GEOPHYSICAL FOUNDATION MODEL: UNMASKING THE TRACES

EXECUTIVE SUMMARY

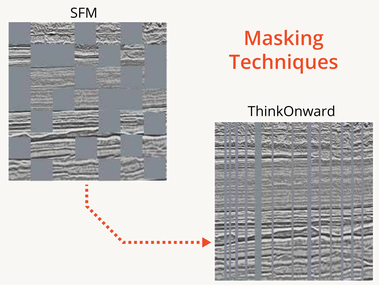
ThinkOnward's Geophysical Foundation Model is a pre-trained Vision Transformer trained on 450 synthetically generated Synthoseis 3D seismic volumes. We use a new elastic architecture and trace masking process to fine-tune the Geophysical Foundation Model for the downstream task of seismic interpolation. We use 50 3D seismic volumes from the Patch the Planet Challenge, hosted by ThinkOnward as our benchmark hold-out dataset. Using a Structural Similarity Index Metric (SSIM) to compare results we document that the Geophysical Foundation Model is 2-3 times better than Shang et al. (2023), and similar to Lasscock et al. (2024).

INTRODUCTION

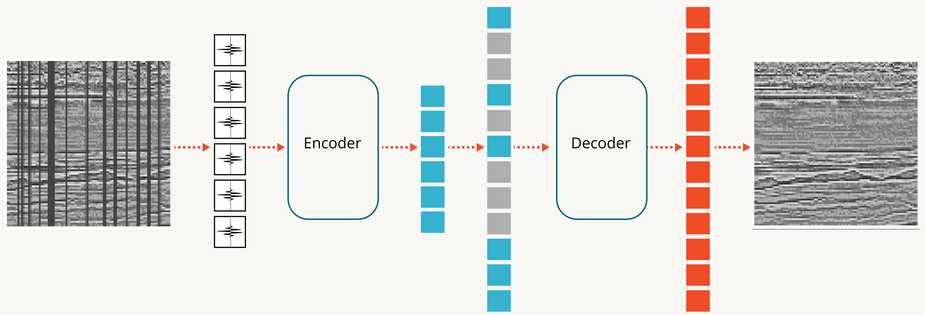
Sheng et al.'s (2023) innovative Seismic Foundation Model (SFM) paper lays the groundwork for the first peer reviewed geophysics based foundational model. The model builds upon the Vision Transformer Masked Autoencoder proposed by Meta in He et al. (2021). Sheng et al. (2023) curated a large seismic dataset containing more than two million images from various basins around the world. Sheng et al. (2023) used random masking with 14x14 pixel size patches to pre-train their Vision Transformer, and used the encoder weights to fine-tune for specific downstream tasks, like interpolation.

PROBLEM AND APPROACH

There are two key issues with the SFM. First, seismic input images are required to be 224x224 pixels in size, due to the architecture of the model. These are not realistic image sizes for 2D seismic data. The second issue is the masking method for seismic images during pre-training. The method depends upon the size of the images and is limited to square patches.



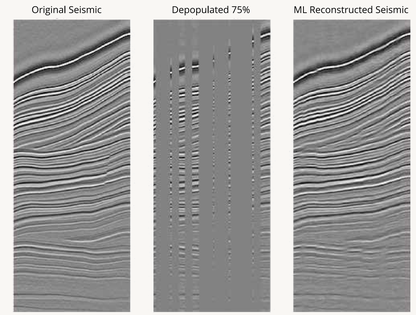
Conceptual encoder/decoder architecture for the trace based masking



ThinkOnward's Geophysical Foundation Model addresses the image size and masking issues by rethinking the entire process. We considered the question: "What is the fundamental aspect of a seismic dataset?". Our answer to this question is the seismic trace, a 1D representation of the data recorded for 1 channel. By adjusting the data masking process to traces and making adjustments to the internal architecture, the model not only accepts seismic images of any size for pre-training and fine-tuning, but also honors the fundamental aspect of seismic data. With the trace-based masking and data loading pipeline we train the backbone on 450 synthetic seismic volumes released as part of the Patch the Planet Challenge. After pre-training the backbone, we then designed and built a regression head for the Vision Transformer so that we can then fine tune for a variety of downstream tasks. For this poster we are interested in interpolating missing traces, with an example of one additional downstream task

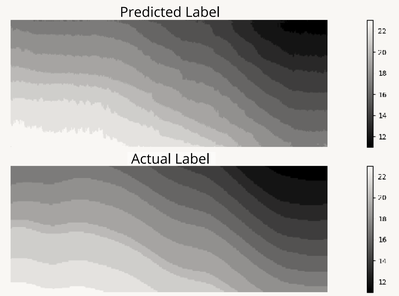
RESULTS / LESSONS LEARNED

For the interpolation downstream task we find that the Geophysical Foundation Model performs reasonably well even with highly depopulated seismic volumes.



Masking traces increases overall performance over masking patches

For the segmentation downstream task we find that the Geophysical Foundation Model performs reasonably well at segmenting seismic horizons with a classification head.



RECOMMENDATIONS

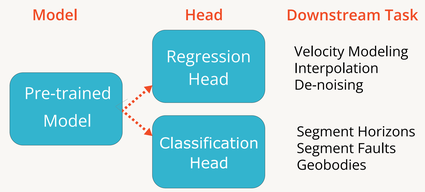
- Trace based masking should be the standard for subsurface vision models
- SSIM should be used for ground truth regression head task evaluations
- A variety of downstream tasks need to be evaluated

Continued development for the regression and classification heads are key for different downstream tasks.

Regression head downstream tasks include:
- De-noising
- Interpolation
- Velocity Modeling

Classification head downstream tasks include:
- Horizon segmentation
- Geobody segmentation
- Fault segmentation

Additional evaluation on how traces are masked (random, uniform, or clustered) will also help inform future models in this space.



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