

3D Printed Stair Climbing Robot Using Plate Support Mechanism

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Abstract - In this paper, we present a 3D printed stair climbing robot (Plate support mechanism) design and working that achieves autonomous climbing and descending of stairs. The robot works by PIC 16F877A. The robot parts made were from 3D printing for its lightweight requirement. The motions required to climb the stairs are divided into three parts, i.e. the riding on the stairs, going on stairs and landing part. In the riding on the step, front wheels are above the step edge at the same time plate supports the rear of the robot for balancing. While riding the belt drive helps to maintain grip between the wheels and stairs.

Keywords – 3D Printing, Robot, Climbing Robot, Plate support.

I. INTRODUCTION

In the last few years we have observed a strong inclination towards walking and climbing robots. A number of articles and papers with regards to stair climbing robots have been published over the past few years. Most of them focused on surveillance security and rescue applications. Here all the parts of stair climbing robot are manufactured using Delta 3D printer as the parts were not available in the market as per requirements. 3D printing is any of various processes used to make a 3 dimensional object. In 3D printing additive processes are used in which successive layers of material are laid down under computer control. These objects can be of almost any shape and geometry and are produced from electronic data source.

Stair climbing has been carried out with robots using different types of locomotion. One can roughly distinguish wheeled, legged, and tracked robots.

A. Wheeled Robots

Wheeled robots usually have to resort to mechanic extensions to overcome stairs. One application of such a technique is inpatient rehabilitation, where stair climbing could greatly enhance mobility, and thus quality of life, of people confined to wheelchairs.

B. Legged Robots

In order to climb stairs, the robot relies on an open-loop control algorithm implemented as a finite-state machine. The main limitation of the approach is that operating in a different staircase necessitates manual recalibration. The employed algorithm, however, is strictly open-loop. It is thus unable to prevent collisions with the stair walls or balustrades and cannot compensate large heading deviations induced by slippage or shocks.

C. Hybrid Locomotion

The robot forward-tilt angle is estimated by a combination of angular velocity integration and gravity vector measurements, although details about the estimation of the center of gravity location are omitted. The torque derivations are based on a quasi-static analysis, assuming low robot speed and smooth motion. Moreover, the stair dimensions are used as parameters of the control law, but are not estimated online and therefore need to be known a priori.

D. Tracked Robot

Several works have examined stair climbing for tracked robots, which is within the focus of this paper. Tracked robots have a larger ground contact surface than wheeled vehicles and are more stable than bipeds due to their low center of gravity.

II. MATERIAL USED FOR PRINTING 3D COMPONENTS

3D printing builds up components layer by layer using materials which are available in fine powder form material. A range of different metals, plastics and composite materials can be used. Here polymers and plastics like AB, Nylon and ABS are used for producing parts like chassis, wheels and scale.

A. Printer used for printing 3D parts

A 3D printer is a type of industrial robot. Here we used Delta 3D printer as shown below.



Fig: 1 Printer used for printing 3D parts

B. Mechanical design

The robot has dimension (65X45X15) cm which length, width and height resp. as shown in fig



Fig. 2 Mechanical design

III. COMPONENTS OF ROBOT PRODUCED BY 3D PRINTER

A. Slotted wheels

The robot requires four wheels with diameter of 12cm as shown in fig. two of them joined together for robot movement

and the pother two joined in similar fashion. We used a belt drive to join the wheels to be able to climb the stairs.



Fig. 3 Slotted wheels

B. Chassis of robot

The chassis was printed by 3D printer due to light weightlessness as it helps in climbing the stairs.



Fig 4 Chassis of robot

C. Plate

The plate was used to support the robot while climbing the stairs. It helps in avoiding the backward movement of the robot while climbing upward. The plate reduced the complicated mechanism while ultimately reduced the cost of the robot.



Fig 5 Plate

D. Other components of robot

a. DC motor

The DC motor shown in the figure is used as the power engine of stair climbing robot. The stair climbing robot needs



minimum current with high torque for the robot to be able to climb stairs. Two types of motors are needed as follows:

- 1. Brushless DC motor.
- 2. Viper motor.

Minimum current and high speed is supplied from brushless DC motor. High torque is supplied from gears of viper motors.



Fig. 6 Viper Motor

b. Power source

Here Lithium batteries (Li-ion) as a primary source of power because of its advantages as well as its characteristics. Two batteries (12V 9A) delivers respectively to provide 24V. The batteries can be recharged using battery charger. The brain of the robot is PIC16F877A.

IV. MANUFACTURING OF INDIVIDUAL ROBOT PARTS – STEP BY STEP

- 1. First layer is built as nozzle deposits material where required onto the cross sectional area of first object slice.
- 2. The following layers are added on the top of previous layers.
- 3. Layers are fused together upon deposition as the material is in a melted state.

V. RESULT ANALYSIS

The image shows the stair profile used. The height of each step length arranges from 10-18 cm and width of a step 30-40 cm. The slope range is 25° - 45° . The above height, width and slope specification were used to test the robot working. The motions required to climb the stairs are divided into three parts, i.e. the "riding on the stairs", "going on stairs" and "landing" part. In the riding on the step, front wheels are above the step edge at the same time plate supports the rear of the robot for balancing. While riding the belt drive helps to maintain grip between the wheels and stairs.



Fig. 7 Climbing Robot 1



Fig.8 Climbing Robot 2

VI. CONCLUSION

The robot faces problem in climbing the stairs of height more than 18 cm. The robot faces difficulty in climbing more than 60° on stairs. Direction control circuit is working properly and also receiving the signals effectively. The robot receives the direction control signals and changes the direction as expected up to the distance 250m. The support plate mechanism is working satisfactorily.

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