Advanced robot control in MuJoCo

ETF Robotics Lab — project brief (one-pager)

Level: Bachelor/Diploma/Master (1-3 students possible)
Duration (per student): 105 hours. Comprises: *~20 hours self-guided learning, ~15 hours guided learning, ~20 hours self-guided exploration, ~10 hours progress reporting, ~30 hours project realization, ~10 hours final project reporting*
Expected timeline and work: 3 months (35 hrs/month, i.e., 8 hrs/week)
Start: By agreement
Mentors: Filip Bečanović

Overview and Technology: Make robot manipulators fetch objects while avoiding collisions, make quadrupeds walk or jump, make bipeds walk or stand up. Used technologies (software only):

- Bash command line
- Git+GitHub
- Python3
    - Versioning (conda/pip)
    - Virtual environments (venv, virtualenv)
    - Package distribution (pip)
    - Numerical computation packages (PyTorch, Jax, NumPy, CasADi, gymnasium ...)
- MuJoCo
    - Modeling (MJCF)
    - Simulation (mujocopy)
    - Control (gymnasium or mjx or CasADi)

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Platforms / hardware	**Software & tools**
• Your PC • Lab PC with NVidia GPU	• Git + GitHub • MuJoCo (MJCF, mujocopy, mjx, gymnasium) • Python 3 (conda/pip, venv/virtualenv) • Pytorch, Jax, NumPy, CasADi, ...

Project options (projects can be modified based on student interests**)**

- Manipulator robot pick-and-place with collision avoidance
- Quadruped robot gait or jump
- Biped robot gait or stand-up

Expected outcomes	**Recommended background**
• Clean, well-ordered public GitHub repository • Re-usable and clean software API • Multiple video demonstration to be showcased on the lab's website	• Introductory knowledge of robot kinematics, dynamics, and motion planning • Above introductory experience with Python 3 • Object-oriented

Literature

- Mostly hands-on tutorials
- Software documentation
- Introductory books on Robotics, Numerical Optimization, Reinforcement Learning.
- Lynch, K. M., & Park, F. C. (2017). *Modern robotics*. Cambridge University Press.
- Nocedal, J., & Wright, S. J. (2006). *Numerical optimization*. New York, NY: Springer New York.
- Sutton, R. S., & Barto, A. G. (2018). Reinforcement Learning: An Introduction, MIT Press, Cambridge, MA.