POSTER Nº

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Compressed sensing in 4-D marine – recovery of dense time-lapse data from subsampled data without repetition

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Time-lapse seismic

Current acquisition paradigm:

- *repeat* **expensive** *dense* acquisitions & *independent* processing
- compute *differences* between *baseline* & *monitor* survey(s)
- hampered by *practical challenges* to ensure **repetition**

Compressive sampling paradigm:

- **cheap** *sub*sampled acquisition, e.g., via time-*jittered* marine *sub*sampling
- may offer *possibility* to *relax* insistence on *repeatability*
- *exploits* insights from *distributed* compressed sensing

Aim: recovery of **both** vintages & time-lapse signal from incomplete data

Distributed compressed sensing

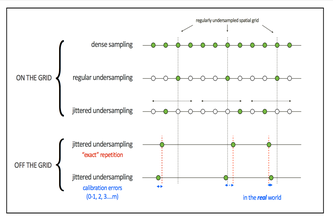
- *joint* recovery model (JRM)
- *different* vintages *share* common information

$$\underbrace{\begin{bmatrix} \mathbf{A}_1 & \mathbf{A}_1 & \mathbf{0} \\ \mathbf{A}_2 & \mathbf{0} & \mathbf{A}_2 \end{bmatrix}}_{\mathbf{A}} \underbrace{\begin{bmatrix} \mathbf{z}_0 \\ \mathbf{z}_1 \\ \mathbf{z}_2 \end{bmatrix}}_{\mathbf{z}} = \underbrace{\begin{bmatrix} \mathbf{b}_1 \\ \mathbf{b}_2 \end{bmatrix}}_{\mathbf{b}} \begin{matrix} \rightarrow \text{baseline} \\ \rightarrow \text{monitor} \end{matrix}$$

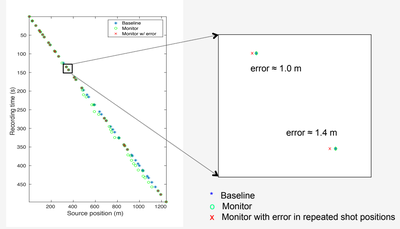
vintages $\mathbf{x}_1 = \mathbf{z}_0 + \mathbf{z}_1$, $\mathbf{x}_2 = \mathbf{z}_0 + \mathbf{z}_2$ differences

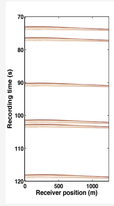
$\mathbf{z}_0$: common component

Randomized sampling in (4-D) marine



Time-*jittered* marine acquisition
(for 50% overlap in baseline & monitor acquisitions)



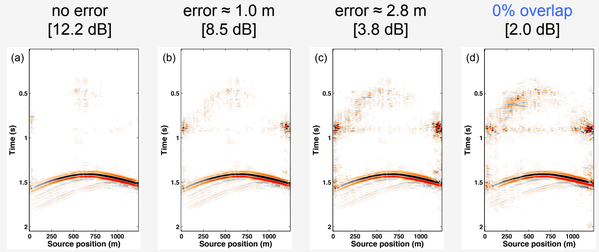


subsampled and blended data
(50 seconds of total recording time)

no repetition => 0% overlap in baseline and monitor acquisitions (shot positions)

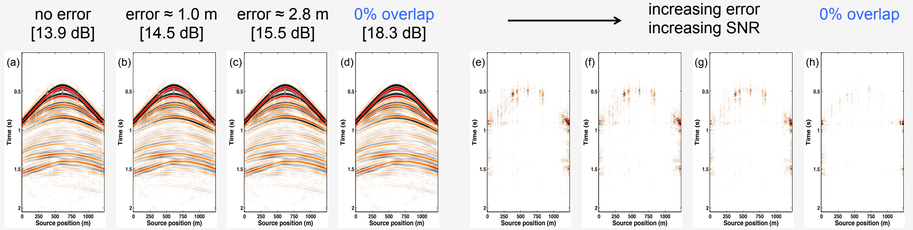
4-D recovery (Joint recovery method)

As the calibration error increases, the 4-D signal recovery decreases significantly (b,c). Moreover, the recovery becomes comparable to the recovery with 0% overlap between the surveys, i.e., randomized acquisition without repetition (d).



50% overlap in acquisition matrices

Monitor recovery (Joint recovery method)



(a), (b), (c), (e), (f), (g) 50% overlap in acquisition matrices

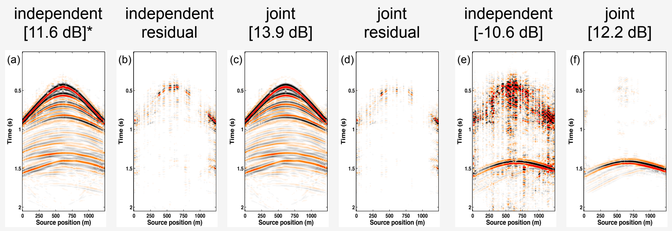
Residual

Independent vs. Joint recovery method

Processing data *jointly* (by exploiting *common* features of surveys) leads to *improved* recovery of **both** vintages and time-lapse signal.

Note: all results for 50% overlap in acquisition matrices with no calibration errors.

* [SNR dB] : signal-to-noise ratio



Monitor recovery and residual

4-D signal

Conclusions

Processing time-lapse data *jointly* leads to *improved* recovery of *both* vintages (baseline and monitor) and time-lapse signal

Given the context of randomized subsampling, calibration errors

- *deteriorate* recovery of the *time-lapse* signal
- *improve* recovery of the *vintages*

Since *calibration errors* are *inevitable* in the *real* world, the insistence on *repetition* in time-lapse surveys can be *relaxed*

Possible to recover *dense* time-lapse data from *randomized sub*sampling and *joint* processing

Acknowledgements

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