

Balancing Robot

1 Project Introduction



What is the purpose of this project?

To have fun, while you learn:

- ▶ how to make a robot balance on its wheels, but NOT just that!
- ▶ lot's of cool stuff about automatic control, for example, how to design control schemes in the real world, and all these through using a simple and fun object!
- ▶ how things around us work!



Does it remind you of anything?



Does it remind you of anything?

- ▶ The Segway is the first **self-balancing**, electric-powered transportation device
- ▶ **Dynamic stabilization** enables the Segway to work seamlessly with the body's movements
- ▶ **Sensors** in Segways monitor a user's center of gravity at about *100 times a second*
 - ▶ when a person leans slightly forward, the Segway moves forward
 - ▶ when leaning back, the Segway moves backward



Does it remind you of anything?

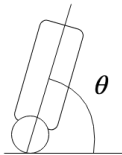
- ▶ The Segway is the first **self-balancing**, electric-powered transportation device
- ▶ **Dynamic stabilization** enables the Segway to work seamlessly with the body's movements
- ▶ **Sensors** in Segways monitor a user's center of gravity at about *100 times a second*
 - ▶ when a person leans slightly forward, the Segway moves forward
 - ▶ when leaning back, the Segway moves backward



Can you think of any other examples?

General idea for balancing

- ▶ Find the **balancing point** - this will be called *the reference angle*

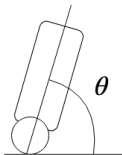


- ▶ Adjust the angle by controlling the **actuators**
 - ▶ In this case, the *motors* are our only actuators
- ▶ Measure the angle by reading from the **sensors**
 - ▶ What kind of sensors do we need?



General idea for balancing

- ▶ Find the **balancing point** - this will be called *the reference angle*



- ▶ Adjust the angle by controlling the **actuators**
 - ▶ In this case, the *motors* are our only actuators
- ▶ Measure the angle by reading from the **sensors**
 - ▶ What kind of sensors do we need?
 - ▶ **Gyroscope**: an instrument for measuring **orientation** and **angular velocity**
 - ▶ **Accelerometer**: an instrument for measuring the **acceleration** of a moving body
- ▶ **Try to keep the angle at the reference angle value!**



What are the challenges?

- ▶ For designing the rules (controller) for the motor (actuator),
 - ▶ we need to understand the *dynamics* of the robot, i.e., how it responds when the motors are activated
 - ▶ for doing so, we need to build the *mathematical model* of the robot
 - ▶ we need to use what we can measure
- ▶ The mathematical model does not represent the dynamics accurately, so
 - ▶ we need to consider this on the design of the controller and counteract the difference



What are the challenges?

- ▶ For designing the rules (controller) for the motor (actuator),
 - ▶ we need to understand the *dynamics* of the robot, i.e., how it responds when the motors are activated
 - ▶ for doing so, we need to build the *mathematical model* of the robot
 - ▶ we need to use what we can measure
- ▶ The mathematical model does not represent the dynamics accurately, so
 - ▶ we need to consider this on the design of the controller and counteract the difference

We will learn about all these throughout this project!

