

# 8 DOF Quadrupedal Hopping Robot

## Senior Project Report

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## **Abstract**

The goal of our senior project was to fabricate an eight degree of freedom (DOF) prototypical quadrupedal robot, develop a controller that commands the quadruped to repeatedly jump 10 cm in the air, and fabricate a modular test stand to safely deploy our controller on the quadruped. The creation of a functional quadruped will bring attention to Dr. Siyuan Xing and Charlie Refvem's research group, Cal Poly Legged Robots, and will give future Cal Poly undergraduate and graduate students a learning tool to explore dynamic control of biomimetic robotic systems.

Over the course of our senior project, we successfully manufactured the mechanical quadrupedal prototype, we fabricated a wire harness to power and communicate with the actuators in our system, we developed a controller in MATLAB/Simulink that commands our quadruped to repeatedly jump 10 cm in the air, and we fabricated a modular test stand that holds our necessary electronics and facilitates the quadruped's dynamic motion. This hopping robot will be a platform for future Cal Poly students to develop control algorithms for future senior projects and master theses, with one such being student Patrick Ward's Master's Thesis in which he is developing a bounding gait simulation in MATLAB/Simulink that will be deployed onto the quadruped in a later senior project.

Our success in developing a quadrupedal prototype and verifying its functionality (durability, centered mass, manufacturability) has also drawn attention to Cal Poly Legged Robots from both students at Cal Poly and the Industrial Advisory Board (IAB). This will ensure that future students at Cal Poly are interested in becoming involved with CP Legged Robots and that funding will be available to continue researching and improving our software, electronic hardware, and mechanical system.

# Introduction

Our project's goal was to manufacture an 8 DOF prototypical quadrupedal robot and develop a controller to make the robot execute a repeatable jumping motion. In addition, we wanted to fabricate a modular test stand to let us safely test our controller on the quadrupedal prototype. We successfully achieved these goals and were able to manufacture both the quadruped and test stand and develop a MATLAB/Simulink controller that commands the robot to execute a repeatable hopping motion with a 10 cm vertical.

This report is divided into four sections, each a separate report. Below is a list of the four sections that compose our senior project report

Part I: Scope of Work

Part II: Preliminary Design Review (PDR)

Part III: Critical Design Review (CDR)

Part IV: Final Design Review (FDR)

The first section is our Scope of Work (SOW) document, which convinces our sponsor that we clearly understand what the problem statement and scope of the project are. It also verifies that we have studied existing solutions and performed initial analysis to define the problem. For the SOW document, we also developed a process to effectively solve the problem and acquired the necessary resources and time to complete the tasks related to the project.

The second section of this report is the Preliminary Design Review (PDR) document, in which we describe our concept generation and selection processes, then explain our selected design concept, and lastly provide evidence indicating that our concept will work.

The third section of our report is the Critical Design Review (CDR) document, which contains the full details of our design such that someone else could build it for us. Another purpose of this document is to convince our sponsor that our final design will meet all our specifications. We provide the full details and explanation of our final design, in addition to details explaining how it will meet the design specifications. The CDR document also gives a detailed description of how to produce our verification prototype and describes the planned tests and required resources.

The final section of our report is the Final Design Review (FDR), which contains any new material since CDR. It also describes the manufacturing and design verification activities that we have completed since CDR. The FDR report also contains our final project budget, bill of materials, user manual, and test procedures.

These four reports comprise our entire senior project experience and the process we took to develop the quadrupedal prototype and test stand.