2021 GSH-SEG ONLINE SPRING SYMPOSIUM

DATA SCIENCE AND GEOPHYSICS: HOW MACHINE LEARNING AND AI WILL CHANGE OUR INDUSTRY

April 27th-28th 2021

PROCEEDINGS

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Welcome to the 2021 GSH-SEG Spring Symposium!

Matthew Blyth

1st VP GSH

After the wild ride that was 2020, I am happy to announce that the GSH is back with our first Spring Symposium since April 2019! This year, thanks to the lasting effects of covid-19, we are holding our first entirely online symposium event. The theme for this year is how the ever-growing field of data science will change the way we work as geophysicists in the coming years. We have all heard the buzz words "digital transformation of the oilfield" being used more often recently, but what does it actually mean for our day-to-day jobs? The tools of data science can be applied in two ways. The first is to automate those tasks which humans find routine or highly repetitive. Many aspects of seismic processing workflows can be categorized in this way and machine learning tools can help relieve this burden and are doing so already. A more challenging task is finding out if these tools can allow us to do new things that we were incapable of doing previously. What is clear already is that all geophysicists will become increasingly exposed to data science tools in their day-to-day jobs and understanding how they work, and their strengths and weaknesses will be key for all of us!

Moving to an online format has meant that some of the traditional components of a GSH symposium, such as the roasting of the honoree, and the evening dinner have had to be postponed for another day, but others, such as the Challenge Bowl event have been transformed and adapted to this new world. I would like to thank the symposium committee members for all their hard work in making this event happen, our presenters for their willingness to share their work, our sponsors for their kind donations and of course all our attendees for helping support the GSH and for keeping us going through what has been a very tough year for both the society and our industry at large. We hope you will enjoy what we believe will be an informative, entertaining and interactive event!

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The Future of Petroleum Geoscience in a Digital World

Jake Umbriaco

Subsurface Digital Platform and Services Manager

Subsurface, Chevron Technology Company

Bio

Jake comes to the Digital Platform and Services role with recent experiences in High Performance Computing Strategy and digital partnerships. Prior to that, Jake was the Exploration Advisor for Chevron Africa and Latin America Exploration and Production Company, focused on building growth portfolios in Brazil, Suriname, and Mexico, and served on Chevron's Global Exploration Leadership Team.

Previously, Jake served in the New Ventures Team for Chevron North America Headquarters focused on asset valuations, technology and market strategies in unconventionals, and supply-side forecasting. Prior to that he established multiple teams focused on unconventional resource development in the Permian Basin.

Jake joined Chevron in 2005 as a technical geophysicist in the Deepwater Gulf of Mexico with roles spanning exploration and appraisal. Jake also served as the Business Operations Manager for the Geophysics and Petrophysics Division of ETC – Earth Science.

Jake is proud to serve on the Advisory Board for SEARCH Homeless Services in Houston, TX. He is a member of the Society of Exploration Geophysicists.

Day 1 Agenda

Day 1	April 27th
9:00	Introduction and Welcome - Matthew Blyth
	Keynote Speaker *The Future of Petroleum Geoscience in a Digital World" - Jake Umbriaco, Chevron*
10:00	
	Deep Learning Applications for Automating Evergreen Subsurface Model Building - Aria Abubakar (Schlumberger)
11:00	Break
	Wavefield separation via principle component analysis and deep learning in the local angle domain - Elive Menyoli (*Emerson)*
12:00	**GSH Gulf Coast Challenge Bowl Competition & Lunch Break**
13:00	
	Break
	The Scientific Universe from Square One to SOM - Tom Smith (GeoInsights)
14:00	
	Predicting reservoir properties from seismic and well data using deep neural networks - Jon Downton (CGG)
15:00	Day 1 Closing Remarks

Deep Learning Applications for Automating Evergreen Subsurface Model Building

Aria Abubakar

Schlumberger

Abstract

An accurate and evergreen subsurface model is crucial for various O&G workflows such as well placement, production forecasting, etc. Conventional subsurface model building consists sequential work steps, many of which require manual user interactions. Hence, the turnaround time of the conventional subsurface model building is long and it will take significant effort to iterate through multiple cycles and update when new data come in (the evergreen model concept). In this presentation, we will discuss an end-to-end framework for subsurface model building powered by various deep learning algorithms. Starting from seismic data, well logs, and other geophysical data such as MT, CSEM, Gravity, etc., the overall aim is to obtain 3D distribution of subsurface properties such as porosity, density, velocities, etc. From seismic data and well logs, deep learning algorithms, both supervised and unsupervised, are employed to obtain relevant derived data such as fault maps, stratigraphic layers, facies, Relative Geological Time model, and properties at well locations. Next by using a semi-supervised deep learning approach, seismic data, well logs, other geophysical data and their relevant derived data are integrated to obtain 3D distribution of target reservoir properties. Finally, from the estimated 3D properties, we can either generate synthetic seismic and other geophysical data using physical simulators or synthetic migrated seismic data by training another deep learning model. The residual between measured data and synthetic data can be further used to validate the results and/or to drive active/reinforcement learning to update the deep learning models used to generate the 3D properties. Various results will be shown to illustrate the potential of the "automated" subsurface model building workflow powered by Deep Learning.

Bio

Aria Abubakar was born in Bandung, Indonesia. He received an M.Sc. degree in electrical engineering in 1997 and as well as a Ph.D. in technical sciences in 2000, both from the Delft University of Technology, The Netherlands. Aria is currently the Head of Data Science for the Digital Subsurface Solutions at Schlumberger. His main responsibility is to oversee and coordinate the utilization of artificial intelligence, machine-learning and data-analytics technology for digital subsurface applications throughout Schlumberger. Aria is quite active in SEG and currently serves as: Associate Editor of Geophysics, Vice Chair of Research Committee, Director of SEAM, and 2021 SEG Annual Meeting Technical program Co-Chair. Aria was the 2014 SEG North America Honorary Lecturer and 2020 SEG-AAPG Distinguish Lecture. He holds 40 U.S. patents/patent applications, has published five book/book chapters, 100 scientific articles in journals, 200 conference proceedings papers, and 60 conference abstracts.

Wavefield Separation Via Principal Component Analysis and Deep Learning in the Local Angle Domain

Elive Menyoli, Duane Dopkin

Emerson

Abstract

The recorded seismic dataset is a composite of many wavefields. The standard seismic image volume is dominated by the high-energy specular data associated principally with reflectors and fault planes. Consequently, lower energy wavefields associated with stratigraphic pinchouts, reefs, karst edges and small faults are often lost in the standard processing and imaging process.

This presentation shows an evolution of full-azimuth imaging technology, performed in the Local Angle Domain, for characterizing subsurface features from migrated seismic data. The system decomposes the recorded seismic wavefield, in-situ at the subsurface image points, into full-azimuth reflectivity and directivity components comprised of thousands of dips and azimuths. In the directivity gathers, different traces may contain energy from different features in the subsurface. We will demonstrate the use of Principal Component Analysis (PCA) with its inherent data reduction, to derive the principal components of the different energies contained in the decomposed wavefield. PCA measures are performed in local windows around individual depth slices and all directivity bins within the directional gathers. The next stage involves using the power of convolutional neural network (deep learning) to train and classify these principal component directivity wavefields into geological features, such as reflectors, point diffractors, faults, plus other identifiable components, such as ambient noise, acquisition footprint or coherent migration “smiles”. This is a reliable method for separating these components and produce targeted images from the decomposed wavefield. The training

of the deep learning algorithm use a data library containing many examples of different geometrical features, therefore increasing the credibility of the network learning process.

Deep learning algorithm consist of multiple layers, where each layer contains a set of learnable filters with a small visual field of the input image. During the training process, each filter is convolved across the width and height of the input image, computing the dot product between the entries of the filter and the input, and producing an activation map of that filter. As a result, the network learn filters that activate when it detects a specific type of geometric feature at some spatial position in the input. The results reveal superior high-resolution images over previous diffraction weighted stack filters. Additionally, the deep learning approach offers significantly better time-to-results.

Bio

Elive Menyoli is Geoscience Business Development Manager for Emerson E&P software solutions. In this role, he helps to develop new business opportunities for Emerson’s Geoscience Services in North America as well as being a technical advisor for Emerson’s Seismic Processing and Imaging software products.

Elive has over 17 years of experience as a geophysicist and has led exploration teams analyzing producing basins and drilling hydrocarbon wells around the world for large and midsize companies, including Total SA and Marathon Oil. Immediately prior to joining Emerson, he was the principal and founder of a geological/geophysical consulting firm, SITA Energy, LLC, working with small and midsize operators in offshore East and West Africa.

Elive holds an M.S. in Physics from Georg-August University of Goettingen, Germany and a Ph.D. from University of Hamburg, Germany. He is a member of the SEG, AAPG, SPE, GSH, HGS and OTC.

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- Menal Gupta

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- Brandon Bush
- Sireesh Dadi

2009 **Rice University**
- Maximiliano Bezada
- Amy Lasseigne

2007 **University of Houston**
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To donate to the 2019 Gulf Coast Challenge bowl hosted at the Spring Symposium, go to:
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The Scientific Universe from Square One to SOM

Tom Smith

Geophysical Insights

Abstract

Probability and statistics are a part of everyday life which plays an important role in exploration and production of oil and gas resources. In this presentation, we lightly trace concepts of probability from first principles to an unsupervised machine learning algorithm, the Self Organizing Map, or SOM. SOM was discovered by Teuvo Kohonen, a Finish academician who categorized multi-dimensional data by their natural clusters of higher sample density with dimensionality reduction to a two-dimensional neural network.

We have found that SOM is an ideal machine learning method to classify multi-attribute seismic samples. During training, neurons adjust to fit natural clusters of samples that have stacked in attribute space. On completion, each winning neuron in the neural network has classified subsets of training samples. The trained neural network then classifies the survey in the zone of interest. Those who use SOM to classify seismic data find that geologic information is captured in neural networks with dimensions of 12x12 or less. However, because these classifications are on a seismic sample level, accurate time-depth relations are required to correlate SOM classifications with well data. We make no illusions of simplicity. These new machine learning algorithms produce statistical models that still require our comprehension and refinement for deeper analysis. There is no “one-and-done” with these new seismic interpretations.

An advantage of SOM is that it is completely unbiased, as training samples are taken strictly from survey samples without forcing adjusts to wells. Indeed, with accurate time-depth relations at the wells, seismic interpretation is greatly aided by these classified seismic samples. SOM classifications correlate with wireline interpretations across dozens of wells and across many miles of consistent reflections. Where there are wireline interpretation changes, so are there changes in SOM classification. SOM classification extends geologic prediction which is preserved in seismic traces between downhole wireline predictions. Interpretation is required to sort out which winning neurons have seismic samples of geologic interest. Others may have stacked because of coherent noise. SOM classifications are subdivided into closed surface geobodies. We illustrate the importance of seismic interpretation with machine learning tools with several recent advances. We demonstrate that SOM classification correlates across multiple wells. We show how the method assists interpretation of a heterogeneous gas reservoir using geologic geobodies. We illustrate semi-supervised machine learning for fault identification with 3D fault models constructed with Deep Learning of the seismic data, thus avoiding any bias from manual training. A SOM with mixed attributes for fault geobodies clearly identifies fault surfaces as well as tectonic fault style.

Bio

Dr. Tom Smith received a BS and MS degree in Geology from Iowa State University. His graduate research focused on a shallow refraction investigation of the Manson astrobleme. In 1971, he joined Chevron Geophysical as a processing geophysicist but resigned in 1980 to complete his doctoral studies in 3D modeling and migration at the Seismic Acoustics Lab at the University of Houston. Upon graduation with the Ph.D. in Geophysics in 1981, he started a geophysical consulting practice and taught seminars in seismic interpretation, seismic acquisition, and seismic processing. Dr. Smith founded Seismic Micro-Technology in 1984 to develop PC software to support training workshops which subsequently led to the development of the KINGDOM Software Suite for integrated geoscience interpretation with world-wide success.

The Society of Exploration Geologists (SEG) recognized Dr. Smith's work with the SEG Enterprise Award in 2000, and in 2010, the Geophysical Society of Houston (GSH) awarded him an Honorary Membership. Iowa State University (ISU) has recognized Dr. Smith throughout his career with the Distinguished Alumnus Lecturer Award in 1996, the Citation of Merit for National and International Recognition in 2002, and the highest alumni honor in 2015, the Distinguished Alumni Award. The University of Houston College of Natural Sciences and Mathematics recognized Dr. Smith with the 2017 Distinguished Alumni Award.

In 2009, Dr. Smith founded Geophysical Insights, where he leads a team of geophysicists, geologists and computer scientists in developing advanced technologies for fundamental geophysical problems. The company launched the Paradise® multi-attribute analysis software in 2013, which uses Machine Learning and pattern recognition to extract greater information from seismic data.

Dr. Smith has been a member of the SEG since 1967 and is a professional member of SEG, GSH, HGS, EAGE, SIPES, AAPG, Sigma XI, SSA, and AGU. Dr. Smith served as Chairman of the SEG Foundation from 2010 to 2013. On January 25, 2016, he was recognized by the Houston Geological Society (HGS) as a geophysicist who has made significant contributions to the field of geology. He currently serves on the SEG President-Elect's Strategy and Planning Committee and the ISU Foundation Campaign Committee for Forever True, For Iowa State.

Predicting Reservoir Properties from Seismic and Well Data Using Deep Neural Networks

Jonathan E. Downton and Daniel P. Hampson

CGG GeoSoftware

Abstract

Since the 1990's geophysicists have used supervised neural networks to quantitatively predict elastic and rock properties from the seismic and well data. In the traditional workflow, the neural network learns a relationship between the target log property and input features, which consist of seismic attributes generated from the poststack seismic data and extracted at the well locations. The generation and selection of these attributes require human input and expertise. The optimal attributes change depending on the target so predicting multiple target properties can be quite laborious. With the recent advent of deep neural networks (DNNs), it has become possible for the machine to learn the features automatically. This paper compares two DNN architectures to predict elastic and rock properties. The first architecture, a fully connected (FC) DNN, uses handcrafted features as input, while the second architecture, a convolutional neural network (CNN) uses seismic gathers segmented into a series of images. The generation and determination of the optimal features is implicitly performed as part of the training of the convolutional layers, avoiding the labour-intensive procedure of generating and selecting attributes.

In these supervised learning approaches, the seismic-to-rock property relationship is learned from the data. One of the major factors limiting the success of these methods is whether there exists enough labelled well data to train the neural network adequately. To overcome this issue, we generate synthetic data. First, we simulate many pseudo-wells based on the well statistics in the project area. In addition, the reservoir properties, such as porosity, saturation, mineralogy and thickness, are all varied to create a well-sampled dataset. Elastic and synthetic seismic data are then generated using rock physics and seismic theory. The resulting collection of pseudo-well logs and synthetic seismic data, called the synthetic catalog, is used to train the neural network. The derived operator is then applied to the real seismic data to predict reservoir properties throughout the seismic volume.

This synthetic data workflow is applied to a Gulf Coast dataset. In this study only one well is used to generate hundreds of synthetic wells and seismic gathers. Any of the simulated logs can serve as a target. In this case, the P-wave impedance, P-wave to S-wave velocity ratio, density and saturation are estimated. The synthetic wells and seismic gathers are used to train both the FC DNN and CNN. Figure 1 compares the density estimated by the FC DNN, the CNN and a deterministic inversion. Both the FC DNN and CNN compare favorably to the deterministic inversion. The input to the FC DNN are seismic attributes generated from angle stacks. To determine the optimal attributes for each target, the FC DNN must be trained separately for the four target properties. In contrast, the input to the CNN are the seismic gathers. Hence, the CNN is trained simultaneously for all four targets, providing a more efficient workflow. A key to successfully training both these networks is the big data supplied by the synthetic catalog.

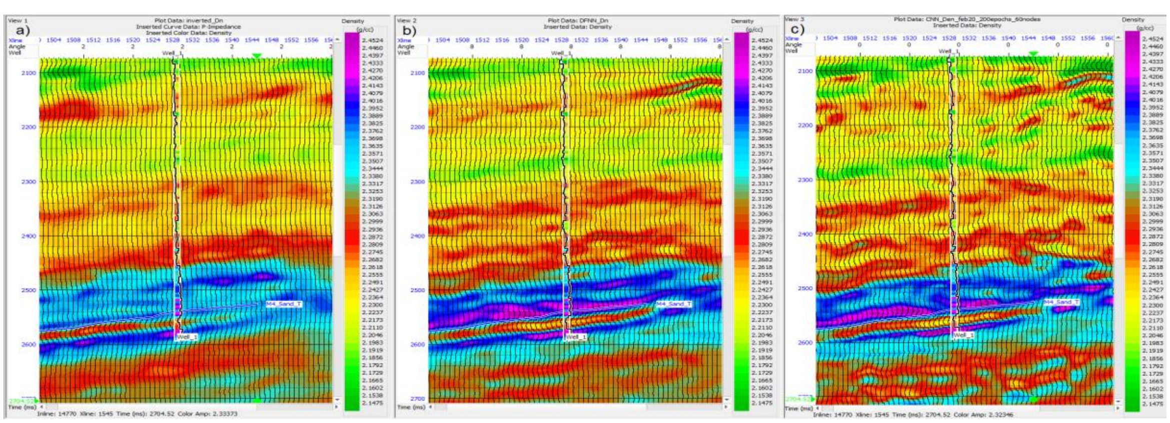

Figure 1: The density estimated from deterministic inversion a), a fully connected deep neural network b) and a convolutional neural network (CNN) c). The gas sand is the low density unit around 2560 ms.

Bio

Jon Downton is a Senior Research Advisor with CGG GeoSoftware focused on the HampsonRussell Software Development. Over his 35 years in the industry, Jon has worked as a reservoir geophysicist, research geophysicist and research manager. He was a cofounder of Integra Geoservices. After selling Integra to Core Labs in 1999, he went back to university and did his Ph.D. on AVO inversion. Since that time, his research has focused on reservoir geophysics and the seismic processing associated with this. His current research focus is the application of machine learning to the field of reservoir geophysics. Jon has extensive experience in estimating rock and fluid properties from seismic data, including AVO, AVAz inversion and rock physics. Jon is a member of the CSEG, SEG, EAGE and APEGA and is a past president of the CSEG.

Day 2 Agenda

Day 2	**April 28th**
10:00	Day 1 Review - Matthew Blyth
	Some machine learning applications for seismic facies classification - Satinder Chopra (SamiGeo)
11:00	*Automated Fault Detection from 3D Seismic Using Artificial Intelligence -* Hugo Garcia (Geoteric)
	Break
12:00	**Machine Learning Competition Awards & Lunch Break**
13:00	Break
	Progressive transfer learning for low frequency prediction in FWI - Wenyi Hu (AGT)
14:00	*Estimation of time-lapse timeshifts using machine learning* - Yuting Duan (Shell)
	Closing Remarks

Some Machine Learning Applications for Seismic Facies Classification

Satinder Chopra[+], Kurt J. Marfurt[†] and Ritesh Kumar Sharma[+]

[+]**SamiGeo, Calgary**; [†]The University of Oklahoma, Norman

Abstract

An ongoing challenge for seismic interpreters is to identify and extract heterogeneous seismic facies on data volumes that are continually increasing in size. Geometric, geomechanical, and spectral attributes help to extract key features but add to the number of data volumes to be examined. Common analysis tools include interactive corendering, crossplotting, and 3D visualization where we examine more than one attribute at a time; data reduction, where we mathematically reduce the number of data volumes to a more manageable subset; clustering, where the goal is to identify voxels that have similar expressions; and supervised classification, where the computer attempts to mimic the skills of an experienced interpreter.

Machine learning uses mathematical operations to learn from the similarities and differences in the provided data and make decisions or predictions. There are three broad families of machine learning algorithms. The first algorithm family includes dimensionality reduction algorithms such as principal component analysis (PCA) and independent component analysis (ICA). When plotted against a 2D color bar, the interpreter may “see” clusters, but the algorithm output is a continuum of data in a lower dimensional space. The second, unsupervised classification algorithm family attempts to explicitly cluster the data into a finite number of groups that in some metric “best represent” the data provided. Before the analysis, there is no interpretation assigned to any given group; rather, “the data speak for themselves”. However, the choice of input attributes biases the clustering to features of interpretation interest. Biasing the training data to favor geologic features of interest (e.g. by more heavily weighting a bright-spot anomaly) also provides interpreter

control of the output. Self-organized mapping (SOM) and generative topographic mapping (GTM) are two techniques that can be used for the purpose. The third, supervised classification algorithm family attempts to map each data point or voxel to a suite of features defined by the interpreter. In this talk, we illustrate supervised learning using the well-established Bayesian classification workflow, where the classes are defined by petrophysical analysis. Other supervised learning algorithms such as multilayer feed-forward neural networks, support vector machines, random forest decision trees, and convolutional neural networks require the interpreter to define zones/facies of interest by picking voxels, drawing polygons, or extracting data about producing vs. non-producing wells, microseismic events, or image-log anomalies.

In this talk we compare several of the more well-established machine learning techniques: waveform classification, PCA, k-means clustering, and supervised Bayesian classification to a seismic data volume from the Delaware Basin. We also examine some less common clustering techniques applied to seismic attributes including ICA, self-organizing mapping and generative topographic mapping. Although supervised learning provides answers to questions we know how to ask, it does not answer questions that weren't asked. A common problem is to define classes based on well-log data, say sand, shale, and carbonate. In this scenario, any anhydrite found in the seismic data volume would be guaranteed to be misclassified. In contrast, while unsupervised may identify the anhydrite as a distinct class, it provides no indication of what it means geologically. Finally, the selection of the input data is critical. If we wish to differentiate lateral changes in shale properties, geomechanical attributes are valuable input, if we wish to map chaotic facies, texture attributes are useful, while structural attributes such as coherence and curvature may be valuable in delineating lateral compartments.

In summary, we find that the machine methods hold promise as each of them exhibits more vertical and spatial resolution than the waveform classification, or the supervised Bayesian classification. Amongst the machine-learning methods, the ICA furnishes more detail than the PCA. Both the SOM and GTM methods provide promising results, with the latter yielding more accurate definition as seen on the displays.

Bio

Satinder Chopra is the founder and President of SamiGeo Consulting Ltd., based in Calgary. He has 36 years of experience as a geophysicist specializing in processing, reprocessing, special processing, and interactive interpretation of seismic data. He has rich experience in processing various types of data such as vertical seismic profiling, well-log data, seismic data, etc., as well as excellent communication skills, as evidenced by the many presentations and talks delivered and books, reports, and papers he has written. He has been the 2010–2011 CSEG Distinguished Lecturer, the 2011– 2012 AAPG/SEG Distinguished Lecturer, and the 2014–2015 EAGE e-Distinguished Lecturer. He has published eight books and more than 470 papers and abstracts and likes to make presentations at any beckoning opportunity. His work and presentations have won several awards, the most notable ones being the AAPG Distinguished Service Award (2019), EAGE Honorary Membership (2017), CSEG Honorary Membership (2014) and Meritorious Service (2005) Awards, APEGA Frank Spragins Award (2014), the AAPG George Matson Award (2010), and the AAPG Jules Braunstein Award (2013), SEG Best Poster Awards (2007, 2014), CSEG Best Luncheon Talk Award (2007), and several others. His research interests focus on techniques that are aimed at the characterization of reservoirs. He is a member of SEG, CSEG, CSPG, EAGE, AAPG, and the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Automated Fault Detection from 3D Seismic Using Artificial Intelligence – Practical Application and Examples

Hugo Garcia+

Geoteric

Abstract

Understanding the fault network and structural history setting up the petroleum systems associated with oil and gas reservoirs has been an essential step in the E&P process for decades. However, description of structural information and its subsequent impact on reservoir performance is one of the most generalized components within modern basin and reservoir modeling workflows. Thankfully that gap is being closed as we move forward in a new era of understanding brought about by 'AI'-derived 3D seismic attributes which capture the intricate details of a realistic subsurface. Deep learning – a particular subset of machine learning, which in itself is a form of artificial intelligence – is carving a niche in the realm of seismic attributes given its well established strengths in image pattern analysis and recognition. With this in mind, a Convolutional Neural Network (CNN) was developed using a large amount of labelled data to identify faults in a seismic cube, assigning the detected fault a confidence score on a per voxel basis. Having now been tested and QC'ed on over 60 previously unseen 3D datasets, we call this CNN our 'Foundation Model'. We present a workflow in which an AI fault attribute can be quickly derived using the Foundation Model on a 3D seismic dataset. The data is first analyzed by the network to provide a first-pass fault attribute. The model is then fine-tuned using a small amount of interpretation to adjust and account for subtle geologic details specific to the structural regime of each unique dataset. This also has the effect of reducing false positives in the original output relative to the true fault signal. The finetuned fault cube can then be analyzed using other high-fidelity attributes and filtered based on criteria such as confidence or fault azimuth. We then automatically extract fault sticks which are easily edited and grouped to form fault surfaces. As a final step, the fault cube can be co-rendered with a Frequency Decomposition RGB color blend, providing QC of the AI

attribute as well as greater geological understanding. The final attribute and resultant fault interpretation are shown to be far superior to a traditional workflow using coherence algorithms. The automated components of the AI-assisted workflow have demonstrated tremendous value in significantly reducing interpretation turnaround times while simultaneously increasing accuracy and comprehensiveness of the interpretation itself. Likewise, the interpreter component – providing the fault 'labels' in the fine-tuning step and ultimately controlling which sticks are grouped together to form the fault network – is an absolutely vital element of the workflow as well. Examples demonstrating the practical application of the workflow will be shown using datasets from the U.S. Gulf of Mexico as well as the North Slope of Alaska.

Bio

Since joining Geoteric in 2011, Hugo's extensive knowledge of seismic attributes and frequency decomposition has seen him provide thorough technical support across processing, exploration and development workflows amid various global geological settings. Today, a Senior Geoscientist he brings his comprehensive knowledge and practical understanding as he works with the global geosciences team on developing Geoteric's AI Fault Interpretation Service.

In cooperation with Sonangol SA, he holds an MSc in Exploration Geology which saw a 7 months internship in Sonangol's Interpretation Department in Luanda focusing on salt tectonics and deep-water exploration. In addition, he holds a BSc in Geological Engineering from the University of Aveiro in Portugal.

Geophysics in the Cloud 2021 – A Cloud-based Machine Learning Competition

Eduardo Alvarez and
Altay Sansal

GSH Special Interest Group:
Data Science and Machine Learning

The winning team will be special guests.

Summary of GITC21:

Geophysics in the Cloud 2021 (GITC21) kicked-off on April 1st and marked the beginning of a different flavor of geoscience competition. GITC21, per the name, was a 3-week competition that took place on the AWS cloud – where teams of up to 3 participants – worked together to develop novel alternatives to conventional seismic inversion with machine learning models. During this lunch session the SIG's Chair, Eduardo Alvarez, will showcase some of the highlights of the competition and the immense value generated for the community through this initiative. Special Events team member, Altay Sansal, will review the technical aspects of the competition and announce the winning team. The winners will give a short presentation to highlight their solution.

Competition Sponsors:

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ENTHOUGHT

Progressive Transfer Learning for Low Frequency Prediction in Full Waveform Inversion

Wenyi Hu[1], Yuchen Jin[2], Xuqing Wu[2], and Jiefu Chen[2]

1. Advanced Geophysical Technology, Inc,
2. University of Houston

Abstract

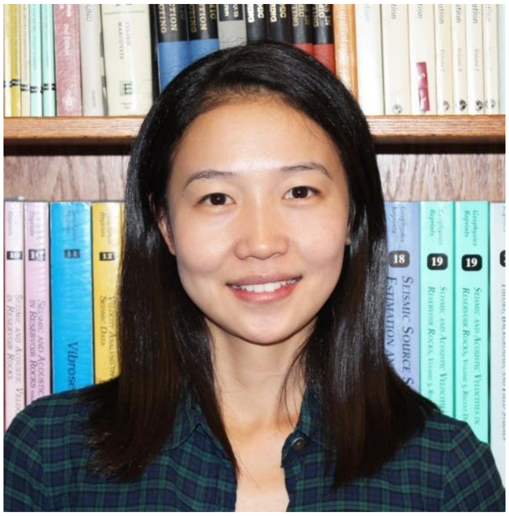
For the purpose of effective suppression of the cycle-skipping phenomenon in full waveform inversion (FWI) cursed by the lack of low frequency components in most acquired seismic datasets, we developed a Deep Neural Network (DNN) based approach to predict the absent low frequency information by exploiting the hidden relationship linking the low frequency data and the high frequency data implicitly through the subsurface geological structures and geophysical properties. In order to efficiently and accurately solve this challenging nonlinear regression problem, two novel strategies were proposed to design the DNN architecture and to optimize the learning process: 1) Dual Data Feed structure; 2) Progressive Transfer Learning. With the Dual Data Feed structure, not only the high frequency data, but also the corresponding Beat Tone data are fed into the neural network to relieve the burden of feature extraction, substantially reducing the network complexity and the network training cost. The second strategy, Progressive Transfer Learning workflow, enables us to unbiasedly train the DNN using a single training dataset that is generated by an arbitrarily selected velocity model. Unlike other established deep learning approaches for this category of nonlinear regression applications, our training dataset is not fixed. Instead, within the framework of the Progressive Transfer Learning strategy, the training velocity model and the associated training dataset continuously evolve in an iterative manner by gradually absorbing more and more reliable subsurface information retrieved by the physics-based inversion module, progressively enhancing the low frequency prediction accuracy of the DNN and propelling the velocity model inversion process out of the local minima. The Progressive Transfer Learning strategy, alternatingly updating the sole training velocity model and the DNN parameters in a complementary fashion until the convergence, saves us from being

overwhelmed by otherwise tremendous amount of training data and avoids the overfitting issue. The numerical experiments validated that, without any a priori geological information, the low frequency data predicted by the Progressive Transfer Learning network are sufficiently accurate for a standard FWI engine to produce reliable subsurface velocity models free of cycle-skipping-induced artifacts. The field data testing also demonstrates promising results

Bio

Wenyi Hu received his Ph.D. degree in Electrical Engineering from Duke University, Durham, NC, USA, in 2005. From 2005 to 2009, he was a Research Scientist at Schlumberger-Doll Research. He joined ExxonMobil Upstream Research Company in 2009 and worked there as a Senior Research Specialist. Since March 2013, he has been with Advanced Geophysical Technology, Inc. as the Vice President of Research. His current work is focused on a variety of R&D projects on tackling large-scale forward and inverse problems for the oil and gas industry. His active research spans different areas of applied geophysics for petroleum exploration and production, including seismic earth imaging and modeling, full waveform inversion (FWI), velocity model building, electromagnetics modeling & inversion, signal processing, and deep learning and data analytics. He has more than 40 technical publications and has six US patents / patent applications.

Estimation of Time-lapse Timeshifts Using Machine Learning



Yuting Duan

Shell

Abstract

Time-lapse (4D) seismic is a proven technology to monitor oil & gas production. Timeshifts, defined as the time-lapse difference in two-way travel time or depth of seismic images, are commonly used as a key attribute for 4D seismic interpretation. They can be directly related to velocity or geomechanical changes or be used to align monitor and baseline seismic data to estimate amplitude-related 4D attributes.

A common approach to compute timeshifts is trace-by-trace cross-correlation (XCOR), which is reliable, fast, and easy to implement. However, when seismic amplitudes change as is typical near producing reservoirs, baseline and monitor seismic data cannot be perfectly aligned and, as a result, XCOR often produces anomalous timeshifts, which leads to false 4D interpretation. In addition, using XCOR requires tuning the window length, which can be challenging in certain scenarios. Alternatively, solving an inverse problem is another method to estimate timeshifts, which can potentially avoid the timeshifts anomalies. However, the inversion is typically non-linear and can be limited by complicated setup and local minima issues.

We will present an approach to estimate timeshifts in time-lapse seismic data using machine learning (ML). We build physical reservoir models generating trace-based data with ground-truth timeshifts for Neural Networks training and validation. Using synthetic experiments and real data acquired in two oil fields with different types of reservoir changes, we will show you that this proposed method improves resolution and accuracy of timeshift/timestrain compared to traditional cross-correlation results.

Bio

Yuting Duan is a research geophysicist at Shell International E&P, working primarily on the applications of time-lapse monitoring technologies. Yuting received a M.S. in Geophysics from Peking University in 2012 and a Ph.D. in Geophysics from Colorado School of Mines in 2016. Her research interests are seismic imaging and processing, Distributed Acoustic Sensing (DAS) technology for borehole seismic acquisitions, and Machine learning for geophysical applications.

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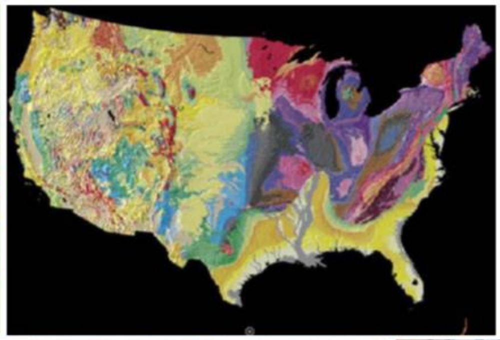

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