Exploring numerical calculations with CalcNet

Authors

Ashish Rana
Thapar Institute of Engineering & Technology, India
arana_be15@thapar.edu

Avleen Malhi
Aalto University, Finland
avleen.malhi@aalto.fi

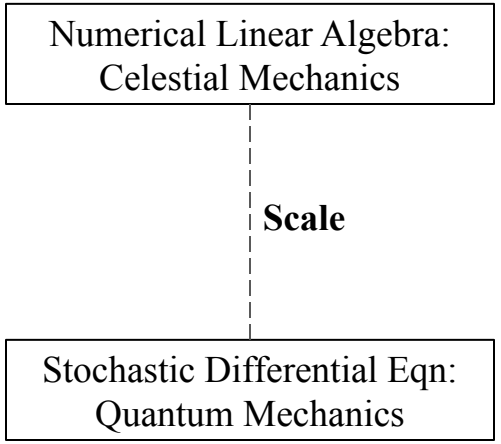
ICTAI 2019
Portland, Oregon, USA

Table Of Contents

Numerical approximations

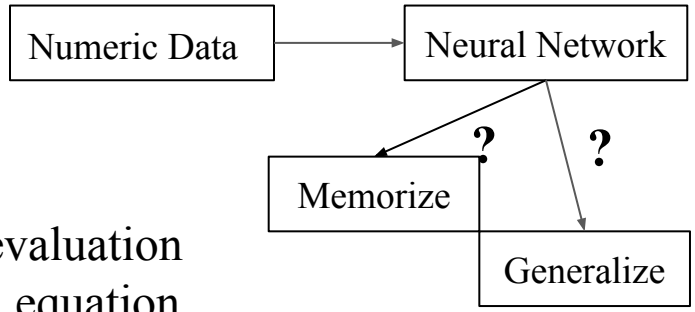
For all practical calculations in engineering domains a suitable numerical analysis approximation method is used.

For example, root finding algorithms helps in finding roots of continuous functions. These methods can be iterative like fixed point or direct polynomial root evaluation methods.



Research motivation

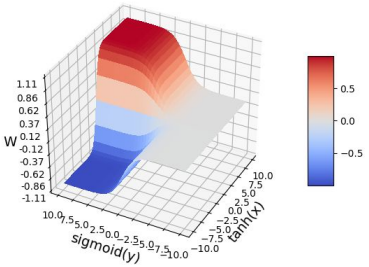
Involvement of neural networks for numerical expression evaluation is very limited. As they struggle to truly understand equation fundamentals behind experimental data.



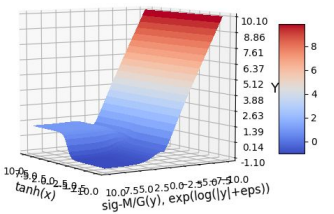
Existing literature

Trask et al. [1] already with their numerical biased units have demonstrated neural networks numerical manipulation for simple operators for both interpolation and extrapolation tasks.

Neural Accumulator (NAC)



Neural Arithmetic Unit (NALU)



Left: Neural unit biased with -1,0,1. ***Right:*** Similar biases superimposed with scaling bias factor.

Current limitations

Only simple operators handled, NALU misses out positive targets and bad with exponentials.

Trask, Andrew, et al. ”Neural arithmetic logic units.” Advances in Neural Information Processing Systems. 2018

Calcnet: An improved calculation pipeline

An effective neural network architecture with numeric expression parser and operator evaluation neural modules.

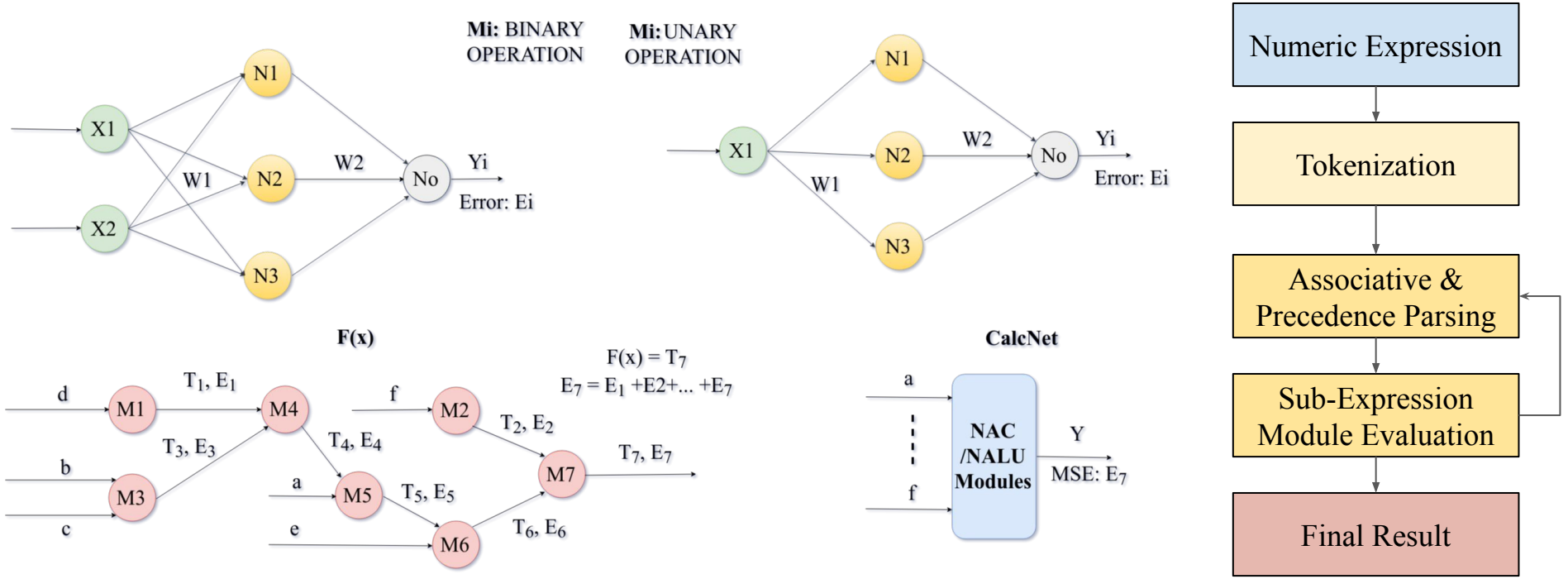
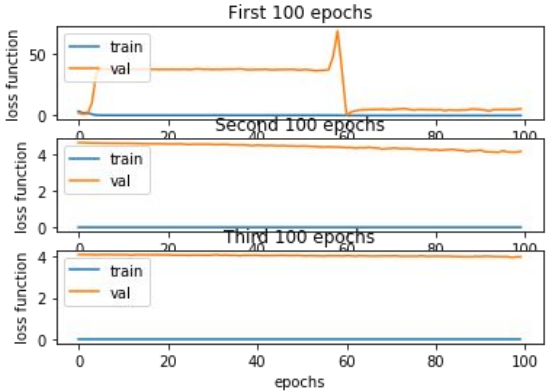


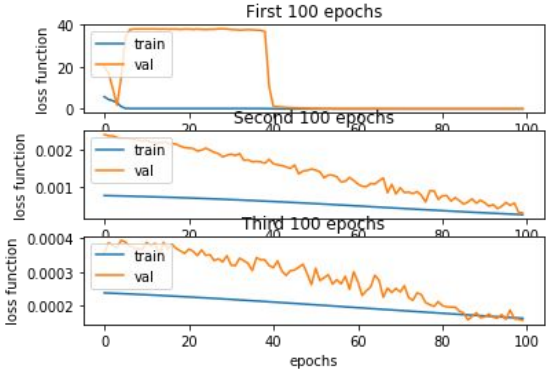
Fig. Calcnet numeric expression fundamentals.

Experiments: New neural units & Equation approximation

Static Arithmetic Operation task on simple operators: Our Golden ratio based NACs and NALUs outperformed the earlier standard units with their softer gradient propagation surfaces.



MSE for square root operator evaluation by standard NALU



MSE for square root operator evaluation by golden ratio based NALU

Equation Approximation: Our CalcNet neural network pipeline outperforms other neural network models and for extrapolation tasks the relative accuracy was also increased as compared to interpolation tasks demonstrating high generalization abilities.

Experiment: One Shot Learning & Robustness

Biquadratic Root Evaluation: CalcNet again shows small error of 9% for this root approximation evaluation task with very less standard deviation of 0.60% that reflects upon robustness of the model trained.

One Shot Learning: Model weights from previously trained experiments were used. This does demonstrate high generalization abilities of CalcNet for arithmetic evaluation tasks.

Limitations

The performance for power operation is still bad with this pipeline's parser. But, does shows an improvement when the power operation is simplified as multiplication one.

The performance with division operator gets challenged when denominator closes to approximately zero.

Conclusion

Our neural network pipeline demonstrated higher accuracies for both interpolation & extrapolation tasks. Hence, demonstrating true numeric manipulation understanding.

Future improvements

- Expression simplification by theorem and identity recognition in the parsing algorithm.
- Predicting stochastic results for quantum physics differential equations.

Thank you

Comments & Questions