Multi-Legged All-Terrain Exploration Robot

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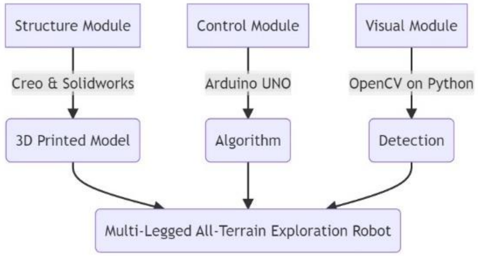
Abstract

In current extraterrestrial exploration, particularly in lunar and extreme terrain conditions on Earth, common wheeled robots encounter issues such as high friction, challenging steering, and floating dust. In response to these challenges, this paper proposes a multi-legged robot that reduces friction with the ground and achieves easy steering. The design of the linkage mechanism was based on arthropod's movement patterns, which was modeled and simulated using Creo, controlled by Arduino, and integrated with a vision module developed through Python's OpenCV platform and esp32cam kit. Ultimately, a remotely operated multi-legged exploration robot with image feedback was designed. This design offers a novel approach for exploration equipment under special terrain conditions and paves the way for unmanned exploration in a wider range of scenarios.

Composition



Structure Module

The robot mainly consists of the body, the intelligent interaction module, six legs and the steering mechanism.

The main structure of the body is two parallel and opposite hollow flat plates connected by a rotational axis. The body houses a power unit and a controller, and is equipped with a microcontroller and a Bluetooth module on the surface for interaction. A camera is mounted on the bracket extending from the top of the body. The leg mechanism is designed as six mirrored parts symmetrically distributed on both sides of the body, utilizing a linkage mechanism (specifically, a six-bar linkage).

Due to the superior performance of the legged structure, the robot can naturally overcome obstacles during travel. By repeating this cycle, the robot can achieve forward and backward movement.

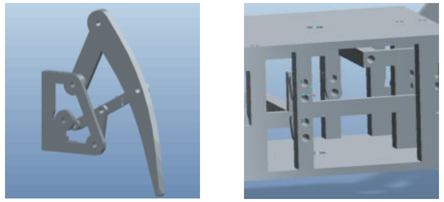


Fig. Detector partial structure

Control Module

The control algorithm, which is based on Arduino UNO, includes the pace input of the movement, and the robot's response to different scenarios
(acceleration, deceleration, steering, emergency stop). The driving power of the robot is provided by two two-phase 57 stepping motors, and the wiring mode of the stepping motor has also become a problem to be considered. In addition, the basic procedure requires that the external keys can control the positive reversal of the motor, accelerate the deceleration and stop. In the wiring of the controller, this design adopts the common cathode wiring method.

During motion, two motors control the movement of both groups of legs simultaneously. And if it were to shift the direction of the motion, the robot merely have to manipulate the steering motor to rotate to a certain angle.

Fig. 57 Stepper motor and TB6600 drive

Visual Module

The visual recognition section developed based on Opencv enables the probe robot to have object recognition capabilities, which can recognize and classify objects around it through visual sensors and image processing algorithms. It can recognize specific objects and act accordingly as needed. This function is of great significance in applications such as search and rescue, patrol and safety monitoring.

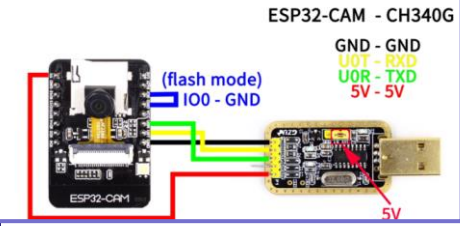


Fig. ESP32-CAM Module wiring diagram

Fig. Partial code of recognition

Result

The robot designed ultimately has a total length of 74.85~80.85cm (including the legs), a body length of 30.00cm (not including the legs), a total width of 25.00cm, and a height of 33.50cm (not including the camera).

Given the current advancement of multi-legged robots, this design holds substantial potential for further development and practical implementation.

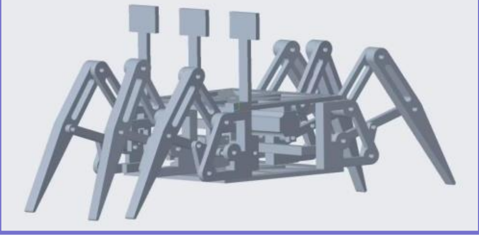


Fig. Overall robot structure

Fig. Expected application scenario