

The Roadrunner: A 2-D Powered Rimless Wheel Robot for Energy-efficient and Rough Terrain Locomotion

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1. Motivation

Our prime motivation is to develop energy-efficient rough terrain legged robots. In the past, we have developed energy-efficient legged robots leading to a 40 mile endurance walking record [1]. However, in that work, the robot walked at a single speed and only on level terrain. In this paper, we provide design details and preliminary work on the development of a rimless wheel based legged robot.

2. Robot design details

Our robot, called the Roadrunner (see Fig. 1), is based on the passive rimless wheel studied by Coleman et al [2]. The robot consists of two rimless wheel subassemblies, connected to each other through a shaft. The shaft is connected to a 22.2 V brushless DC motor through a timing belt and is shown in Fig. 2. The motor is powered by two 3S Lithium Polymer batteries connected in series and is controlled by an Arduino Mega 2560 micro-controller, all of which are housed inside the box shown in the Fig. 2. A gamepad controller can be used to actively control the speed of the robot through radio frequency communications with a range exceeding 100 feet.

The legs have an axial spring to provide compliance and there are point feet. Our design allows replacement of the springs and feet (material and shape), if so desired. The legs of the robots are 3D printed which makes it light weight, while the rest of the assembly, the flange and the axle are made of aluminum.

3. Preliminary work and future plans

We have experimentally tuned the springs stiffness and hand-tuned the controller to reach a top speed of 6 miles/hour [3].

We are currently work on; (i) developing a hi-fidelity and experimentally verified model of the rimless wheel robot, (ii) development of model-based control strategies for energy-efficient locomotion on rough terrain, and (iii) experimental verification of the control strategies on the robot.

References

- [1] Bhounsule, P. A., Cortell, J., Grewal, A., Hendriksen, B., Karssen, J. D., Paul, C., & Ruina, A. (2014). Low-bandwidth reflex-based control for lower power walking: 65 km on a single battery charge. *The International Journal of Robotics Research*, 33(10), 1305-1321.
- [2] Coleman, Michael J., Anindya Chatterjee, and Andy Ruina. "Motions of a rimless spoked wheel: a simple three-

dimensional system with impacts." *Dynamics and stability of systems* 12.3 (1997): 139-159.

[3] Roadrunner: A rimless-wheel based legged robot
<https://www.youtube.com/watch?v=xTSG48KMMR4>



Fig. 1 – The Assembled Roadrunner Robot

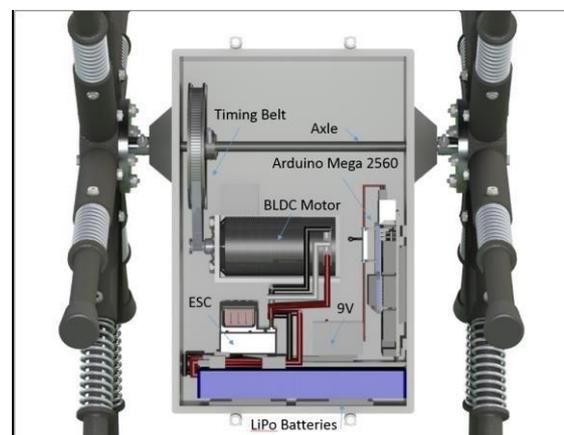


Fig. 2 – Case Assembly