Id 103

Artificial intelligence-based prediction of effective thermal conductivity of cryogenic insulations

B Nitin [a], *Pritam Saha* [a], *Rajendra Kumar* [a], ***Emel V Kurian*** [a], *Chamarthi Bharat Surya* [a], *Chaitanya Patil* [a], *Pavitra Sandilya* [a]

[a] Cryogenic Engineering Centre, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, India
Email for correspondence: profsandilya@gmail.com

Introduction

- The Effective thermal conductivity (ETC) of MLIs depend upon multiple parameters
- Theoretical determination of ETC is complicated and usually not possible and hence correlations are used
- Reported correlations → Limited scope
- No general method is available to estimate ETC of MLIs
- Here, we use AI to predict the ETC of MLIs

Objective

- To develop an AI based tool that predicts the effective thermal conductivity of cryogenic insulations.

NN Training

- **Step 0:** Initialize the weights
- **Step 1:** Forward propagate the input through the network
- **Step 2:** Find the error between the obtained output and the actual output
- **Step 3:** Back propagate the error through the network and update the weights
- **Step 4:** Go to Step 1, STOP when convergence criteria is met

Activation functions : ReLU, ELU

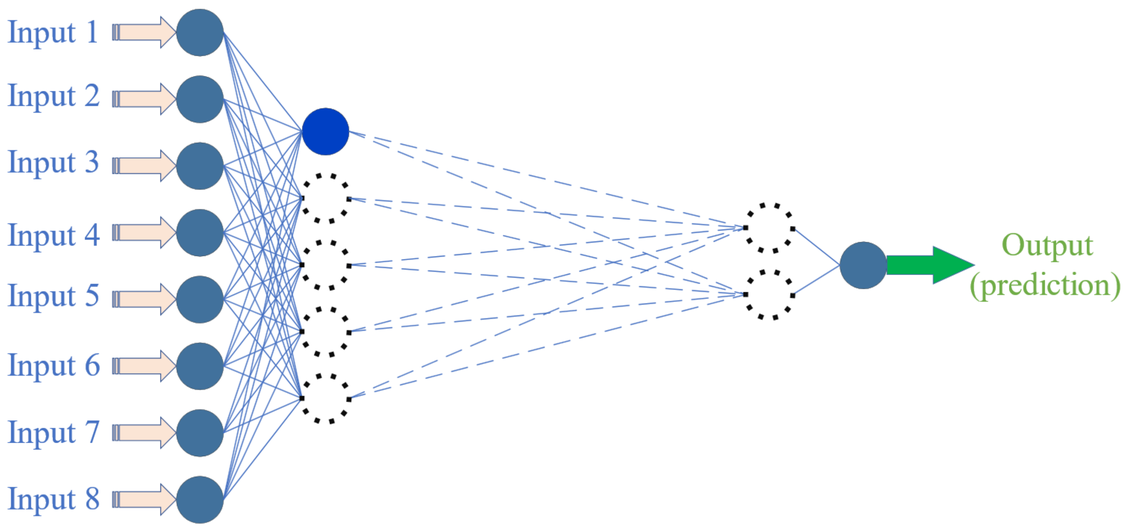
$$ReLU(x) = max(0, x)$$

$$ELU(x) = \begin{cases} x \; if \; x > 0 \\ \alpha(e^x - 1) \; if \; x \leqslant 0 \end{cases}$$

$$ReLU'(x) = \begin{cases} 1 \; if \; x > 0 \\ 0 \; if \; x \leqslant 0 \end{cases}$$

$$ELU'(x) = \begin{cases} 1 \; if \; x > 0 \\ ELU(x) + \alpha \; if \; x \leqslant 0 \end{cases}$$

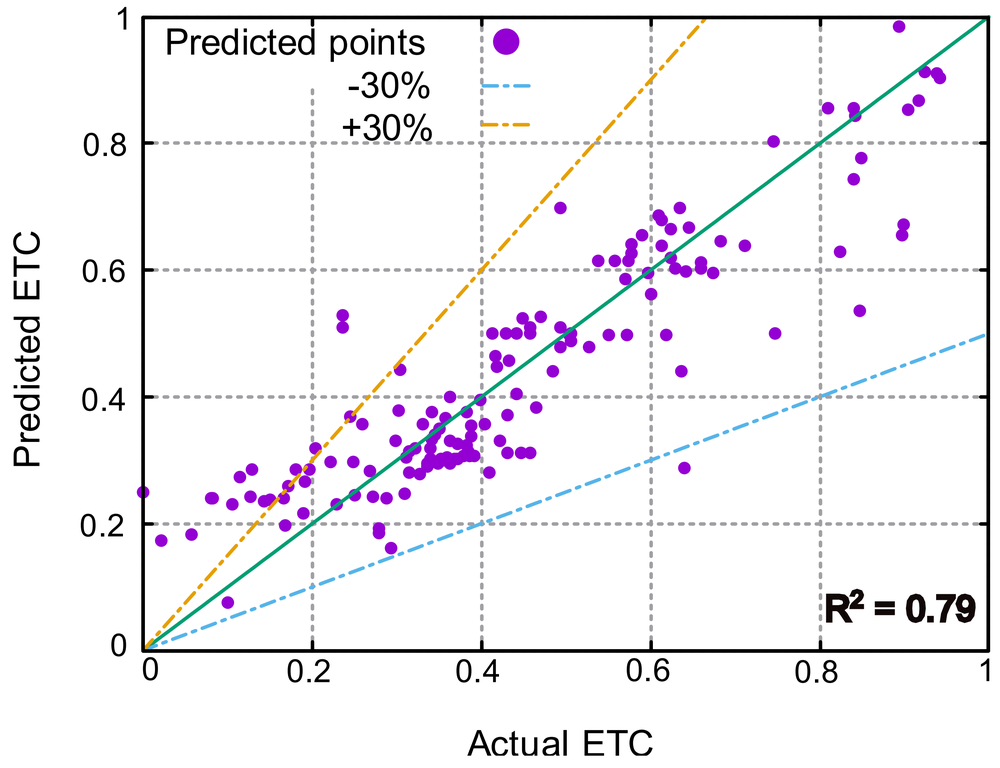
Architecture of the NN



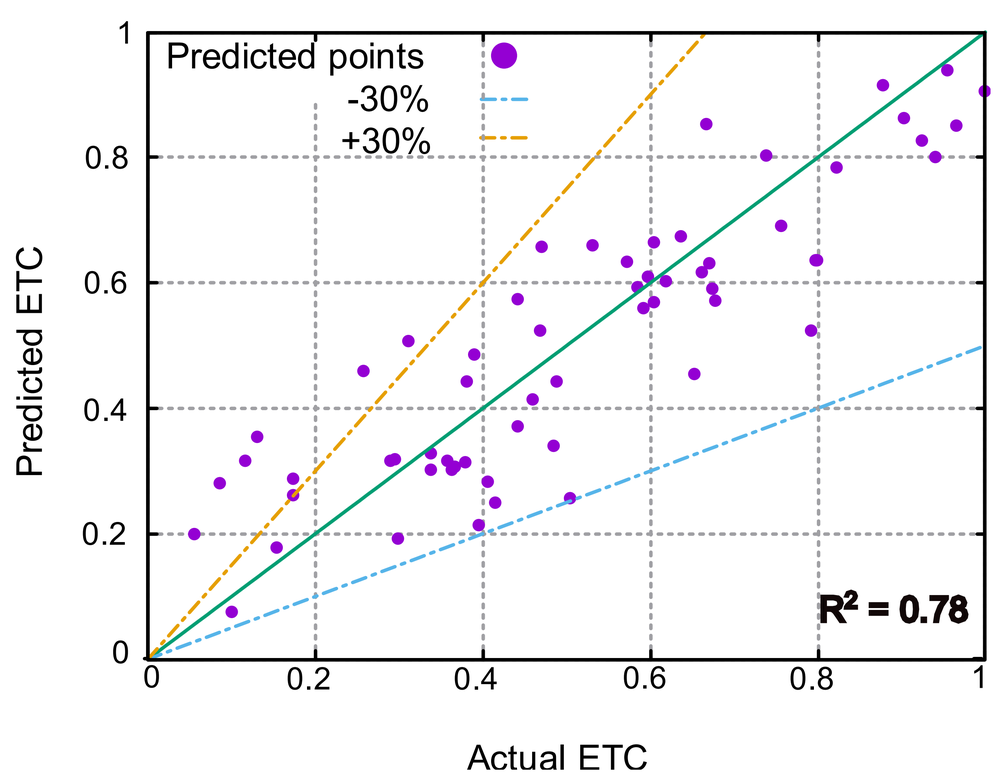
Results and Discussion

Hyper-parameter	Value
ELU factor (α)	0.85
Learning rate (η)	0.005
Test-Train ratio	60:40
Momentum constant (β)	0.75
Convergence criterion	Max MAE< 0.35

Training Parity



Testing Parity



Conclusion

- The NN model satisfactorily predicts the effective thermal conductivity of insulations with a training R^2 of 0.79 and testing R^2 of 0.78
- The error in predictions for certain range of values of ETC may be attributed to insufficient number of datapoints available for training in and around that range

Selected References

- Yogiraj Sargam, Kejin Wang, and In Ho Cho. Machine learning based prediction model for thermal conductivity of concrete. Journal of Building Engineering, 34:101956, 2021
- Pratihar, D.K., 2013. Soft computing: fundamentals and applications. Alpha Science International, Ltd.