Ein: A Modular Robotic Leg

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1 Introduction

Our motivation in this research is to develop a modular robotic leg for locomotion research. Such a robotic leg can be used as a monoped or combined with more legs to construct a multi-legged robot. Our prime design considerations are: light legs to enable energy-efficient swinging motion, an ability to generate ankle push-off for reduced collisional losses during support transfer, and adequate ground clearance for hilly terrain. Our research builds on previous research on the energy-efficient walking robot, the Cornell Ranger [1], that set a endurance walking record but was limited to walking on level grounds due to limited foot clearance.

2 Robot Description

Our robotic leg, Ein, is shown in Fig. 1. The robot has a thigh and a shank with a spherical foot. The leg on the left side is machined from aluminum while the one on the right is 3D printed and is half the size of the machined one. In either design, the spherical foot is composed of about a 2-3mm thick polymeric outer layer that is filled with a silicon-based support polymer.

The leg has two degrees of freedom; rotary hip motion and linear foot motion. The aluminum leg uses Dynamixel MX-106 motor that powers the hip, and a Dynamixel MX-64 motor that powers the foot. A slider crank motion converts the rotary motion of the Dynamixel MX-64 to linear motion. The 3D printed leg uses Dynamix XL 320 motors. The slider crank mechanism enables ample foot clearance (foot retraction) as well as a push-off (foot protraction). Since both the motors are mounted at the hip, the legs are light in weight. Currently, the motors are powered by an external power supply at 15V and with a current limit of 5A. Robotis OpenCM9.04 micro-controller to program the joints to follow a time-based reference trajectory.

3 Preliminary Results

We tested a single step on Ein by securing the robot to a test fixture and programming the leg to swing back and forth and the shank to move up/down for ground clearance [2]. In a different setup, with the robot foot touching the ground, we tested the motors ability to generate a push-off.

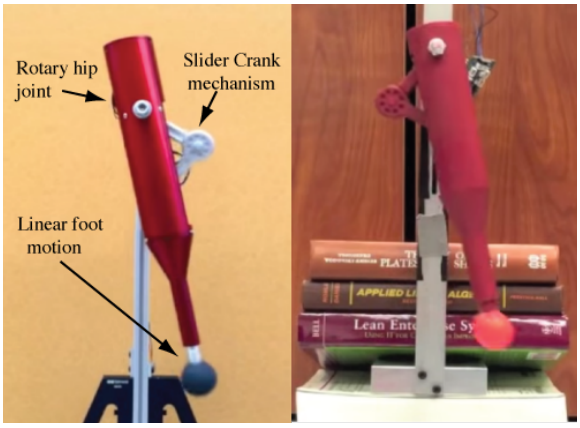

Figure 1: Modular robotic leg: Left: Machined from aluminum; Right: 3D printed. This one is half the size of the one shown on the left.

4 Future work

Future work involves modifying the lengths of the crank and connecting rod to increase the mechanical advantage for greater push-off forces and integration of two modular legs to develop a bipedal robot for walking research.

References

[1] Pranav A. Bhounsule, Jason Cortell, Anoop Grewal, Bram Hendriksen, J.G. Daniël Karssen, Chandana Paul, and Andy Ruina. Low-bandwidth reflex-based control for lower power walking: 65 km on a single battery charge. *International Journal of Robotics Research*, 33:1305 – 1321, 10 2014.

[2] Robert Brothers, Raquel De La Garza, Eric Sanchez, and Christian Trevino. Ein: A modular robotics leg for locomotion research. `https://youtu.be/_gyI_xIkAdw`, June 2015.