

# Overview

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This is the repeatability evaluation package for the tool paper entitled "Verse: A Python library for reasoning about multi-agent hybrid system scenarios", by Yangge Li, Haoqing Zhu, Katherine Braught, Keyi Shen, Sayan Mitra, which is going to appear in the proceedings of the 35th International Conference on Computer Aided Verification, 2023.

The artifact is a virtual machine that contains instruction and software to reproduce all experiment results in the paper.

Password for artifact VM:[cav2023-re](#) DOI: 10.6084/m9.figshare.22679485

Instructions for reproducing experiments in the paper: [artifact\\_evaluation.txt](#)  
[artifact\\_evaluation.md](#) [artifact\\_evaluation.pdf](#)

Alternative urls for download:

[https://figshare.com/articles/software/Verse\\_A\\_Python\\_library\\_for\\_reasoning\\_about\\_multi-agent\\_hybrid\\_system\\_scenarios/22679485](https://figshare.com/articles/software/Verse_A_Python_library_for_reasoning_about_multi-agent_hybrid_system_scenarios/22679485)

<https://drive.google.com/file/d/1SFABQ1bkFXijCpANFODQAMdvFnBXpw0a/view?usp=sharing>

Interactive tutorial (Jupyter notebook): <https://github.com/AutoVerse-ai/Verse-library/blob/main/tutorial/tutorial.ipynb>

Tutorial (pdf):<https://github.com/AutoVerse-ai/Verse-library/blob/main/tutorial/tutorial.pdf>

Public url:<https://github.com/AutoVerse-ai/Verse-library>

## Approximate Running Time for Experiments

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The running time for the experiments may differ based on the configuration state of the host machine. In our experiments, the time required to generate Table 1, Table 2 (Simulations) and Table 2 (Verification) were approximately 20 mins, 3 mins, and 26 mins.

## Instructions for Replication Test

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0. Move to the root directory of the tool:

```
cd /home/cav23/Desktop/Verse-library
```

1. For results in Table 1 run

```
python3 artifact_evaluation/exprs.py
```

The script generates the raw data from all the experiments about running time, memory usage, cache hits, etc., and then produces the output LaTeX table code for Table 1, as below:

```
2 & Q & M6 & DryVR & No & 8 & 34.54\\
2 & Q & M5 & DryVR & No & 5 & 31.67\\
2 & Q & M5 & NeuReach & No & 4 & 261.41\\
3 & Q & M5 & DryVR & No & 7 & 42.67\\
7 & C & M2 & DryVR & No & 37 & 59.95\\
3 & C & M1 & DryVR & No & 5 & 26.36\\
3 & C & M3 & DryVR & No & 4 & 34.23\\
3 & C & M4 & DryVR & No & 7 & 74.02\\
3 & C & M1 & DryVR & Yes & 5 & 26.85\\
2 & C & M1 & DryVR & No & 5 & 23.0\\
2 & C & M1 & NeuReach & No & 5 & 319.34\\
1 & V & N/A & DryVR & N/A & 1 & 13.85\\
1 & S & N/A & DryVR & N/A & 3 & 14.7\\
1 & G & N/A & DryVR & N/A & 3 & 22.99\\
```

Each row corresponds to one entry in the table from left to right, top to bottom.

## 2. For Simulation results in Table 2 run:

```
python3 artifact_evaluation/inc-expr.py s
```

The results for the experiments in Table 2 (Simulation section) should be generated as below:

```
& repeat & 45 & 16.92 & 430 & 1.05 & 438 & 3.83 & 83.33 \\
& change init & 24 & 14.93 & 431 & 12.98 & 436 & 4.07 & 75.91 \\
& change ctr & 45 & 16.1 & 431 & 8.49 & 438 & 4.38 & 78.19 \\
```

## 2b. For Reachability results in Table 2 run:

```
...
python3 artifact_evaluation/inc-expr.py v
...
```

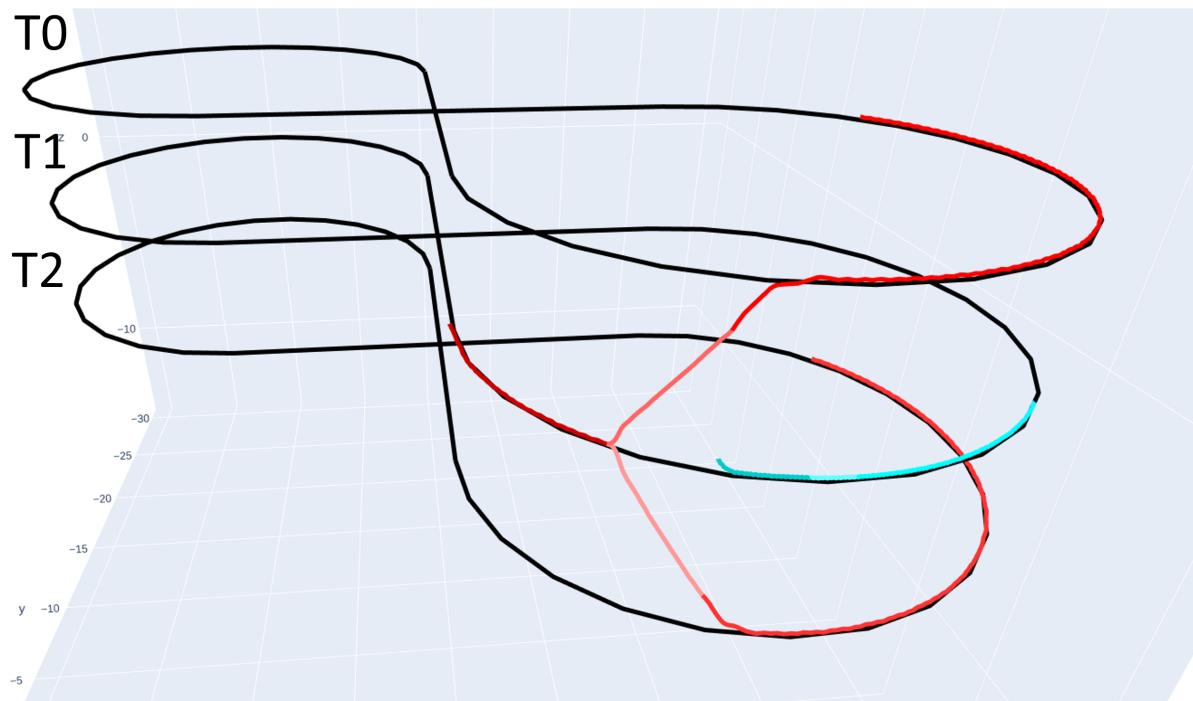
The results for the experiments in Table 2 (Verification section) should be generated as below:

```
...
& repeat & 105 & 464.77 & 498 & 58.99 & 482 & 3.23 & 76.79 \\
& change init & 49 & 384.84 & 486 & 362.25 & 500 & 3.7 & 73.21 \\
& change ctr & 93 & 428.83 & 498 & 227.49 & 491 & 4.0 & 73.44 \\
...
```

3. To reproduce Fig. 1 **Center** run:

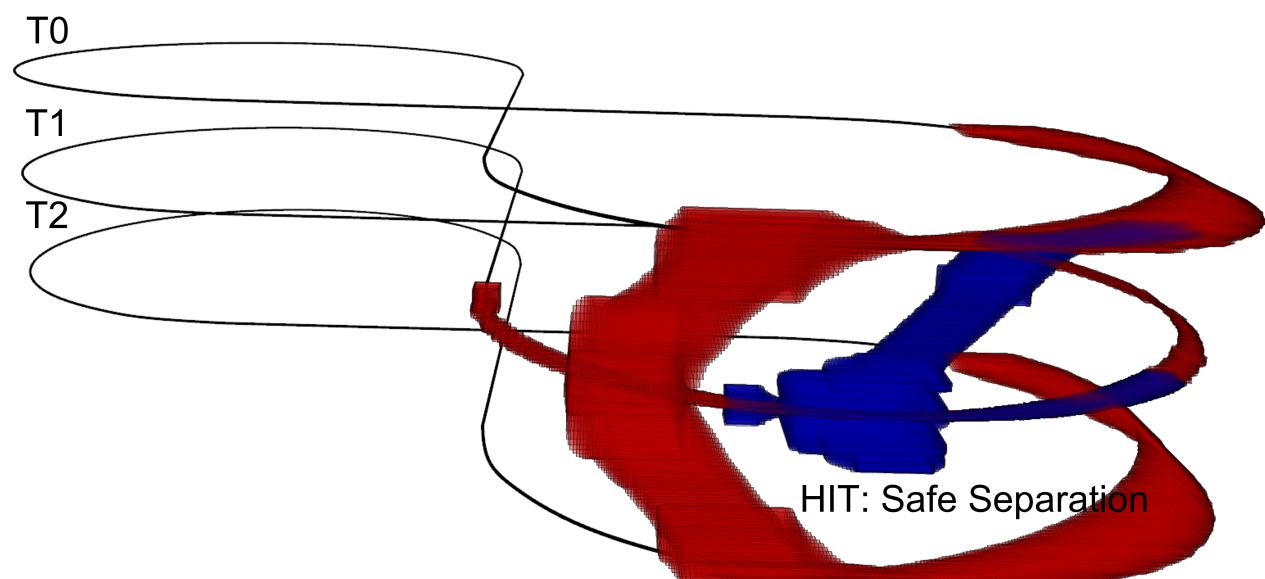
```
python3 demo/cav2023/exp1/exp1_sim.py p
```

Verse will automatically open a browser window to show the resulting plot as below.



**Right:** Run command

```
python3 demo/cav2023/exp1/exp1.py p
```

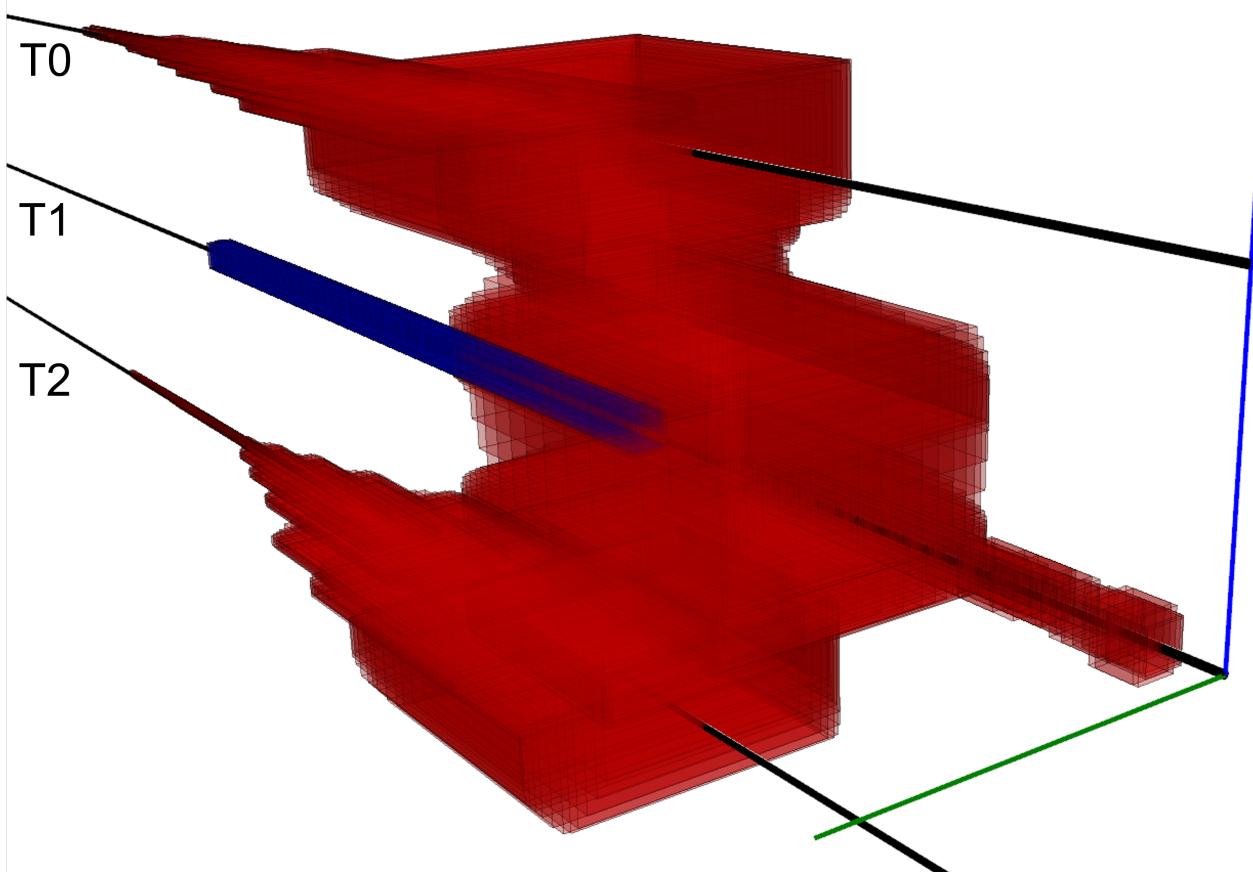


#### 4. To reproduce Fig. 4, from left to right

##### (1) Run command

```
python3 demo/cav2023/exp9/exp9_dryvr.py pl
```

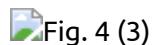
The result will look like below.



##### (2)-(3) Run command

```
python3 demo/cav2023/exp9/exp9_dryvr.py pc
```

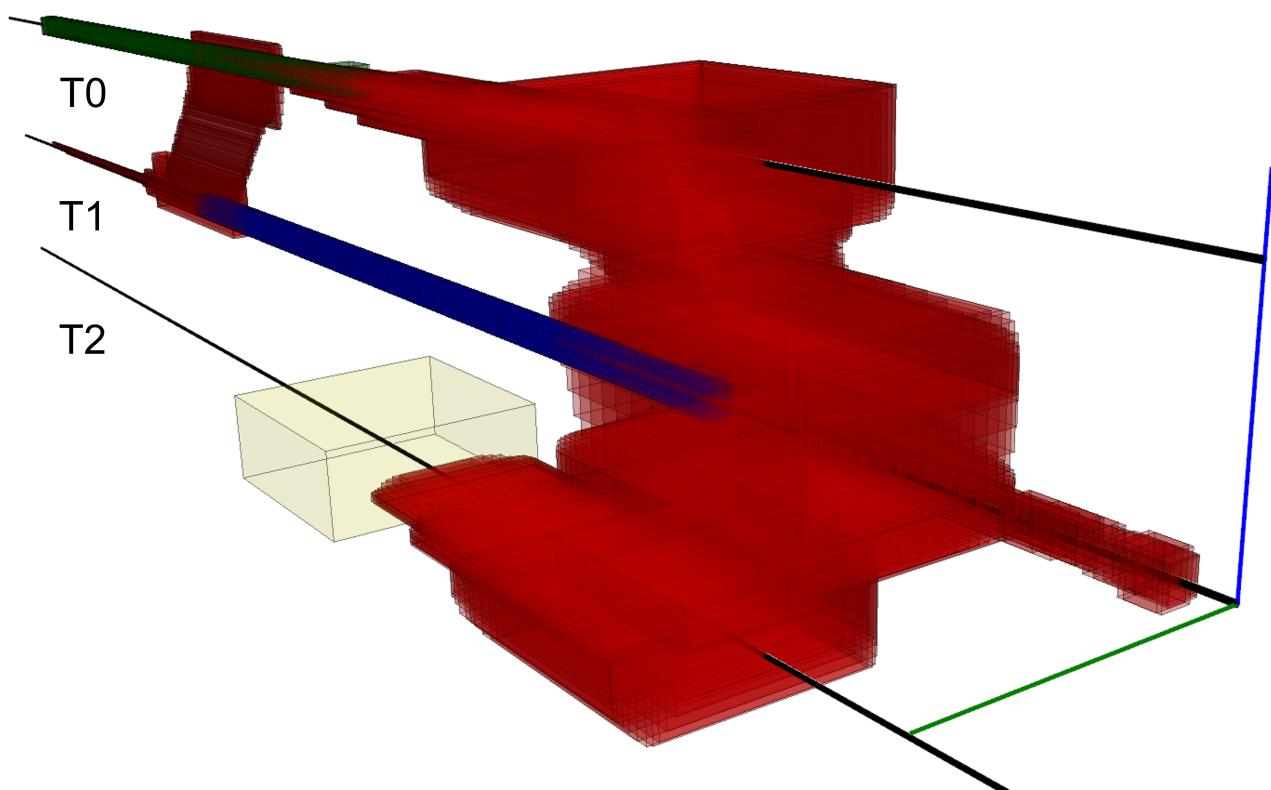
Verse will automatically open two browser windows to show the two resulting plots as below. Note that the yellow boxes in the figures are drawn separately. Fig. 4 (2)



##### (4) Run command

```
python3 demo/cav2023/exp10/exp10_dryvr.py p
```

The result will look like below.

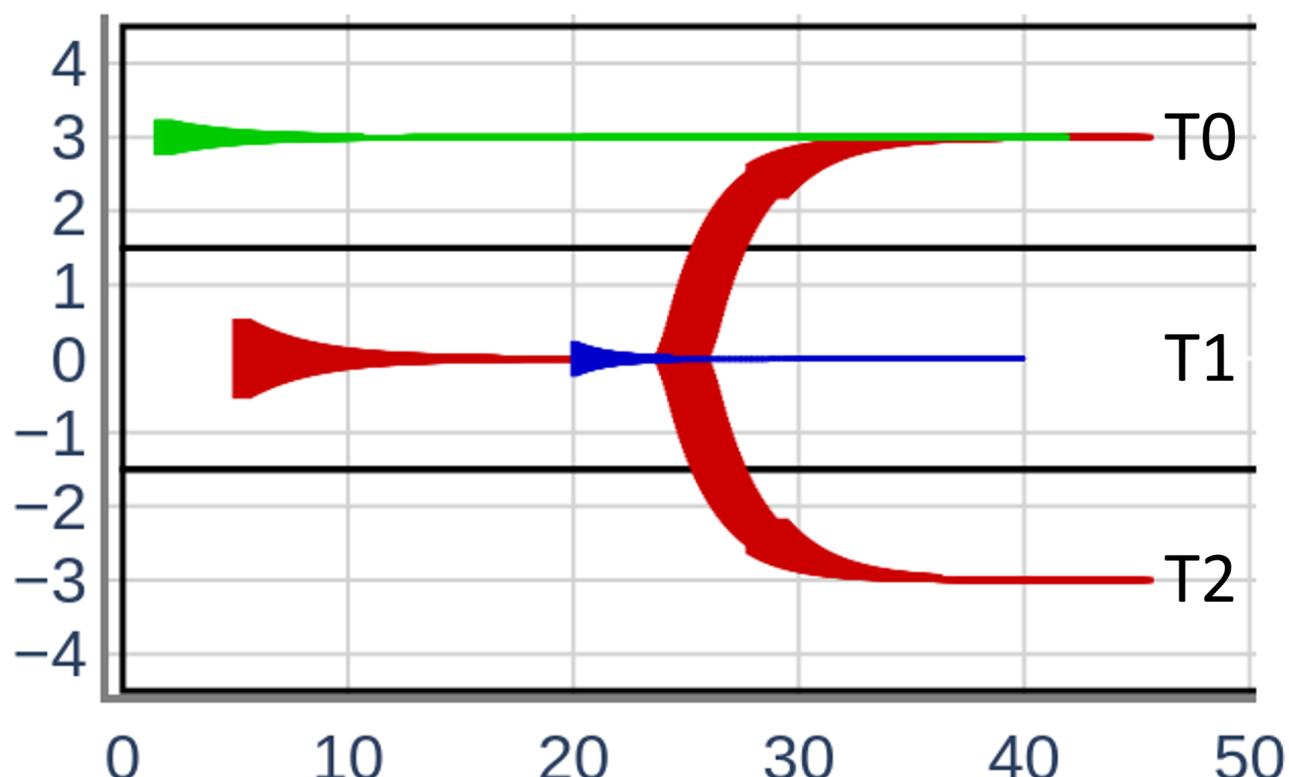


5. To reproduce Fig. 6,

**Left:** Run command

```
python3 demo/cav2023/exp2/exp2_straight.py p
```

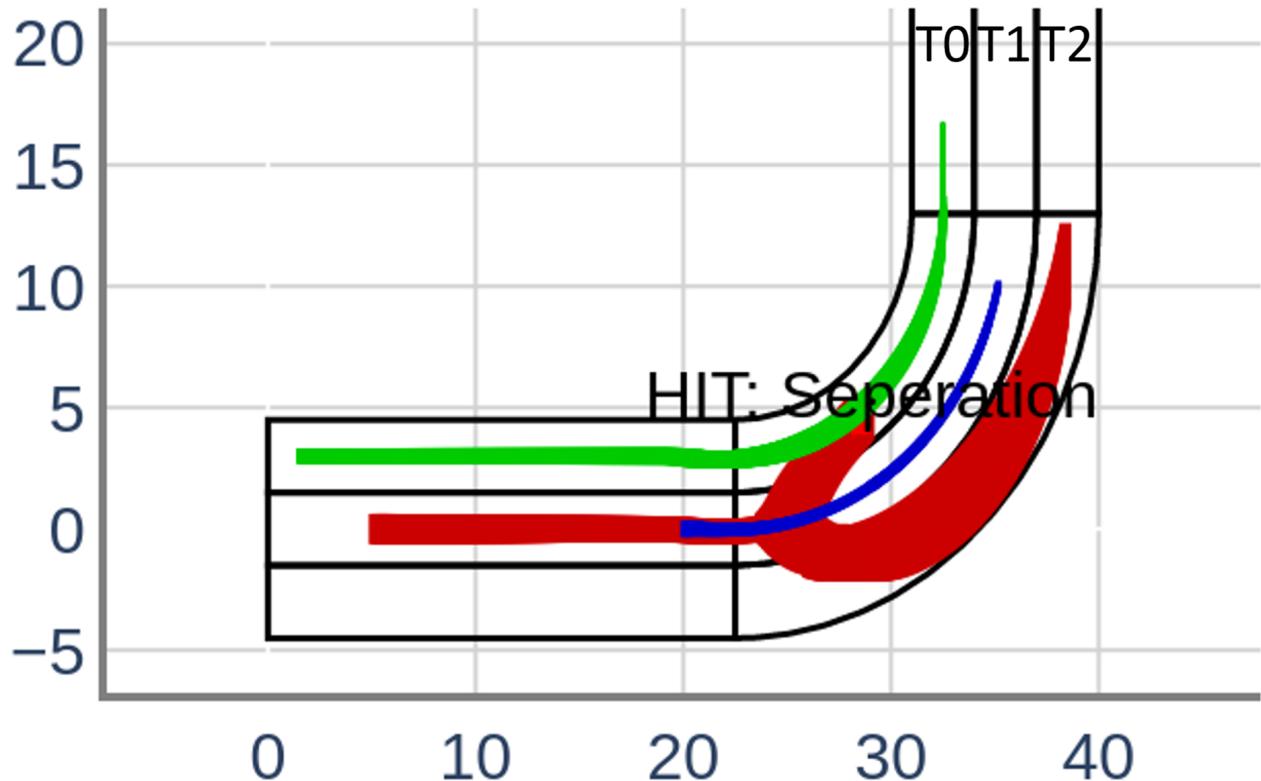
Verse will automatically open a browser window to show the resulting plot as below.



**Center:** Run command

```
python3 demo/cav2023/exp2/exp2_curve.py p
```

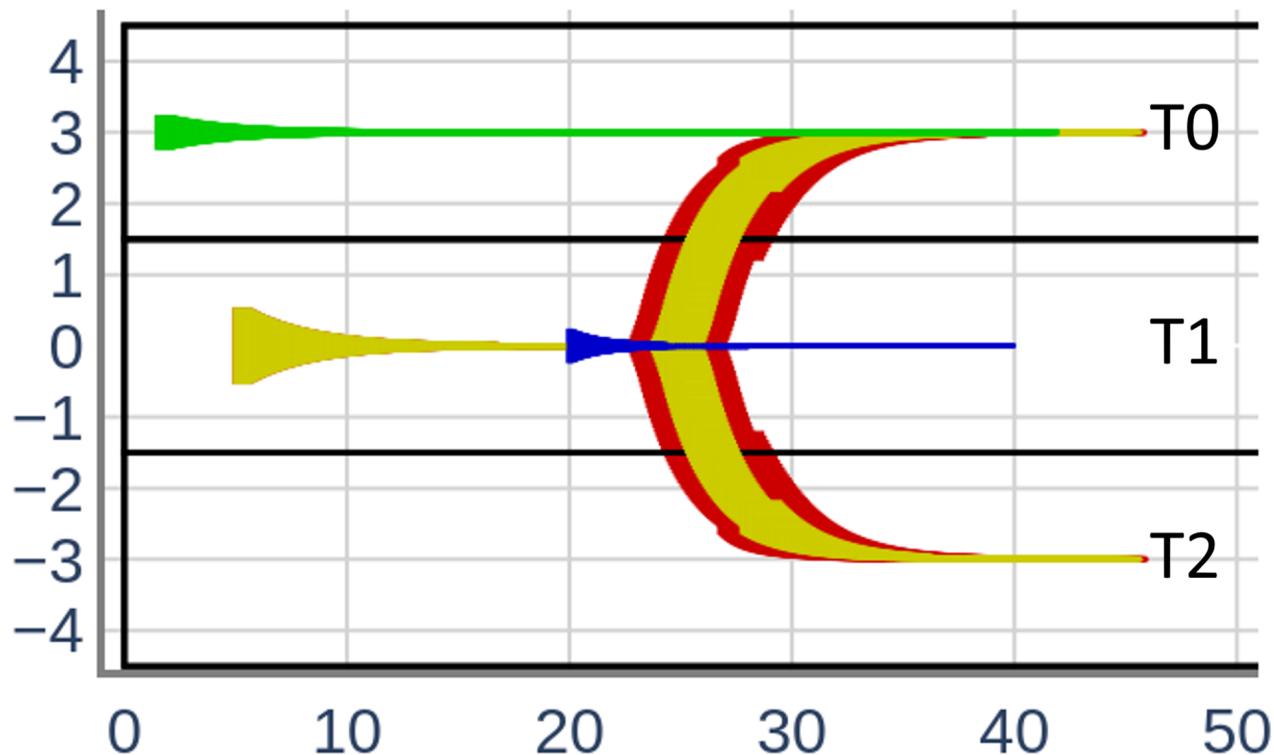
Verse will automatically open a browser window to show the resulting plot as below.



**Right:** Run command

```
python3 demo/cav2023/exp4/exp4.py p
```

Verse will automatically open a browser window to show the resulting plot as below.



6. To reproduce Fig. 8 in Appendix, run command

```
python3 demo/cav2023/exp7/exp7.py p
```

Verse will automatically open two browser windows to show the plots as shown below. Fig. 10 Left

Fig. 10 Right

7. To reproduce Fig. 7 in Appendix, run command

```
python3 demo/cav2023/exp5/exp5.py p
```

Verse will automatically open a browser window to show the resulting plot. The right figure is a zoom in of the left figure as shown below. Fig. 8

8. To reproduce Fig. 10 in Appendix,

**Left:** Run command

```
python3 demo/cav2023/exp6/exp6_neureach.py p
```

Verse will automatically open a browser window to show the resulting plot as shown below. Note that due to the randomization in NeuReach's algorithm, the generated figure can be slightly different from the one included in the paper. Fig. 9 Left

**Right:** Run command

```
python3 demo/cav2023/exp6/exp6_dryvr.py p
```

Verse will automatically open a browser window to show the resulting plot as shown below.

 Fig. 9 Right

9. To reproduce Fig. 11 in Appendix, run command

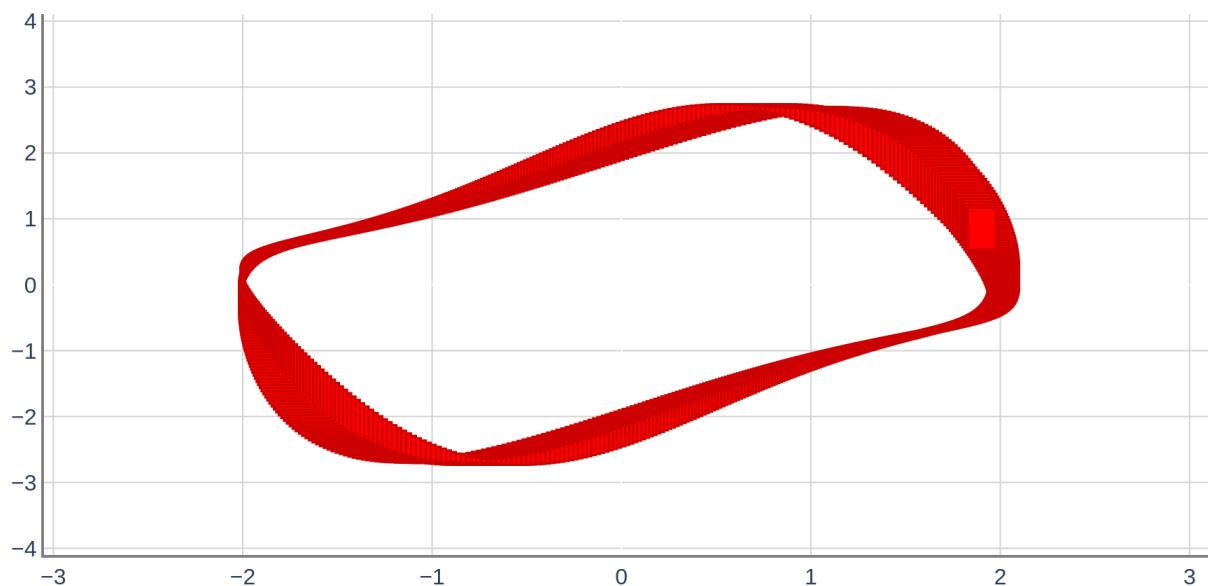
```
python3 demo/cav2023/exp3/exp3.py p
```

Verse will automatically open a browser window to show the resulting plot as shown below.  Fig. 11

10. To reproduce Fig. 12 in Appendix, run command **Left:** Run command

```
python33 demo/cav2023/exp12/vanderpol_demo2.py p
```

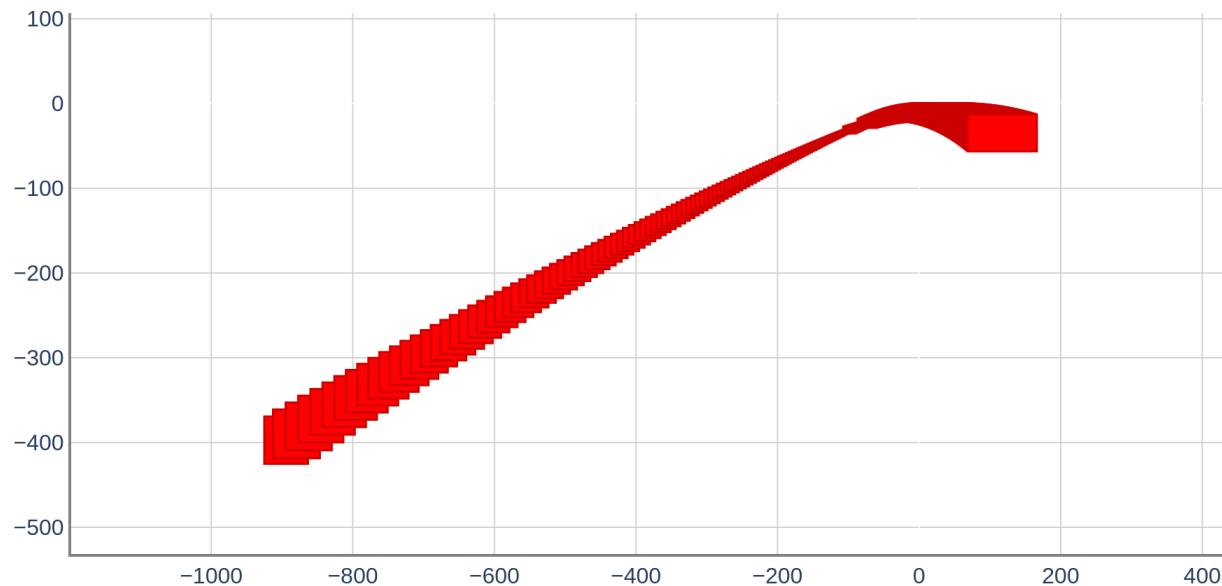
Verse will automatically open a browser window to show the resulting plot as shown below



**Center:** Run command

```
python33 demo/cav2023/exp12/vanderpol_demo2.py p
```

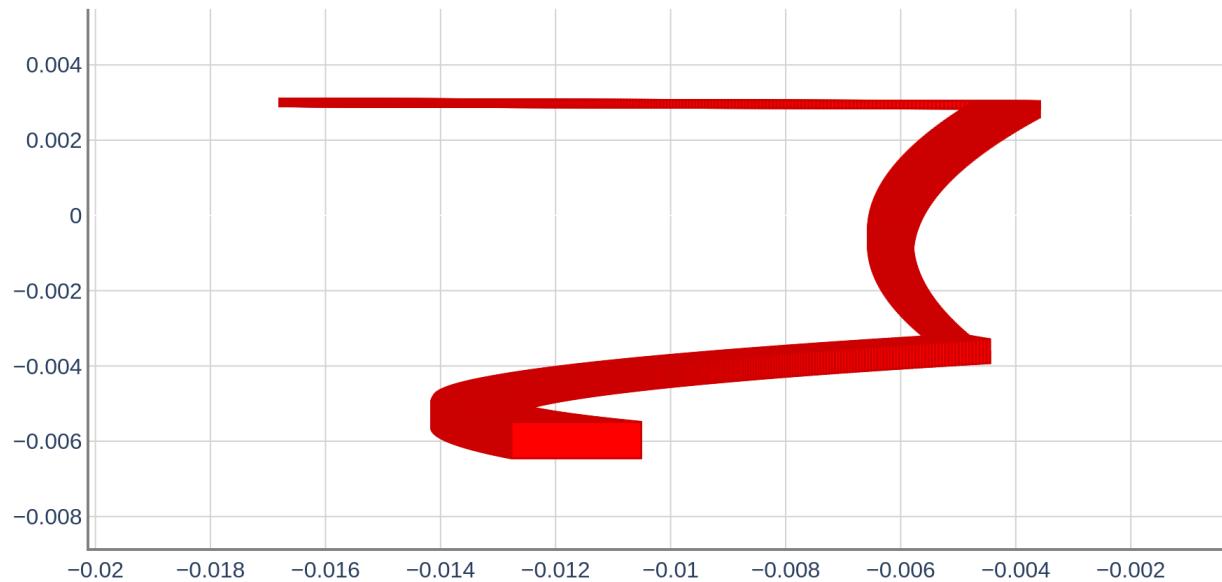
Verse will automatically open a browser window to show the resulting plot as shown below



**Right:** Run command

```
python33 demo/cav2023/exp12/vanderpol_demo2.py p
```

Verse will automatically open a browser window to show the resulting plot as shown below



11. To reproduce Fig. 13 in Appendix **Left:** Run command

```
python3 demo/cav2023/exp11/inc-expr.py sbp
```

Verse will automatically open a browser window to show the resulting plot as shown below

Fig. 12 Left

**Right:** Run command

```
python3 demo/cav2023/exp11/inc-expr.py vbp
```

Verse will automatically open a browser window to show the resulting plot as below.  Fig. 12 Right

12. To reproduce Fig. 16 in Appendix **Left:** Run command

```
python3 demo/cav2023/exp11/inc-expr.py snp
```

Verse will automatically open a browser window to show the resulting plot as below. Note that the red box in the figure is added separately.  Fig. 15 Left

**Right:** Run command

```
python3 demo/cav2023/exp11/inc-expr.py vnp
```

Verse will automatically open a browser window to show the resulting plot as below. Note that the red box in the figure is added separately.  Fig. 15 Right

13. To reproduce Fig. 17 in Appendix **Left:** Run command

```
python3 demo/cav2023/exp11/inc-expr.py s8p
```

Verse will automatically open a browser window to show the resulting plot as below. Note that the red box in the figure is added separately.  Fig. 15 Left

**Right:** Run command

```
python3 demo/cav2023/exp11/inc-expr.py v8p
```

Verse will automatically open a browser window to show the resulting plot as below. Note that the red box in the figure is added separately.  Fig. 15 Right