UNIVERSITY of HOUSTON PETROLEUM ENGINEERING

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



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AIM-DEEP Consortium

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<u>What</u>: New UH program aimed at bridging the gap between the needs and related capabilities in Artificial Intelligence, Machine Learning and Data Analytics (AIM-DEEP) for Energy Exploration and Production.



Why: AI-ML-DA have the potential of reshaping E&P operations, strategy and competition. AIM-DEEP intends to accelerate this transformation by creating a symbiotic AI platform where select people (students, faculty, experts) are immersed in E&P technologies (exploration, drilling, development and production) to speed up the adoption of AI-ML-DA concepts in the industry.

Unique benefits:



- Access to UH cross-discipline experts on AI-ML-DA
- Built on external academic and Big Tech partnerships
- Close interaction with the Houston-based energy industry
- Nurturing the next generation of AI-savvy geo-scientists/engineers
- Flexible membership (base + individually sponsored projects)

Artificial Intelligence and Related Topics



Artificial Intelligence /ML/DL



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

Development **D**

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

Production

Ρ

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

Big Data (4V)



Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS

https://www.ibmbigdatahub.com/sites/default/files/infographic file/4-Vs-of-big-data.jpg

Big Data 4V in Oil and Gas



WOrkflow for Data Driven Analysis



Characteristics of Smart Systems The key components of "smart system": **Measure-Model-Update**

- Measure system properties (D)
- Model actual vs desired behaviour (M)
- Derive required Innovation Process (adaptive control) (M-D)
- Implement updates
- Recursive updating



Is Machine Learning, & Data Analytic the Next breakthrough after Hydraulic Fracturing?

- Narrative: About 20 years ago advances in Hydraulic Fracturing (HF) and horizontal drilling helped exploit the 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
 - Machine Learning (ML), Artificial Intelligence (AI) and Data Analytic (DA) for exploration, drilling, production and sustainability of energy resources is the possible answer?

Why AIM-DEEP

- Artificial Intelligence, Machine earning and Data Analytic (AI-ML-DA) usage in the oil and gas industry has been increasing steadily in Upstream Exploration and Production applications in recent years.
- ➤ There is a big gap between the energy industry AI-ML-DA needs and the related capabilities in the industry.
- ► AIM-DEEP fills this gap and rapidly adopts current AI capabilities to the energy needs.
- ➤ AIM-DEEP will be a platform to assess the industry needs, identify specific challenges and become a catalyst for development, implementation and application of ML-AI-DA.
- AIM-DEEP will be a consortium supported by oil and gas producers, high tech companies, and government entities, selected startups and academic researchers brought together to help identify key energy problems requiring multi-disciplinary AI-ML-DA solutions

Explosion of Machine Learning Papers in the last two decades in OnePetro



Organization of UH AIM-DEEP



AIM-DEEP Hybrid Structure

➤ AIM-DEEP Base Project

- Member's Access to general results of Base AIM-DEEP results,
- Access to AIP-DEEP resources and its partners,
- Input to prioritization of Base project mix,
- A seat on each of the Technical and Strategic Advisory Boards,
- Partial access to ISP projects (with ISP member concurrence).
- ➤ AIM-DEEP Individually Sponsored Projects (ISP)
 - Access to AIM-DEEP Base Project Results,
 - Flexibility in the scope of ISP Member focused project,
 - Limited distribution of data and results,
 - Increased interaction between ISP member and UH,
 - Possible involvement of AIM-DEEP Academic and Vendor Partners in ISP.

Uniqe 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
- Closer interaction with Houston-based Industry
- ► 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 syndrome" building on external academic partnership

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 AI applications in oil and gas
- 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. Combining Machine Intelligence with Human Intelligence to address key E&P problems
- 8. Edge Computing for Predictive Maintenance and Pump Failure Diagnostic
- **9.** Digitalization in the Oil and Gas sector Getting the most value out of digital threads and digital twins
- **10.** Carbon sequestration applications of DA-ML
- 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?

A Few Examples of Use of AI-ML-DA in E&P

Reservoir Characterization



Multidisciplinary Reservoir Characterization adopted from Yu et al.(2011)

Determining Fracture Distribution





Cross-line

HYBRID FZI ATTRIBUTE MAPPING (ANN) $FZI_n = F\{\phi_n, Z_n, V_{Pn}, V_{Sn}, \rho_n, V_{En},\}$

In-line

Identify fractures & generate fracture logs

Maity, and Aminzadeh, 2015: Interpretation, 3(3), T155–T167. 18

Sand Thickness Prediction



Segmentation of thin and thick sands using Support Vector Machine, Zhao et al (2008)

Cyclic Neuro - Fuzzy Water-Steam Flooding Fuzzy Bang-Bang Control

Bang-bang fuzzy controller requires soft fuzzy engine, and a hardware relay to accomplish Bang-bang control action.
 The controller has fuzzy decision making capability in its inputs and normally have two fixed levels Bang-bang output*



Provisional patent filing pending, Cyclic Fuzzy Water-Steam Flooding, Aminzadeh, 2017

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).



Porosity Prediction Results- Farnsworth Unit (FWU) oilfield .



QC of the applicability of Gassmann equation.

Aminzadeh (2018) DOE / NETL DE-FE0026825 Final Report

http://www.energy.psu.edu/ucfer/sites/default/files/files/images/files/summaries/5551-Aminzadeh-RFP01.pdf

AI-Based Failure Detection via IoT & Edge Computing

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



DNA Finger Printing for High-Grading Drilling Prospects and EOR Candidate

- Correlating DNA fingerprinting logs is useful for DNA stratification.
 By forming such pairs, we can pictorially represent a DNA sequence to specific oil type for stacked reservoirs
- The first step in DNA Fingerprinting is isolating the individual microorganisms from the bacterial colonies.



A Schematic view of integrating different data types to create a reservoir finger printing (from Aminzadeh, 2005)

Frequently Asked Questions

- ➤ When does the consortium launch?
 - AIM-DEEP was launched Mid- September when I talked at a Graduate seminar at UH that was open to public. We will make the start date of AIM-DEEP as of November 15, 2020.
- ➤ What is the fee? The BASE membership fee is \$40K/year.
 - We are offering a 25% discount for "the early adopters" who express their interest to join by 11/15/2020 and make the payment by 12/15/2020. The "Individually Sponsored Project" or ISP membership where we work with a particular company (or a subset of BASE member companies) on a specific project just for them. The fee for ISP membership is highly dependent on the scope of the project.
- ➤ How many sponsors do you need to launch?
 - We will launch AIM-DEEP independent from the number of sponsors. We do hope to have at least 3 "early adopter" and 12 members by January 31, 2021.
- ➤ How many sponsors have signed up?
 - We have made some progress with a few companies as early adopters but at this time we have no signed agreement.

Conclusions

- AI-ML-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,
- A close collaboration between the AI-ML-DA community, oil & gas operators and service providers as well as the high-tech companies with input from academia is crucial,
- UH's AIM-DEEP creates a platform to facilitate collaboration among different stake holders and speed up adoption of AI-ML-DA concepts by oil and gas end users,
- Challenging times requires rising to the occasion to make transformative changes- AIM-DEEP will be a catalyst to do this.