Reachability Analysis of a General Class of Neural Ordinary Differential Equations

Instructions to reproduce the results in the paper “Reachability Analysis of a General Class of Neural Ordinary Differential Equations”.

The code for the paper can be found in: https://github.com/verivital/nnv/tree/master/code/nnv/examples/Submission/FORMATS2022 , although we prepared a docker image to reproduce the different artifacts within this work, and all the code required is in the zipped folder provided to reproduce the results.

Follow the next steps:

1) Go to directory where zip file has been downloaded and extract the files

```
cd your_folder
unzip formatsAE_neuralode.zip
```

2) Set MAC-address and MATLAB R2021b License
    a. MAC-Address: Substitute the MAC address (now set to 00:00:00:00:00:00) in the file "run_subset" with the MAC address of your local machine.
    b. MATLAB License: For the docker container to run MATLAB, one has to create a new license file for the container. Log in with your MATLAB account at https://www.mathworks.com/licensecenter/licenses/ . Click on your license, and then navigate to
        i. > "Install and Activate" > "Activate to Retrieve License File" (...may differ depending on how your licensing is set up).
        ii. Create a new license file with the following data:
            1. - MATLAB version: 2021b,
            2. - MAC address: MAC address of your local machine
            3. - User: root
        iii. Finally, download the generated file "licence.lic" and put it into the current directory "your_folder/license/"
3) Run the code (from your_folder, where the files were extracted):

```
chmod +x run_subset # make script executable
./run_subset        # build docker image and run subset results
```

4) The results will be generated in subdirectory “results” (your_folder/results)
5) **Results**

    Go to subdirectory “logs”, where a set of pictures (*.png) and tables (*.tex) are generated (Ignore the other subdirectories).

    - Table3.tex

    - Corresponds to table 3 of the manuscript (partially).
    - The columns are in the same order as the paper (Flow*, GoTube, JuliaReach, NNVODE (ours))
    - The rows reproduced in the table are the following
        - Row 1 in table3.tex -> SpiralL1
        - Row 2 in table3.tex -> SpiralL2
        - Row 3 in table3.tex -> SpiralL3
        - Row 4 in table3.tex -> FPA1
        - Row 5 in table3.tex -> FPA2
        - Row 6 in table3.tex -> FPA3
- Table4.tex
    - Corresponds to table 4 of the manuscript (partially)
    - We only reproduce the results of the first 3 rows corresponding to the FNODE models
- Table5.tex
    - Corresponds to table 5 of the manuscript.
    - We only reproduce the reachability of the first 3 models (XS, S, M)
- acc_linear.pdf
    - Corresponds to Figure 5b
- acc_orig.pdf
    - Corresponds to Figure 5a
- fpa_compare.pdf
    - Corresponds to Figure 4c
- fpa_compare_zoom.pdf
    - Corresponds to Figure 4g
- spiralL_compare_0.1.pdf
    - Corresponds to Figure 4a
- spiralL_compare_0.1_zoom.pdf
    - Corresponds to Figure 4e

The instructions above correspond to reproducing a subset of the results, which can be computed within 2-3 hours.

If we want to reproduce all the artifacts in the paper (>3 days of computation), we need to follow the same steps from above, with a few modifications:

1) On step 2a), modify the MAC-ADDRESS in the “run_all” file.
2) On step 3) substitute those commands for:

```
chmod +x run_all # make script executable
./run_all        # build docker image and run all results
```

3) **Results**

The tables generated (table3.tex, table4.tex, table5.tex) are fully reproduced, and all rows and columns correspond to those from the paper.

In addition to the previous figures, the following will also be generated:

- spiral_compare_0.1_nl.pdf
  - Corresponds to Figure 4b
- spiral_compare_0.1_nl_last.pdf
  - Corresponds to Figure 4f
- cartpole_compare.pdf
  - Corresponds to Figure 4d
- cartpole_compare_zoom.pdf
  - Corresponds to Figure 4h
- dampedOsc_compare0.pdf
  - Corresponds to Figure 3a
- dampedOsc_compare0_zoomed.pdf
  - Corresponds to Figure 3b
- dampedOsc_compare1.pdf
  - Corresponds to Figure 3c
- dampedOsc_compare1_zoomed.pdf
  - Corresponds to Figure 3d