Single-legged hopping robot (Proposal)

1st Isara Cholaseuk
Department of Mechanical Engineering
Boston University
Boston, MA
isara@bu.edu

I. Problem Statement and Project Goal

In this project, I will derive a dynamical model for a single-legged robot, apply control algorithms, and simulate its motion in MATLAB. The robot will have 3 compound joints (ankle, knee, and hip). The ankle will have 2 rotational actuators; the knee will have 1 rotational actuator; and the hip will have 2 rotational actuators. This means that the robot will consist of 4 rigid bodies connected by the 5 revolute joints. The simulated motions will include 1) no actuation under different initial conditions, and 2) with active stabilization control.

II. Approach

The approach will start by formulating the Lagrange's equations of motions, creating a dynamical simulation in MATLAB under no controls with gravity, and developing control strategies to stabilize the robot at various configurations. The dynamical simulation would consider a constraint where one of the end links (foot) is fixed to the ground. This simulation will be used to examine the dynamical motions of the robot under no actuation and under stabilization control.

III. Experimental Design and Assessment

For the first step of simulation (simulating the dynamics under gravity and a foot attached to the ground), the total internal energy should remain the same, so plotting the total energy over time can help ensure the resultant motion is correctly solved. Then, once the damping force is added to joints, the total energy should converge to zero over a sufficient period of time regardless of the initial energy. After having a fundamental physical simulation correct, the simulation should be robust enough to test control algorithms on.

IV. Comparison Versus Project Specification

Comparing to one of the examples given on the project details document, this project highly resembles the 3-link manipulator in 3D, which should satisfy the complexity. If however, the project is too simple, and there is time, I plan to implement and simulate either a pushing and jumping motion of the robot using the derived model or 2) a SLIP model.

V. Possible Challenges and Mitigation Plan

The foreseeable challenges include 1) the equations of motion would be complex to derive, and difficult to determine their correctness, and 2) the stabilization controller on a multiple-link manipulator is a new concept for me. If by December, the simulation phase is not yet completed, or at anything, the project seems too difficult, a mitigation plan could be to implement only a robot under no actuation in Python or C++ as suggested.