ELECTROMAGNETIC IMAGING SYSTEM USING MACHINE LEARNING

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Introduction

- Nonlinear electromagnetic inverse scattering is an accurate, non-destructive imaging tool.
- It is used in various fields such as medical imaging, geophysics, and materials science.
- Deep learning in nonlinear electromagnetic inverse scattering uses neural network architectures to solve complex inverse problems, where the goal is to reconstruct the properties of an object or medium from scattered electromagnetic fields.

Specifications and Design Requirements

- The software has a graphical user interface (GUI) for better user experience.
- The reconstruction tool takes the measured complex E-field values as input.
- The input file should contain 36 receivers x 15 transmitters = 540 field values.

Solution Methodology

- The Finite Element Method (FEM) is used to solve the wave equation

$$(\nabla^2 + k_0^2)\,\vec{E} = 0$$

  and calculate field values to be used in DL training and testing.
- Back-propagation algorithm is used for approximating the scattering object as an initial guess.
- For the deep learning, CNNs are used. Throughout the algortihm, ‘relu’ activation function is used. For the optimizer, ‘adam’ optimizer is used and the epoch number is set to 40 for the best results.

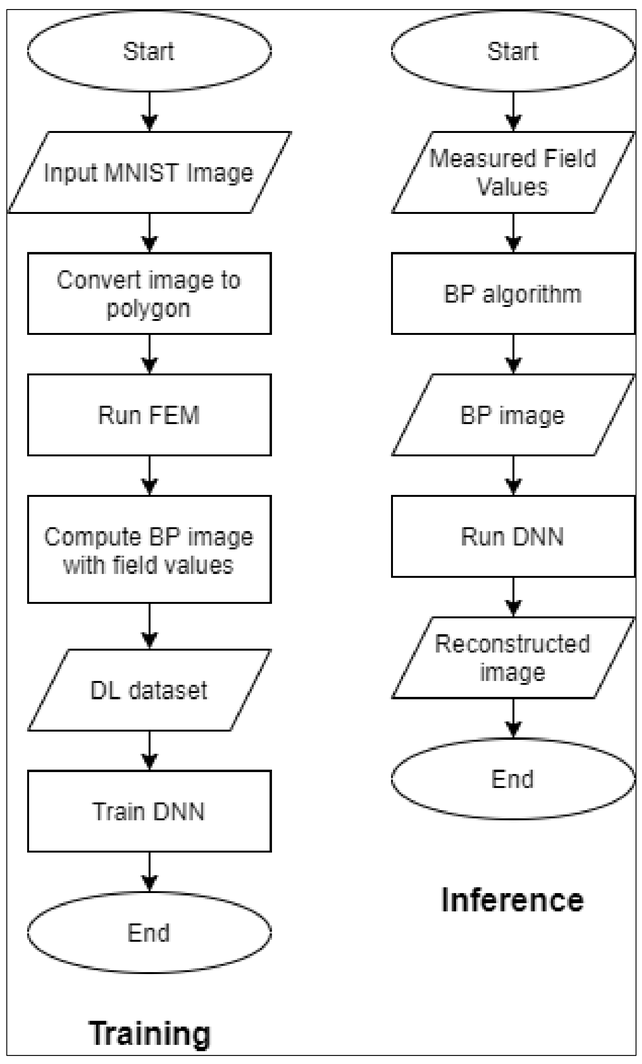


Figure: Flowchart of overall process.

Results and Discussion

- The final results of the projects can be seen below.

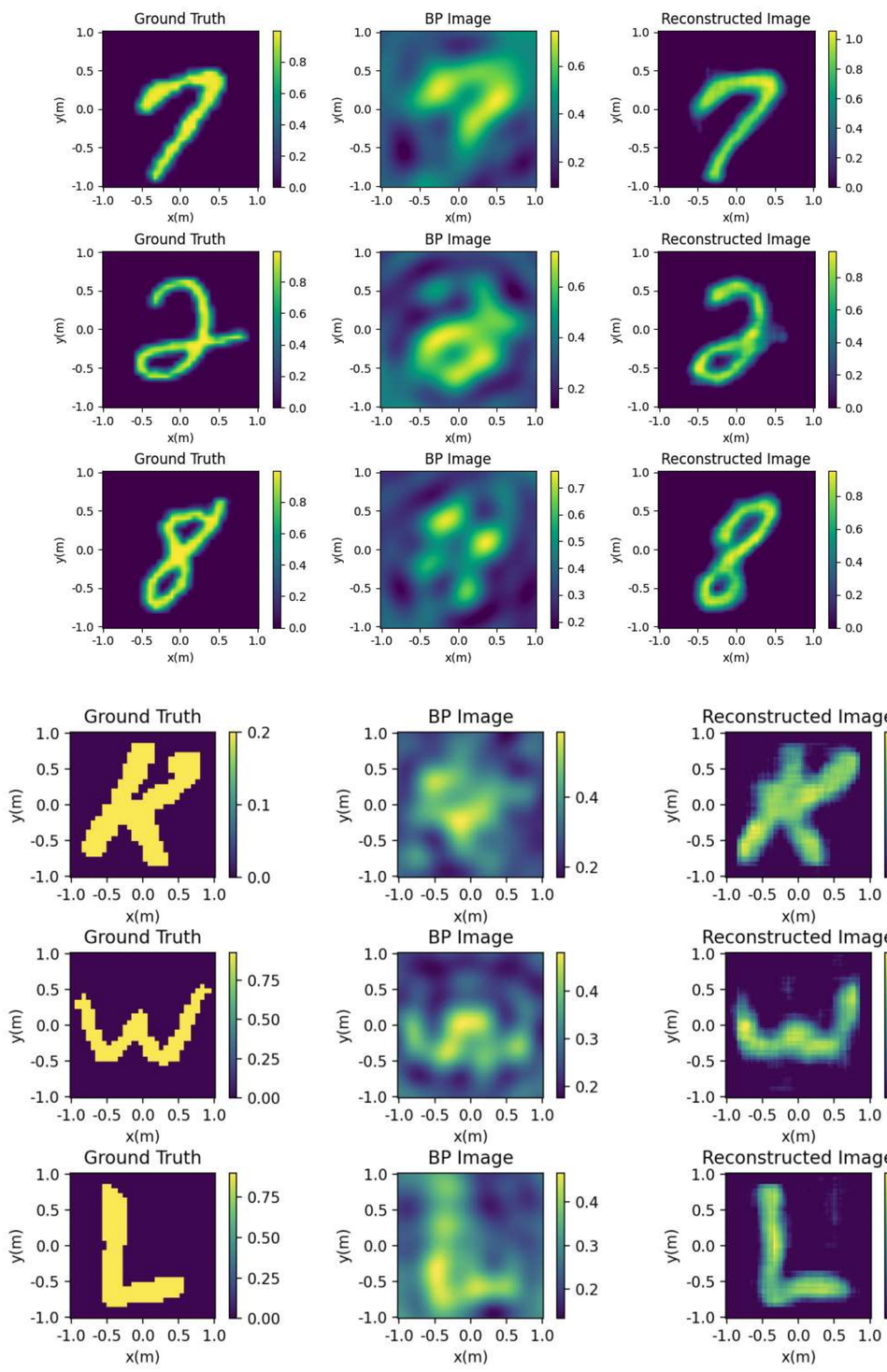
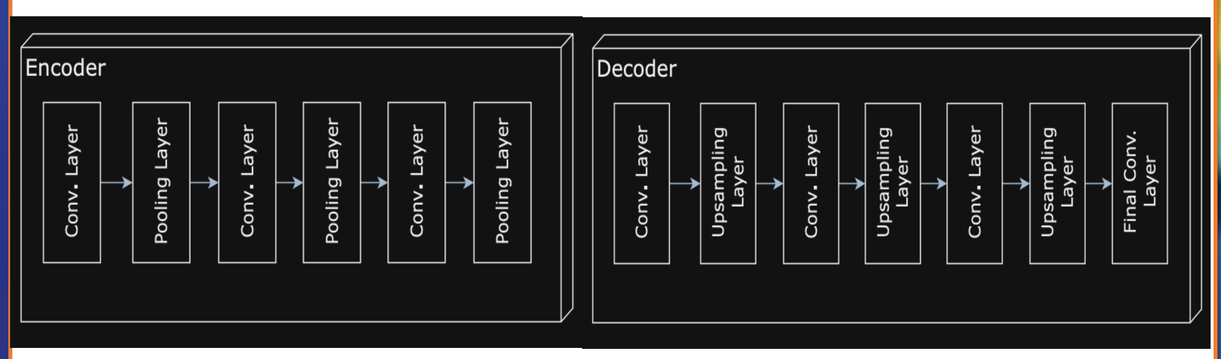


Image Reconstruction

- The image reconstruction algorithm is made up of CNNs. There are two main modules, an encoder and a decoder. Both modules have three conv. layers followed by another layer based on the module. The final layer is also a conv. layer located in the decoder module.



References

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- Z. Wei and X. Chen, "Deep-Learning Schemes for Full-Wave Nonlinear Inverse Scattering Problems," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 57, no. 4, pp. 1849-1860, April 2019, doi: 10.1109/TGRS.2018.2869221.
- Machine Learning Mastery, https://machinelearningmastery.com/

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