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Matrix Completion on Unstructured Grids: 2-D Seismic Data Regularization and Interpolation

Introduction

- acquisition challenges
- need fully sampled data
- regularization & interpolation
- exploit low-rank structure of seismic data

Matrix Completion:

- Low rank/fast decay of singular values
- Sampling scheme
- Missing data increase rank in “transform domain”
- Recovery using rank penalization scheme

Regularization & Interpolation

- Figure 2: Regularization and Interpolation
  - Ground truth at (a) irregular grid, (b) and with missing traces.
  - (c, d) Recovery and difference using proposed rank-minimization on unstructured grids with a SNR of 19.3 dB.

Quantifying regularization error

Let \( X_r \in \mathbb{C}^{n \times m} \), \( h = \text{RM}(X_r) + e \) with \( \|e\| \leq \eta \), and\( \|N(X_r) - X_r\|_F \leq \epsilon \). Let \( \hat{X} \) be the solution of \( \text{BPDN}_{\epsilon} \), then

\[
\|X_r - \hat{X}\|_F \leq \frac{C_1}{\sqrt{k}} \sum_{l=1}^{k} \sigma_l(X_r) + C_2 \epsilon + C_2 \eta
\]

where

\[ l = \min\{n, m\} \]

\[ C_1 \text{ and } C_2 > 0 \]

Rank approximation Regularization noise

Regularization

- Binning does not preserve the underlying low-rank structure of seismic data
- Incorporation of grid-irregularity in matrix-completion benefits the regularization & interpolation process and preserve the low-rank structure of seismic data
- Propose matrix-completion framework is computationally affordable for large-scale problems since its SVD-free

Conclusion

References

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Applications: 249–274.


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