Towards a Fast, Practical Alternative to Joint Inversion of Multiple Datasets: Model Fusion
Omar Ochoa¹
Mentors: Ann Gates¹, Vladik Kreinovich¹, Aaron A. Velasco²

Center of Excellence for Sharing Resources for the Advancement of Research and Education through Cyberinfrastructure (Cyber-SHARE)
¹Department of Computer Science,²Department of Geological Sciences
University of Texas at El Paso, El Paso TX 79968, USA
omar@miners.utep.edu, agates@utep.edu, vladik@utep.edu, velasco@utep.edu

Abstract
There are many sources of data for Earth tomography models. Currently, each of these datasets is processed separately, resulting in several different Earth models that do not capture the correct accuracy or spatial resolution. These models often provide complimentary geophysical information on earth structure. To combine the information derived from these complementary models, we propose a practical solution to fuse the Earth models coming from different datasets.

Need to Combine Data from Different Sources
In many areas of science and engineering, we have different sources of data. For example, in geophysics, there are many sources of data for Earth models such as:
- First-arrival passive seismic data (from the actual earthquakes).
- First-arrival active seismic data (from the seismological experiments).
- Gravity data.
- Surface waves, and
- Others

Databases coming from different sources provide complimentary information. For example, different geophysical datasets contain different informatics on earth structure (e.g., P and S wave velocity structure).

Joint Inversion: An Ideal Approach
This approach can be used to produce a single model.
- Current situation: at present, there are no efficient algorithms for simultaneously processing all the different datasets.
- Challenges: designing such joint inversion techniques presents an important theoretical and practical challenge.

Proposed Solution: Model Fusion
- Main idea: fuse models coming from different datasets.
- Simplest case: data fusion, when we have several measurements X₁, X₂, ..., Xₙ of the same quantity, with (possibly different) accuracy σ₁, σ₂, ..., σₙ
- Data fusion algorithm: use the Least Squares method, find a set for which the sum of the smallest
- Problem: in our case, different measurements have not only different accuracy, but also different spatial resolution.

Model Fusion: Technical Details
Our solution accounts for three different types of approximate equalities:
- Each high-resolution value Xᵢ is approximately equal to the actual value Xᵢ in the corresponding smaller area cell, with the accuracy σᵢ corresponding to the accuracy σᵢ of the higher-resolution Earth model Xᵢ ≈ Xᵢ
- Each lower-resolution value Xᵢ is approximately equal to the average of values of all the smaller cells Xᵢ ≈ Xᵢ / k

Proof of Concept
To assess the model fusion idea, we performed preliminary proof-of-concept experiments with simplified datasets (i.e., with synthetic data).
- Our preliminary results show that this method indeed leads to a fused model that effectively combines accuracy and resolution of different Earth models.

Conclusions
- We propose a new approach to combining data from different sources, an approach that is a fast practical alternative to joint inversion of multiple datasets.
- On the example of simulated (synthetic) geophysical data, we show that model fusion indeed improves the accuracy and resolution of individual models.

Future Work
Plans for future work:
1) apply the model fusion techniques to more realistic simulated data;
2) use the results of these applications to adjust the techniques;
3) apply the adjusted model fusion techniques to real geophysical data;
4) use the results of these applications to further adjust the techniques.

References