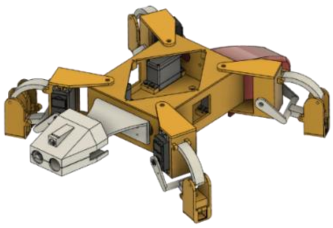

Fig. 9 Third-generation products

The highlight of the fourth generation is the addition of tracks and McNamee wheels, which give the robot the ability to not only move in all directions, but also steer in a more flexible manner. The fourth generation is shown in Fig. 10.

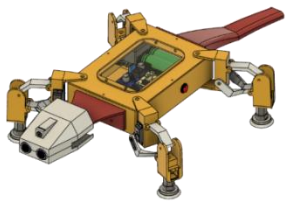

Fig. 10 Fourth generation products

Finally, the fifth generation product has undergone an in-depth industrial design to resemble the appearance of the robot to a turtle, giving it a more vivid and adorable image and enhancing its user-friendliness. The fifth generation product is shown in Fig. 11.

Fig. 11 Fifth generation products

At each iteration stage, we conducted system tests and analysed the results to ensure stability and performance optimisation of the new features. These tests included the robot's performance in various terrains and environments, its manoeuvrability, the reliability of the automatic obstacle avoidance function, the effectiveness of omnidirectional movement, and the aesthetic design.

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