Master's Thesis 2026

Title

Jonatan Haraldsson
Jesper Noord

Department of Industrial and Materials Science
Division of Material and Computational Mechanics
Chalmers University of Technology
Gothenburg, Sweden 2026

Title

Supervisors:
Examiner:

Master's Thesis 2025
Department of Industrial and Materials Science
Division of Material and Computational Mechanics
Chalmers University of Technology
SE-412 96 Gothenburg

Cover:

Typeset in LaTeX
Printed by Chalmers Reproservice
Gothenburg, Sweden 2025

Title

Jonatan Haraldsson & Jesper Noord
Department of Industrial and Materials Science
Division of Material and Computational Mechanics
Chalmers University of Technology

Abstract

bla bla

Keywords: *Physics Informed Neural Network, ..., ...*

Acknowledgements

List of Acronyms

EV electric vehicle. 1

FE finite element. 1

Li lithium. 1

Li B lithium-ion battery. 1

NN neural network. 3

PINN physics-informed neural network. 1

RMSE root-mean-squared error. 4

Contents

1 Introduction

1.1 Background

With an ever growing demand for convenient energy storage, the use of lithium-ion batteries (Li Bs) in portable devices have skyrocketed over the last 30 years.

physics-informed neural network (PINN), electric vehicle (EV), lithium (Li)

Contents

- Why batteries? (Nobel prize 2019, a game changer in our modern lives, necessary for climate change)
- However, there are still problems, and the hunt for even more energy efficient batteries requires models to describe the physical properties of batteries.
- While models based on finite element (FE) can be used to simulate such systems to a high accuracy, they are often computationally costly [ ]. Instead, .

1.2 Aim and Scope

Continuing the introduction with a cite [.]

2
Theory

2.1 Overview of Batteries

- A battery's parts, anode, cathode, electrolyte. Cell vs. module.
- The general working principle: charging and discharging. Potential negative effects that need to be considered. Heat development, or other factors affecting performance of the cell.
- What equations are governing? (Thermodynamics, Mechanics, electric, chemical)

2.2 Neural Networks

- General overview of neural networks. Explain neurons, weights, bias, loss function, different types of NNs. RNN??
-
- How to make NNs PINNs? Regularization term in the loss function that penalizes NN solutions that aren't physically viable.
- Motivate the use of neural networks (NNs) w/ the Universal Approximation Theorem, i.e. the fact that a single layer perceptron NN can achieve universallity. Put differently, any continuous function can be modelled to the desired degree of accuracy with this NN (wiki-link).
-

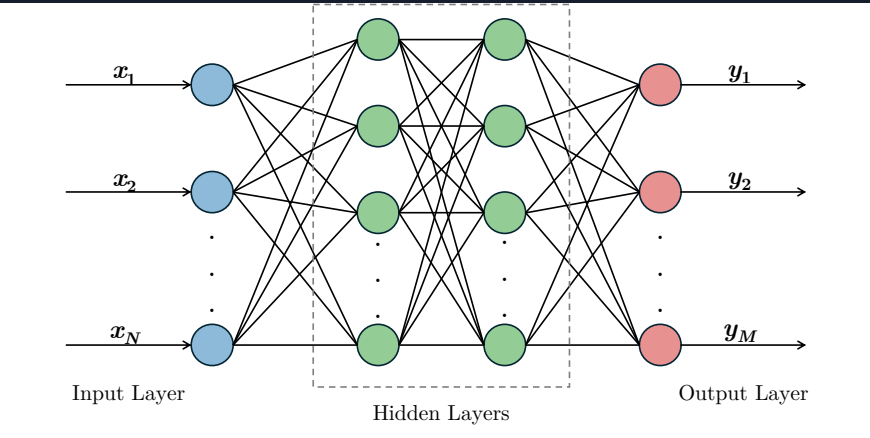

FIG 2.1: Schematic view of a neural network where each circle represents a single neuron. An input signal $\boldsymbol{X} = \{\boldsymbol{x}_i\}_{i=0}^{N}$ enters the model in the input layer, proceeds through the hidden layers, and exits from the output layer. This process produces an output $\boldsymbol{Y} = \{\boldsymbol{y}_i\}_{i=0}^{M}$, which can be interpreted as a prediction based on the input data.

Loss function, such as root-mean-squared error (RMSE).

3
Method

Here's the method

4
Results and Discussion

Here are the results

5
Conclusion

Here's the conclusion

Bibliography

[1] A. Asheri, M. Fathidoost, V. Glavas, S. Rezaei, and B.-X. Xu, "Data-driven multiscale simulation of solid-state batteries via machine learning," *Computational Materials Science*, vol. 226, p. 112 186, 2023, ISSN: 0927-0256. DOI: https://doi.org/10.1016/j.commatsci.2023.112186. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0927025623001805.

[2] J. Haraldsson, "Msc thesis," *Chalmers*, vol. 1, no. 1, 2026.

A
Appendix A: Extra Stuff

In Fig. A.1, ...

Fig A.1: hej