

Balancing Robot

Controlling a Mini Segway



Learning goals

- ▶ **Recognize** what is *an unstable system* and *under actuation*
- ▶ **Know** what one needs to control
- ▶ **Understand** the main principles of feedback control



Unstable system



Unstable system

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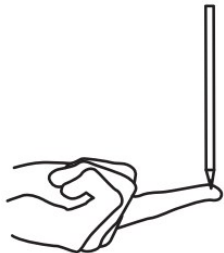
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- ▶ Some systems are **marginally stable**, that is they become unstable if certain conditions are not met
- ▶ Minseg, Segway and balancing a pen with a finger are actually marginally stable systems!



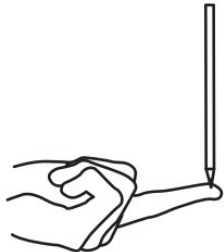
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Can you think of any other examples?

Underactuation



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- ▶ Practically this means that we can only control the robot in two ways, but the control will affect 3 things



Feedback Control



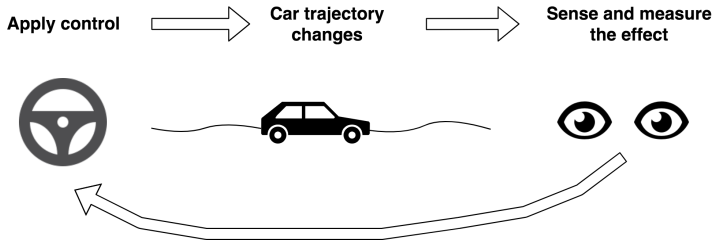
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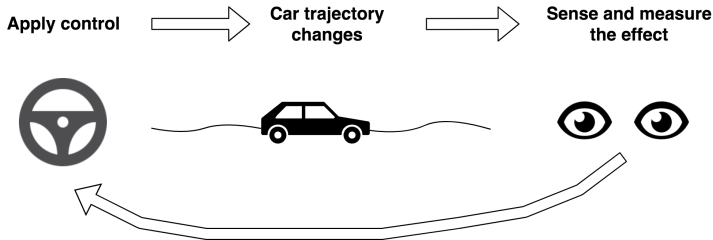
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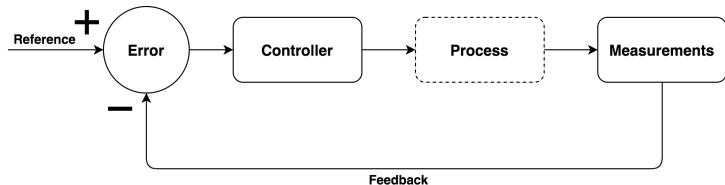
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- ▶ Here, your brains act as **the controller**, the car trajectory is **the process** and your eyes do **the measurements**. Then your brains calculate **the error** from **the reference** path according to the images sent by your eyes!

Feedback Control

- ▶ Negative feedback control loop



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- ▶ If we want the robot to go forward as we want it, we need to also keep up with a *reference value*



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- ▶ This also has a side effect, can you figure out what it could be?
- ▶ Some systems are *self regulating processes*, this means the process in itself includes integration and no integral control is needed
- ▶ If you are interested in identifying these systems and learning more control methods, you are more than welcome to come and study control theory!

