Linear Inverted Pendulum Walker

16-311: Introduction to Robotics

Contents

Learning Objectives

1. Derive the equations of motion for the Linear Inverted Pendulum Model.
2. Gain exposure to non-traditional robots.
3. Work through the challenges of creating a walking robot in simulation.

1 Derivations

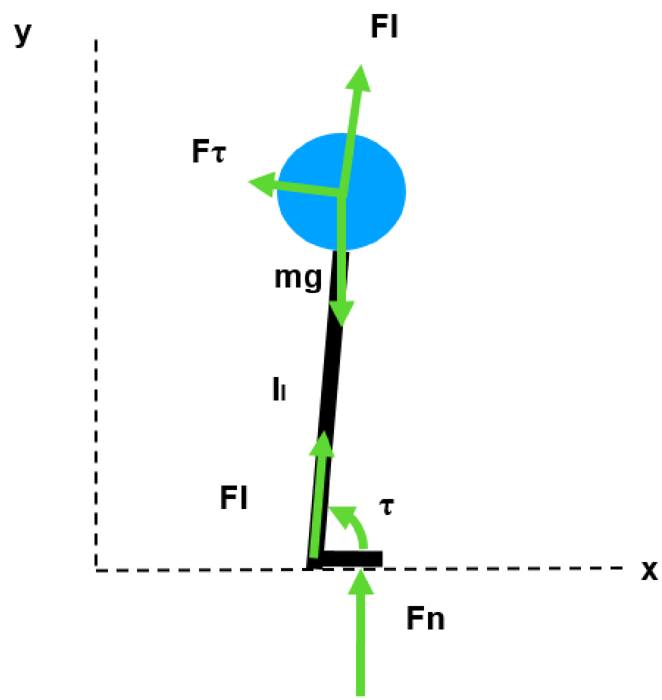

Figure 1: Image showing forces on the leg for the Linear Inverted Pendulum Model. The COM height is y_0.

1. Just looking at the point mass, sum the forces in the y direction. [5 points]

2. For the LIPM, what should the sum of the forces in the y direction be equal to? [5 points]

3. Just looking at the point mass, sum the forces in the x direction. [5 points]

4. The sum of the forces in the x direction simplifies to $\frac{mgx-\tau}{y_0}$. Write this equation in terms of m, g, x, y_0 and COP (the center of pressure location). [10 points]

2 Questions

1. For the linear inverted pendulum model (LIPM), how would the capture point change if the initial velocity increased? Does this make sense intuitively? [5 points]

2. For the LIPM, if the mass is increased but initial velocity and height remains the same, how does the capture point change? Does this make sense intuitively? [10 points]

3. How close or far is the LIPM model from how humans actually walk? (You may have to do a quick search to answer this one) [10 points]

3 Implementation

Download the following starter code: `https://drive.google.com/drive/folders/12bZuO1JsZYuY_Kcetea-lZzCXgGaXDl0?usp=sharing`. Implement the equations you solved for in the 1 section. You will need to decide when you want to take a step. Then you will need to determine how long to make that step (your first step should ensure that you have the desired velocity). After that you will calculate the change in position and change in velocity for the center of mass. Finally, you will integrate these changes to update the states. For the integration, you can use Euler Integration or Runge-Kutta or any other method that you like.

Take a video of your walker in action.Link the video on your .pdf [50 points for a successful walker, 40 points for something that takes one step at any velocity]

What To Submit

Submissions are due on Gradescope by the date specified in the Syllabus.

1. Create a .pdf file with the written answers ALL THE SECTIONS named pdw.pdf.

2. Ensure that your .pdf contains the answers for Part 1 and 2, and the video for Part 3.