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National
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School of Computing

College of Engineering, Computing
and Cybernetics (CECC)

Unleashing the power of Machine Learning in Geodynamics

— 12 pt Honours project (S2 2023)

A thesis submitted for the degree
Bachelor of Advanced Computing (Honours)

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Abstract

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Introduction

Background

Related Work

A machine-learning-based surrogate model of Mars' thermal evolution ([Agarwal et al., 2020](#))

Deep learning for surrogate modeling of two-dimensional mantle convection([Agarwal et al., 2021](#))

Geoid prediction

4.1 Dataset of Geoid prediction

4.2 Fully connected Neural Networks (FNN) for Prediction

Mantle Convection Simulation

- 5.1 Dataset of mantle convection simulation
- 5.2 Compression of temperature fields
- 5.3 Fully Connected Neural Network (FNN) for Prediction
- 5.4 Long short-term memory (LSTM) for Prediction

Concluding Remarks

6.1 Conclusion

6.2 Future Work

Bibliography

- AGARWAL, S.; TOSI, N.; BREUER, D.; PADOVAN, S.; KESSEL, P.; AND MONTAVON, G., 2020. A machine-learning-based surrogate model of mars' thermal evolution. *Geophysical Journal International*, 222, 3 (may 2020), 1656–1670. doi:10.1093/gji/ggaa234. <https://doi.org/10.1093/gji/ggaa234>. [Cited on page 3.]
- AGARWAL, S.; TOSI, N.; KESSEL, P.; BREUER, D.; AND MONTAVON, G., 2021. Deep learning for surrogate modeling of two-dimensional mantle convection. *Physical Review Fluids*, 6, 11 (nov 2021). doi:10.1103/physrevfluids.6.113801. <https://doi.org/10.1103/physrevfluids.6.113801>. [Cited on page 3.]