Physical Modelling and the Design Cycle

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Lab Group 2-4pm Thurs #2 : Reno, Daniel, David, Aaron and Michael

Executive Summary

The goal of the report is to document my initial designs and ideas of a passive dynamic walker (PDW). This includes the current state of technology, justification of choosing to model a simple 2D walker instead of a 3D walker, and draft measurements for a walker.

This report also details the work done by Group #2 of Lab Thursday 2-4pm. Which the group designs were brought together and ranked to choose the most effective design to iterate and improve. The design was chosen on the biases of an agreed matrix of appropriate measures.

Problem

To design, iterate and implement a model of a 2D Passive dynamic walker to be able to be stable enough to be able to walk a repeatable amount of steeps.

Initial Design

2D Passive Dynamic Walkers

A 2D Passive Dynamic walker (PDW), is a good 'first-step' into the field of passive actuators. This is because it allows for a simple entry point instead of something that would be too daunting to be thrown into like a 3D PDW. The more simpler model, like a 2D PDW, enables a wider range of people to gain the core concepts of modelling a system and passive walkers.

Results of Simulations

The results of simulations were varied. Some changes lead to the taking of first steps, others lead to a stand still. After researching the different components acting in the system, reading through the lab resources and getting MatLab to respect the changes made to the scripts some working variables were found.

Ways to Improve Simulation tools

A possible improvement to the simulation tools given would be having value sliders for the initial and parameter variables to rapidly test the new changes and cut down on time wasted on repeating the same task of running the scripts in an order so the changes are actually introduced to the simulation.

Results of prototype measurements

Measurement Name	**Value**
Leg Length (Both legs)	0.2m
Foot Radius (Both legs)	0.19m
Vertical Distance (hip to CoM) (Both legs)	0.01m
Horizontal Distance (hip to CoM) (Both Legs)	0
Mass of Leg (Both legs)	0.7kg

The above table is the measurements of the PDW that works with the initial values of:

Initial Condition Name	**Value**
Angel of inner leg ($\Phi 1$)	11.545°

Angel of outer leg (Φ2)	10°
Rotational Velocity of inner leg (Φ1D)	-1.40 rad/s
Rotational Velocity of outer leg (Φ2D)	-1.1205 rad/s

These initial values with the given measurements do produce a working simulation.

Requirements for equipment and resources

The requirements of the equipment I would need to complete the project would be the stock standard set-up with no custom parts required to complete the project.

Justification of Choosing my Design

The main point of justification of choosing my design and set of values would be to have a base of working values that could be iterated upon to gain more reliable results and can be changed to fit if any errors in my interruption or knowledge of the design constraints are faulty.

Peer Review

Raw Table

Difference	Reno	Daniel	David	Aaron	Michael	Tess	James
Steps Taken	-	10	10	10	10	-	-
Custom Parts	-	10	10	10	10	-	-
Resistance to Change	-	5	5	5	8	-	-
Assembly Time	-	8	8	8	7	-	-
Overall Mass	-	8	8	9	8	-	-
Feasibility	-	10	10	10	10	-	-
TOTAL	**-**/60	**51**/60	**51**/60	**52**/60	**53**/60	**-**/60	**-**/60
Contribution to the Group	9	10	9	9	10	-	-

Note: -'s for the differences indicate that the person did not submit a design. While a '–' in the contribution indicates no attendance to any lab.

Weighted Table

Difference	Weighting	Daniel	David	Aaron	Michael
Steps Taken	1	10	10	10	10
Custom Parts	0.8	8	8	8	8
Resistance to Change	1	5	5	5	8

Difference	Weighting	Daniel	David	Aaron	Michael
Assembly Time	0.8	6.4	6.4	6.4	5.6
Overall Mass	0.5	4	4	4.5	4
Feasibility	0.8	8	8	8	8
TOTAL		**41.4**/49	**41.4**/49	**41.9**/49	**43.6**/49

The comments and criticism from the peer-review from my initial design was on the lack of testing with a variety of different scenarios which is shown by my low score in the "Resistance to Change" category. I could of also provided more information in the form of image and/or graphs of my design in action.

To objectively judge each design in a meaningful manner our group came up with six categories to compare against. "Steps Taken" describes the number of steps taken in the simulation program. "Custom Parts" is to given weight to the design that does not require any additional manufacturing or design. "Resistance to Change" measures the ability of the design to work within reasonable range of parameters or initial conditions. "Assembly Time" is given a large weight as it governs how fast we can build the given design into a prototype for faster testing. "Overall Mass" is compared to get a comparison of an approximate idea of the cost of materials of a design. "Feasibility" describes how likely the design is to work given to work at testing.

The design that was taken forward was Michael's design as it scored the highest in both raw and weighted matrices.

Final Design

Measurements taken from Michael's design.

Measurement Name	**Value**
Leg Length (Both legs)	270-300mm
Foot Radius (Both legs)	190mm
Vertical Distance (hip to CoM) (Both legs)	200mm
Horizontal Distance (hip to CoM) (Both Legs)	0
Mass of Leg (Both legs)	0.7kg

Initial Condition Name	**Value**
Angel of inner leg ($\Phi1$)	-5°
Angel of outer leg ($\Phi2$)	-15°

Rotational Velocity of inner leg (Φ1D)	0 rad/s
Rotational Velocity of outer leg (Φ2D)	0 rad/s

With our finial design described above in testing we consistently got three full steps, one step being : moving from outer legs to inner legs then back to outer legs.

Simulation verses Reality

The simulation of our final model did not match our testing of our prototype system very well. While our implemented design was walking a solid three steps each time, our simulation of the same conditions did not. This may have been caused by the assumptions made by the simulation such as friction and air resistance, though small forced summed up to overall changes.

While testing some potential changes to our system we decided to test changing the centre of mass of the legs, and thus moment of rotational intra. In the simulations this showed great success with over 30 steps, but once we testing this with our model we found that any changes to our system had no positive effect. We tested two configurations of altered centre of masses with no significant results we left this measurement unchanged.

In our final round of testing we tried to change the initial angles of release of the prototype. In simulation the results varied with the most promising results focusing around the -5° for the inner leg and -15° for the outer leg. Our testing found these measurements matched the simulated results.

Discussion

The differences between our simulation and final model are caused by a combination of many factors. The most prominent is the the failure of some assumptions made by the simulation. The assumption that caused the most difference would be the: in the simulation the feet can go through the ground, this is emulated in the testing with having gaps between each step to allow for the swing of the legs. This caused a problem with the physical model not getting the spacing between each step correct and falling over. This problem is hinted in the simulation with the strides of the walker getting bigger each time, but we assumed that this was caused by a lack of friction in the simulation thus the friction caused by the steps would regulate this increasing stride length. In the testing this was proven to be incorrect, the increasing stride length was a clear problem. We attempted to fix this with the use of weights to move the centre of masses of the legs and later tried a range of initial starting angles of the leg to get rid or even dampen the problem.

Appendices

Test 3 Results

Inner Leg Angle	Try 1	Try 2	Try 3	Try 4	Try 5
5°	0	0	0	0	0
15°	2	3	2	3	3
25°	3	2	4	5	3
30°	0	0	0	0	0

Slope : 3° Outer Legs: 15°

Test Schedule

written by Daniel

Test 2	**Change**	**Result**
	Decreasing slope angle	Made it work nicer, though if we decreased it by to much it fell over to quickly
Test 3	**Change**	**Result**
	Higher angle	See test 3 results
	Release angle (middle leg) -15 degrees	See test 3 results
	Release angle (middle leg) -25 degrees	See test 3 results
	Release angle (middle leg) -35 degrees	See test 3 results
	Release angle (middle leg) -45 degrees	See test 3 results
	Start outside legs at an angle of 0 degrees and just use the middle leg swinging to build up momentum	Did not go well
	Centre of mass	Had no significant effect