Final Project For ECE228 Track Number # 2

Group Number #: First Name, Last Name **First Name, Last Name**

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Abstract

Please write your abstract here. It should be a snapshot of the entire report.

Submission guideline: Please remove THIS section and all the blue instructions from your final submission

Submission guideline

- Please mention the track number at title (**Track 1**: Reproducing an existing machine learning + physical / engineering / science application paper and implement improvement ideas on top ot it; **Track 2**: Open-ended project.
- Please enter the **Group Number #** before the first name of the team. You can find your group number in this Google sheet.
- Maximum page limit is 8-page except the Appendix and Reference.
- For citing related literature, please use `\cite` and Bibtex file (bib.bib in the current folder) to manage your citations.
- A good report should include the following:
  - Introduction, Background and Related Works. What task/problem are you targeting? What are the prior works in tackling this problem and what are their limitations? What is your contribution to this problem?
  - What method do you propose to solve the problem (e.g. data collection/processing, model input/output, model architecture design, loss function design, incorporate physics knowledge etc)? What's new in your approach? What are the technical challenges that you tackled?
  - Validate your proposed method with experiments and compare your model with existing baselines. What hyper-parameters/dataset are you using? How does your approach compared to other methods under a fair comparison setup? Did you use a package or write your own code (for some parts)? It is fine if you use a package, though this means other aspects of your project must be more ambitious.
  - Summarize your findings from the project. Highlight your contributions and discuss the limitations. Outlook for future work.
- As you work on your final project, ensure you start early and plan your tasks effectively. Document each section clearly in your report. Good luck!

1 Introduction

Introduction [10%]: provide the background and motivation of the problem, and why it is important. Also, include an overview of your project and a brief summary of contributions (listed in bullet points)

Preprint. Under review.

2 Related work

Related works [5%]: Please review the related work in this area, state the challenges/limitations of the existing methods, and how does your proposed work will help address the prior limitations and/or advance the current state-of-the-art for this problem.

3 Methodology

Method/Approach [40%]: this should be the main section of your report. Describe your approach, any equation and/or algorithm you developed to solve the problem. This part will be evaluated based on both scientific merit and technical depth.
For this project, a subset of the OpenFWI dataset is used to test the various models, and the best-performing model is then run on the entire dataset (622 GB) for the Kaggle competition. Initially, seismic data is given with dimensions (500, 5, 1000, 70). The description for each dimension is provided below:

- 500: The original batch size
- 5: The number of seismic sources
- 1000: The number of timesteps
- 70: The number of receivers

The data is then preprocessed by normalization for certain models and then splitting the dataset by batch size into training, testing, and validation sets. After the data is processed, it is passed to a model, which outputs a 70 by 70 velocity map. This velocity map is then compared to a ground truth velocity map and metrics are computed. The metrics chosen for analysis are as shown below:

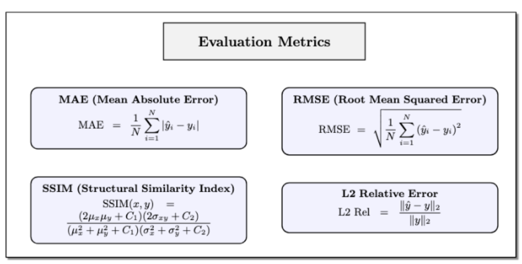

Figure 1: Formulas for chosen metrics

- MAE (Mean Absolute Error): This is the base metric for the Kaggle competition.
- RMSE (Root Mean Squared Error): This metric adds penalty to larger errors and provides a holistic view when analyzed along with MAE.
- SSIM (Structure Similarity Index Measure): This metric is used as a quantitative measure to compare the similarities between a predicted and ground truth image.
- L2 Relative Error: This metric is used to measure the difference between predictions and ground truth by accounting for the magnitudes of the values.

3.1 Models

3.1.1 Neural ODE

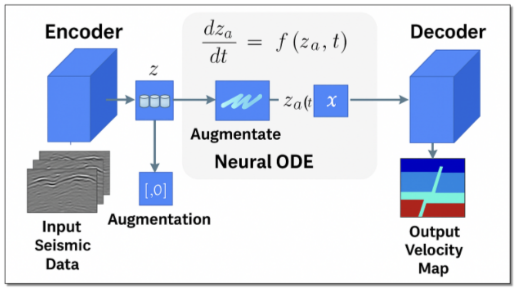

Figure 2: Augmented Neural ODE General Structure

One of the models chosen to experiment with was the Neural ODE as learned in the course. Neural ODEs are differential equation solvers, with the solver essentially being a black-box. The model can be implemented by using the torchdiffeq package in Python and the function odeint from this package. The structure of this model was a convolutional encoder, a three-layer MLP as the base function, and a decoder to shape the output as a 70 x 70 tensor to compare against the ground truth. Two different Augmented Neural ODEs were also created. One model had the same MLP as a base function and the other had a simple convolutional network as its base. Both models had an augmented dimension of 1. Augmented Neural ODEs were chosen because the augmented dimension helps in cases where an extra dimension is needed so that trajectories do not intersect. As can be seen in **Figure 2**, the input seismic data is passed into an encoder and then augmented. This augmented data is passed into the differential equation solver and then decoded into the output velocity map. In **Figure 3**, the more specific structure of the Augmented Neural ODE with the MLP base is illustrated for further information.

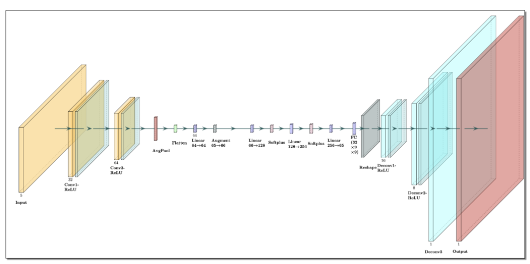

Figure 3: Augmented Neural ODE (MLP)

4 Experiments

Results [30%]: present your results and provide sufficient discussions of the results. 1) Describe what dataset is being used, details in data processing, train-test data split, and hyperparameter choices in your model etc. Provide the sufficient details such that if a reader would like to reproduce your results, they have enough information to do it. 2) Include figures and/or tables showing the quantitative and qualitative performance of your method; 3) Comparison to necessary baseline methods and comparison to your proposed method.

5 Conclusion

Conclusion [5%]: Summarize your project and findings. High-level discussion about what you have learned from this project, what works, and what does not work, and ideas/suggestions for future work if you/others want to work on this problem.

The following sections do not count towards the 8-Page Limits.

Appendix

Github Link

Github Link [10%]. Include a Link to your Project Github with your project codes with necessary documentation. Please include a top-level README.md file in your github repo. This top-level README should explain the layout of this repository and instructions such that users can run your code. Ensure your code can run and reproduce the results you presented in the report. Note that it is your responsibility to ensure that the code repo is working and the README.md is clear to follow.

Team Member Contribution

Describing each team member's contribution for this project (e.g., conceptualization, Data curation, Methodology, Software/Experiments, Report Writing, Poster preparation, etc)

References