Spring 2019 Newsletter

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Texas Consortium for Computational Seismology • The University of Texas at Austin

Welcome to the 17th *TCCS Newsletter*!

The Texas Consortium for Computational Seismology is a joint initiative of the Bureau of Economic Geology (BEG) and the Oden Institute for Computational Engineering and Sciences at The University of Texas at Austin. Its mission is to address the most important and challenging research problems in computational geophysics as experienced by the energy industry while educating the next generation of research geophysicists and computational scientists.

TCCS Sponsors

TCCS appreciates the support of its 2019 sponsors: Anadarko, BP, Chevron, ConocoPhillips, Equinor, ExxonMobil, Saudi Aramco, Sinopec, Shell, and Total.

Spring Meeting

The Spring 2019 Research Meeting of the Texas Consortium for Computational Seismology will take place in Houston on April 18–19. Hosted by the Bureau of Economic Geology, it will be held at the Bureau's Houston Research Center. Representatives of participating companies are invited to register for the meeting by following the link at http://www.beg.utexas.edu/tccs/.

See You in San Antonio in September

TCCS has submitted 17 expanded abstracts to the 2019 SEG Annual Meeting in San Antonio. The submitted papers fall into seven different subject areas: Anisotropy, Borehole Geophysics, Interpretation, Machine Learning, Seismic Processing: Migration, Seismic Processing: Multiples, Noise and Regularization, Acquisition and Survey Design.

Professional Awards

Xinming Wu's presentation "Least-squares seismic horizons with local slopes and multigrid correlations" at the 88th SEG Annual Meeting in Anaheim was selected for the list of Top 25 SEG presentations.

Xinming was also selected as the 2020 **SEG Honorary Lecturer for South & East Asia**.

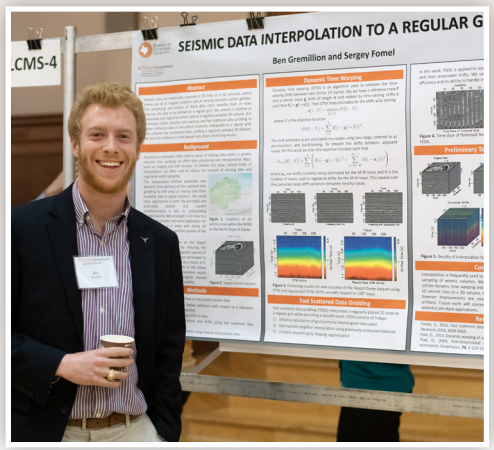
Sergey Fomel was selected as **Spring 2020 SEG Distinguished Lecturer**.

New Sponsors

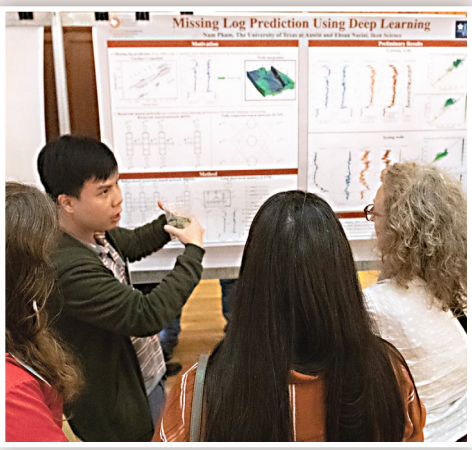
TCCS welcomes its new sponsors Shell, and Sinopec. TCCS is also grateful to the NVIDIA Corporation, who has granted the TITAN Xp Graphics Card to TCCS to promote machine-learning research.

Spring 2019 Jackson School Research Symposium

Each spring semester, students of the Jackson School of Geosciences at UT Austin present their research in a day-long poster competition. Throughout the day, faculty, research scientists, and industry representatives evaluate the posters. The goal of the symposium is to provide cross-disciplinary collaboration among graduate students, undergraduate students, and faculty/research scientists at the Jackson School. The event is sponsored by ConocoPhillips.



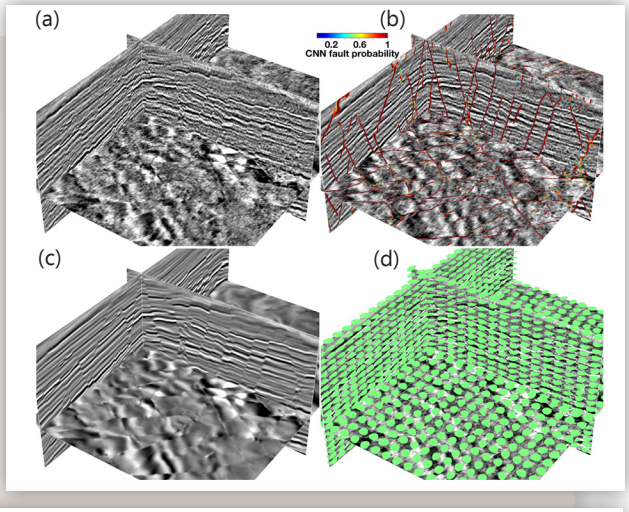
Ben Gremillion with his poster "Seismic data interpolation to a regular grid."



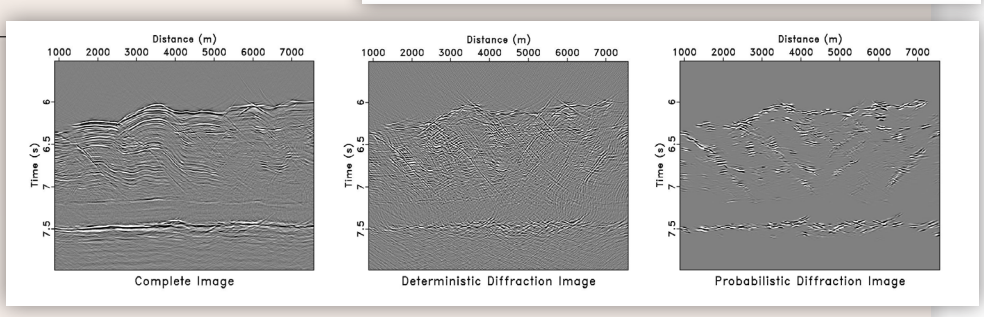
Nam Pham presenting his poster "Missing well log interpretation using deep learning" to judges.

Research Highlights

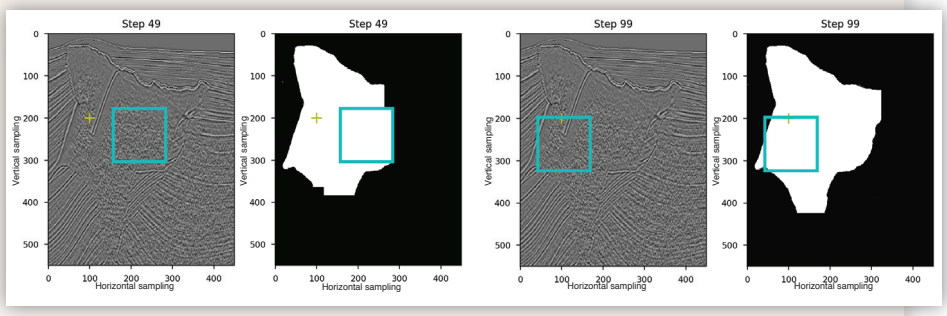
Xinming Wu has been working on (a) seismic images using deep learning for (b) local seismic image processing of fault detection, (c) structure-oriented smoothing with edge preserving, and (d) seismic normal estimation. All three seismic image processing tasks are related to each other and all involve analyzing seismic structural features. In conventional seismic image processing schemes, however, these three tasks are often independently performed by different algorithms, and challenges remain in each of them. Xinming proposes to simultaneously perform all three seismic image processing tasks by using a single convolutional neural network (CNN).



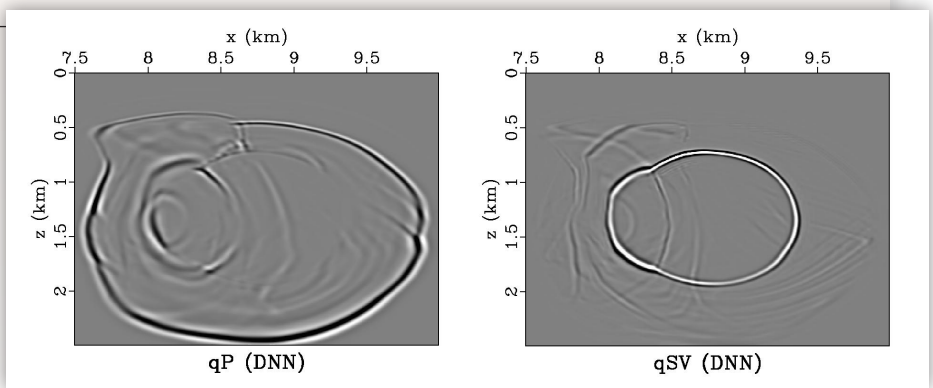
Luke Decker has been working on probabilistic methods for imaging seismic diffractions. The method uses gather semblance output from oriented velocity continuation to construct a number of weights tied to diffraction characteristics that represent the likelihood of a diffraction occurring at a location in the seismic image. This method does not require advance knowledge of migration velocity, which it generates as an output, and is able to suppress noise, migration artifacts, and remnant reflections in seismic images while amplifying diffractions. Shown are the results of applying the method to a 2D field dataset of the Nankai Trough: from left, a deterministic complete image, a generated deterministic diffraction image, and a probabilistic diffraction image employing the new method.



Yunzhi Shi has been working on interactive tracking of seismic geobodies using a deep-learning flood-filling network. The algorithm performs iterative segmentation and moving of the field of view (FoV). Instead of an end-to-end segmentation from the image to the classification mask, the proposed network takes the previous mask output, together with the seismic image in a new FoV, as a combined input to predict the mask at this FoV. The movement of the FoV is guided by the flood-filling algorithm in order to visit and segment the full extent of a geobody.



Harpreet Kaur has been working on elastic wave-mode separation in heterogeneous anisotropic media using deep learning. The proposed algorithm uses deep neural networks (DNNs) to circumvent the need to solve the Christoffel equation at each spatial loca-tion of the medium for each time slice, which makes the algorithm efficient. The network is trained using five to six time slices of horizontal and vertical components of the seismic wavefields along with the corresponding qP- and qS-wave modes for a particular source location and then tested on all other time slices with different source locations, which are not a part of training. Figures show one snapshot of the separated qP- and qS-wave modes at t=0.39s for the BP 2007 TTI model, using DNNs.



Papers Accepted and Published 2018–2019

http://www.beg.utexas.edu/tccs/publications

Accepted

S. Bader, X. Wu, and S. Fomel, 2019, Missing log data interpolation and semiautomatic seismic well ties using data matching techniques: Interpretation.

B. Engquist and Y. Yang, 2018, Seismic imaging and optimal transport: Communications in information and systems.

B. Engquist and Y. Yang, 2018, Seismic inversion and the data normalization for optimal transport: Methods and Applications of Analysis.

D. Merzlikin, S. Fomel, and M. Sen, 2019, Least-squares path-summation diffraction imaging using sparsity constraints: Geophysics.

N. Pham, S. Fomel, and D. Dunlap, 2019, Automatic channel detection using deep learning: Interpretation.

Y. Shi, X. Wu, and S. Fomel, 2019, SaltSeg: Automatic 3D salt segmentation using a deep convolutional neural network: Interpretation.

X. Wu, L. Liang, Y. Shi, and S. Fomel, 2019, FaultSeg: Using synthetic datasets to train an end-to-end CNN for 3D fault segmentation: Geophysics.

Published 2019

Y. A. Stovas and S. Fomel, 2019, Generalized velocity approximation: Geophysics, v. 84, C27–C40.

X. Wu and Z. Guo, 2019, Detecting faults and channels while enhancing seismic structural and stratigraphic features: Interpretation, v. 7, T155–T166.

C. Wang, Z. Zhu, H. Gu, X. Wu and S. Liu, 2019, Hankel low-rank approximation for seismic noise attenuation: IEEE, v. 57, 561–573.

Published 2018

Y. Chen and S. Fomel, 2018, EMD-seislet transform: Geophysics, v. 83, A27–A32.

B. Engquist and H. Zhao, 2018, Approximate separability of the Green's function of the Helmholtz equation in the high frequency limit: Communications on Pure and Applied Mathematics, v. LXXI, 2220–2274.

S. Greer and S. Fomel, 2018, Matching and merging high-resolution and legacy seismic images: Geophysics, v. 83, V115–V122.

Y. Sripanich and S. Fomel, 2018, Fast time-to-depth conversion and interval velocity estimation with weak lateral variations: Geophysics, v. 83, S227–S235.

G. Wu, S. Fomel, and Y. Chen, 2018, Data-driven time-frequency analysis of seismic data using nonstationary Prony method: Geophysical Prospecting, v. 66, 85–97.

X. Wu and S. Fomel, 2018, Automatic fault interpretation with optimal surface voting: Geophysics, Geophysics, v. 83, O67–O82.

X. Wu and S. Fomel, 2018, Least-squares horizons with local slopes and multi-grid correlations: Geophysics, v. 83, IM29–IM40.

X. Wu, S. Fomel, and M. Hudec, 2018, Fast salt boundary interpretation with optimal path picking: v. 83, O45–O53.

X. Wu, Y. Shi, S. Fomel, and F. Li, 2018, Incremental correlation of multiple well logs following geologically optimal neighbors: Interpretation, v. 6, T713–T722.

Q. Xu and B. Engquist, 2018, A mathematical model for fitting and predicting relaxation modulus and simulating viscoelastic responses: Proceedings of the Royal Society A, v. 474, 20170540.

Z. Xue, S. Fomel, and J. Sun, 2018, Increasing resolution of reverse-time migration using time-shift gathers: Geophysical Prospecting, v. 66, 726–735.

Z. Xue, J. Sun, S. Fomel, and T. Zhu, 2018, Accelerating full-waveform inversion with attenuation compensation: Geophysics, v. 83, A13–A20.

Z. Xue, X. Wu, and S. Fomel, 2018, Predictive painting across faults: Interpretation, v. 6, T449–T455.

Y. Yang and B. Engquist, 2018, Analysis of optimal transport and related misfit functions in full-waveform inversion, Geophysics, v. 83, A7–A12.

Y. Yang, B. Engquist, J. Sun, and B. Hamfeldt, 2018, Application of optimal transport and the quadratic Wasserstein metric to full-waveform inversion: Geophysics, v. 83, R43–R62.

TCCS Staff

The TCCS group consists of people from five countries. Our research staff includes two principal investigators, four Ph.D. students, two M.S. students, and a postdoc:

Luke Decker (Ph.D. 3rd year)
Björn Engquist (PI)
Sergey Fomel (PI)
Zhicheng Geng (Ph.D. 2nd year)
Ben Gremillion (M.S. 2nd year)
Harpreet Kaur (Ph.D. 2nd year)
Nam Pham (M.S. 2nd year)
Yunzhi Shi (Ph.D. 4th year)
Xinming Wu (Postdoc)

TCCS group members and family at Austin's Emma Long Metropolitan Park for a weekend barbeque.

For more information, see http://www.beg.utexas.edu/tccs/staff.

Testimonial

Yuhan Sui
(Visiting scholar: Harbin Institute of Technology, China)

I joined TCCS as a visiting scholar in November 2017. The research group is filled with incredibly smart people who bring different skill sets and perspectives to research projects. During my time with TCCS, I have had an opportunity to work with several of my colleagues to understand and solve extremely challenging, but interesting, problems; it was amazing to see how productive and encouraging my colleagues were, even as the problems grew more complex. TCCS is a family of young, fun-loving, and passionate research scientists who enjoy seeking answers to the most challenging problems in geophysics. I will cherish this bond for many years to come. Dr. Fomel is extremely kind and approachable; he allows us to work on projects that interest us, providing guidance and insight when we need it. I can honestly say that joining TCCS is one of the best decisions I have ever made in my life. I hope that TCCS will always be a warm and nurturing family for many future generations of geophysicists.

Ph.D. Dissertations

Name	Year	Title	Current Employer
Dmitrii Merzlikin	2018	Diffraction Imaging by Path- Summation Migration	The University of Texas at Austin
Yunan Yang	2018	Optimal Transport for Seismic Inverse Problems	Courant Institute
Yanadet Sripanich	2017	Seismic Anisotropy Analysis Using Muir-Dellinger Parameters	PTTEP
Zhiguang Xue	2017	Regularization Strategies for Increasing Efficiency and Robustness of Least-Squares RTM and FWI	CGG
Junzhe Sun	2016	Seismic Modeling and Imaging in Complex Media Using Low-Rank Approximation	ExxonMobil
Yangkang Chen	2015	Noise Attenuation in Seismic Data from the Simultaneous-Source Acquisition	Zhejiang University
Parvaneh Karimi	2015	Seismic Interpretation Using Predictive Painting	Occidental Petroleum
Vladimir Bashkardin	2014	Phase-Space Imaging of Reflection Seismic Data	BP
Christina Frederick	2014	Numerical Methods for Multiscale Inverse Problems	Georgia Institute of Technology
Siwei Li	2014	Imaging and Velocity Model Building with Linearized Eikonal Equation and Upwind Finite-Differences	Chevron
Jack Poulson	2012	Fast Parallel Solution of Heterogeneous 3D Time-Harmonic Wave Equations	Hodge Star Scientific Computing
Xiaolei Song	2012	Application of Fourier Finite Differences and Lowrank Approximation Method for Seismic Modeling and Subsalt Imaging	BP
Paul Tsuji	2012	Fast Algorithms for Frequency-Domain Wave Propagation	Lawrence Livermore National Laboratory
William Burnett	2011	Multiazimuth Velocity Analysis Using Velocity-Independent Seismic Imaging	ExxonMobil

M.S. Theses

Sean Bader	2018	Seismic and Well Log Data Integration Using Data-Matching Techniques	EOG
Mason Phillips	2017	Geophysical Data Registration Using Modified Plane-Wave Destruction Filters	DownUnder Geosolutions
Kelly Regimbal	2016	Improving Resolution of NMO Stack Using Shaping Regularization	ExxonMobil
Ryan Swindeman	2015	Iterative Seismic Data Interpolation Using Plane-Wave Shaping	Enthought
Luke Decker	2014	Seismic Diffraction Imaging Methods and Applications	The University of Texas at Austin
Shaunak Ghosh	2013	Multiple Suppression in the t-x-p Domain	CGG
Salah Alhadab	2012	Diffraction Imaging of Sediment Drifts in Canterbury Basin	Saudi Aramco
Yihua Cai	2012	Spectral Recomposition and Multicomponent Seismic Image Registration	Shell

B.S. Honors Theses

Sarah Greer	2018	A Data Matching Algorithm and Its Applications in Seismic Data Analysis	MIT
Lubna Barghouty	2013	Surface-Related Multiple Elimination and Velocity-Independent Imaging	MIT
Yanadet Sripanich	2013	An Efficient Algorithm for Two-Point Seismic Ray Tracing	PTTEP