Hands-on Project

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Human-centered Assistive Robotics

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Hands-on Project

Arrange groups of three students (S1, S2, S3)

Task for each group:

- Implement 3 models (S1+S2+S3)
- Implement a model-based RL approach (S1)
- Implement a model-free approach (S2)
- Implement an approach based on optimal control OR on deep RL (S3)
- Each student is allowed to propose a creative solution
- Compare the performance of the approaches (S1+S2+S3)

Report

Structure:

- Sec. 1: Introduction (Max 5 sentences) (S1 + S2 +S3)
- Sec. 2: Model-based RL (S1)
  - 2.1 Algorithm
  - 2.2 Results
- Sec. 3: Model-free RL (S2)
  - 3.1 Algorithm
  - 3.2 Results
- Sec. 4: Optimal Control / Deep RL (S3)
  - …
- Sec. 5: Comparison and Discussion (S1 + S2 + S3)
- Sec. 6: Conclusion (Max 5 sentences) (S1+S2+S3)
- Max 4 pages – ICRA template

Hands-on Project

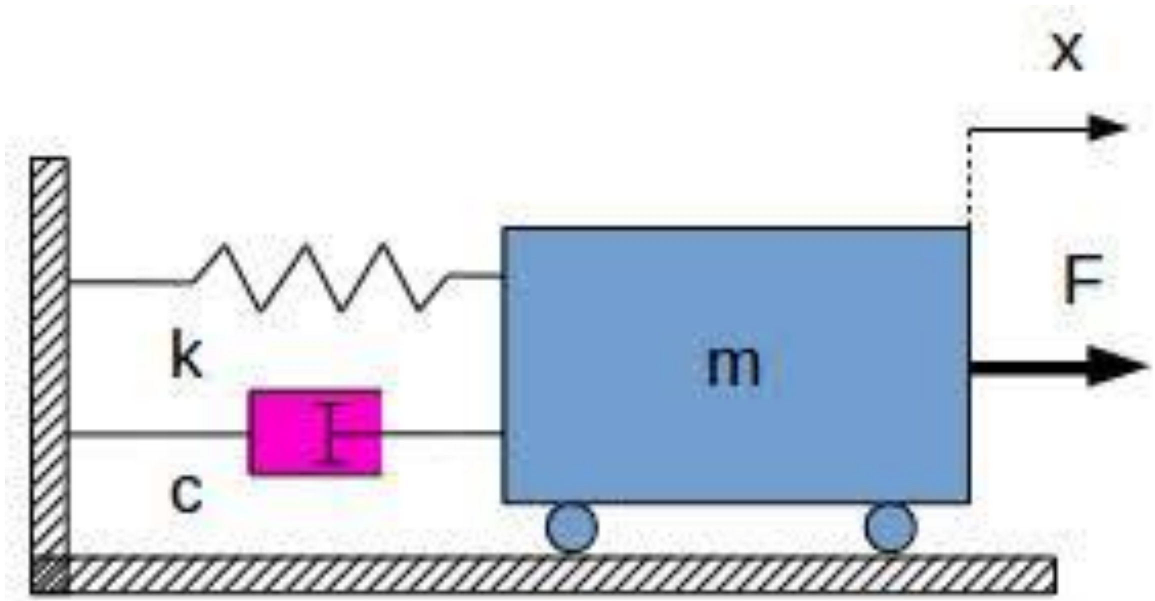
- Three different systems and learning problems

- For each system, apply three approaches and compare the results

- Besides this, you are free to propose creative solutions with more complex problems

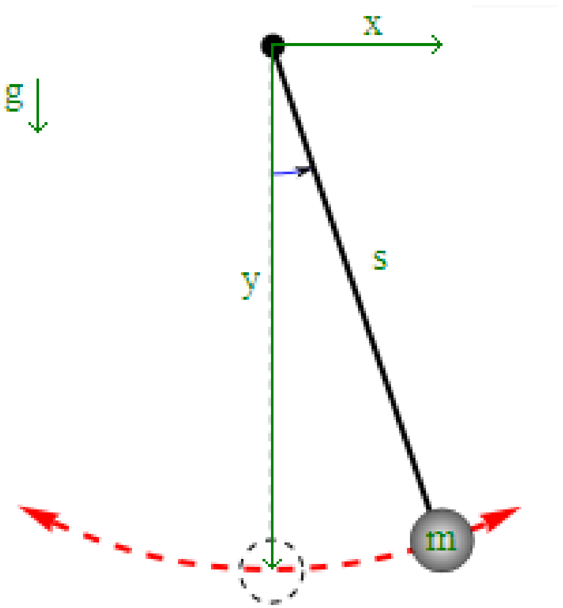
Mass-Spring-Damper

- System data: m= 1kg, k=1N/m, c=0Ns/m
- Bring the system to 1.5m
- Compare different approaches



Inverted pendulum

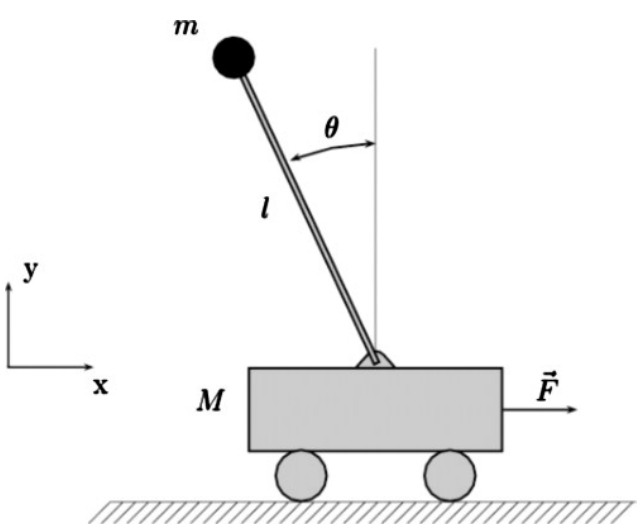
- Balance the pendulum in the upper vertical position $\theta(t_f) = \pi$, with $\theta(0) = 0, \dot{\theta}(0) = 0$
- A motor provides the torque $\mathcal{T}$
- $m = 1Kg, s = 1m, c = 0.2Ns/m$



Cartpole

- Parameter of the system m=0.2 kg, M=1kg, l=0.5m, c=0.2Ns/m
- Balance the pendulum on the vertical position
- Try different initial angles

$$\theta_0 = 10\,\mathrm{deg},\ \theta_0 = 180\,\mathrm{deg},\ \theta_0 = 90\,\mathrm{deg}$$



If you want to do more

- MuJoCo Engine – free for educational projects: https://www.roboti.us/index.html

- Tensor Flow, tool for deep networks: https://www.tensorflow.org/tutorials/

- OpenAI Gym

https://arxiv.org/abs/1606.01540

Why you are asked to model systems

- Modeling and simulating the systems is part of the project
- In general, it is fine to use tools to model complex systems
- It is important to know how to model (simple) systems
- Without modeling skills, intuition about the physics does not usually develop

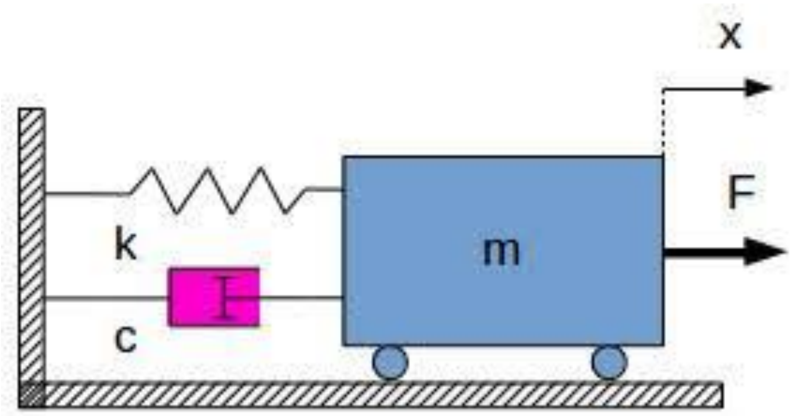
Evaluation of Learning Algorithms

- Discuss in the report the comparative performance of the different algorithms

- Some criteria commonly used…
  - Accuracy
  - Number of Interactions with external world
  - Data Required for learning
  - Learning time
  - Prior knowledge required
  - Control Energy

Exercise 1

- Use the PILCO algorithm to find a controller that brings the state of the system used in the last lesson at x=0.6m
- Design a suitable Reward Function
- Choose a suitable policy representation
- Assess the performance in terms of number of rollouts, control energy, and accuracy



Exercise 2 (optional)

- Use PILCO to find a policy that brings the mass in the unstable equilibrium state
- The system start from the stable equilibrium state
- Define a reward function and select a policy representation