# End-to-End Optimization of mcTangent using JAX-FLUIDS

Wesley Lao

January 2023

## 1 Introduction

## 2 End-to-End Optimization

[1]

## 3 Training mcTangent

### 3.1 Densely-Connected Architecture

Following work done in [4], a densely-connected network with a single hidden layer was chosen as the baseline architecture. The performance of all following architectures will be compared to the dense network. It has been shown that single-layer networks with rectified polynomial units of any order are universal approximators [2]. In [3] single layer architectures, and the more general parallel unit architectures, can be regularized so as to guarantee global optimality.

However, it will soon become clear that densely-connected networks are not well-suited to training within a finite-volume solver. The discontinuities at cell faces are not as easily learned as piecewise-continuous functions. For the initial training of dense networks. The input state is taken to be the cell centers, so that a scheme similar to

## 4 References

## References

[1] Deniz A. Bezgin, Aaron B. Buhendwa, and Nikolaus A. Adams. "JAX-FLUIDS: A fully-differentiable high-order computational fluid dynamics solver for compressible two-phase flows". In: *Computer Physics Communications* 282 (Jan. 2023). arXiv:2203.13760 [physics], p. 108527. ISSN: 00104655. DOI: 10.1016/j.cpc.2022.108527. URL: http://arxiv.org/abs/2203.13760 (visited on 12/02/2022).

[2] Tan Bui-Thanh. *A Unified and Constructive Framework for the Universality of Neural Networks*. arXiv:2112.14877 [cs, math, stat]. Jan. 2022. DOI: 10.48550/arXiv.2112.14877. URL: http://arxiv.org/abs/2112.14877 (visited on 01/25/2023).

[3] Benjamin D. Haeffele and René Vidal. "Global Optimality in Neural Network Training". In: *2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*. ISSN: 1063-6919. July 2017, pp. 4390–4398. DOI: 10.1109/CVPR.2017.467.

[4] Hai V. Nguyen and Tan Bui-Thanh. "A Model-Constrained Tangent Slope Learning Approach for Dynamical Systems". In: (Nov. 2022). arXiv:2208.04995 [physics, stat]. DOI: 10.48550/arXiv.2208.04995. URL: http://arxiv.org/abs/2208.04995 (visited on 01/11/2023).