ETH zürich

Institute for Dynamic Systems and Control

Control Systems 1

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About Me

- **Johannes Schute-Vels (jschul)**
- **5. Semester Mechanical Engineering**
- **Former Informatik II TA**
- **Wokring on the PEGASUS focus project** (ARIS) as a controls engineer. Rotating Detonating Rocket Engine (don’t even know yet what that is)

- **3 Fun facts about me**:
  - I lie to everyone that I’m 2 meters tall
  - I am 2 meters tall
  - I like to lie

Organisation

Course and Exercise Structure

- **Weekly lecture on Wednesday, 16:15 - 18:00**
- **Weekly Exercises on Friday 10:15 - 12:00**
  - **1. hour:** Theory Recap and example problems
  - **2. hour:** You solve the exercises and can ask questions. Of course you can leave if you do not have any questions or do not want to solve the exercises.
- **Study Center starting from the 3. Week.**
  I will be there in the first few weeks. Good to ask questions!
- **The entire course will be held in English.**
  However, feel free to ask in **German** as well!

Materials

- Lecture Slides and Lecture Recordings
- **Weekly Problem Sets** for you to solve. Starting from next week. (**not** to be handed in)
- There won’t be any Bonus ☹

Supplementary Materials

- **Script made from TAs** to improve your learning experience (weekly updated on moodle)
- **Jupyter Notebooks and interactive Tools**. (We go through the setup later)
- **CS1 GPT** (also on moodle)

This is all without guarantee for correctness!
Though we try our best, and ChatGPT hopefully as well

Materials

Polybox

PW: jschul

Website

https://n.ethz.ch/~jschul

Exam Info

- **150 min**
- **MC** and some **open questions.** However you never receive partial points.
- Written on **Paper**
- **No calculators allowed**
- **40 Pages** of hand written notes allowed (wth!?)
- **2 Page summary will be provided** (updated during semester)

Personal Tips for Control Systems

- **This course may seem very abstract in the beginning** (it is kind of)
- **Early incorporation of different subjects**:
  - Linear Algebra II → Systems of ODEs
  - Mechanics III and Thermodynamics → Modeling
  - Analysis III → Laplace Transforms

Don’t let this intimidate you! It’s a lot easier than that

- If you **follow the rules** and let me help you, it will make sense in the end!

Frazzolis Mantra

What are Control Systems

Systems

- **A system is something physical:**
  - Car
  - Plane
  - Etc.

- **We want the system to do a certain thing**

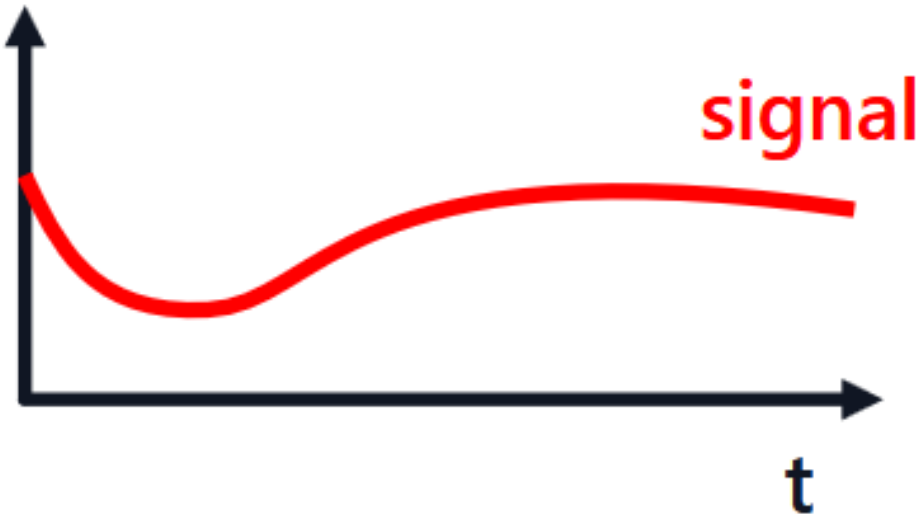
- **A system transforms a signal and maps input to an output**

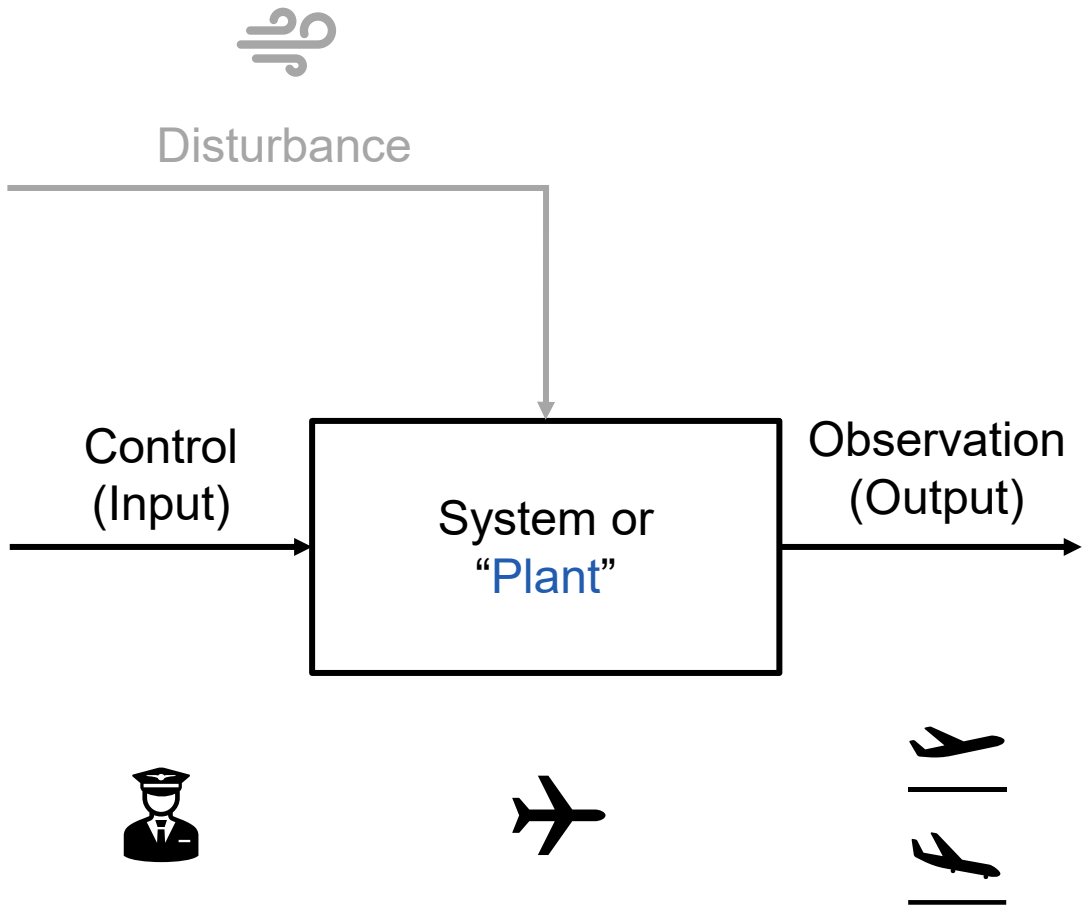
- We will only look at **Single Input - Single Output systems** (**SISO**)
  But there exist more! (MIMO: Multiple Input – Multiple Output)

- We also will mainly look at **linear systems**

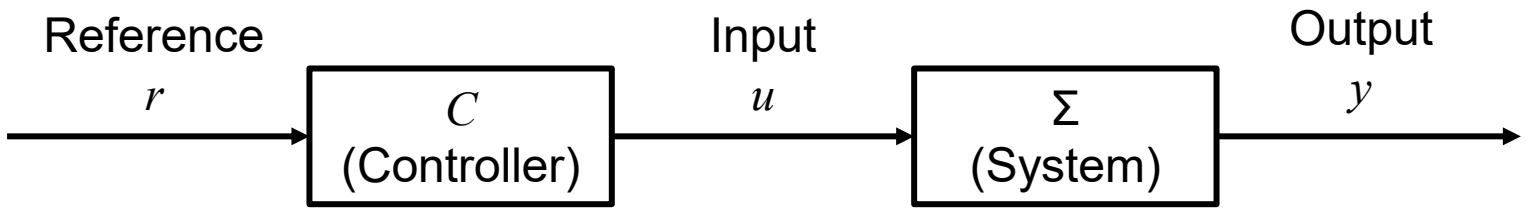
Signals

- **Both the input and the output of the system are signals**
- **Signals:**
  - a function of time
  - can be any physical observable

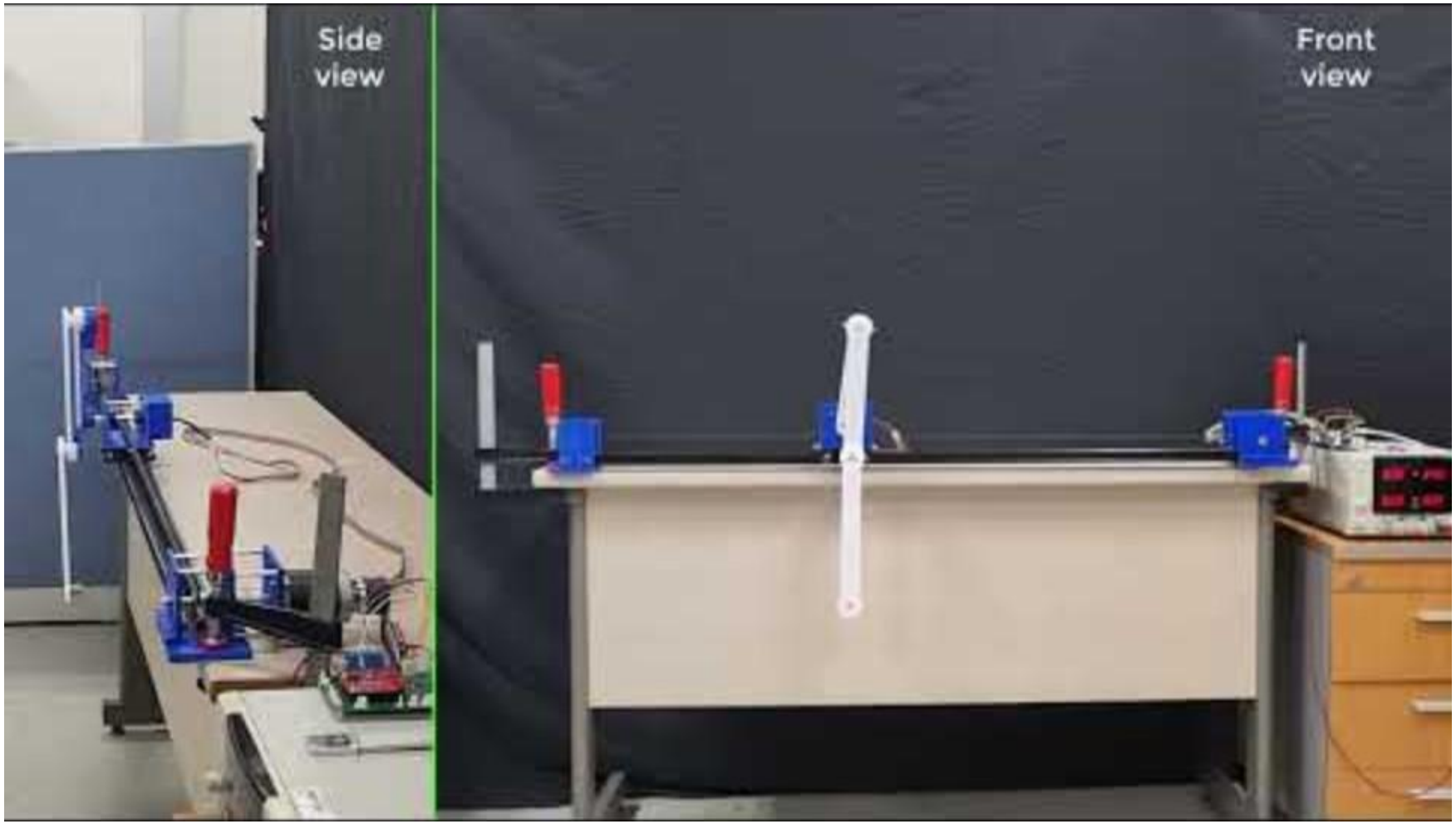



Disturbance
Control
(Input)
System or
“Plant”
Observation
(Output)

- The objective is to make the System behave in some desired way, given by a reference
- Controller transforms the reference to an input signal



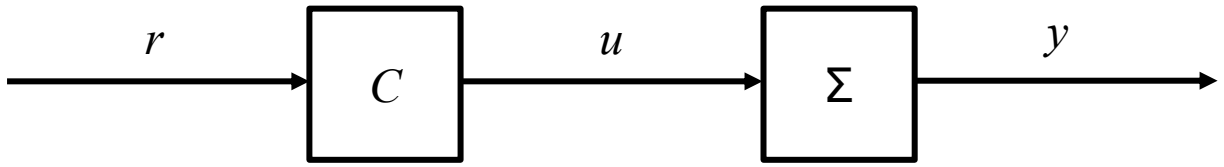
Inverted Pendulum



https://www.youtube.com/watch?v=Rh7JuL3PRSY

Inverted pendulum

Open-loop system



Reference r :

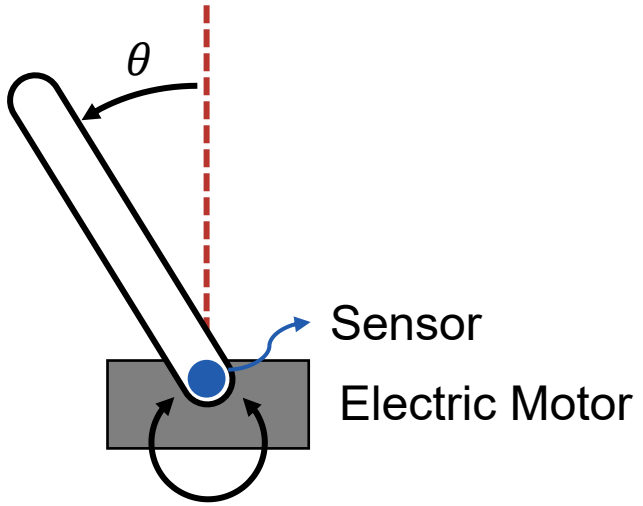
- Some desired angle θ

Input u :

- Electrical signal to motor

Output y :

- Current angle θ of pendulum



Inverted pendulum

Reference r :

- Some desired angle θ

Input u :

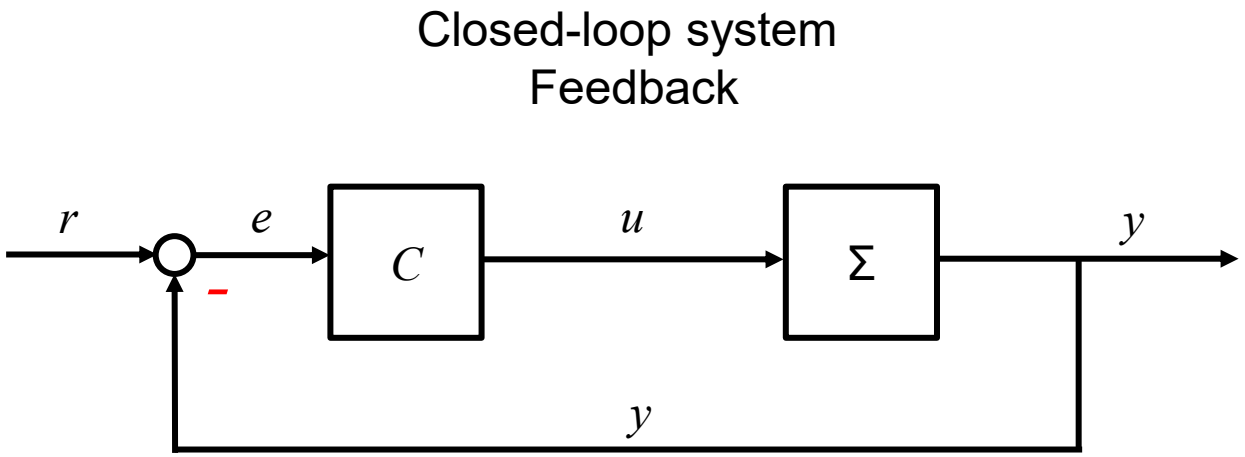
- Electrical signal to motor

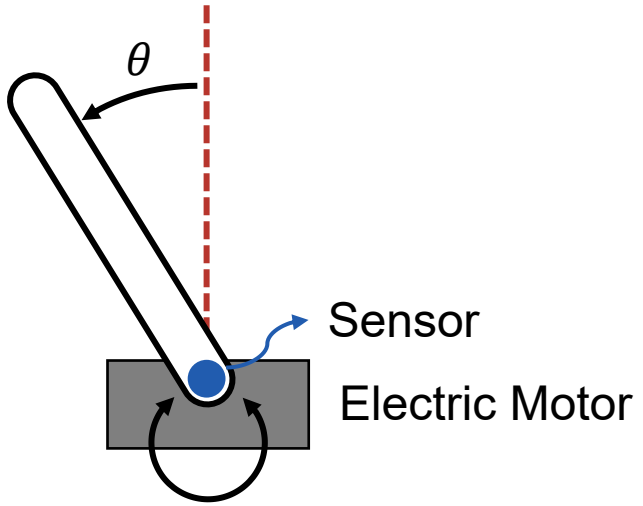
Output y :

- Current angle θ of pendulum

Error e:

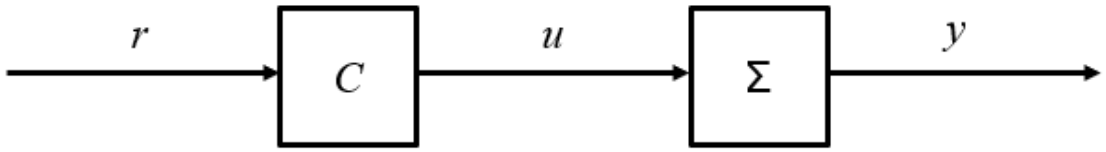
- Difference between reference and current angle $e = r - y$





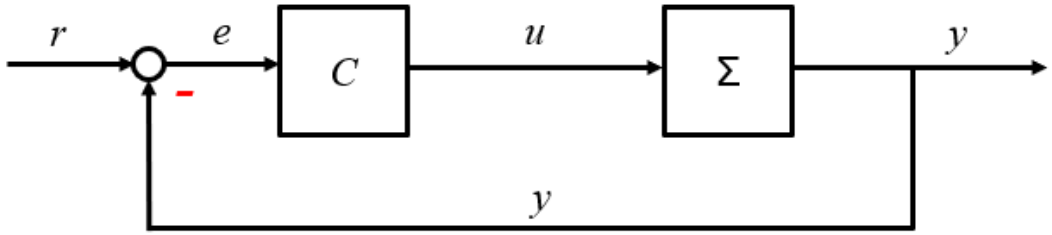
System Comparison

Open-loop system



- No feedback ➞ Input doesn't depend on output
- Simple but unprecise

Closed-loop system
Feedback



- Feedback! ➞ Input depends on output
- More complex
- Can become unstable (we will later look at what that means)

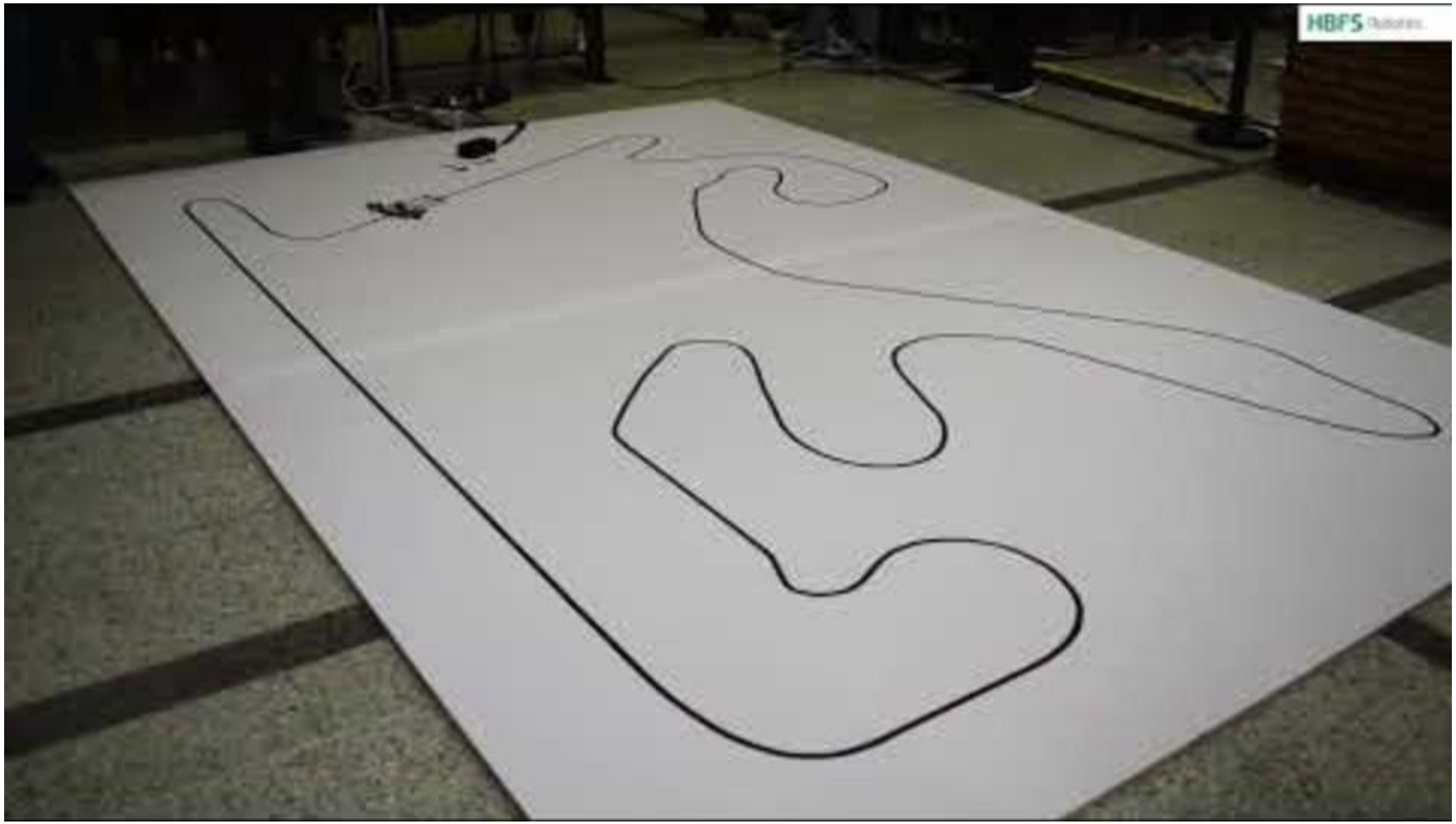
Our Objects as a Control Engineer

1. **Performance:**
   - Execute the desired task as accurately as possible.

2. **Robustness:**
   - Perform well in the presence of external disturbances, measurement noise, etc.

3. **Stability:**
   - System doesn’t blow up, outputs stay under control

Line Follower



https://www.youtube.com/watch?v=oT3jdxmgo8M

Quadrcopter Juggle

https://www.youtube.com/watch?v=3CR5y8qZf0Y

Cubli

https://www.youtube.com/watch?v=n_6p-1J551Y

Our Objectives in the Course

1. **Modeling:**
   - Learn how to represent a dynamic system in such a way that it can be treated effectively using mathematical tools.

2. **Analysis:**
   - Understand the basic characteristics of a system (e.g., stability), and how the input affects the output.

3. **Synthesis:**
   - Figure out how to change a system, typically by feedback, in such a way that it behaves in a desirable way.

Thanks

- Thank you to **Nicholas Bartzsch** for providing his presentation!

- Thank you to **all of you** for being here and the attention!

Feedback

https://n.ethz.ch/~jschul/Feedback