Measuring the dynamic jumping performance of the Ghost Robotics Minitaur robot with a novel leg testing apparatus

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Introduction

Legged robots are at the forefront of modern robotic technology being studied by many major robotics companies and the United States Army Research Laboratory. The industry is now turning to walking robots to do the jobs of wheeled robots, such as carrying large loads, disposing of hazardous materials, and even working as scouts on the battlefield. Legged robots can walk impressively in mud and on rough terrain. According to Ackerman (2017), “With fixed objects, obstacles, and vertical surfaces in the path of a tracked robot with no alternative path, legged robots are superior.” Many legged robots jump and generally use thin, light legs with a large spring force to propel the robot upwards. This project tested one these robots: the Ghost Robotics Minitaur™ robot. The Ghost Robotics Minitaur™ robot is capable of large leaps and autonomous walking. The purpose of this project was to design and fabricate a robot leg testing apparatus and use it to analyze the effect of different leg materials on the jump height of the Ghost Robotics Minitaur™ robot.

Methods and Materials

Experiments were conducted using the Ghost Robotics Minitaur™ leg connected to the boom arm of the testing apparatus, as shown in Figure 1.

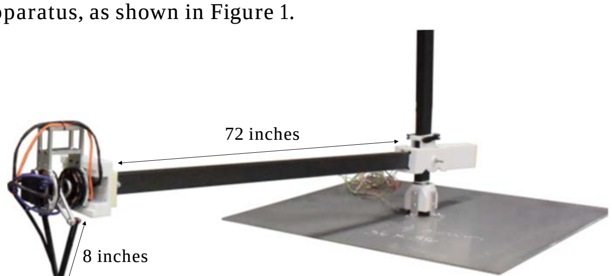


Figure 1 (above): Minitaur robot leg attached to the testing apparatus

The robot leg and boom apparatus were engineered with the computer-aided design program SolidWorks®. The Minitaur mainboard controller was programmed using Arduino. The boom apparatus is the first of its kind. It was made of carbon fiber with a 3-D printed plastic connector mounted on the end of the arm. The stand is made of carbon fiber and machined aluminum. The boom apparatus allows the leg to jump up and down without fear of tipping or rotating while in the air. The counterweights on the boom arm allow for proper balancing of the Minitaur leg.

Methods and Materials (cont.)

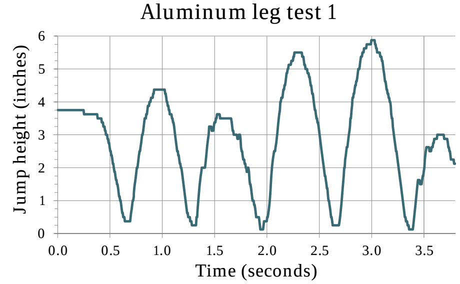
To operate the leg, the tester must flip a switch connected to the Minitaur microcontroller to power the leg motors and start a jump. Flipping the power switch back removes the power and shuts the leg off.

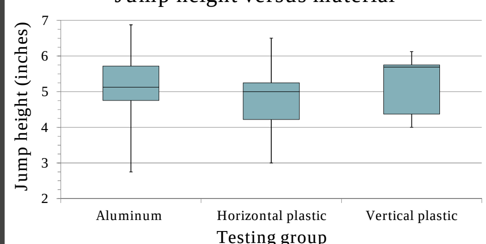
Three types of leg materials were tested: horizontally-aligned 3-D printed plastic, vertically-aligned 3-D printed plastic, and machined aluminum. The alignment refers to the direction of the 3-D printing process. Plastic and aluminum were selected as the best candidates since 3-D printing plastic is inexpensive and aluminum is easy to acquire. Machined aluminum legs served as the control group, while plastic legs served as the two experimental groups. The jump heights for each leg were recorded by Lynxmotion Rotary Encoders. Each encoder has 2000 ticks per rotation, so one tick equates to 0.226 inches of jump height on the 72 inch boom arm. Ten tests were performed for each leg, thirty tests in total.

Results

Graph 1 shows the jumping motion of the robot leg for the first jumping leg test. The leg starts 4 inches in the air so the motors can push off the ground and force the leg upwards.

Graph 1 (right): Graph of the jump height over time for test 1 of the aluminum leg.





Graph 2 (left): Box-and-whisker plot of leg material versus jump height.

Results (cont.)

The data shown in Graph 2 was entered into Microsoft Excel and analyzed in the statistical analysis program Minitab. The standard deviation for the aluminum leg (1.103) was higher than the standard deviations for the horizontal 3-D printed plastic leg (0.974) and the vertical 3-D printed plastic leg (0.834), yet the difference in standard deviations was not statistically significant, meaning the legs have similar spreads. A one-way analysis of variance (ANOVA) test was conducted using Minitab. The p-value for the ANOVA test was 0.604, much higher than the significance value of 0.05. The test shows there was not a statistically significant difference in the jump height of each type of leg. The 3-D printed plastic leg pieces weighed much less (17.66 grams) than the aluminum leg pieces (54.05 grams).

Conclusion

The purpose of the project was to develop and construct a testing apparatus and use it to determine if changing the material of the Ghost Robotics Minitaur™ leg affects its jump height. The jump heights for the three legs ended up being so alike because the intrinsic properties of each leg are similar for the range of forces applied.

There is at least one reason why these materials did not have a greater difference in jump height. If the tests had lasted longer, the legs may have reached a higher point over time since the jump height of each leg increased after each consecutive jump.

Engineers using the Ghost Robotics Minitaur™ robot to jump could change the material of their current legs to 3-D printed plastic legs since they weighed much less, were less expensive, and performed just as well as the leg made of aluminum.

Further experiments using the Ghost Robotics Minitaur™ could test each leg for fatigue and deflection. The boom will be used by the United States Army Research Laboratory for future projects, where previously jumping robot performance had only been simulated (Austin et al., 2016).

References

Ackerman, E. (2017) Ghost robotics minitaur displays impressive new skills. *IEEE Spectrum*. Retrieved from https://www.grasp.upenn.edu/news/ghost-robotics-minitaur-demonstrates-impressive-new-skills-ieee-spectrum

Austin, M., Blackman, D., Brown, J., Clark, J., Pusey, J., & Nicolson, J. (2016). *Running and jump dynamics of a symmetric 5-bar leg design*. Tallahassee, FL: Florida State University College of Engineering.