

UNIVERSITY of HOUSTON PETROLEUM ENGINEERING



Artificial Intelligence, Machine Learning and Data Analytics for Energy Exploration and Production

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Is Artificial Intelligence, & Data Analytic the Next E&P breakthrough after Hydraulic Fracturing?

Narrative: Last two decades witnessed many advances in Hydraulic Fracturing (HF) and horizontal drilling leading to development of massive shale resources and ensuring energy security for the US. New Challenge: What is the next transformative energy related technology for the next two decades? Is Effective use of Artificial Intelligence (AI) and Data Analytic (DA) for exploration, drilling, production and sustainability of energy resources is the possible answer?

DA and AI-ML-DL

Data analytics (DA)

Systematic computational analysis of data to discovery patterns for decision making

Artificial Intelligence (AI)

Universe of Intelligent Agents, Especially
Intelligent Programs

Machine Learning (ML)

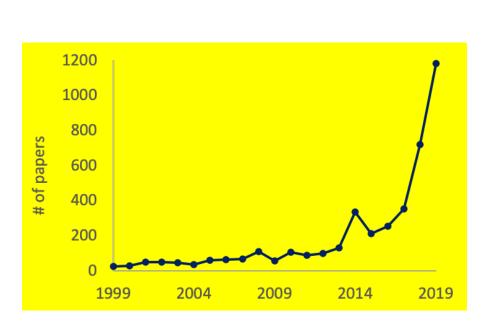
Systems allowing to learn from experience and make prediction

Deep Learning (DL)

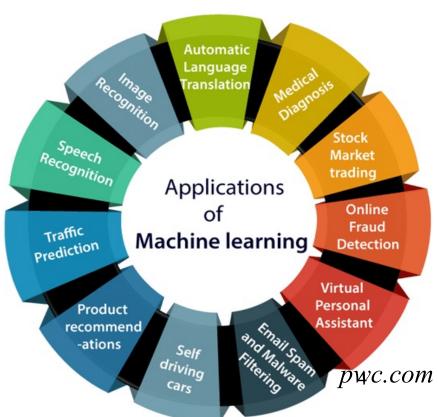
ML based on learning data representation or feature learning

Why AI-DA is Transformative Technology for E&P?

- ➤ Artificial Intelligence, Machine Learning and Data Analytic (AI-DA) have been impactful in many other industries and application areas.
- ➤ Although AI-DA usage has been growing in steadily in E&P in recent years, I believe we have only scratched the surface.
- There is still a big gap between the energy industry AI-DA needs and the related capabilities in other industries.



OnePetro- SPE



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AIM-DEEP Resources

Birol Dindoruk (PETR), Kyunj Jae Lee (PETR) Fred Aminzadeh (PETR), Jiefu Chen (ECE) Faculty

(Ali Rezaei, Pablo Guillen...) Post Docs Ahmet Ershin, Anand Selveindran (Students) (J. Behura, F. Brouwer, H. Khaniani, A. Shahin E. VonLunen, and R. Ashena ...) Consultants TBD External Academic Members

AIM-DEEP Vendor Partners DeepCast.AI

dGB
EnfiniteTech
NEC
Nvidia
PetroLern
Tetrale

Unique Benefits of AIM-DEEP

- ➤ Quick access to experts on Machine Learning at UH-AIM-DEEP and with its Academic and Vendor partners.
- Receiving the software and other technical material on machine learning carried out under BASE membership
- ➤ Hybrid Structure of AIM-DEEP:
 - BASE Membership
 - Individually Sponsored Project (ISP)
- ➤ Closer interaction with Houston-based Petroleum Industry
- Capitalizing on the opportunities from close interactions between Oil and Gas Operators/ Service companies and Computer/Data companies
- ➤ Having a vote for technical direction with seats on TAB and SAB
- Priority access for student internship and recruiting
- Crossing discipline boundaries within UH
- No "not invented here syndrome", building on external academic partnership

Leveraging Opportunities: Research and Training

- AIM-DEEP provides a platform for providing leveraging opportunities for student education combined with applied research
- Sponsors can also receive such benefits either through student internship or short courses offered by AIM-DEEP and its academic and vendor partners
- The formal training (PTER 5397 course) on Data Analytics and Machine Learning for E&P is another element of creating leveraging opportunities.

	Topic	Date	Lecture #
	Introduction to Data Analytics and Machine Learning for E&P	1/25/2021	1
	Conventional Statistics (CS) and Numerical Methods	2/01/2021	2
	Fundamentals of Neural Networks	2/08/2021	3
	Fundamentals of Fuzzy Logic	2/15/2021	4
	Fundamentals of Genetic Algorithms (GA)	2/22/2021	5
thods	Integration of Statistical and Different Al Techniques: Hybrid Me	3/01/2021	6
	Artificial Intelligence (AI), Machine Learning (ML) and Natural Language Processing (NLP)	3/08/2021	7
	Spring Break	3/15/2021	

Торіс	
BIG DATA and other aspects of Data Analytics	
Case Histories: DA-ML for Exploration	1

10	4/05/2021	Case Histories: DA-ML for Drilling
11	4/12/2021	Integration of Physics Based and Data Based Approaches
12	4/19/2021	Case Histories: DA-ML for Reservoir Characterization
13	4/26/2021	Case Histories: DA-ML for Production Optimization and EOR
14	5/03/2021	Student presentations on Team projects, and Feedback
	5/10/2021	Final Exam

AI- Data Analytics Application Areas in E&P

Combining streaming data with past performance to predict potential failures

Exploration Data Mining

Finding hidden patterns in large geoscience datasets

Predictive Maintenance

Real-time prediction of system response (drilling, fluid injection)

Performance Forecasting Reservoir Management

Identifying factors for improved performance

Proxy Modeling

Creating fast system "emulators"

Reduce cost, improve productivity, increase efficiency, reduce environmental footprint,

Every Step of **EDP** Can benefit from Application of Machine learning and Data Analytic Tools

Exploration **E**

Data Acquisition
Data Mining
Risk Assessment
Prospect Ranking
Reserves Evaluation
Exploratory Drilling

Drilling/Development **D**

Well Path Design
Optimum Mud weight
Geo-steering
Reservoir Pressure Mon.
Kick Monitoring
MWD / LWD / SWD
Completion

Production / EOR

Res. characterization
Production Optimization
Reservoir Surveillance
Optimizing EOR
Hydraulic Fracturing
Economic Forecasting

10

Big Data 4V in Oil and Gas

Exploration

3D Seismic
Real-time Visualization
Subsurface Imaging
Reservoir Characterization

Drilling/ Development

MWD, LWD, SWD
Data transfer from drill bit
Geo-Steering
Reservoir Simulation

Production

4D Seismic Reservoir Surveillance Production Optimization Enhanced Oil Recovery

Volume Shear Data Size

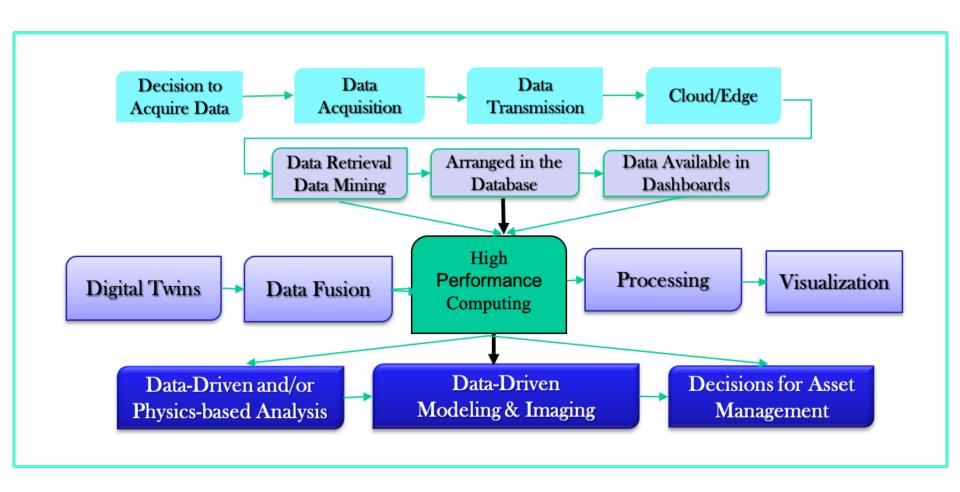
Velocity Data Streaming

Variety

Data Forms

Veracity
Data Uncertainty

Workflow for Data Driven Analysis

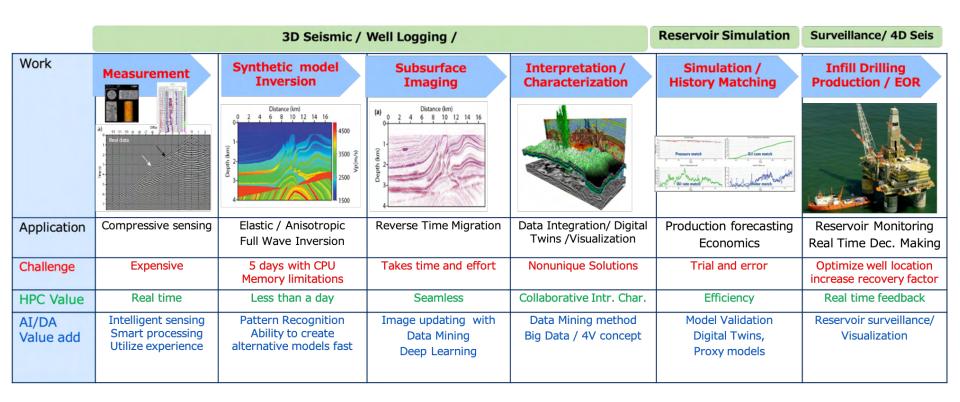


Possible AIM-DEEP Project Focus Areas

- 1. Intelligent Seismic Attribute Analysis and Reservoir Characterization
- 2. Combining machine learning concepts with geomechanics and microseismic information for Stimulated Reservoir Volume, prediction.
- 3. High performance computing for Seismic Imaging, Reservoir Simulation and AI applications.
- 4. ML-AI-DA for Producing Cost Reduction of Unconventional Resources
- 5. AI- Assisted Reservoir Simulation and History Matching
- 6. Integrating Physics-Based and Statistics Based Approaches using machine learning and Data Analytics
- 7. AI-DA for Geothermal Resources Exploration and Production
- 8. Edge Computing for Predictive Maintenance and Pump Failure Diagnostic
- 9. Digitalization: Getting the most value out of digital threads and digital twins in O&G
- **10.**Carbon sequestration applications of DA-ML
- 11. How AI can help oil companies reach their ESG Objectives
- 12.AI-Based Prediction of Estimated Ultimate Reserves (EUR) and the Uncertainty
- A. What are **YOUR** top 3 focus area for Base membership priorities (either from the above list or a topic of your own?
- B. Would you consider any of the above topics or a new topic for an Individually Sponsored Project (ISP) membership?

13

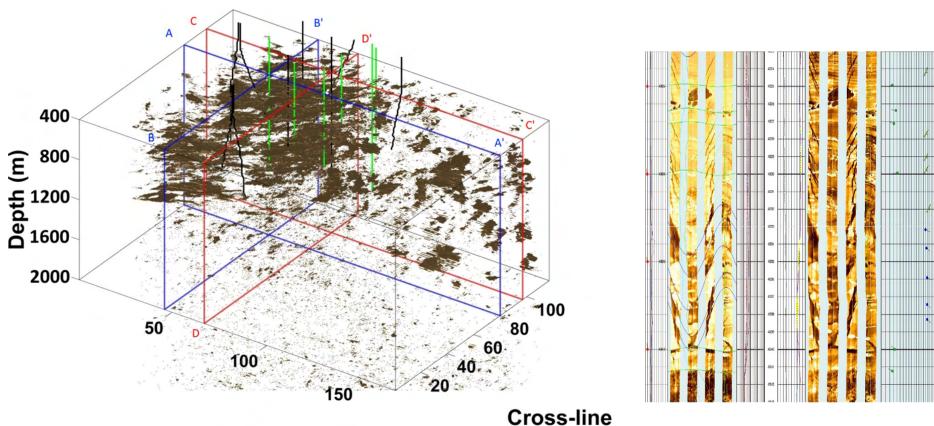
Value addition of HPC and AI/DA at E&P



HPC+AI-DA Reduces Exploration Cost and Improves Recovery Factor

Courtesy of NEC Corporation Aminzadeh and Ikuta, (2021)

Determining Fracture Distribution



In-line

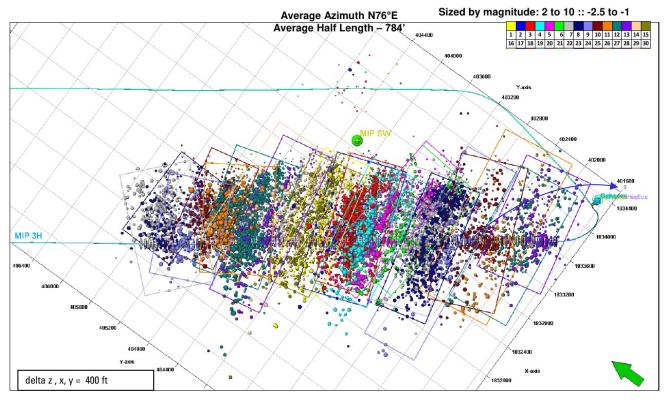
HYBRID FZI ATTRIBUTE MAPPING (ANN)

 $FZI_n = F\{ \phi_{n}, Z_{n}, V_{Pn}, V_{Sn}, \rho_{n}, V_{En}, \}$

Identify fractures & generate fracture logs

Maity, and Aminzadeh, 2015: *Interpretation*, 3(3), T155–T167.

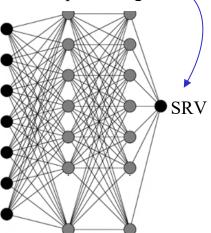
Stimulated Reservoir Volume (SRV) Prediction



Area (or volume of the stimulated reservoir) as a scalar representing SRV

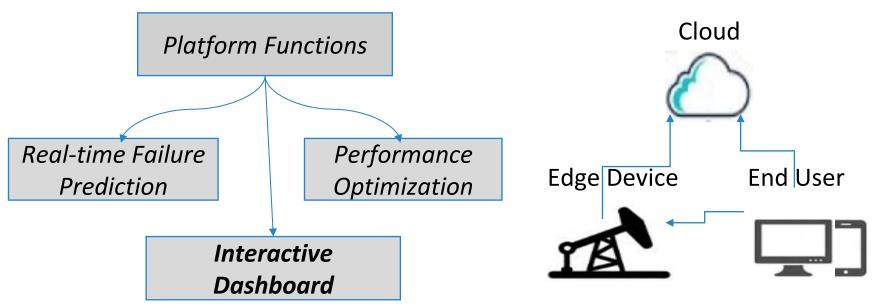
Proppant volume
Injected fluid volume
Recorded pressure

Stress Mineralogy

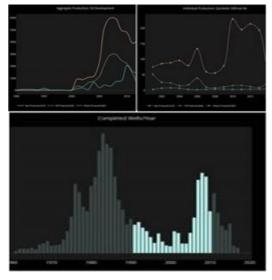


Rezaei et al. (2021)

Al-Biased Failure Detection via an IoT Platform



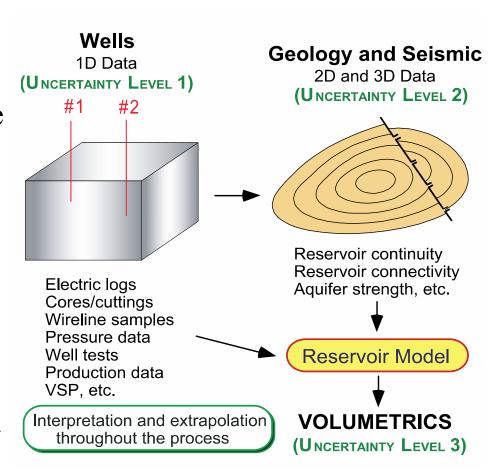
End-to-end visibility and control of artificial lift assets, devices and reporting



Interactive Dashboard

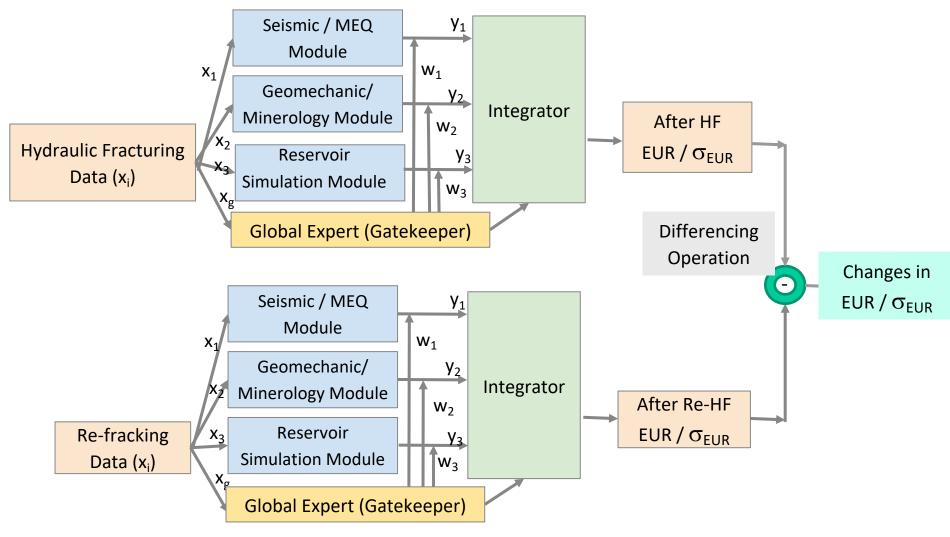
Al for Uncertainty in Reserves (EUR) Prediction

- A. 1D data for reservoir properties such as porosity, saturation, oil viscosity
- B. As 1D reservoir properties are extrapolated to 2D and 3D with the help of geology, seismic, and production data, simplifying assumptions are made and errors are incurred
- C. EUR estimation process involves many complications, especially for Unconventional



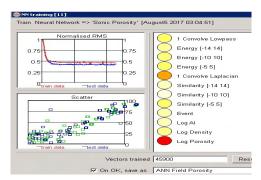
Effective Volume = Area * Thickness * Φ * (1 - Sw) * RF / FVF

Prediction of EUR and its Uncertainty Using Modular Neural Networks (MNN)

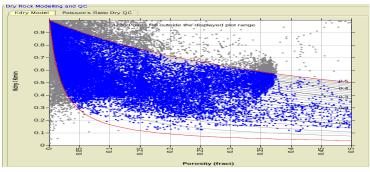


CO₂ Sequestration using Integrated Physics based and Machine Learning

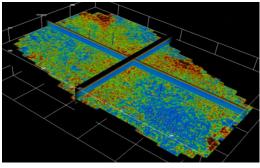
- 1. To model and identify effective and low-cost monitoring techniques for CO₂ Carbon Capture and Storage.
- 2. To derive geophysical techniques (seismic) and attributes for an accurate and robust CO₂ monitoring system.
- 3. To evaluate geophysical monitoring ideas for safe CO₂ storage, and identify any geohazard risks.



ANN Training Progress with 12 Input Nodes (45,900 vectors trained).



QC of the applicability of Gassmann equation.



Porosity Prediction Results- Farnsworth Unit (FWU) oilfield.

Conclusions

- ➤ AI-DA tools have the potential to offer new transformative technologies for E&P
- ➤ AI-DA techniques are powerful to address many oil and gas problems such as production optimization, enhanced oil recovery and preventive maintenance,
- ➤ Big Data and its 4V elements are relevant for all stages of O&G operation from exploration and drilling, through development and production,
- ➤ Challenging times requires rising to the occasion to make transformative changes, using AI-DA tools,
- ➤ UH's AIM-DEEP creates a platform to facilitate collaboration among different stake holders and speed up adoption of AI-DA concepts by oil and gas end users.