Welcome to the 18th *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.

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Fall Meeting

The Fall 2019 Research Meeting of the Texas Consortium for Computational Seismology will take place in Austin on **November 5–6.** Hosted by the Oden Institute, it will be held in the Peter O'Donnell Building (POB) at the University of Texas at Austin main campus.

Representatives of participating companies are invited to register for the meeting by following the link at: http://www.beg.utexas.edu/tccs/.

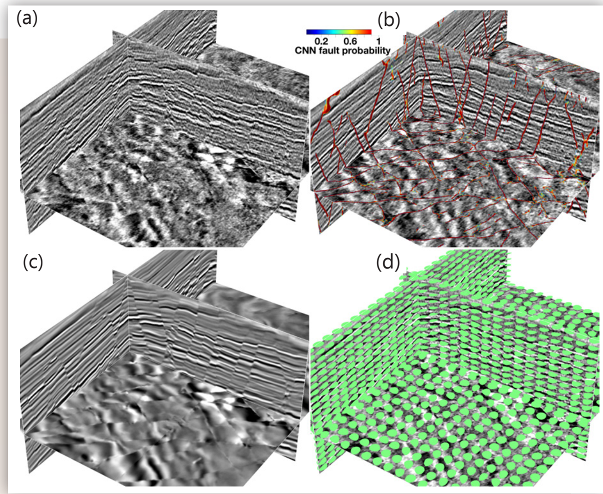
Presentations at SEG in San Antonio

TCCS members and collaborators will make a number of presentations at the upcoming SEG 2019 Annual Meeting in San Antonio. The presentations 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.

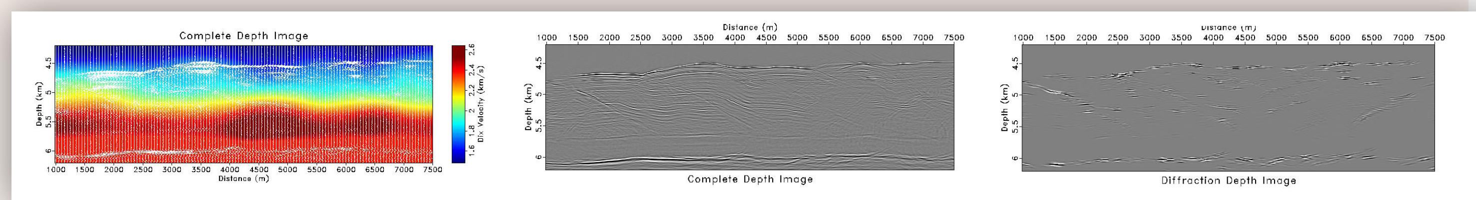
Monday, Sept. 16	1:50 pm	MLDA 1: Seismic Processing	H. Kaur, N. Pham, and S. Fomel	Seismic data interpolation using CycleGAN
	2:40 pm	SSS 1: Recent Advances and the Road Ahead	X. Wu, Z. Geng, Y. Shi, N. Pham, and S. Fomel	Building realistic structure models to train convolutional neural networks for seismic structural interpretation”
	3:30 pm	SPET 1: Signal and Image Processing	S. Greer, S. Fomel, and M. Fry	Prestack phase corrections using local seismic attributes
	4:45 pm	MLDA 1: Seismic Processing	X. Wu, L. Liang, Y. Shi, Z. Geng, and S. Fomel	Deep learning for local seismic image processing: fault detection, structure-oriented smoothing with edge-preserving, and slope estimation by using a single convolutional neural network
Tuesday, Sept. 17	8:30 am	MLDA2: Intepretation 1	Z.Geng, X. Wu, Y. Shi and S. Fomel	Relative geologic time estimation using a deep convolutional neural network
	8:30 am	MLDA 3: Seismic Inversion 1	H. Kaur, N. Pham and S. Fomel	Estimating the inverse Hessian for amplitude correction of migrated images using deep learning
	9:20 am	MLDA 2: Interpretation 1	Y. Shi and X. Wu	Interactive tracking of seismic geobodies using deep learning flood-filling network
	2:15 pm	MLDA 4: Seismic Inversion 2	H. Kaur, S. Fomel, and N. Pham	Overcoming numerical dispersion of finite-difference wave extrapolation using deep learning
	3:05 pm	FWI 3: Cycle-skipping 2	Y. Yang and B. Engquist	Improving optimal transport based FWI through data normalization
	3:55 pm	SPMI 3: Least Squares Migration Applications and Diffraction Imaging	L. Decker and S. Fomel	Path-integral seismic diffraction imaging with probability weights
	3:55 pm	ANI3:Applications 3	L. Decker and Q. Zhang	Correcting residual HTI moveout and determining principal anisotropic azimuth in arbitrarily sampled image gathers using dynamic time warping
Wednesday, Sept. 18	9:20 am	MLDA P8: Geophysics: Novel Concepts	H. Kaur, S. Fomel, and N. Pham	Elastic wave-mode separation in heterogeneous anisotropic media using deep learning
	11:25 am	SPMNR 3: Noise Attenuation, Sampling, Signal Reconstruction	B. Gremillion and S. Fomel	Seismic image interpolation from irregular locations to a 3D grid using dynamic time warping
	1:50 pm	MLDA 6 :Interpretation 3	N. Pham and X. Wu	Missing sonic log prediction using convolutional long short-term memory
	2:40 pm	MLDA 6: Interpretation 3	Q. Zhang, A. Yusifov, C. Joy, Y. Shi, and X. Wu	FaultNet: A deep CNN model for 3D automated fault picking

Research Highlights

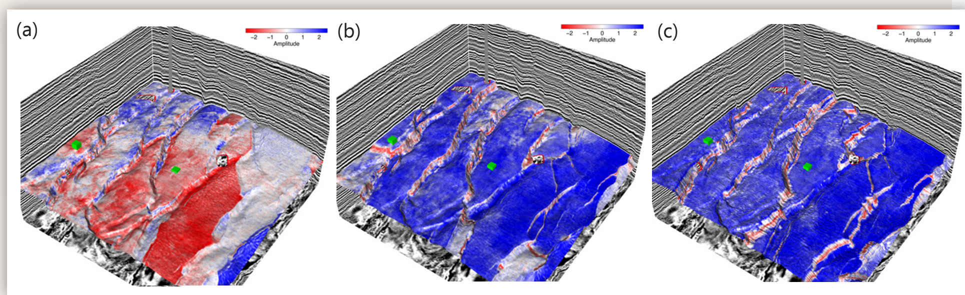
Xinming Wu has been working on deep learning for local seismic image processing of fault detection (b), structure-oriented smoothing with edge preserving (c), and seismic normal estimation (d). All the three seismic image processing tasks are related to each other and they all involve analyzing seismic 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 the three seismic image processing tasks by using a single convolutional neural network (CNN).



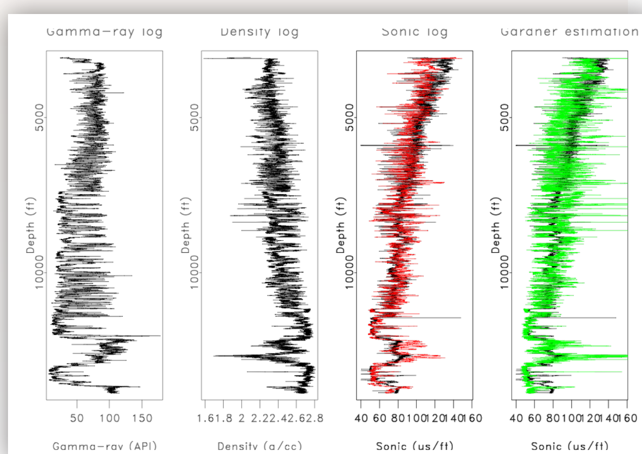
Luke Decker has been working on probabilistic approaches for simultaneously imaging seismic diffractions and determining migration velocity. Shown are the results of applying the method to a 2D field dataset of the Nankai Trough: left is a complete depth image overlaid on the Dix velocity determined using the method, middle is the complete depth image, and right is the probabilistic diffraction image in depth. The seafloor is clearly visible in the probabilistic diffraction image, as are thrust faults sloping downward from left to right, the plate boundary near 6.1 km depth, and a velocity inversion that occurs around 5.7 km depth



Yunzhi Shi has been working on an unsupervised machine-learning-based horizon picking method, Waveform Embedding, consisting of a deep convolutional autoencoder network to learn to transform seismic waveform samples to a latent space in which any waveform can be represented as an embedded vector. The method can guide the horizon picking across lateral discontinuities such as faults and is insensitive to noise and lateral distortions. The figure shows the comparison of horizon picking between (a) slope-based method, (b) multi-grid correlation method, and (c) the proposed method.



Nam Pham has been working on missing well-log prediction using a convolutional long short-term memory neural network. The network captures the geological trend and the local shaping information of logs. An experiment is done on predicting sonic logs from gamma-ray and density logs. The network is trained on wells from UK continental shelf and successfully predicts missing sonic logs of wells from Norwegian continental shelf and Scotian shelf offshore Canada. The model uncertainty is computed simultaneously using dropout layer at test time.



Papers Accepted and Published 2018–2019

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

Accepted

Y. Sripanich, S. Fomel, J. Trampert, W. Burnett, and T. Hess, 2019, Probabilistic moveout analysis by time-warping: Geophysics, accepted.

X. Wu, Y. Shi, S. Fomel, L. Liang, Q. Zhang, and A. Yusifov, 2019, FaultNet3D: Predicting fault probabilities, strikes, and dips with a single convolutional neural network: IEEE Transactions on Geoscience and Remote Sensing, accepted.

Z. Zhong, T. Carr, X. Wu, and G. Wang, 2019, Application of a Convolutional Neural Network (CNN) in permeability prediction: A case study in the Jacksonburg-Stringtown Oil Field, West Virginia, USA: Geophysics, accepted.

Published 2019

S. Bader, X. Wu, and S. Fomel, 2019, Missing log data interpolation and semiautomatic seismic well ties using data matching techniques: Interpretation, v. 7, T347–T361.

D. Merzlikin, S. Fomel, and M. Sen, 2019, Least-squares path-summation diffraction imaging using sparsity constraints: Geophysics, v. 84, S187–S200.

N. Pham, S. Fomel, and D. Dunlap, 2019, Automatic channel detection using deep learning: Interpretation, v. 7, SE43–SE50.

Y. Shi, X. Wu, and S. Fomel, 2019, SaltSeg: Automatic 3D salt segmentation using a deep convolutional neural network: Interpretation, v. 7, SE113–SE122.

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

Y. Sripanich, S. Fomel, A. Stovas, 2019, Effects of lateral heterogeneity on time-domain processing parameters: Geophysical Journal International, v. 219, 1181–1201.

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

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

X. Wu, L. Liang, Y. Shi, and S. Fomel, 2019, FaultSeg3D: Using synthetic data sets to train an end-to-end convolutional neural network for 3D seismic fault segmentation: Geophysics, v. 84, IM35–IM45.

Z. Xue, H. Zhang, Y. Zhao, and S. Fomel, 2019, Pattern-guided dip estimation with plane-wave destruction filters: Geophysical Prospecting, v. 67, 1798–1810.

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.

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.

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, 067-082.

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: Geophysics, v. 83, 045–053.

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.

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 2 principal investigators, 6 Ph.D. students, a postdoc, a visiting scholar, and a visiting scientist:

Raymond Abma (Visiting Scientist)
Luke Decker (Ph.D. 4th year)
Björn Engquist (PI)
Sergey Fomel (PI)
Zhicheng Geng (Ph.D. 3rd year)
Ben Gremillion (Ph.D. 1st year)
Kristian Jensen (Visiting scholar)
Harpreet Kaur (Ph.D. 3rd year)
Nam Pham (Ph.D. 1st year)
Yunzhi Shi (Ph.D. 5th 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.

Testimonials

Ben Gremillion

TCCS is an outstanding research group that has served as my academic home for the past two years. The diversity of topics being addressed, openness to new ideas, and emphasis on reproducibility all really make this consortium unique. Additionally, the possibilities for industry collaboration offer great opportunities for professional development. Sergey has been a wonderful advisor who encourages students to pursue topics that have real-world applications while simultaneously giving students the freedom to study whatever they choose. I learned a great deal about geophysics from Sergey during my Master's program, and I'm sure I'll learn much more over the course of my Ph.D.

Nam Pham

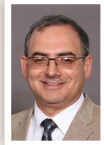
I am fortunate to have joined TCCS group and be surrounded by many innovative, creative, highly productive students and researchers. During my time in TCCS, I am supervised by Dr. Sergey Fomel, who is nice, approachable and knowledgeable. He is open to any ideas that I come up with and encourages me to approach new modern algorithms like deep learning. I can always get answers for my questions from him. I also have a chance to collaborate with exceptional colleagues solving challenging but interesting problems in geophysics. Besides researches, TCCS is a family with encouraging and supportive people. I can honestly say that joining TCCS is one of the best decisions I have made in my life. Seeing that I can have a chance to continue my work in deep learning for geophysical interpretation with the support and guidance from Dr. Sergey Fomel, I decide to continue my Ph.D. to solve some new intriguing and challenging problems of geophysics.

Ben Gremillion and Nam Pham during their Master's graduation ceremony. *(Left to right)* Ben Gremillion, Sergey Fomel, and Nam Pham.

Professional Awards

TCCS members are receiving a number of professional awards at the 2020 SEG Meeting in San Antonio.

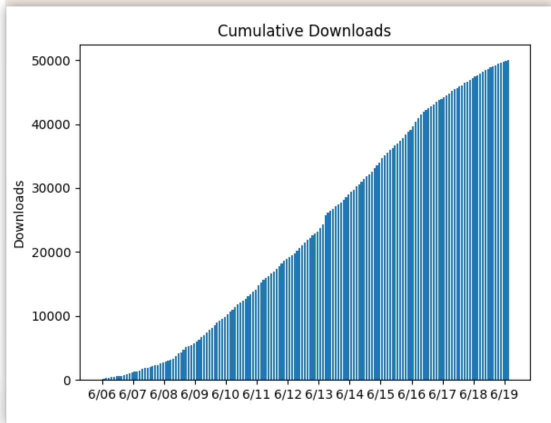
Ximing Wu was awarded Honorable Mention, Best Paper, for his presentation "Least-squares seismic horizons with local slopes and multigrid correlations" at the 2018 Annual Meeting. Xinming was also selected as the 2020 SEG Honorary Lecturer for South & East Asia.



Sergey Fomel, was selected as Spring 2020 SEG Distinguished Lecturer. In his lectures, he will discuss about the recent develop-ments in artificial intelligence and machine learning to automate different tasks in seismic data analysis and interpretation.

Hejun Zhu, a TCCS postdoc in 2013–2015 and currently an assistant professor at UT Dallas, is receiving the J. Clarence Karcher Award, a major SEG award for young geophysicists.

Madagascar-3.0



The major version of Madagascar, stable version 3.0, has been released. The main change is the added support for Python-3. Both Python-2 and Python-3 are now supported. The new version also features 14 new reproducible papers, as well as other enhancements. According to the SourceForge statistics, the previous 2.0 stable distribution has been downloaded about 6,000 times. The top country (with 27% of all downloads) was China, followed by the USA, Brazil, Canada, and India.

In September 2019, the total cumulative number of downloads for the stable version of Madagascar has reached 50 thousand. The current development version continues to be available through Github.

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