Fall 2022 Newsletter

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

Welcome to the 24th *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.

Fall Meeting

The Fall 2022 Research Meeting of the Texas Consortium for Computational Seismology will take place in Austin on October 20–21. Hosted by the Bureau of Economic Geology, it will be held in the it will be held at the University of Texas at Austin, J.J. Pickle Research 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 IMAGE 2022

TCCS members will make a number of presentations at IMAGE 2022 in Houston. The presentations fall into a number of different subject areas: Machine Learning and Data Analytics: Theory and Special Applications, Borehole Geophysics and Geomechanics, Seismic Processing: Multiples, Noise, and Regularization, and Seismic Theory.

August 30	11:10–11:35	Seismic Interpretation 3 (MLDA 6)	Nam Pham and Sergey Fomel	Seismic data augmentation for automatic faults picking using deep learning
	1:20–1:45	Advances in Borehole Geophysics and Geomechanics 2 (BG P1)	Hector Corzo-Pola and Sergey Fomel	Shortest-path multiple well-log correlation
	4:05–4:30	Velocity Model Building and Full-Waveform Inversion 2 (MLDA P5)	Harpreet Kaur, Sergey Fomel, and Nam Pham	Automated hyper-parameter optimization for deep learning framework to simulate boundary conditions for wave propagation
August 31	10:20–10:45	Novel Applications 2 (MLDA P6)	Sahana Vinayak, Ray Abma, and Sergey Fomel	Automatic detection of SEG-Y sampling format errors using machine learning
	10:20–10:45	Regularization and Deblending (SPMNR 3)	Sergey Fomel	Operator chains and seismic data decomposition
	10:45–11:10	Regularization and Deblending (SPMNR 3)	Reem Alomar and Sergey Fomel	Least-squares non-stationary triangle smoothing
	3:10–3:35	Theoretical Developments in Imaging, Inversion, and Wave Phenomena (ST 1)	Sergey Fomel	Shaping regularization by fast explicit diffusion

Professional Award

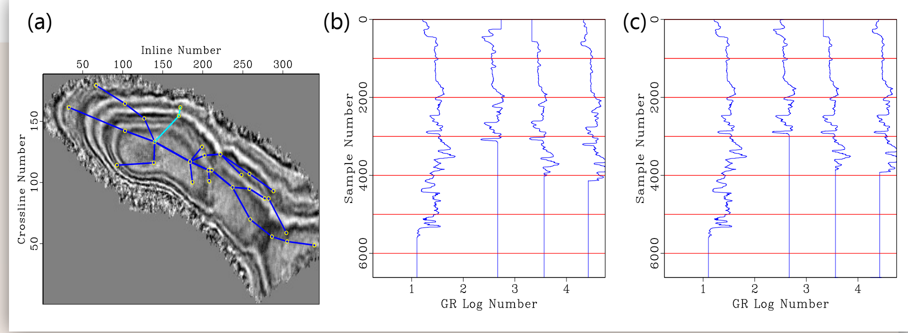
Sergey Fomel is being awarded by SEG with an honorary membership. Such membership is "conferred upon persons who, by unanimous vote of the Honors and Awards Committee and the Board of Directors, have made distinguished contributions, which warrants exceptional recognition, to exploration geophysics or a related field or to the advancement of the profession of exploration geophysics through service to the Society." The award ceremony will take place at the IMAGE conference in Houston.

TCCS Sponsors

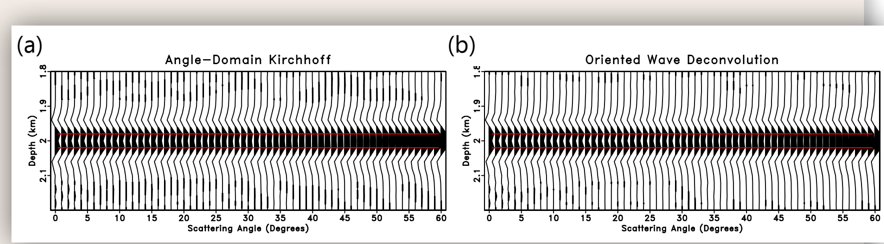
TCCS appreciates the support of its 2022 sponsors: BP, Chevron, ConocoPhillips, Equinor, ExxonMobil, Petrobras, PetroChina, Saudi Aramco, Shell, Sinopec, and TGS

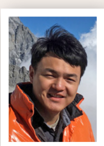
Research Highlights

Hector Corzo Pola has been working on automatic sequential multiple well-log correlation. Multiple well logs can be correlated either simultaneously or sequentially. Sequential correlations are faster to compute than simultaneous correlations; however, they are susceptible to error propagation as the sequence advances and the final error depends on the quality of the correlation sequence. To solve this issue, Hector uses a method that (1) identifies optimal correlation sequences using Dijkstra's shortest path method and then (2) automatically aligns well-logs using local similarity scans. His experimental results on synthetic data show promising results that are as good or better than exhaustive search on possible sequential correlation sequences. The figures show (a) the computed shortest correlation paths from the reference well to every other well, b) unaligned GR logs along the highlighted path and c) the same GR logs after alignment.

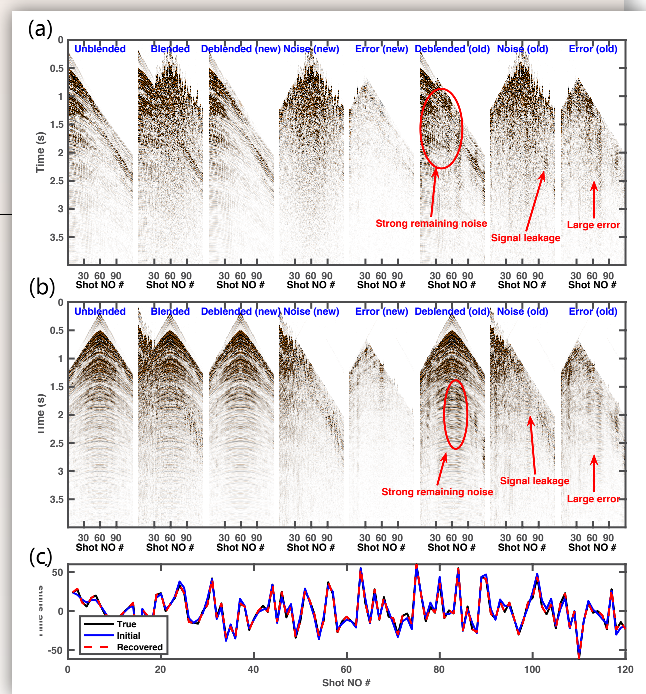


Ben Gremillion has been working on seismic wave propagation and imaging using oriented waves. Conventional wavefields are functions of space and time. Decomposing conventional wavefields into their phase-space components, oriented wavefields are functions of space, time, and propagation direction. Such a construction allows for natural implementation of direction-dependent phenomena, such as angle-dependent reflectivity, anisotropy, and wave vector polarization. The figure shows an angle-domain image of a thin bed obtained using (a) Kirchhoff migration and (b) the deconvolution imaging condition applied to oriented waves.

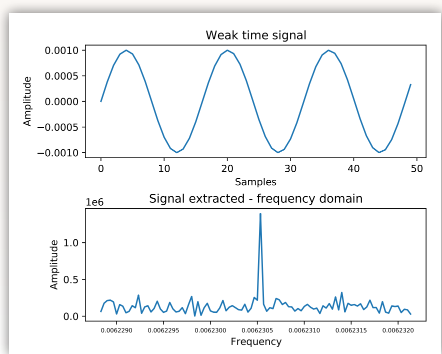




Yangkang Chen has proposed a joint inversion framework to simultaneously separate the blended sources and invert for the shot time. He formulates a nonlinear inverse problem that contains two unknowns, i.e., the unblended data and the shot-time vector, and develops a Gauss-Newton method to iteratively invert the shot-time vector given an estimate of the unblended data. Then, the estimated shot-time vector is fixed for iterative source separation following a traditional deblending framework. The two aforementioned steps are recursively implemented until they converge or reach a maximum number of iterations. The figure shows results of a field data example. (a) Deblending results of the first source. (b) Deblending results of the second source. (c) Comparison of the shot schedules. The inverted shot schedule is almost the same as the ground truth.



Raymond Abma has been working on gravitational wave detection from the International Deployment of Accelerometers (IDA) and USGS arrays. Gravitational waves create weak, low-frequency signals that are normally obscured by noise in accelerometer data. By adapting principles from sign-bit amplitude recovery in seismic data, gravitational wave signals in the IDA and USGS arrays may be resolvable. The figure shows the original weak signal with sub-integer amplitudes on the time (top) and the frequency domain signal (bottom) that has been recovered from noise-contaminated, integer-only data. These developments can also be applied to exploration geophysics, such as in Vibroseis and Popcorn air-gun seismic acquisition.



Papers Accepted and Published 2021–2022

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

Accepted

Y. Chen, S. Fomel, and R. Abma, 2022, Joint deblending and source time inversion: Geophysics, accepted.

H. Kaur, J. Sun, M. Aharchaou, A. Baumstein, and S. Fomel, 2022, Deep learning framework for true amplitude imaging: Effect of conditioners and initial models: Geophysical Prospecting, accepted.

N. Pham and S. Fomel, 2022, Seismic data augmentation for automatic fault picking using deep learning: Geophysical Prospecting, accepted.

L. Yang, S. Wang, X. Chen, W. Chen, O. Saad, X. Zhou, N. Pham, Z. Geng, S. Fomel, and Y. Chen, 2022, High-fidelity permeability and porosity prediction using deep learning with the self-attention mechanism: IEEE Transactions on Neural Networks and Learning Systems, accepted.

Published 2022

Y. Chen, O. Saad, A. Savvaidis, Y. Chen, and S. Fomel, 2022, 3D microseismic monitoring using machine learning: Journal of Geophysical Research—Solid Earth, v. 127, e2021JB023842.

L. Decker and S. Fomel, 2022, A probabilistic approach to seismic diffraction imaging: Lithosphere, v. 2021, 6650633.

L. Decker and S. Fomel, 2022, A variational approach for picking optimal surfaces from semblance-like panels: Geophysics, v. 87, U93–U108.

Z. Geng, Z. Hu, X. Wu, and S. Fomel, 2022, Semi-supervised salt segmentation using mean teacher: Interpretation, v. 10, SE21–SE29.

Z. Geng, Z. Zhao, Y. Shi, X. Wu, S. Fomel, and M. Sen, 2022, Deep learning for velocity model building with common-image gathers: Geophysical Journal International, v. 228, 1054–1070.

G. Huang, X. Chen, O. Saad, Y. Chen, S. Fomel, A. Savvaidis, Y. Chen, 2022, High-resolution and robust microseismic grouped imaging and grouping strategy analysis: Geophysical Prospecting, v. 70, 980–1002.

H. Kaur, A. Sun, Z. Zhong, and S. Fomel, 2022, Time-lapse seismic data inversion for estimating reservoir parameters using deep learning: Interpretation, v. 10, T167–T179.

N. Pham and W. Li, 2022, Physics-constrained deep learning for ground-roll attenuation: Geophysics, v. 87, V15–V27.

O. Saad, Y. Chen, A. Savvaidis, S. Fomel, and Y. Chen, 2022, Real-time earthquake detection and magnitude estimation using vision transformer: Journal of Geophysical Research—Solid Earth, v. 127, e2021JB023657.

O. Saad, Y. Chen, D. Trugman, M. S. Soliman, L. Samy, A. Savvaidis, M. A. Khamis, A. G. Hafez, S. Fomel, and Y. Chen, 2022, Machine learning for the fast and reliable source-location prediction in earthquake early warning: IEEE Geoscience and Remote Sensing Letters, v. 19, 8025705.

H. Wang, Y. Chen, O. Saad, W. Chen, Y. Oboue, L. Yang, S. Fomel, and Y. Chen, 2022, A Matlab code package for 2D/3D local slope estimation and structural filtering: Geophysics, v. 87, F1–F14.

H. Wang, Y. Yunfeng, Y. Oboue, R. Abma, Z. Geng, S. Fomel, and Y. Chen, 2022, Simultaneous reconstruction and denoising of extremely sparse 5D seismic data by a simple and effective method: IEEE Transactions on Geoscience and Remote Sensing, v. 60, 5909212.

S. Zu, H. Cao, S. Fomel, and Y. Chen, 2022, Robust local slope estimation by deep learning: Geophysical Prospecting, v. 70, 847–864.

Published 2021

Y. Chen and S. Fomel, 2021, Nonstationary local signal-and-noise orthogonalization: Geophysics, v. 86, V409–V418.

Y. Chen, S. Fomel, H. Wang, and S. Zu, 2021, 5D dealiased seismic data interpolation using nonstationary prediction-error filter: Geophysics, v. 86, V419–V429.

Y. Chen, O. Saad, G. Huang, Y. Chen, A. Savvaidis, S. Fomel, and N. Pham, 2021, SCALODEEP: A highly generalized deep learning framework for real-time earthquake detection: Journal of Geophysical Research—Solid Earth, v. 126, e2020JB021473.

Y. Chen, O. Saad, X. Liu, and S. Fomel, 2021, A compact program for 3D passive seismic source-location imaging: Seismological Research Letters, v. 92, 3187–3201.

S. Fomel and H. Kaur, 2021, Wave-equation time migration: Geophysics, v. 86, 1JF–V89.

G. Huang, X. Chen, J. Li; O. Saad, Y. Chen, S. Fomel, C. Luo, and H. Wang, 2021, The slope attribute regularized high-resolution prestack seismic inversion: Surveys in geophysics, v. 42, 625–671.

H. Kaur, S. Fomel, and N. Pham, 2021, A fast algorithm for elastic wave-mode separation using deep learning with generative adversarial networks (GANs): Journal of Geophysical Research—Solid Earth, v. 126, e2020JB021123.

H. Kaur, N. Pham, and S. Fomel, 2021, Seismic data interpolation using deep learning with generative adversarial networks: Geophysical Prospecting, v. 69, 307–326.

N. Pham and S. Fomel, 2021, Uncertainty and Interpretability analysis of encoder-decoder architecture for channel detection: Geophysics, v. 86, O49–O58.

Y. Shi, X. Wu, and S. Fomel, 2021, Interactively tracking seismic geobodies with a deep learning flood-filling network: Geophysics, v. 86, A1–A5.

TCCS Staff

The TCCS group consists of people from seven countries. Our research staff includes two principal investigators (PI), four Ph.D. students, one M.S. student, one research scientist, and one visiting scientist:


TCCS group members

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

- Raymond Abma (Visiting Scientist)
- Yangkang Chen (Research Scientist)
- Héctor Corzo Pola (M.S. 3rd year)
- Björn Engquist (PI)
- Sergey Fomel (PI)
- Rebecca Gao (Ph.D. 3rd year)
- Ben Gremillion (Ph.D. 4th year)
- Tyler Masthay (Ph.D. 6th year)
- Nam Pham (Ph.D. 4th year)
- Yiran Shen (Ph.D., 6th year)

Testimonial

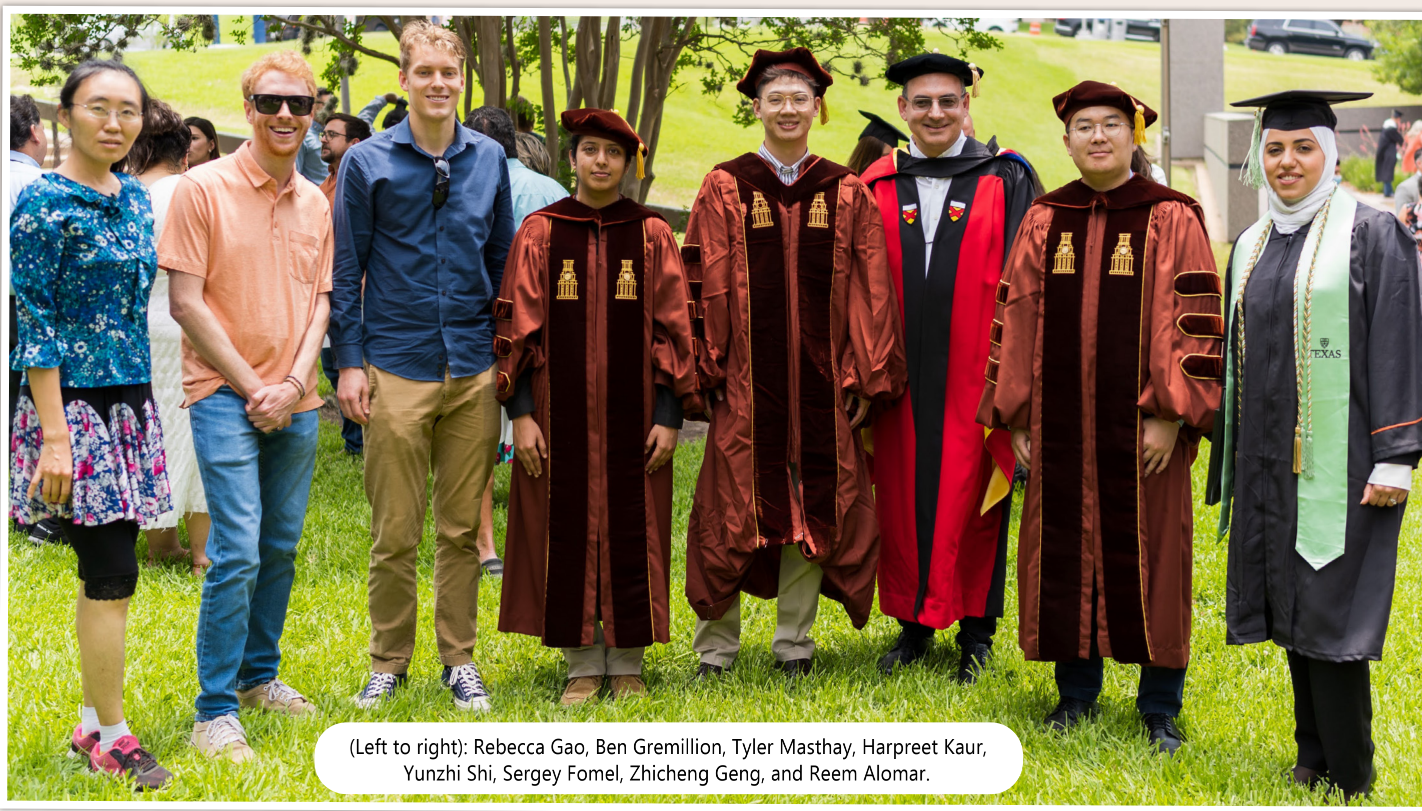
Reem Alomar: *Joining TCCS and conducting research under the supervision of Professor Sergey Fomel has been the most impactful experience of my career as an undergraduate student. Not only did I develop my technical skills as an aspiring geophysicist, but I have also learned the fundamentals of scientific research-embracing novelty and reproducibility.*

TCCS offers a unique atmosphere to grow as a researcher. There is a focus on effective communication-meaning that we convey technical and sometimes complicated information in a meaningful way through writing or presenting. At TCCS, we also embrace creativity, integrity, kindness, and collaboration. Throughout my time here, I have never hesitated to ask any question, no matter how simple or complex.

I am incredibly thankful to have been part of TCCS. Moving forward, I will always carry the unique passion for reproducible research and creative problem-solving that TCCS has imprinted on me.

University Honors

Reem Alomar graduated with highest honors and special honors in geosciences in May 2022, obtaining her Bachelor of Science in Geophysics. She was selected as the distinguished undergraduate speaker for the Jackson School of Geosciences commencement ceremony. *Congratulations Reem!*


(Left to right): Rebecca Gao, Ben Gremillion, Tyler Masthay, Harpreet Kaur, Yunzhi Shi, Sergey Fomel, Zhicheng Geng, and Reem Alomar.

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