Step By Step

Designing a Versatile Bipedal Explorer

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Introduction

Wheeled platforms are commonly utilized in field robotics, yet many designs struggle to handle abrupt changes in elevation. While legged robots offer greater versatility, they lack the speed and agility of their wheeled counterparts. By harnessing the adaptability of legged designs while retaining wheels as the primary driving force, a hybrid design could combine the strengths of both approaches. This project aims to explore the design of such a hybrid, one which can perform controlled jumps, thereby enabling agile movement across elevated terrains. Presented here are the preliminary design considerations for our proposed system.

Objectives

- Develop a cost-effective wheeled biped with robust balance controls and the ability to "hop" across elevated surfaces.
- Conduct comprehensive testing in virtual and physical environments to assess overall performance under varying terrains.
- Share all developed resources openly to foster collaboration and support further exploration of this topic.

Methodology

- Identify design parameters and constraints for the proposed system.
- Develop subsystem models and manufacture physical prototypes for testing.
- Import the full design into a robotics simulator for virtual testing and further optimization.
- Utilize findings from tests to refine physical design and control algorithms.
- Document findings and modifications, iterating as necessary to enhance performance.

Minimizing Airborne Rotation

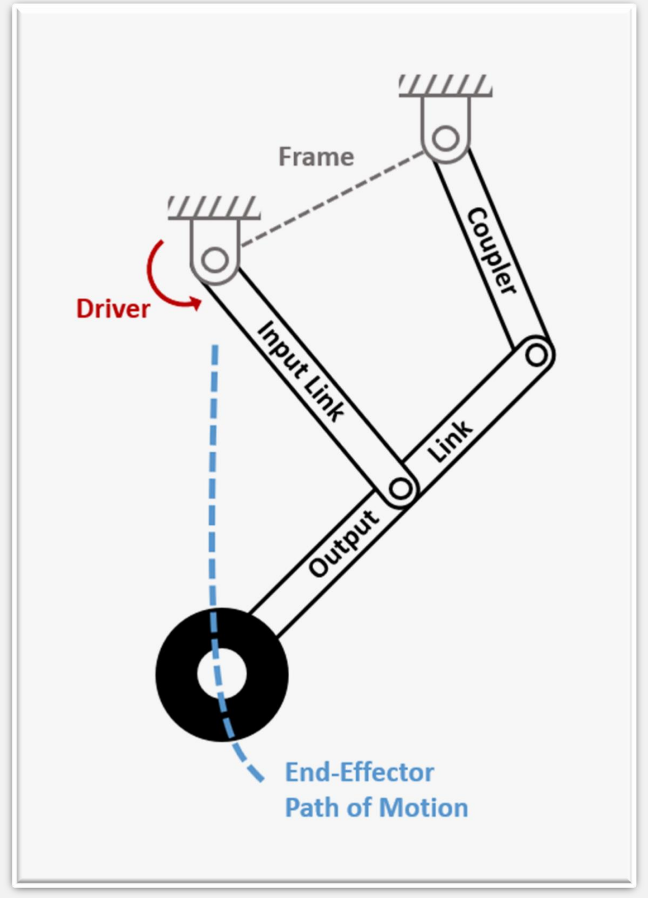

Figure 2: By adjusting linkage proportions in the four-bar mechanism, the path of the end-effector can be manipulated to reduce horizontal translation, thereby minimizing any torque caused by jumping.

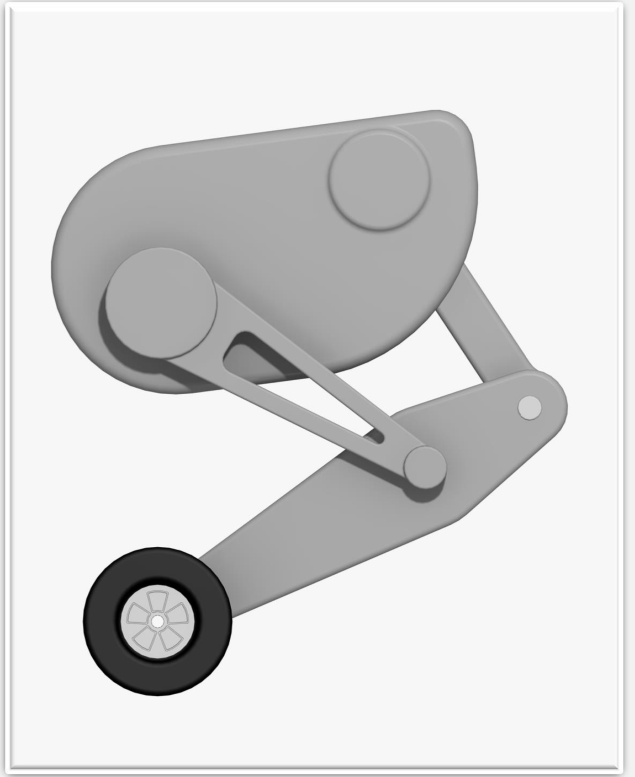

Figure 1: Preliminary CAD of proposed design.

System Dynamics Representation

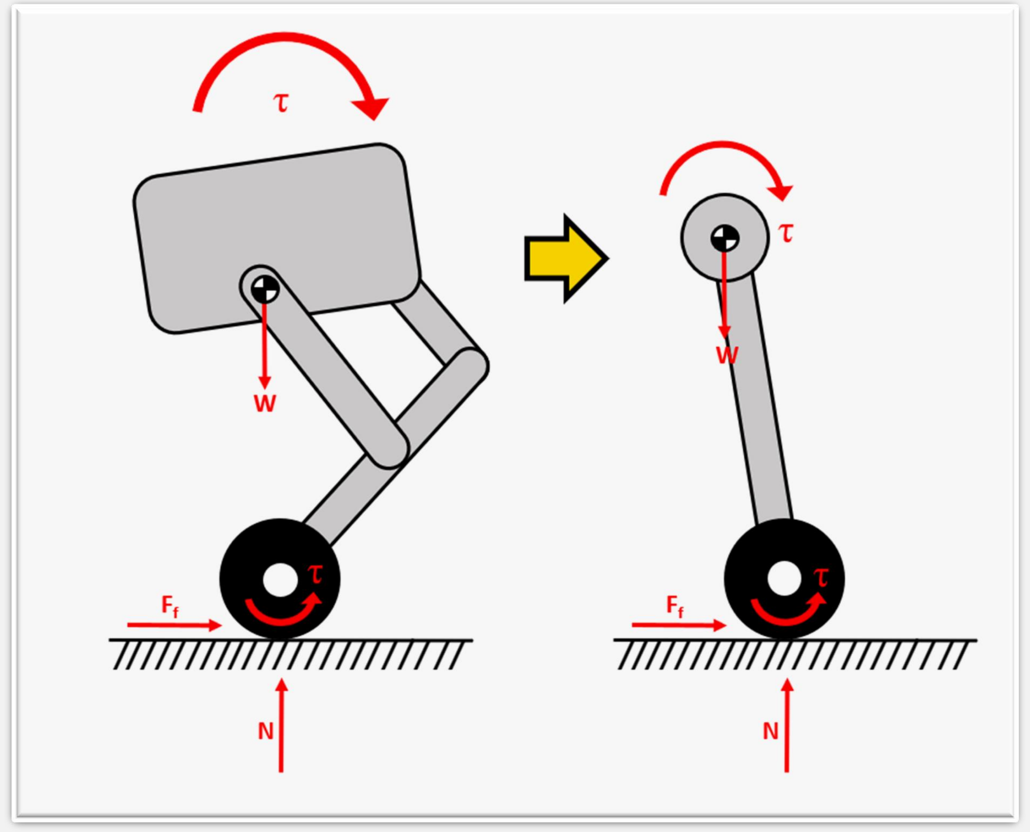

Figure 3: Regardless of input link orientation, the system dynamics can be idealized as an inverted pendulum problem allowing for simplified control.

Identifying Control Transition Points

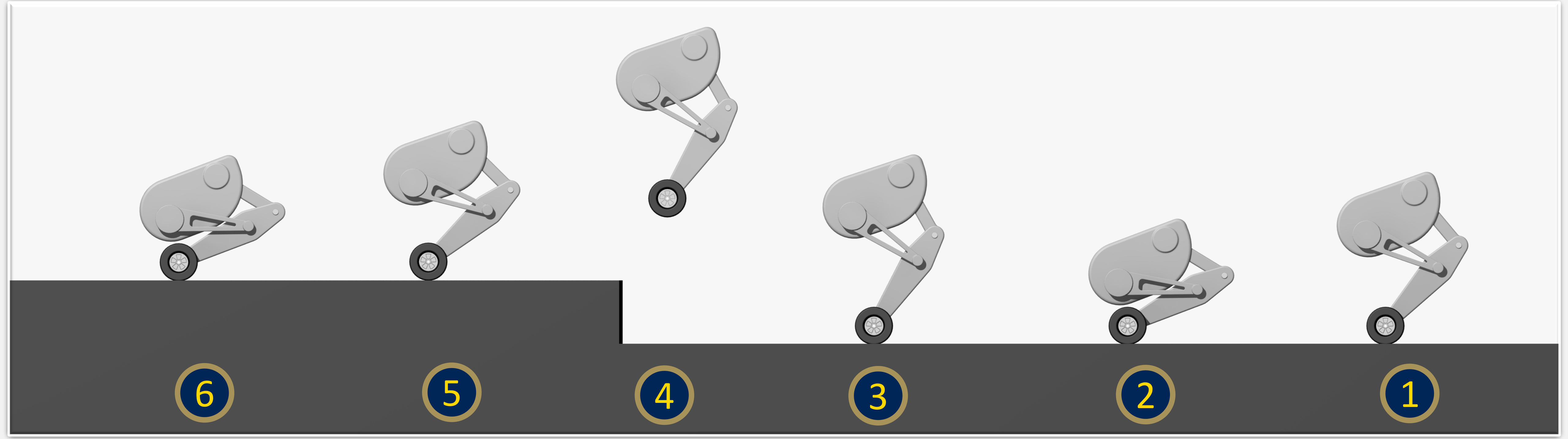

Figure 4: (1) Operator positions the robot towards the ledge; (2) Robot lowers its center of gravity (COG) and begins accelerating forward; (3) Time-of-flight (TOF) sensors detect distance from the ledge, triggering rapid "hip" actuation; (4) Robot becomes airborne, maintaining orientation with fully extended legs; (5) Upon landing, the inertial measurement unit (IMU) detects a sharp acceleration spike, prompting reactivation of balancing behaviors; (6) Robot recovers using a low COG to enhance stability.

Materials

Arduino Mega 2560 Microcontroller: Controls motor operations and interfaces with sensors

6DOF Inertial Measurement Unit: Measures acceleration and rotation rates in three axes.

Quadrature Rotary Encoders: Measures the angular speed and position of the motors.

DC Motors: Drives the wheels for locomotion and hip joints for jumping.

Motor Drivers: Allow for the dual direction control of the motors.

12V Battery: Powers the motors, Arduino, and other electronic components.

Step-down converter: Creates a lower voltage source for the Arduino.

Time-of-Flight Sensors: Measures distance from obstacles for accurate jump timing.

Radio Transceivers: Allow for wireless remote control of the system.

RC Vehicle Tires: Provide traction and support for movement on various surfaces.

Torsional Springs: Generate additional torque for jumping and dampens shock from landing.

Structural Components: 3D printed components, fasteners, etc.

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