# The structural design of turning and control method of semi-passive robot

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## Abstract

**This article has presented the structural design of turning and control method of semi-passive robot. It is controlled easily and steadily. It contains stepped machine, steering device, actuating device which actuating quadruped robot walking, data acquisition unit which collects walking data and master controller which provides walking scheme for stepped machine in real time. This article makes quadruped robot twisting when the leg movement by specific structure, then realizing diversion according to the arc design of a foot. The steering force of steering device passing into twisting kick to drive semi-passive robot turn , and achieving the purpose of cornering through the reaction force of the foot to the ground friction. The mechanism has the advantages of simple structure, simple operation, stable walking and energy saving, which can be widely used in rescue, toys and medical fields.**

## 1. Introduction

Nowadays, robot technology is the hotspot of research in all countries of the world, and the mainstream foot-walking robots are divided into two categories. One is the Japanese Honda Company production Asimo as the representative, is called the active walking robot, it can simulate the various movements of human walking, but they all involve the use of the torque drive system and high-gain feedback control; The other is a more passive walking machine in recent years, compared with traditional robots, passive walking robots have simpler structure and higher energy efficiency, and the walking gait of passive walking robots is more natural, more similar to human walking gait. At present, the research on passive walking robot has achieved good results, and has developed a very representative prototype of physical prototype. For example (1) 2010, the Cornell University developed a passive walking robots "Commandos (Ranger)", the structure of the biggest shortage is the transmission of complex, unfavorable to the actual large-scale promotion. Dutch DELFT University has developed a variety of passive walking robots since 2002, the article "Adding an upper body to passive dynamic walking robots by means of a bisecting hip mechanism" in the semi-passive walking robot Mike (2002), the legs of the knee has a complex self-locking structure, The biggest problem in the structure is the complicated design of leg knee joint. Therefore, it is necessary to design a turning structure of semi-passive quadruped robot with simple structure, easy control and robust stability and robustness.

## 2. Semi-passive robot and the design of turning structure

In this paper, the turning structure of semi-passive four-legged robot, including walking mechanism, driving device used for driving walking mechanism, steering device for four-legged robot, data acquisition device for collecting walking mechanism, and the main control device for providing real-time walking scheme for walking mechanism.

The walking mechanism comprises the legs and the hip, wherein the legs consist of four long straight legs, including the outer leg Ⅰ (1), the upper leg Ⅱ (4), the inner leg Ⅰ (2) and the inner leg Ⅱ (3), the outer leg Ⅰ (1) and the inner leg Ⅰ (2), the outer leg Ⅱ (4) and the inner leg Ⅱ (3) are divided into two hips; The hip joint is the upper part of the outer leg Ⅰ (1) and the inner leg Ⅰ (2) through the Shaking Block Ⅰ (5) and the Shaker Ⅱ (6), respectively, the shaking Block Ⅰ (5) and the rocker Ⅱ (6) are connected with one end of the supporting plate (8), the other end of the support plate (8) is connected with the top of the outer leg Ⅰ (two) and the inner leg (1) respectively through 2 crank; The connecting way of the outer leg Ⅱ (4) and the inner leg Ⅱ (3) and the outer leg Ⅰ (1) and the inner leg Ⅰ (2) are identical; Two steering device between hip.

The steering device comprises a steering rod Ⅰ (9), a steering rod Ⅱ (10) and a connecting module (11). The connection module (11) connects two steering rods to ensure a relative rotation between the two steering rods. The steering rod is arranged on the driving device (12) and the master control device (13).

The driving device (12) comprises a motor and a power supply to provide power to the motor. Power is Battery.

The main control device (13) comprises a micro-control unit for issuing instructions to a quadruped robot, a driving unit for driving a motor, a peripheral interface unit for providing an expansion port for a four-legged robot, and a power management unit for controlling the voltage of each device of the quadruped robot.

The lower end of the leg is arranged with the foot and the collecting device (14). The ground of the foot is curved, and the foot touches the ground with the line. Data acquisition devices include touch sensor groups and gyroscopes. The touch sensor group is set up in the foot and used to detect the ground touching condition. The inner leg and the outer leg are switched to support legs and swing legs through the effect of the driving device (12) alternately.

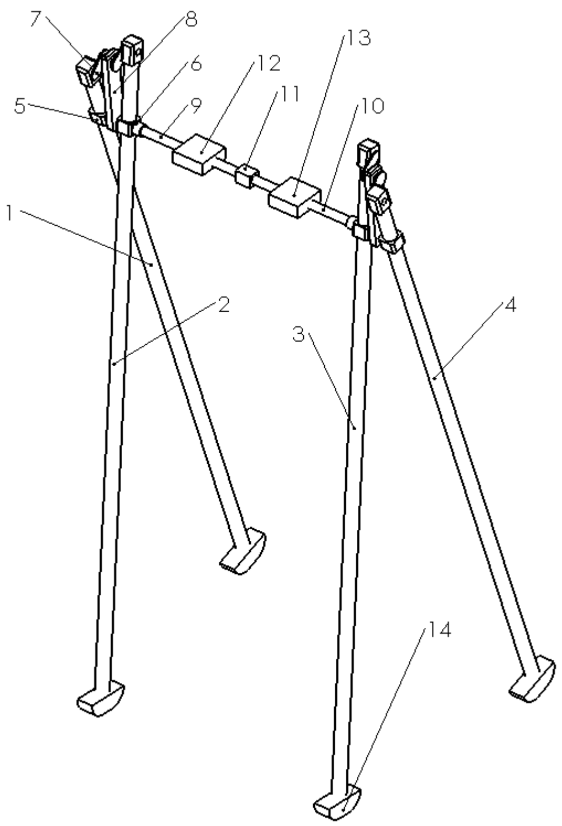


Figure: 1-Outer leg Ⅰ, 2-Inner leg Ⅰ, 3- Inner leg Ⅱ, 4-Outer leg Ⅱ, 5-shaking block Ⅰ, 6-rocker, 7,12-crank, 8-support plate, 9-steering rod Ⅰ, 10 steering rod Ⅱ, 11-Connection module, 12-drive device, 13-master control device, 14-data acquisition device.

Fig. 1 structural drawing

In this paper, long straight legs are hollow thin-walled tubes, and are composed of elastic materials, that is to say, the shape of four long straight legs that constitute the inner and outer legs is identical. In the turning process, the inner leg or the outer leg contact with the ground for the support leg, leaving the ground for swinging leg, the robot about two parts of the leg for synchronous movement.

The leg adopts long straight leg structure, reduces joint connection and control, has good stability, and long straight leg is hollow thin-walled tube, making the leg quality smaller, can reduce energy consumption effectively. This body solves the problem of half-passive four-legged robot in situ turning, has the advantages of simple structure, through the robot two parts of the movement of the left and right leg to twist the robot, and then based on the foot of the arc design to achieve the purpose of steering, has the advantages of convenient operation. At the same time, the data of the main control device analysis data acquisition device provides real-time steering scheme for four-legged robots.

## 3. Control method

The turning process of semi passive robot can be divided into the following steps:

(1) Connecting the devices, and the internal and external leg fork open and the ground into a certain angle in the static equilibrium state; Suppose the inner leg is placed forward as the front leg, the outer legs are placed behind the hind legs, that is left leg of the left part of the right leg forward, the left side of the left leg front, the right-hand part of the right leg toward the rear;

(2) to the main control device microcontroller unit download control procedures, power supply, so that four foot robots start;

(3) Control motor rotation

a. If the left leg moves forward, while the left leg of the right part is backward; The steering device has a relative rotation, followed by the left leg of the left side of the left side of the right part of the leg forward; The two parts of the left and right legs are switched to support legs and swing legs through the function of the driving device alternately, and the quadruped robots continue to turn left;

b. If the left part of the right leg back, while the right-hand leg forward step; The steering device has a relative rotation, then the left leg of the left step backward and the right part of the left leg forward; the left and right legs of the two parts are switched to support legs and swing legs through the function of the driving device alternately, and the four-legged robots continue to turn left;

(4) The data collected by the gyroscope and the foot sensor group are handled by the main control device in real time, and the real-time steering plan is provided for the four-legged robot;

(5) Repeated S3, S4 steps, will realize the four-legged robot in situ cornering;

(6) Conversely, in the step S1, if the outer leg is placed in front of the front legs, the inner leg is placed behind the hind legs, that is, the left leg of the front, the left part of the right leg toward the rear, the left leg toward the right-hand part of the right leg forward;

(7) to the main control device microcontroller unit download control procedures, power supply, so that four foot robots start;

(8) Control motor rotation

a. If the left leg moves forward, while the right leg is backward, the robot is completely symmetrical and the left and right parts, and the steering device has a relative rotation. The robot has the right tendency; then the left leg moves forward while the left leg continues to go backward; the left and right legs of the two parts are switched to support legs and swing legs through the function of the driving device in alternating ways; the quadruped robots continue to turn right;

b. If the left leg of the left step backward, while the right part of the left leg forward, through the steering device has a relative rotation, the robot has the tendency to move to the left; then, the left part of the right leg back at the same time to move forward, the right-hand leg of the two parts through the role of the driving device to alternate ways to switch to support legs and swing legs; four-legged robots continue to turn left;

(9) The data collected by the gyroscope and the foot sensor group are processed by the main control device in real time, and the real-time walking scheme is provided for four-legged robots;

(10) repeated (8), (9) steps to achieve a four-legged robot in situ cornering.

The control flow chart of a half-passive quadruped robot turn is as follows:

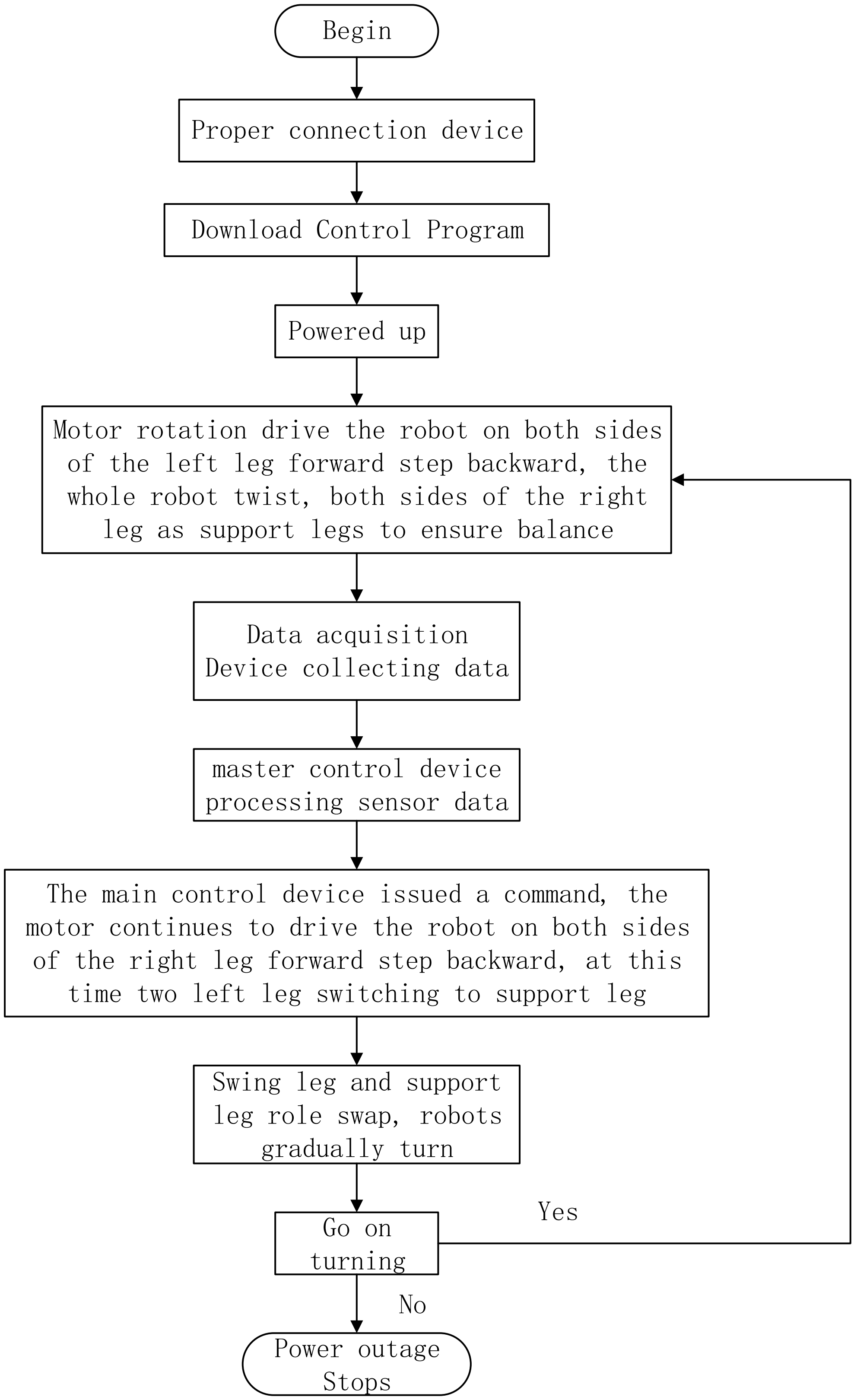


Fig. 2 control flow chart

## 4. Conclusion

In advocating energy-saving emission reduction, green and low pollution of the contemporary society, the low energy consumption, efficient walking way has a great demand. Compared with traditional robots, passive walking robots have simpler structure and higher energy efficiency, and the walking gait of passive walking robots is more natural, more similar to human walking gait. Our design is the traditional passive walking model to make a comprehensive optimization, in energy saving at the same time to solve the problem of turning.

In this paper, a new type of semi-passive quadruped robot turning structure and its control method are specially proposed in the field of passive walking robot. Reduced joint connectivity and control, with good stability, long straight legs for the hollow thin-walled tubes, so that the leg quality is smaller, can effectively reduce energy consumption, this mechanism saves space, simple structure, easy to realize, so that half-passive robots can be more flexible application.

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