Processing Seismic Data in the Presence of Residual Statics

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Motivation

- Processing tools that rely on sparsity or simplisity promotion can fail in the presence of static shifts.
- Many methods can solve for static shifts, but can we still process data with static shifts?
- Here we adapt radon basis functions and reconstruction to work in the presence of small static shifts.

General cost function

$$J = |Ax - b|_2^2 + \mu |x|_1$$

A is a linear operator and depends on your application. x is the model.

Problem: when statics are present A does not produce a sparse model, x.

General cost function

$$J = |\mathcal{S}Ax - b|_2^2 + \mu|x|_1$$

A is a linear operator and depends on your application. $\mathcal{S}$ is a shifting operator. x is the model.

Solution: we add a shifting operator to add static shifts to the predicted data Ax.

Solving the original cost function: FISTA

$$J = |Ax - b|_2^2 + \mu |x|_1$$

$$g_k = |Ax_k - b|_2^2$$

INPUT:μ, α, b
$y_o = x_o = 0$
$t = 1$
$T = \mu / 2\alpha$
for $(k = 0 : N_{iter})$
  $x_{k+1} = \text{Soft}(y_k - \nabla g_k / \alpha, T)$
  $t_{k+1} = (1 + \sqrt{1 + 4t_k^2})/2$
  $y_{k+1} = x_{k+1} + [(t_{k+1} - 1)/t_k](x_{k+1} - x_k)$
end

Solving the modified cost function: FISTA

$$J = |\mathcal{S}Ax - b|_2^2 + \mu|x|_1$$

$$g_k^{\mathcal{S}} = |\mathcal{S}_k Ax_k - b|_2^2$$

INPUT: μ, α, b
$y_o = x_o = 0$
$t = 1$
$T = \mu/2\alpha$
$\mathcal{S}_o = I$
for $(k = 0 : N_{iter})$
$\quad x_{k+1} = \text{Soft}(y_k - \nabla g_k^{\mathcal{S}}/\alpha, T)$
$\quad t_{k+1} = (1 + \sqrt{1 + 4t_k^2})/2$
$\quad y_{k+1} = x_{k+1} + [(t_{k+1} - 1)/t_k](x_{k+1} - x_k)$
$\quad \mathcal{S}_{k+1} \leftarrow Ax_{k+1} \odot b$
end

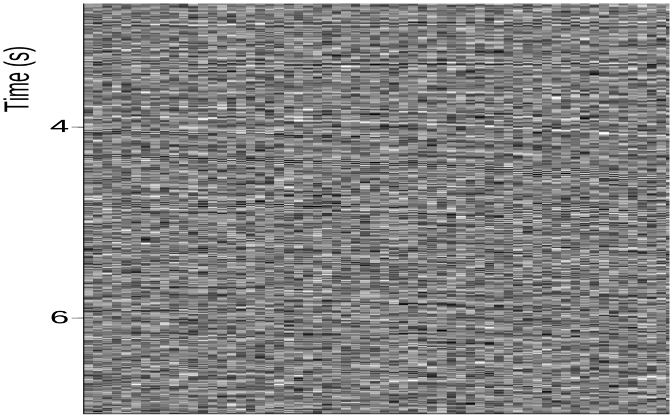
Application to Radon

$$\text{Cost}_1 = |Ax - b|_2^2 + \mu |x|_1$$

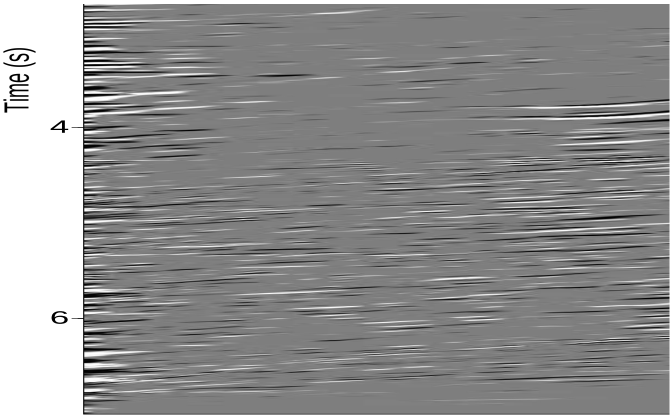
$$\text{Cost}_2 = |\mathcal{S}Ax - b|_2^2 + \mu |x|_1$$

Here A is adjoint of the parabolic radon transform, and $\mathcal{S}$ is a shifting operator, b is a NMO corrected gather, and x is the radon panel.

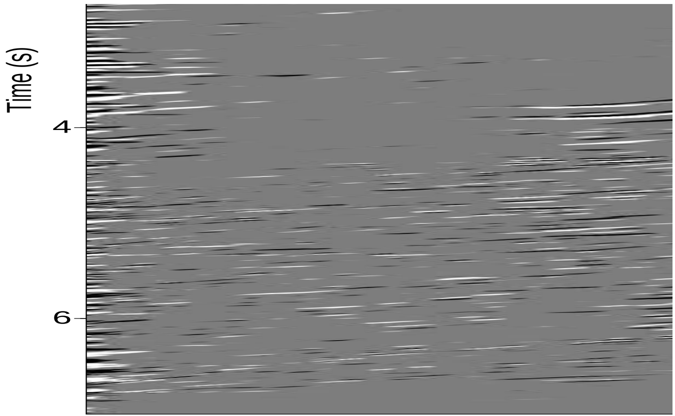
Original data



Radon panel using cost function 1

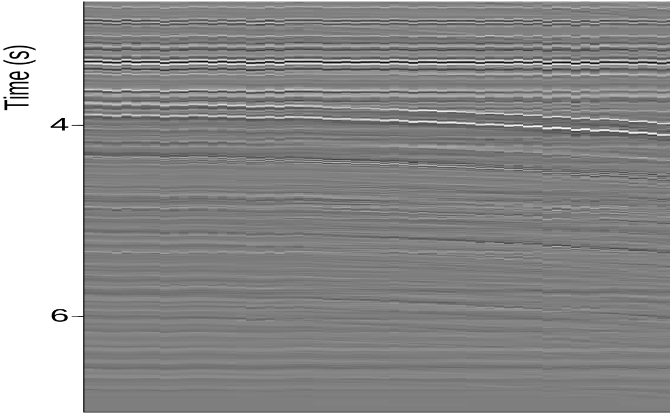


Radon panel using cost function 2



Estimated data using cost function 1

Estimated data using cost function 2



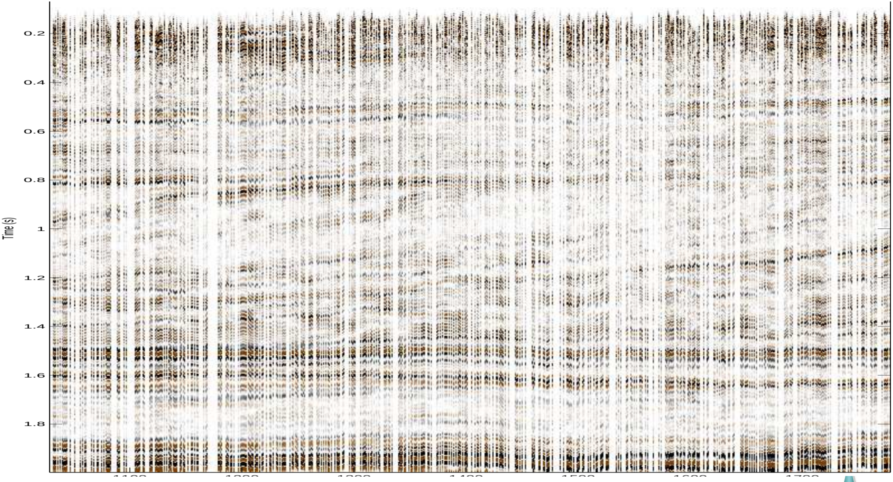
Application to reconstruction

$$\text{Cost}_1 = |Ax - b|_2^2 + \mu|x|_1$$

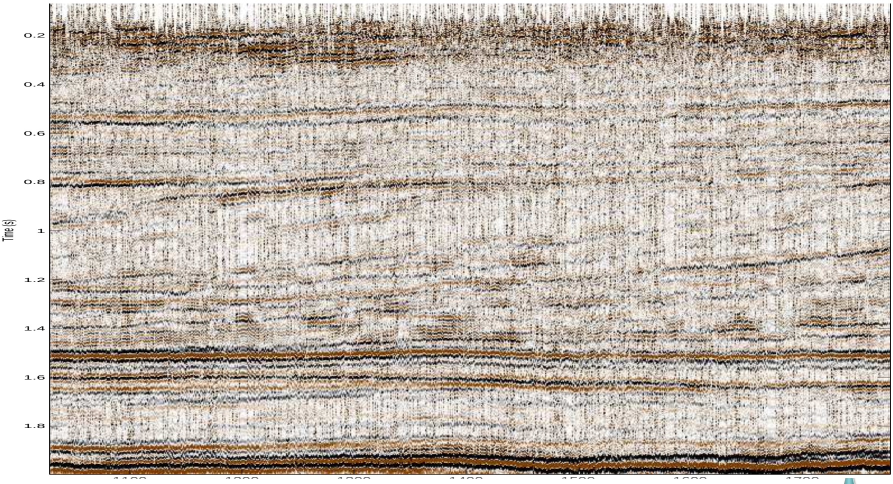
$$\text{Cost}_2 = |\mathcal{S}Ax - b|_2^2 + \mu|x|_1$$

Where $A = TF^H$.
Here F^H is the inverse Fourier transform and T is the sampling operator. $\mathcal{S}$ is a shifting operator, b is the input data, and x are the Fourier coefficients.

Input data



Data after applying reconstruction



Data after applying modified reconstruction

Conclusions

- We have presented a method to allow for sparsity promotion in the presence of small static shifts.
- We applied this method to Radon basis functions and Fourier Reconstruction.
- For both Radon and Fourier transforms including statics in the basis functions resulted in improved signal preservation and reconstruction.

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