Construction of Homogeneity-Inspired Neural ODE

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Abstract

The goal of our research is to restructure the Neural Ordinary Differential Equation (Neural ODE) network in order to model specific continuous-time dynamic systems. Using Python Jupyter in Google Collaborate, we modified the structure of the Neural ODE from Reference 1, introduced a modified SiLU activation function, and trained and tested the network using that activation function. After finding that the original SiLU function consistently performed well, we modified it to more closely resemble the systems we were modeling. By using the modified SiLU function and the restructured Neural ODE network, we were able to closely capture the nonlinearities in the modeled systems. We found that by modifying the Neural ODE network so its structure resembled the system being modeled, we were able to reduce the total loss.

Problem Statement

The current Neural ODE network is unable to accurately model some complex nonlinear dynamic systems, so since we knew that the systems were nonlinear, we changed the structure of the Neural ODE to resemble the systems, which reduced the total loss.

Method & Results

- Changed Neural ODE network structure (figure 2) from original (figure 1)

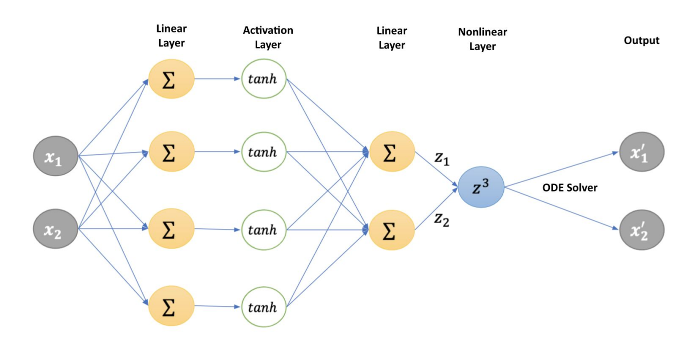


Figure 1. Original Neural ODE network

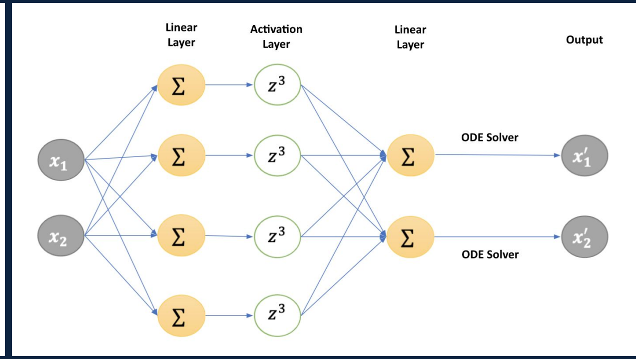
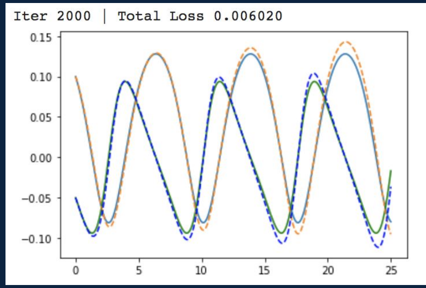
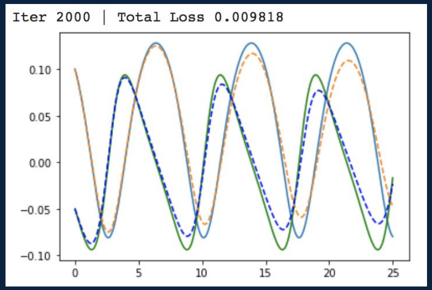


Figure 2. Restructured Neural ODE network

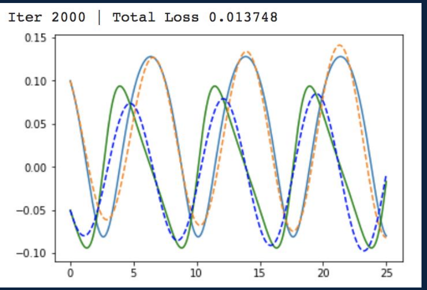
- Trained restructured Neural ODE on system 2



Modified SiLU

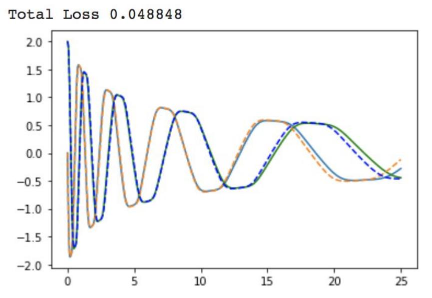


Cubed

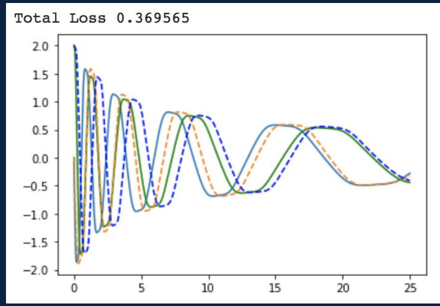


Original SiLU

- Tested restructured Neural ODE + modified SiLU and original Neural ODE + Tanh on system 1



Restructured Neural ODE, Modified SiLU



Original Neural ODE, Tanh

$$dx_1/dt = -0.1x_1^3 - 2x_2^3$$
$$dx_2/dt = 2x_1^3 - 0.1x_2^3$$

System 1

$$dx_1/dt = x_2$$
$$dx_2/dt = -6x_1^3 + 6x_1^2 - x_1$$

System 2

$$\frac{x}{1+e^{-x}}$$

Original SiLU

$$\frac{x^3}{1+e^{-x}}$$

Modified SiLU

Conclusion

Since we knew that the systems were nonlinear, we used a nonlinearity-inspired Neural ODE structure to model them, which reduced the total loss.

Acknowledgements

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References

[1] T.Q. Chen, Y. Rubanova, J. Bettencourt, D.K. Duvenaud, “Neural ordinary differential equations.” Advances in neural information processing systems, 2018.