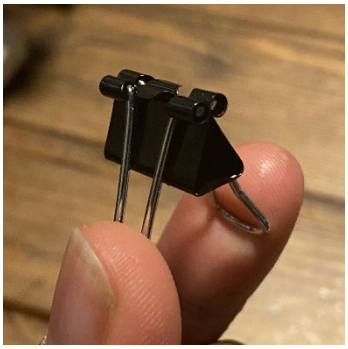
Passive Lego Walker
Info Sheet

***Materials Needed**: Two small binder clips, two large binder clips, pencil, ramp with a small incline (around 5°), patience! Optional: Tape & weights (we used two dimes and electrical tape for example to test).*

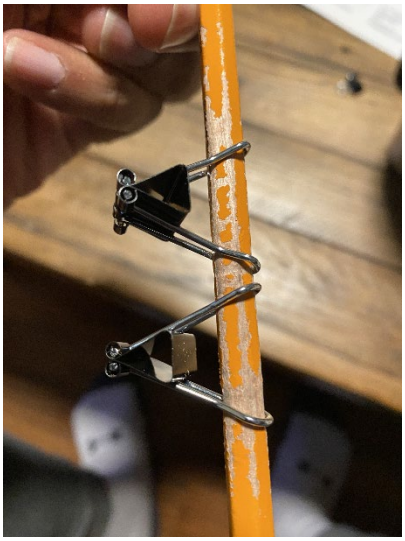
Passive Walker Assembly

1. Fold the two larger binder clips up so they look like the picture below



2. Put the pencil through the silver rings of both the larger binder clips and move them roughly to the center

3. Rotate each binder clips a bunch so it rubs off the wooden pencil. You are basically trying to remove enough wood so the clips can rotate freely. Make sure the wood is nice and worn.



4. Attach the smaller binder clips on to the pencil. Make sure they are on opposite ends of the larger clips. See below.

5. You have yourself a walker! Make yourself ramp by tilting a surface. Make sure there is something with friction on it. Put the walker on, give it a tip and watch it walk!

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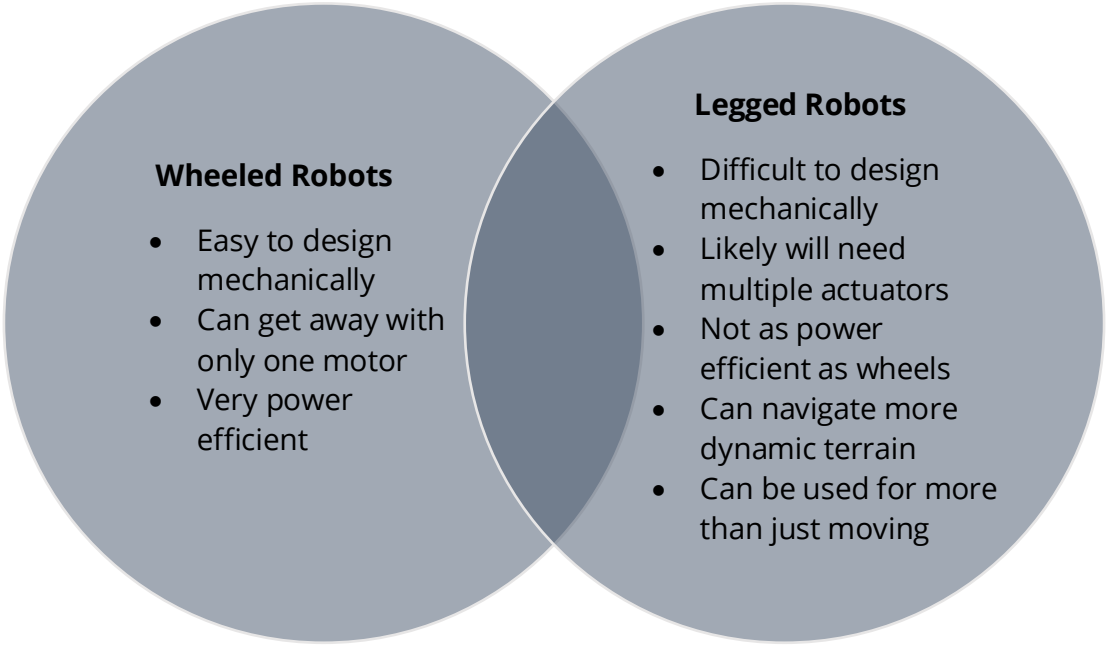
Passive Walker – Tips

- Make sure the legs can swing nice and easily by just rotating the pencil. You might have to keep rotating the rings so that you rub off more wood.
- Might need to keep tapping it. If it doesn't look like it's taking many steps. Also try adding some mass to either ends (make sure it's the same on both sides). This will increase the inertia and give you a bigger wobble.
- Make sure you surface has some sort of friction. Add a mouse pad or rubber mat if you have one.
- Try adjusting the height of the ramp (i.e. adjust the angle). Might need to lower it if your robot is just falling forward. Might need to raise it if your leg isn't swinging enough.

Legged vs Wheeled Robots



Discuss: Where do they overlap?

Passive Dynamic Walking Overview

Passive dynamic walking describes a method to create walker without any power by using the natural dynamics of walking.

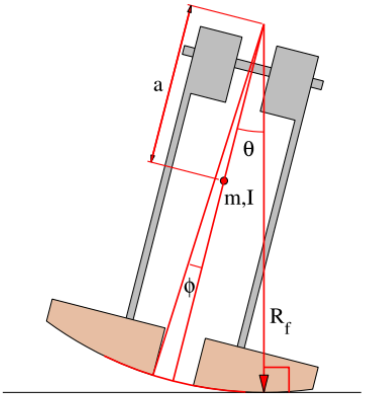


Fig. 2. Frontal Plane Model

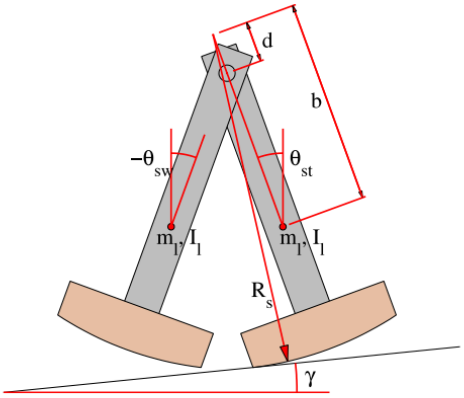
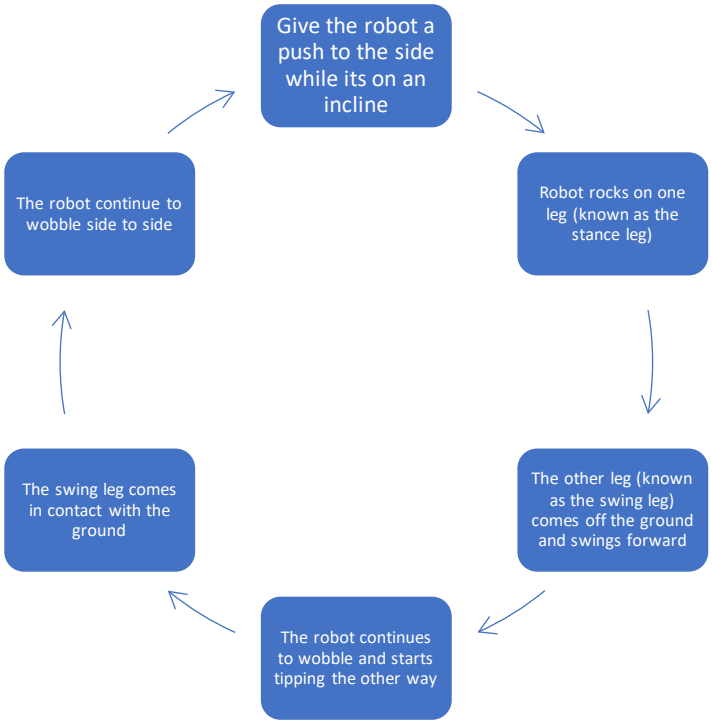


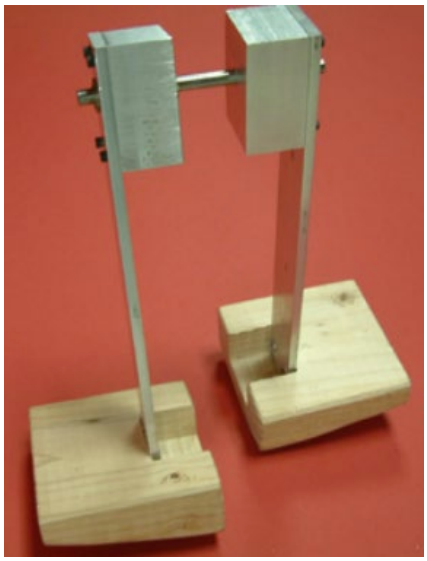
Fig. 3. Sagittal Plane Model

The figure above shows the dynamic model of the passive dynamic walker. There are several key characteristics of this walker, such as:

- Curved feet in both the frontal (front) and sagittal (side) planes.
- Mass (weight) of the robot is concentrated at the hip of the robot or the feet
- Robot is on a slight incline
- Robot given a slight push in the frontal plane to make wobble side to side



From the process on the previous page, we are able to remove complex aspects of traditional walker (like humans) such as knees. We also don't need so many actuators. Think about a human who can retract their knee and also rotate their leg at the hip. A robot would require a bunch of motors to do that, but passive dynamic walking allows to make walker without a knee and actuators.



Creating a Lego Walker

You can see from the picture above and your own experience that LEGO figures are very small. Exactly 4cm small. Since Lego figures are small, it is very difficult to fit multiple actuators, knees, and ankles in a robotic walker that size.

We can leverage passive dynamic walking here to remove the need for knees and so many motors. All we have to do to make a walker at this size is use principles of passive dynamics, have it gain forward momentum, and excite the wobble somehow.

The walker to the left utilizes the principles of passive dynamics and 2 servos that push the legs in and out. The servos are used to excite the wobble, to push off, and gain leg clearance. The feet are curved in the same way as shown previously. Also, the hip is shift forward to make the robot lean forward.

As the one leg extends, the robot tips towards the opposite leg. By doing this, we are able to excite the cycle of passive dynamic walking described previously.

Passive Walker Q&A

- What are your thoughts on this experiment?
- Did it work as expected? If not, what will you try to change?
- What applications might a passive walker have?
- Why would a roboticist choose legs over wheels?

Sources

http://groups.csail.mit.edu/robotics-center/public_papers/Tedrake04.pdf
https://www.cs.cmu.edu/~16311/current/schedule/ppp/LeggedRobotics2020.pdf
https://www.dailymail.co.uk/home/moslive/article-1234465/When-Lego-lost-head--toy-story-got-happy-ending.html