Quadruped Robot

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BACKGROUND

Quadruped (meaning four-legged) robots may help to increase our understanding of the stability and dynamics of four-legged animals that may prove to be useful to both basic research and industrial applications. There are many uses for quadruped robots including but not limited to: aiding in military tasks, exploration, search and rescue, dangerous unmanned tasks, and many other unforeseen functions.

PREVIOUS BUILD

The Quadruped robot is a previously existing project used for research at the University of Utah. In the past years the robot was built and manufactured to include:

- 2 motors to control 4 legs
- D-space controls
- 4 servos to raise the foot
- 4 legs using large springs
- Chassis
- Testing platform

PROJECT OVERVIEW

The primary goal of the Quadruped Robot project is to provide a research tool that will explore passive stability in quadruped robots. In order to better simulate the locomotion of four-legged animals, each leg needs to be controlled independently from one another. The task was to redesign previous versions of the robot to include four motors rather than two, one for each leg. Each motor has the capability to provide the power required to allow the robot to simulate walking and trotting. The challenge of this project was engineering the robot to remain lightweight while designing for the needed torque and speed to attain the desired gaits. The following is a list of the tasks for the project:

- Find four motors to replace the existing two
  - Increases the mobility of the robot and allow it to change gait without needing to be manually reconfigured
- Redesign the Chassis
  - Accommodate new motors and legs while maintaining robustness, stability, and adaptability
- Reconfigure the drive train
  - Accommodate new motors and efficiently distribute power to the legs
- Find servos to lift feet
  - Increase the speed in which feet are lifted to reduce dragging
- Find encoders
  - Assist in controlling the speed and position of motors

In order to increase the probability of technical success, calculations and modeling was used to support design choices where applicable and failure modes analysis was conducted a priori.

CHASSIS REDESIGN

The chassis needed to be robust and give the robot added mobility while increasing stability. Some of the challenges faced included redesigning the chassis with minimal alterations to the center of mass, overall weight distribution, and spatial dimensions of the previous design. A finite element analysis was run to test the cad model using Aluminum 6061 with the failure criteria von Mises (used for ductile materials).

DRIVE TRAIN DESIGN

The drive train components operate with the motors and fit within the supplied dimensions of the chassis. An efficient drive train results in optimal motion capability. The challenges with this task included difficulty finding sprockets and clamps in the correct size, finding cables that were lightweight and strong, and finding clamps that could handle the necessary amount of torque to avoid slipping or breaking.

RESULTS

Below is a table of the specifications for the project provided by the research team and the values the team was able to achieve.

<table>
<thead>
<tr>
<th>SPECIFICATIONS</th>
<th>METRIC</th>
<th>TARGET</th>
<th>ACHIEVED</th>
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<tbody>
<tr>
<td>Motor &amp; Drivetrain Torque Output</td>
<td>20N-m</td>
<td>27 N-m</td>
<td></td>
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<tr>
<td>Motor &amp; Drivetrain Speed Output</td>
<td>70 RPM</td>
<td>62 RPM</td>
<td></td>
</tr>
<tr>
<td>Servo Speed Output</td>
<td>0.0086 sec / 60</td>
<td>0.06 sec / 60</td>
<td></td>
</tr>
<tr>
<td>Servo Torque Output</td>
<td>0.054431 kg-cm</td>
<td>4.5 kg-cm</td>
<td></td>
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<tr>
<td>Chassis Weight</td>
<td>3.17 lb</td>
<td>3.25 lb</td>
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<tr>
<td>Total Weight</td>
<td>19.84 lb</td>
<td>18.97 lb</td>
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<tr>
<td>Chassis Dimensions (L x W x H)</td>
<td>13.00” x 5.75” x 3.35”</td>
<td>15.21” x 6.25” x 5.44”</td>
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CONCLUSION

The main goal of the project was to find four motors to actuate each leg independently and redesign the chassis and drive train to accommodate the new motors. The biggest challenge the team had to overcome was working on a research project where parameters and specs were fluid in that they were constantly subject to change. This made it difficult to ensure that the project would be completed in a timely manner. Despite these setbacks, the project proved successful. The motors are capable of providing the necessary power and speed as per the research requirements.

ACKNOWLEDGEMENTS