Worksheet 1

Issued: Fri 14. 11. 25
Due: Thu 20. 11. 25

E 1.1 · *Setting Up Python Virtual Environment*

Working with packages outside your default installation may require a *virtual environment*:

(a) Create it with `python -m venv <dir>` and activate it via `source <dir>/bin/activate`.

(b) Run `pip install <package>` to install <*package*>, or follow the package instructions.

[**Note:** Under Emacs, `pyvenv` provides a virtual environment with `M-x pyvenv-activate RET <dir>`. Finally, you can deactivate the virtual environment with `deactivate`.]

E 1.2 · *Setting Up Python, Jupyter, & Control*

We will use NumPy (for control and simulation),[1] SciPy (for scientific computing),[2] SymPy (for symbolic computation),[3] Matplotlib (for visualisation),[4] and Control (for control engineering).[5] JupyterLab (or its predecessor Jupyter Notebook) offers a convenient read-eval-print loop (REPL) for Python.

(a) Please, install Jupyter locally[6] or use an online hosted service, such as Google Colab.[7] On Linux, local installation should include the above packages by default.

(b) Next, install Python Control via `pip install control`. You might need a virtual environment for this. After a successful setup, use `import control as ct`.

(c) Finally, you can start the JupyterLab or Jupyter Notebook web-interface from your console with `jupyter [lab|notebook]` or by opening an `.ipynb` file in your file manager.

In-Class Exercises

E 1.3 · *A Simple Room Heating*

(a) Identify the parameters and dynamics for a radiator-heated room. Assume that the room can be approximated by a PT_1-element. Choose the parameter values freely from $[-5, 5]$.

(b) Derive the state-space model for the dynamics and the system response (output equation) according to your results for (a).

(c) Visualise the characteristics (step and impulse responses, etc.) of the room.

(d) Develop a P-controller adjusting a heating element to control the room temperature to reach a particular set-point temperature.

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[1] https://numpy.org
[2] https://docs.scipy.org
[3] https://docs.sympy.org
[4] https://matplotlib.org
[5] https://python-control.org
[6] https://jupyter.org/install
[7] https://colab.google

(e) Visualise the characteristics (step response, etc.) of the closed-loop system.

(f) Simulate the response for a step stimulus with a set-point of 25 ℃ in a room with 15 ℃. Adjust the proportional factor k_s of the controller, if necessary.

E 1.4 · *Simulating a Mode of a Hybrid Automaton*

Model the mode $\mathbf{l}_1$ of the hybrid automaton (HA) for the *heated tank* example ('Modelling Hybrid Automata' slide 12) using the solution method for Exercise 1.3.

(a) Derive the state-space model. Here, you can ignore the invariant.

(b) Encode the closed-loop model using the Python (GNU/Octave or MATLAB) `control` framework.

(c) Investigate the step response. Use the following parameter values: $h_1 = h_2 = 2$, $a_1 = a_2 = 0.01$, and $b_1 = b_2 = 0.005$.

(d) Simulate your model from the state $\mathbf{x}_0 = (0, 50)^\intercal$ for a duration of 100 time units.