MAE 2030 Lecture #28:

4/14/21

Today: Mechanics of walking

* not on exam! *

:)

Control of Bipeds: How to make a robot walk w/o falling (using little power)

- non-linear
- under actuated
- hybrid
- poorly sensed
- non-holonomic
- many DoF
- hysteric

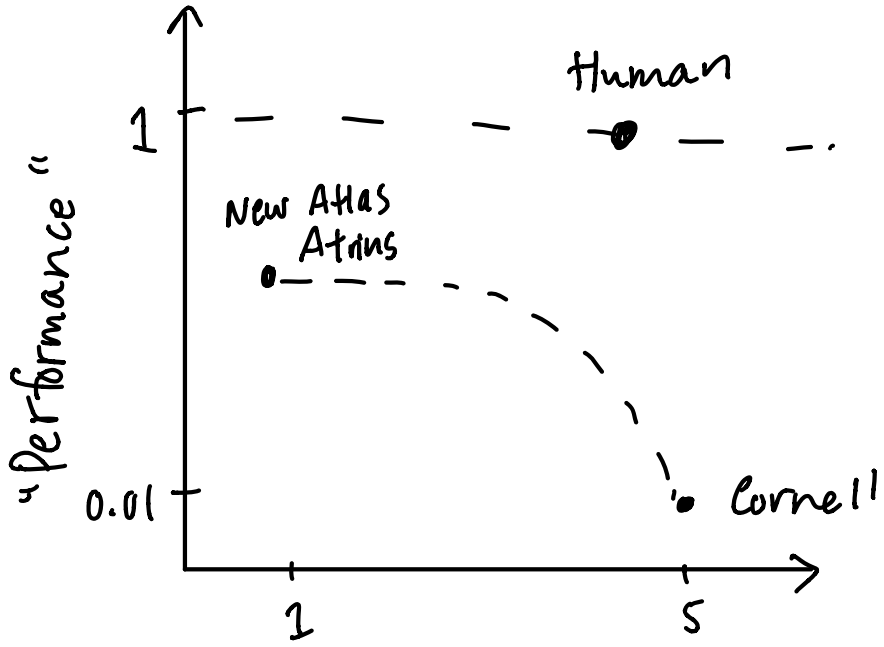
GOAL: make or understand the control system for a robot or animal/person

video: robots falling and failing

Boston dynamics has common sense! That's why they have been successful

What's the overall problem?

- Powered robots use too much power or are too touchy



"Energy effectiveness" $\frac{1}{COT}$

How to make an efficient robot?

→ Try to make a robot that can walk by itself without falling (robot intrinsically wants to walk)

→ Then use that and add control

Bicycles: balances itself when moving (shown mathematically in 1897)

Intentional? unknown but is still part of bike design

Airplanes: Gliders came before planes and flies stably

- add a motor (like rotating the gravity field)
- powered flight

Toys: can "walk" downhill without controls

Human: can be modeled as pendulum

left leg → 1 stick (hinge at hip)
right thigh → 1 stick (hinge at hip)
right calf → 1 stick (hinge at knee)

- McGeer (1990) - "4-legged biped" walks downhill (no motor, no sensors)
- Tinkertoy (Cornell, 1997) - can walk but can't stand
- Wisse/Collins - two leg biped with knees

Idea!

↳ basically McGeer's idea

- Make robots that are like planes or toys (powered by gravity)
- Make them stable
- add a motor and let it run on an incline

Turns out it's a bad idea...

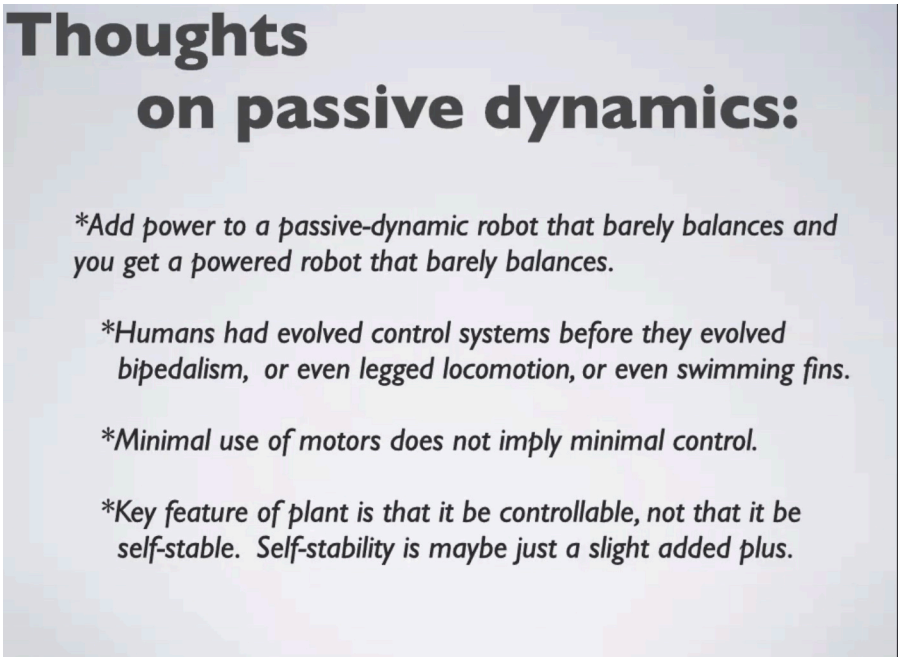
Passive dynamics turns out to be touchy...

and we don't know how to fix it

What's wrong with it?

Wright brothers: master control first, then add power

(passive stability wasn't a direct consideration)



disclaimer: pls watch lecture videos for better notes