Active Contour and Seismic Interpretation

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Outline

- Motivation
- Active Contour
  - Formulation
  - Proposed Method Overview
- Experimental Results
  - Subjective Evaluation
  - Objective Evaluation
- Summary

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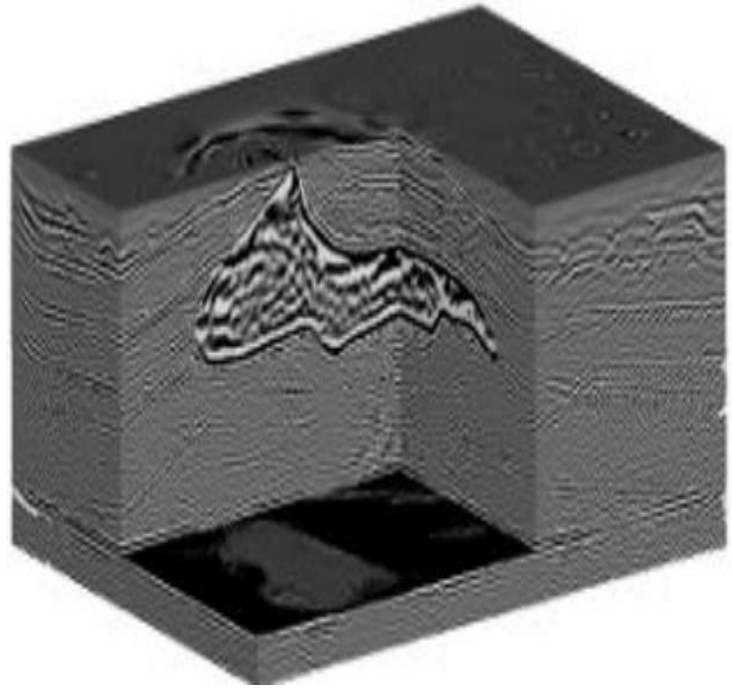
Motivation

- Seismic Interpretation
  - Impermeable
  - Exploration Planning
  - Drilling Layout
- Delineation Methods
  - Edge based Methods
  - Texture based Methods
  - Graph Cut based Methods
  - 2D vs 3D Methods
  - Active Contours



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Active Contour

- An active contour is an energy minimizing, deformable curves that are governed by two energies
  - External energy
  - Internal energy
    - Penalty on curve length
    - Smoothness
- Energy minimization
- Main types include edge and region based active contours.
- Edge-based geodesic active contour with an arc length penalty

PDE Formulation

- Energy function

External Energy

Internal Energy

$$E(C(p,t)) = \int_0^L \Phi dp + \int_0^L \frac{1}{2}\lambda \|C_p\|^2 dp$$

- Energy Minimization using gradient descent

Edge Function design

$$C_t = -((\nabla\Phi.N)N - (\Phi + \frac{\lambda}{2})\kappa N)$$

- The Edge function should be chosen such that the energy is minimum when active contour lie accurately on the salt dome boundary.

$$\Phi(x,y) = \frac{1}{(\epsilon + \|\nabla I\| * G_\sigma)^p}$$

Level Set Evolution and Implementation

- The implicit level set evolution of the curve is computed as follows

$$\Psi_t = \widehat{\nabla\Phi}.\nabla\Psi + (\widehat{\Phi} + \frac{\lambda}{2})\nabla.(\frac{\nabla\Psi}{\|\nabla\Psi\|})\|\nabla\Psi\|$$

- We have used the upwind forward time difference scheme for numerical implementation

$$\Psi(t+\Delta t) = \Psi(t) + \Delta t(\widehat{\nabla\Phi}.\nabla\Psi + (\widehat{\Phi} + \frac{\lambda}{2})\nabla.(\frac{\nabla\Psi}{\|\nabla\Psi\|})\|\nabla\Psi\|)$$

$$\frac{\Psi_x^2\Psi_{yy} - 2\Psi_x\Psi_y\Psi_{xy} + \Psi_y^2\Psi_{xx}}{\Psi_x^2 + \Psi_y^2}$$

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Proposed Method Overview

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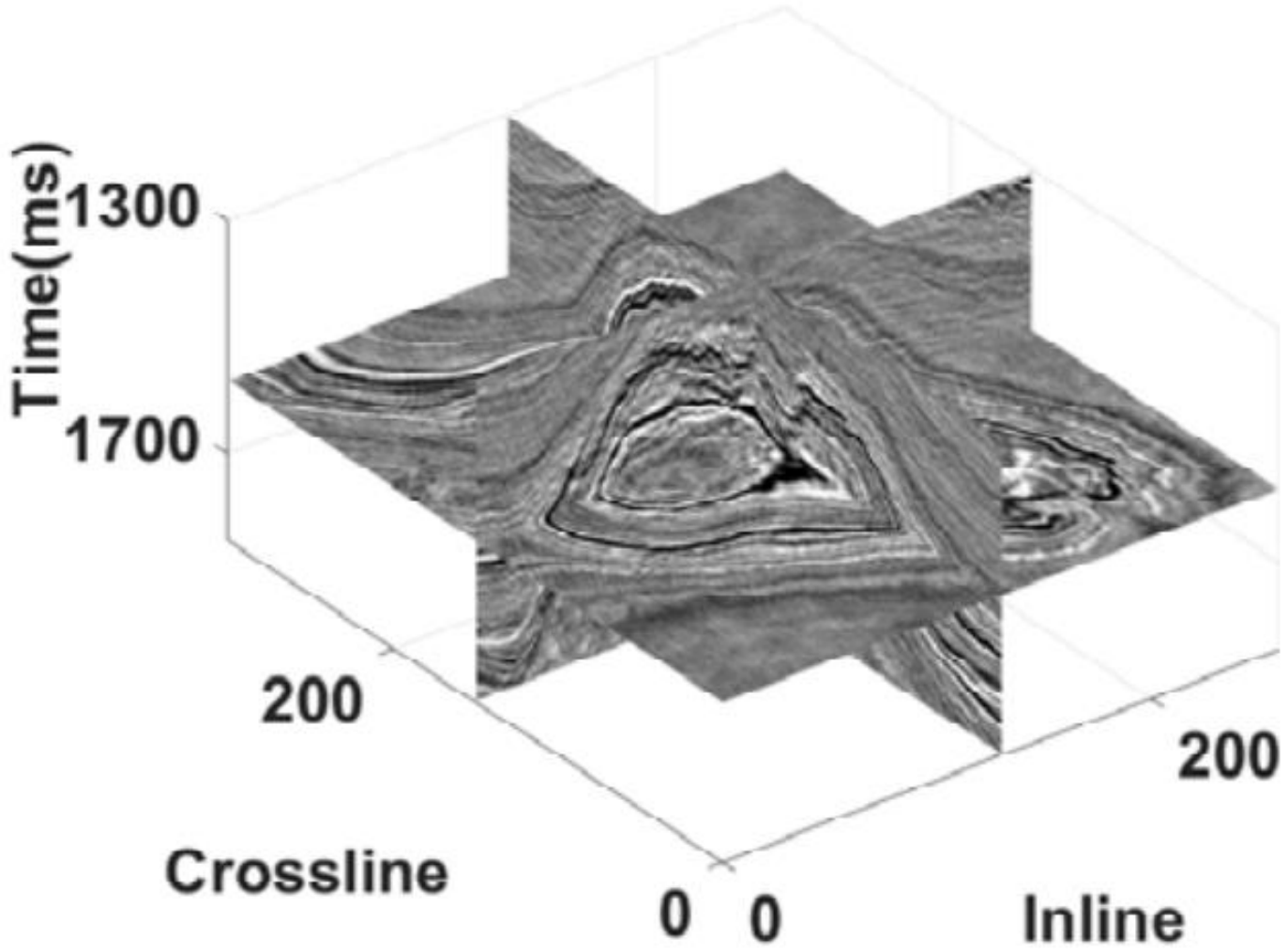
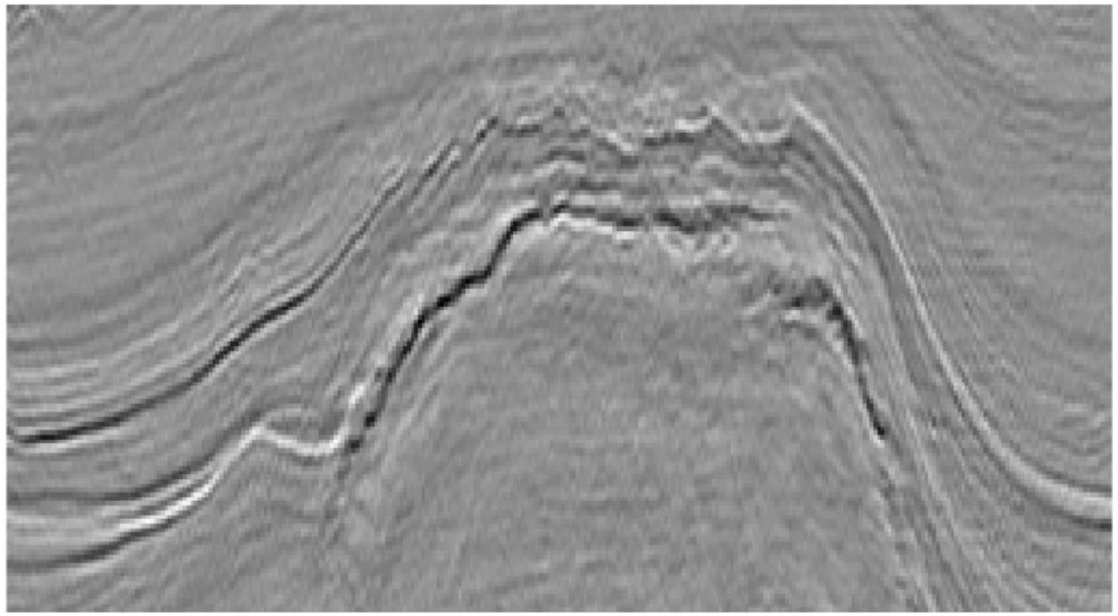
Real Seismic Dataset

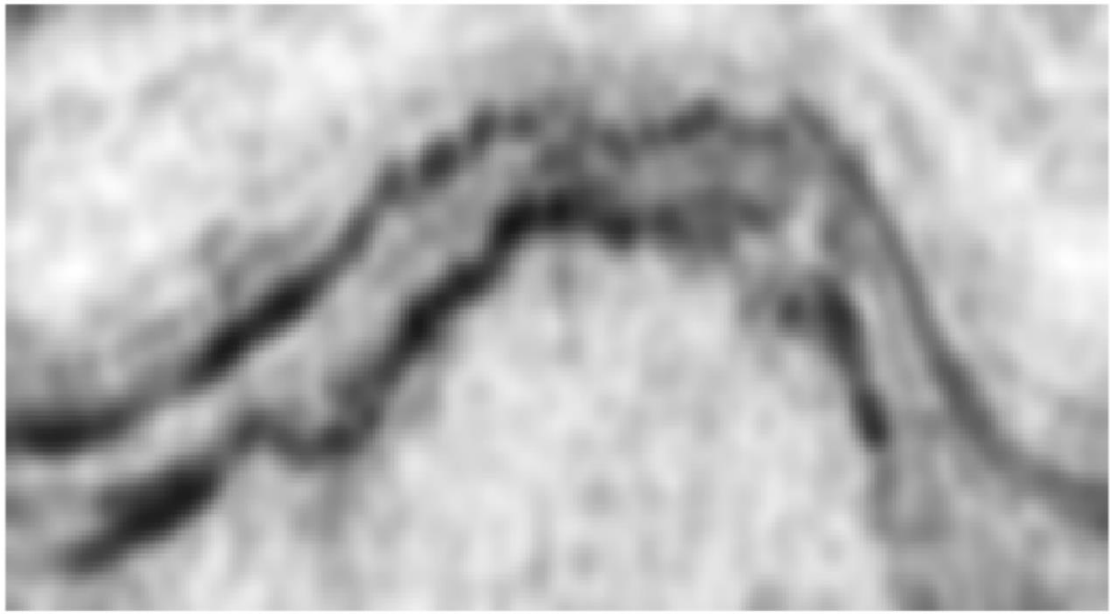


Edge Function

Seismic Section
Inline #369



Edge Function
Inline #369

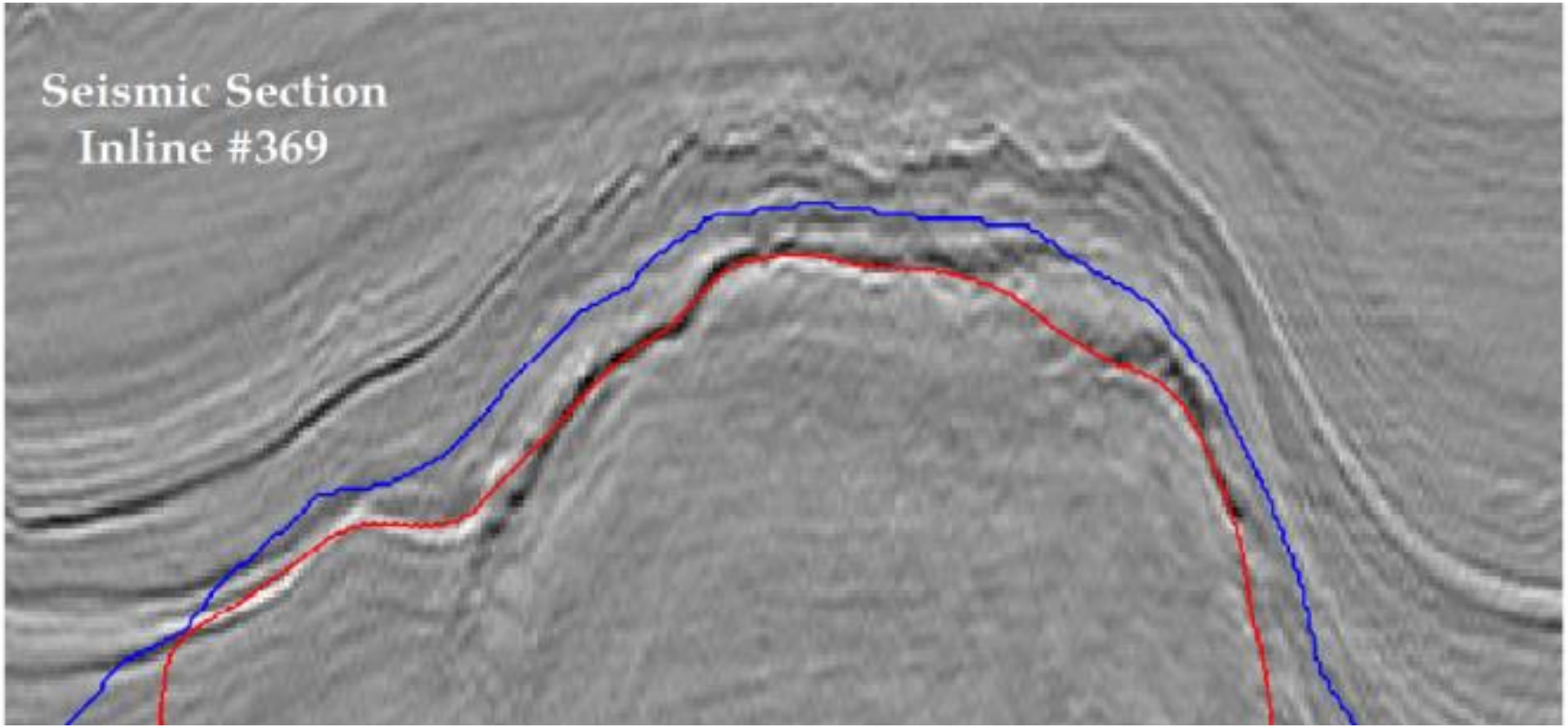


Experimental Results

Seismic Section # 369

Blue: Initial Curve

Red: Curve after level set evolution

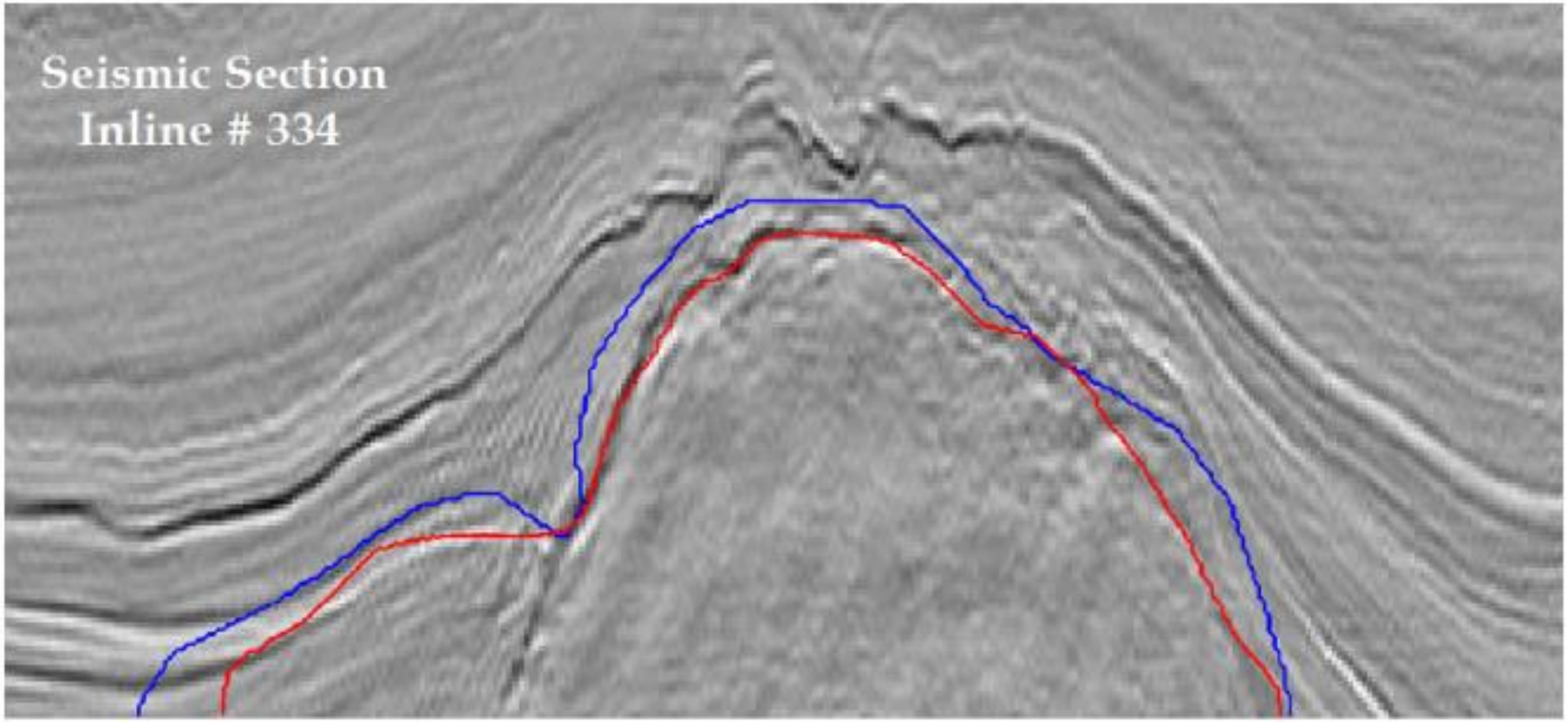


Experimental Results

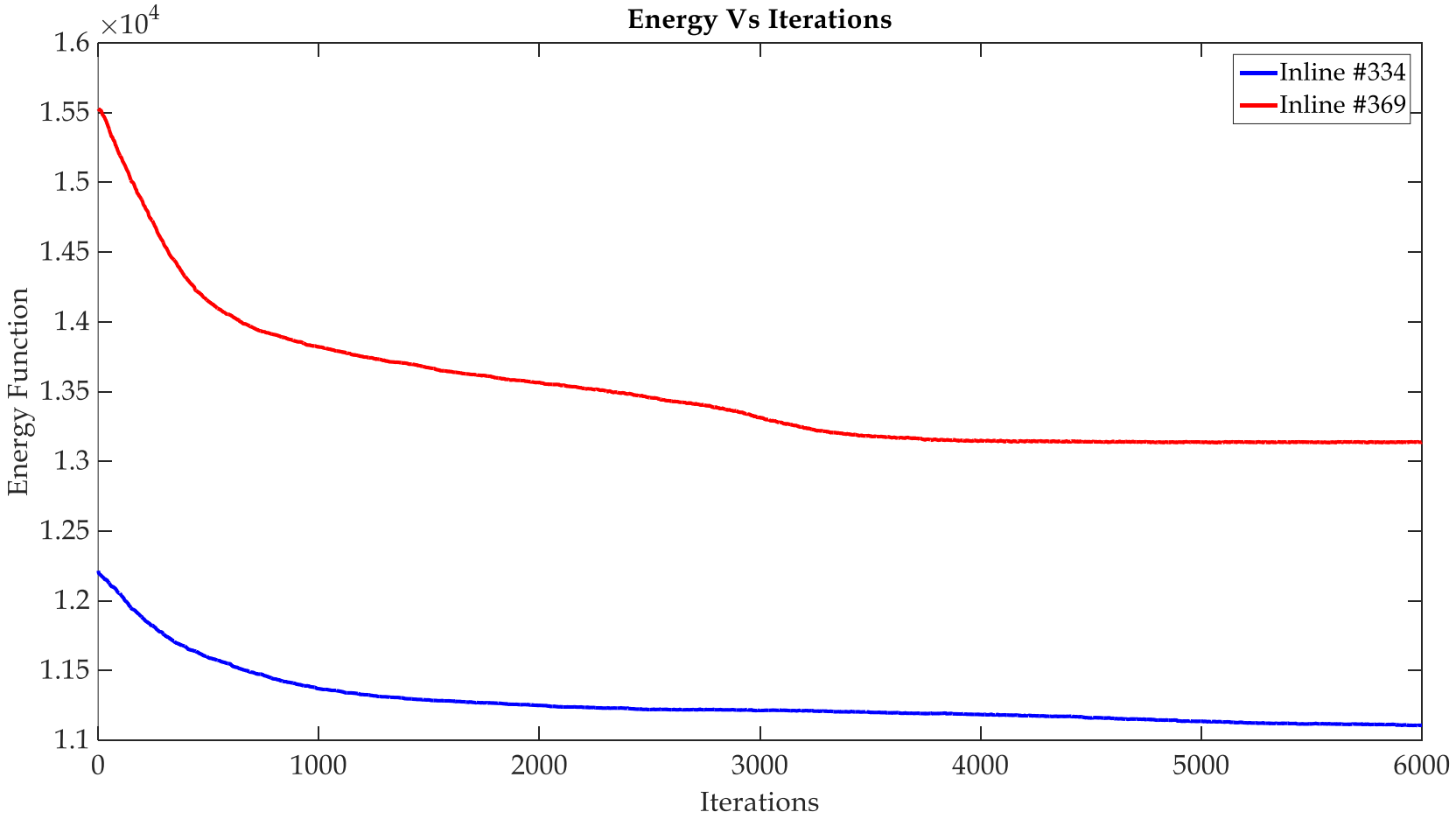
Seismic Section # 334

Blue: Initial Curve

Red: Curve after level set evolution



Energy Minimization



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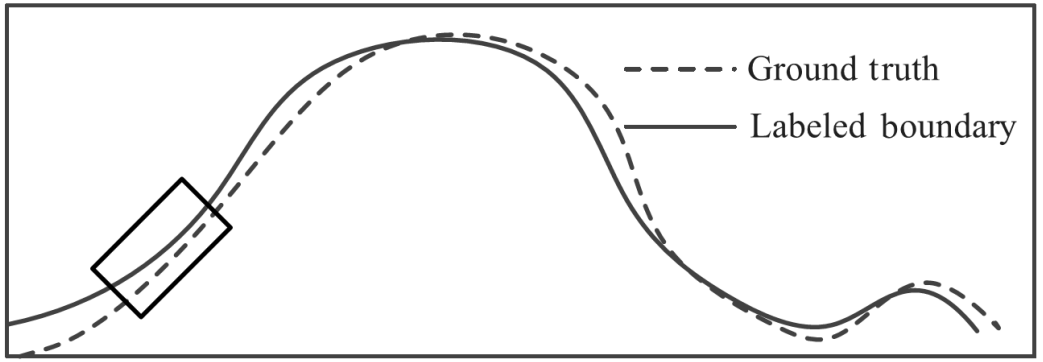
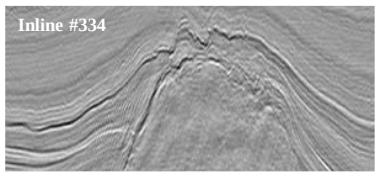
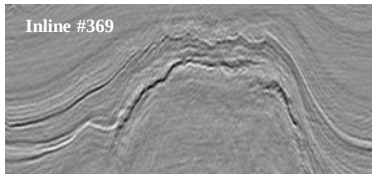
Comparison: Objective Evaluation

- SalSIM: Frechet distance-based similarity index



$$\text{SalSIM} = \underbrace{e^{-\alpha\cdot(\mu_d+\sigma_d)}}_{\text{Local item}} \cdot \underbrace{e^{-\beta\cdot d_{\max}}}_{\text{Global item}}$$

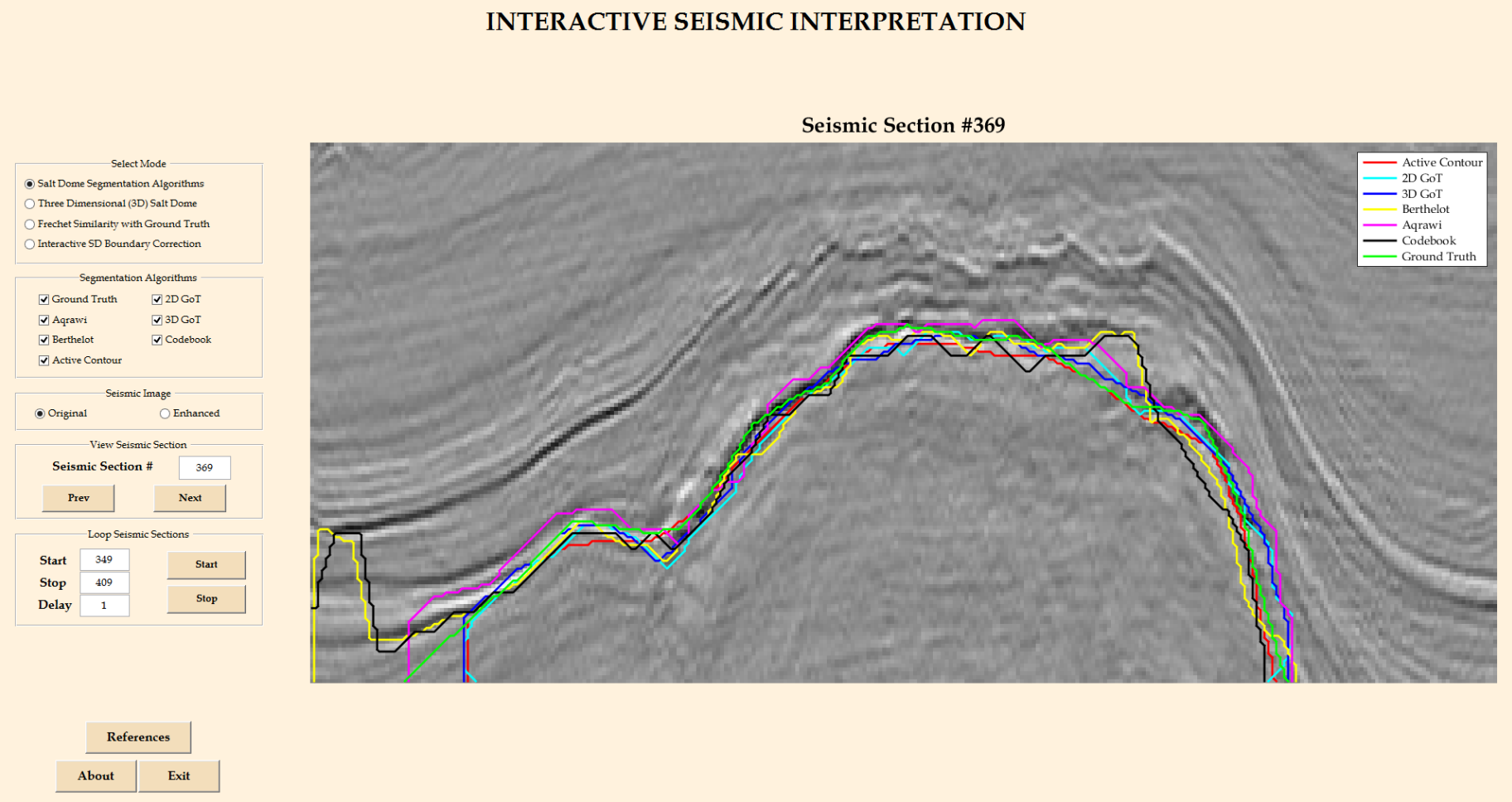




Methods	Inline #334	Inline #369
Aqrawi et al.	0.7048	0.9351
Berthelot et al	0.8463	0.9194
Shafiq et al.	0.8595	0.9378
Active Contour	0.9470	0.9640

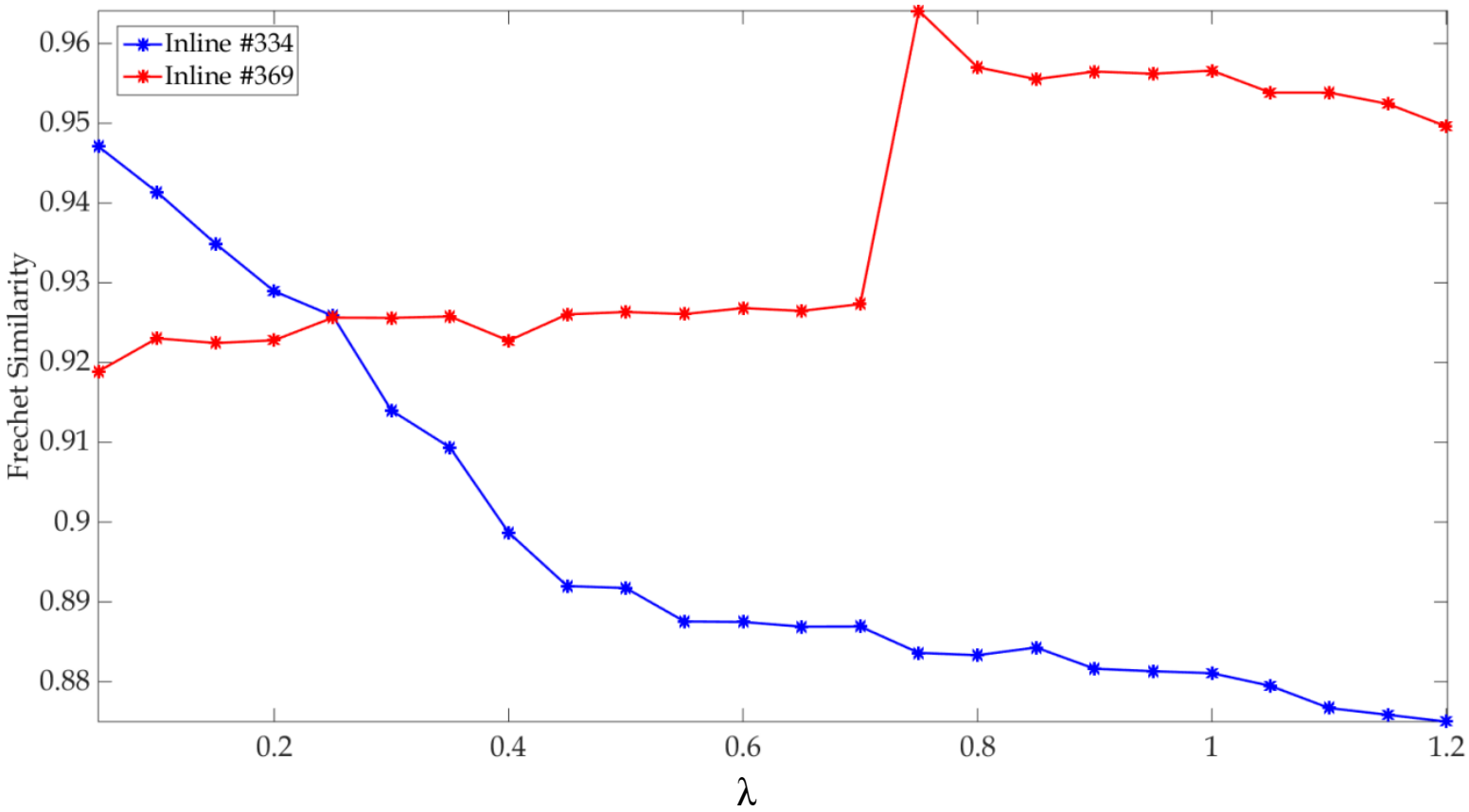
Software Demonstration

http://cegp.ece.gatech.edu/



Curve Length Penalty

- Fréchet similarity vs λ



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Summary

- Geodesic Active contour based method for salt dome delineation.
- Implicit level set implementation using gradient descent.
- Curve length penalty for smoothness and length.
- Experimental results show effectiveness on real dataset of the North Sea, F3 block.
- Better results as compared to the state of the art methods.

References

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Thank You

Questions!

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