AIM-DEEP

UNIVERSITY of HOUSTON

PETROLEUM ENGINEERING

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

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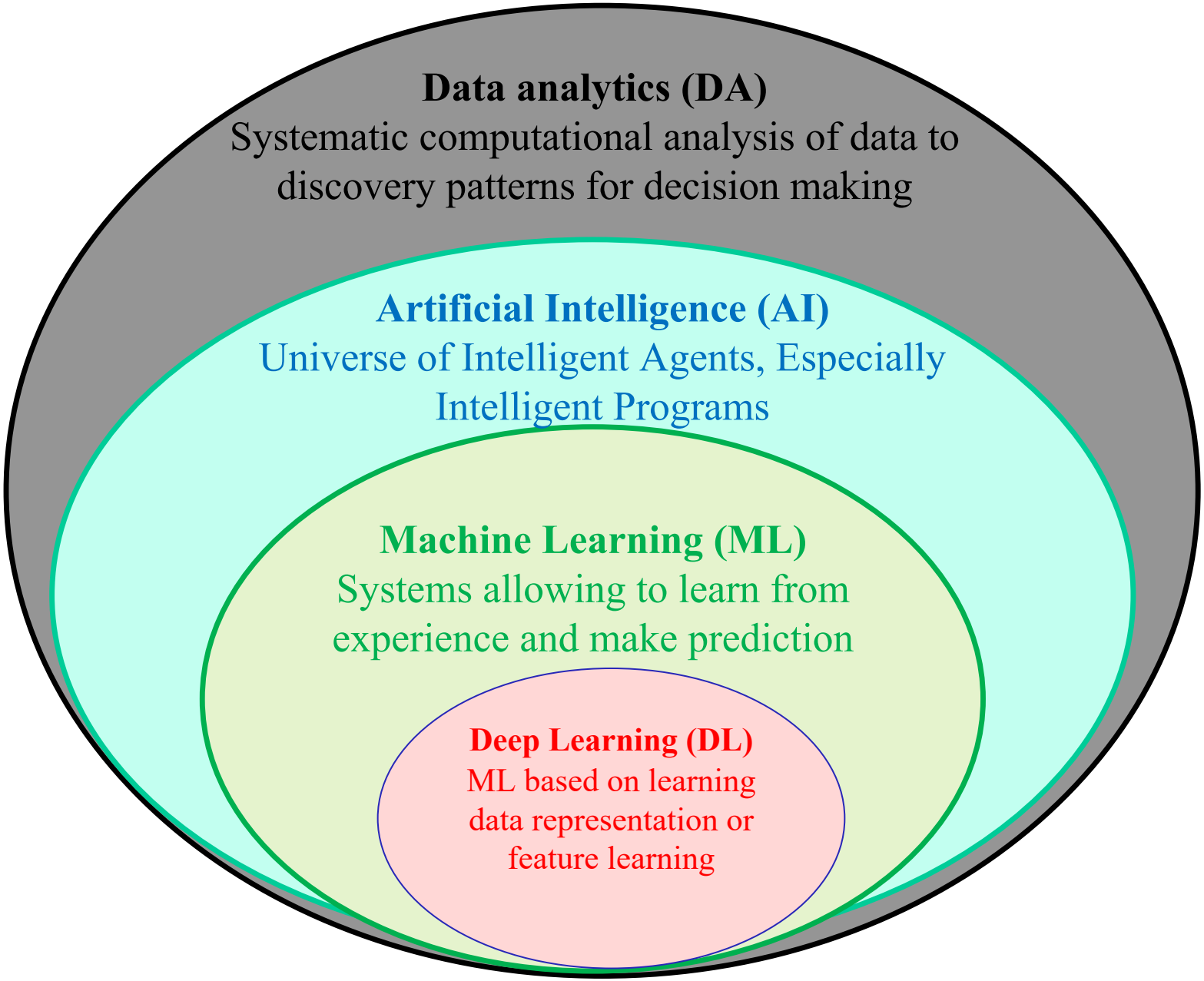
Is Artificial Intelligence, & Data Analytic the Next E&P breakthrough after Hydraulic Fracturing?

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.

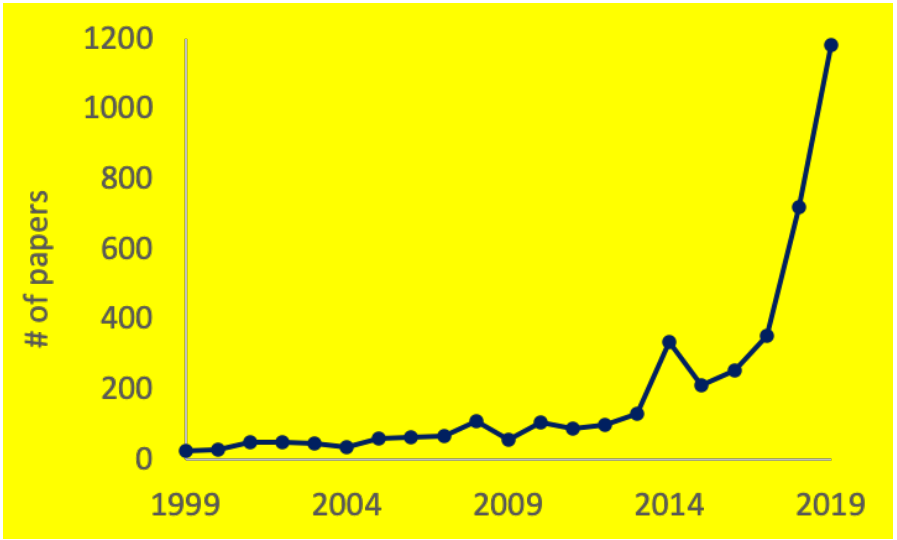
New Challenge: What is the next transformative energy related technology for the next two decades? Is Effective use of Artificial Intelligence (AI) and Data Analytic (DA) for exploration, drilling, production and sustainability of energy resources is the possible answer?

DA and AI-ML-DL

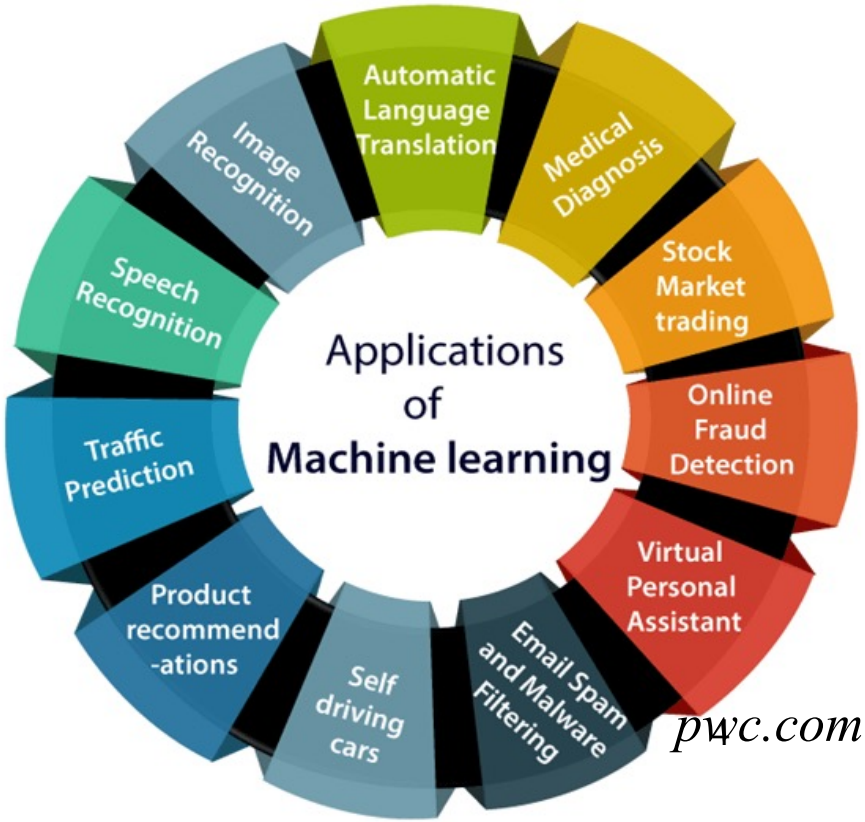


Why AI-DA is Transformative Technology for E&P?

- 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.

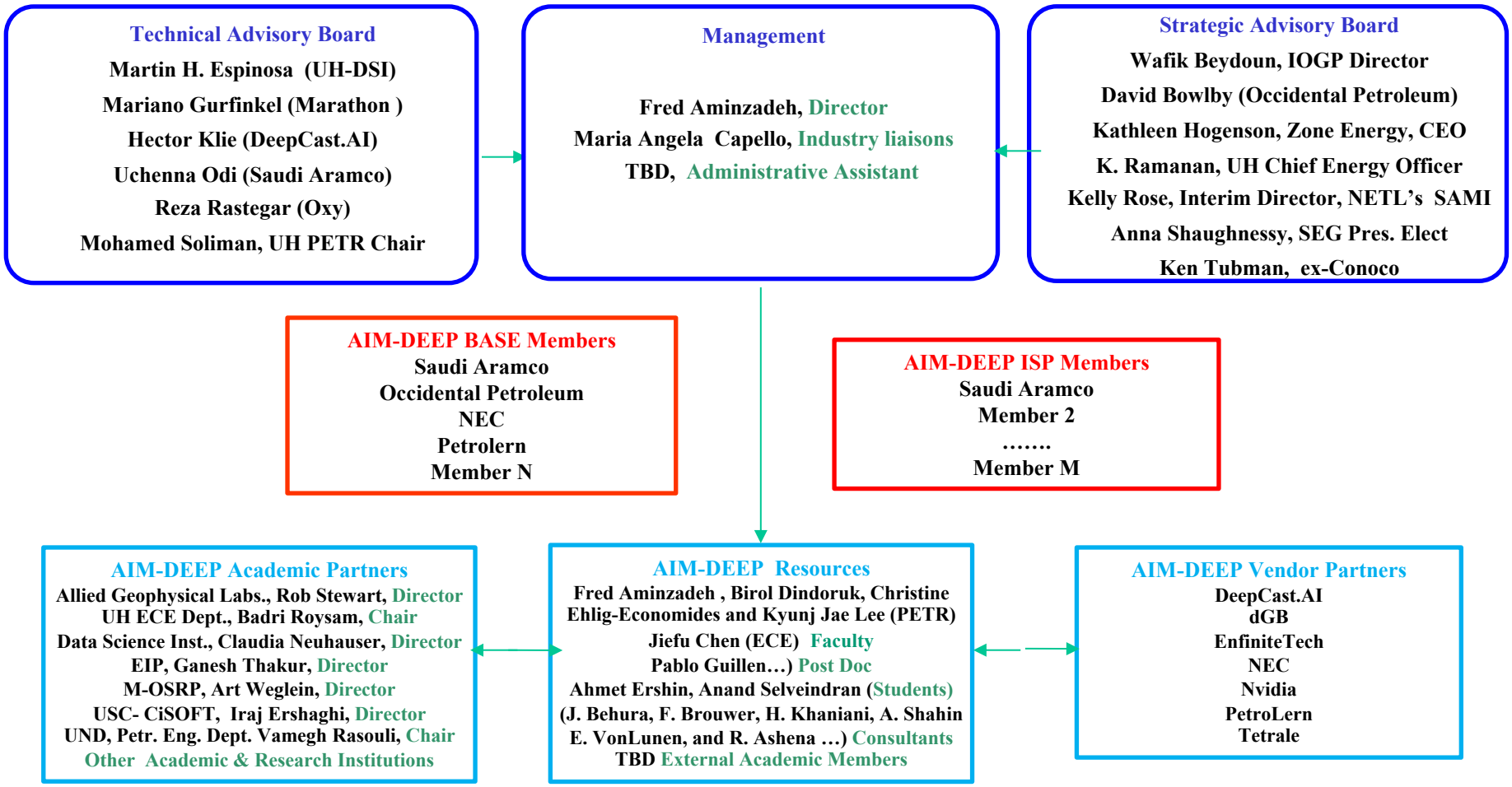


OnePetro- SPE



pwc.com

Organization of UH AIM-DEEP



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

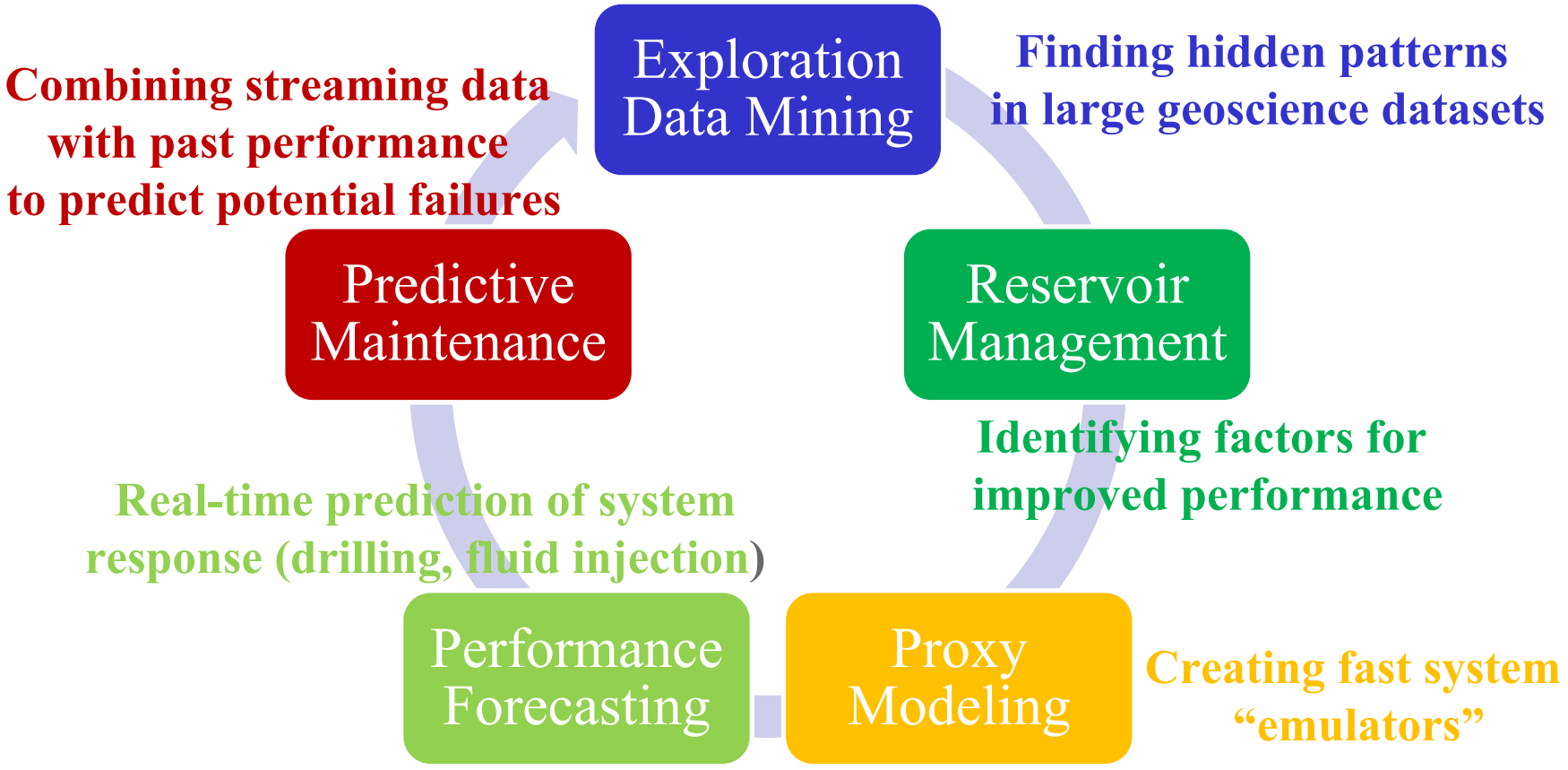
Leveraging Opportunities: Research and Training

- 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.

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

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



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

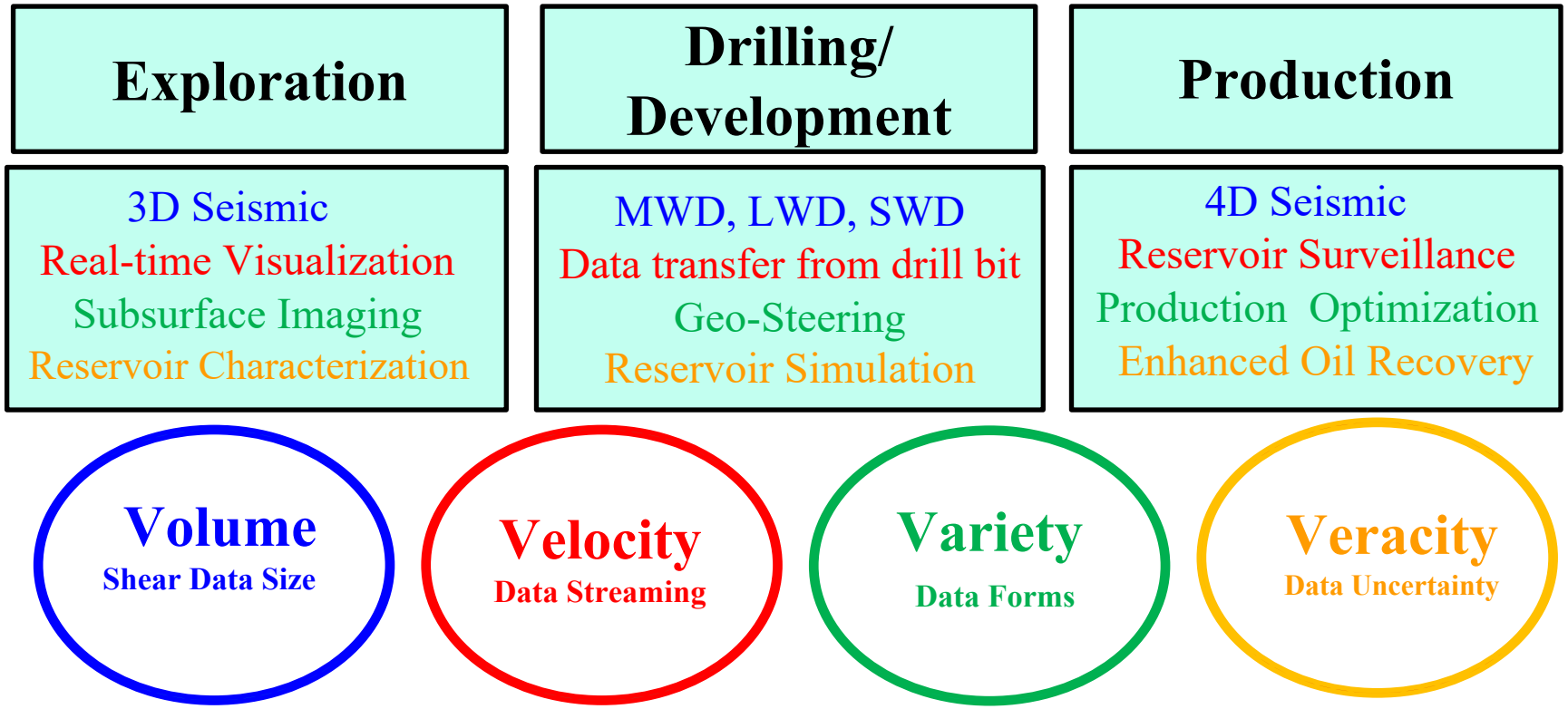
Drilling/Development **D**

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

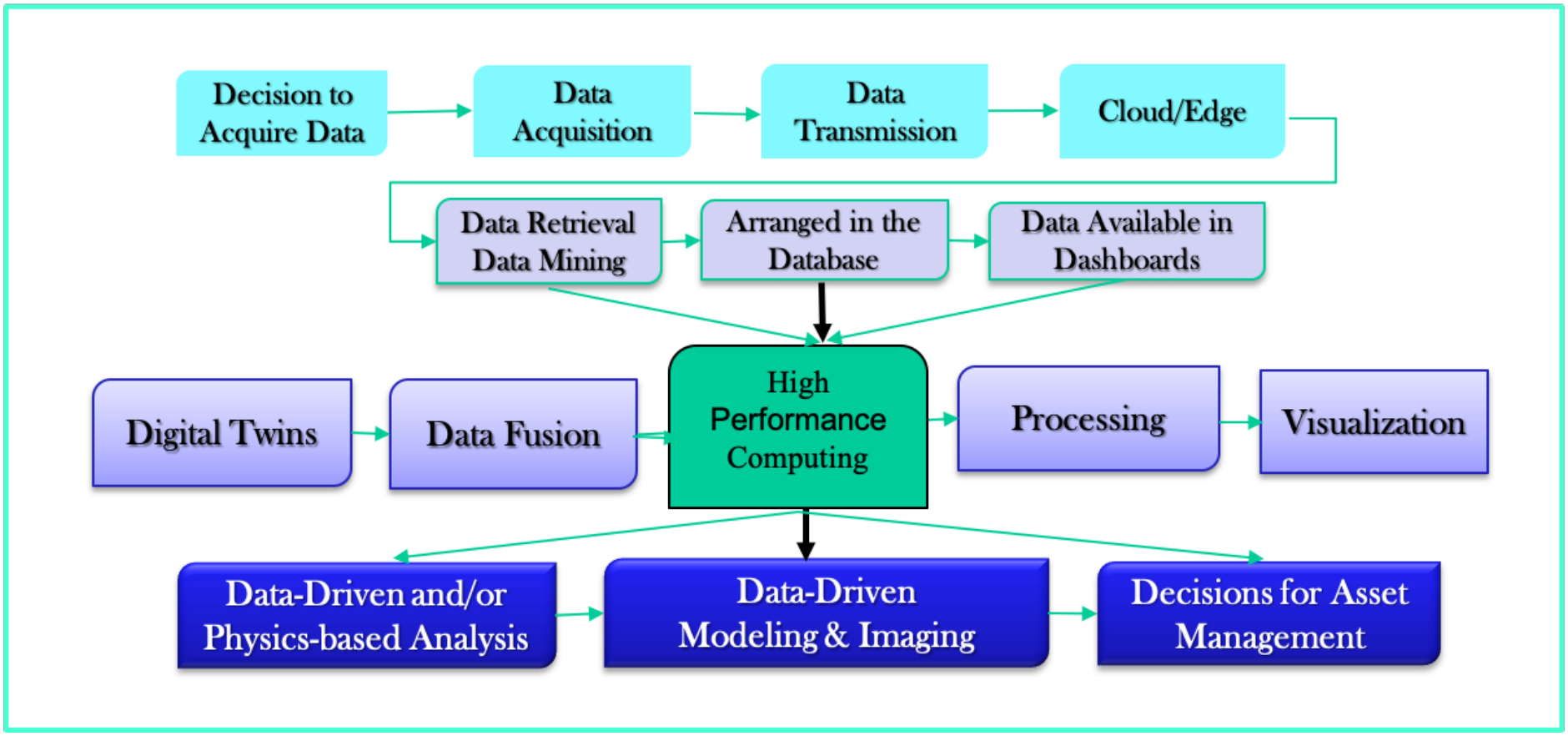
Production / EOR **P**

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

Big Data 4V in Oil and Gas



Workflow for Data Driven Analysis

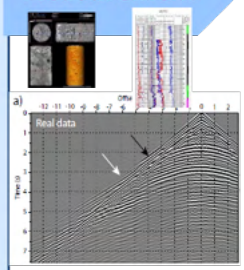
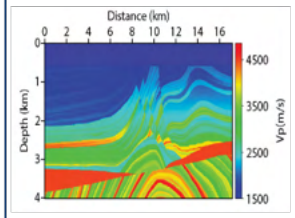
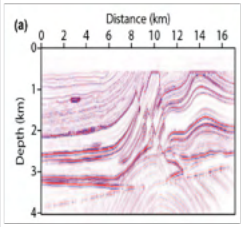
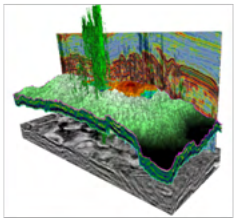
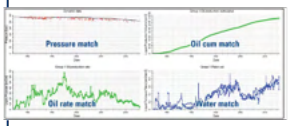


Possible AIM-DEEP Project Focus Areas

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?**

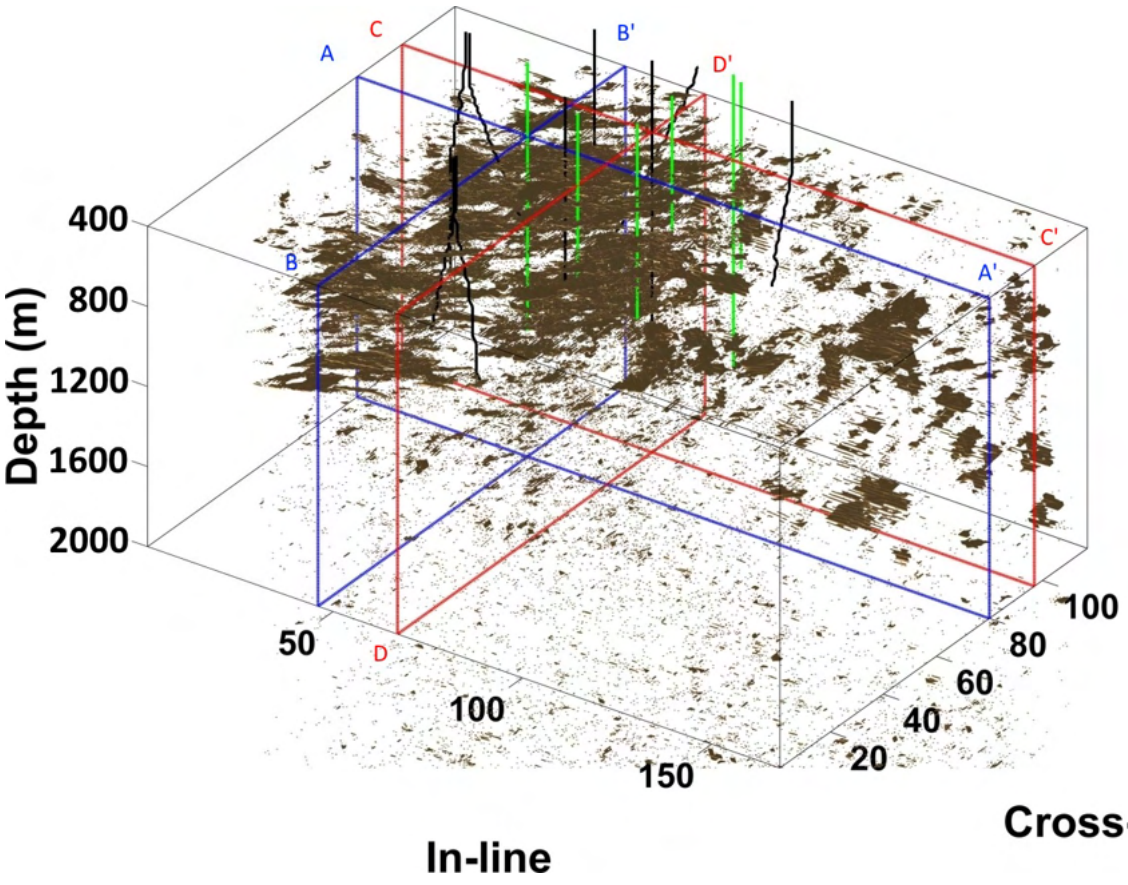
Value addition of HPC and AI/DA at E&P

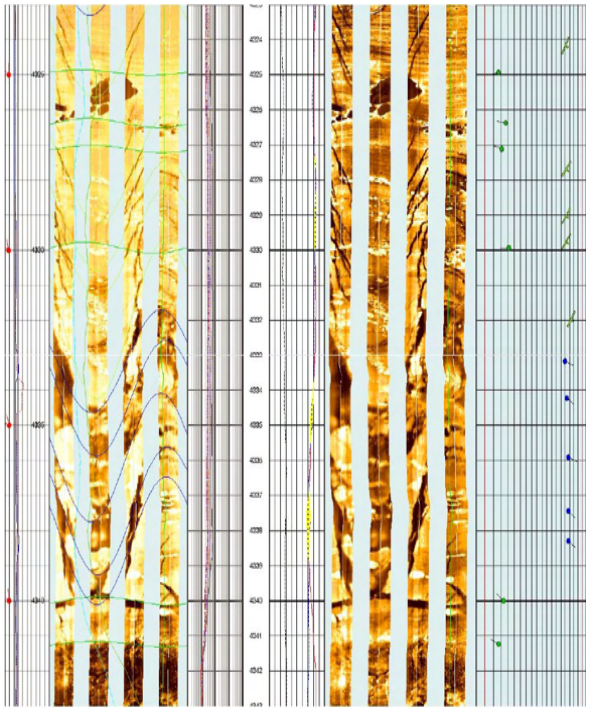
	3D Seismic / Well Logging /				Reservoir Simulation	Surveillance/ 4D Seis
Work	**Measurement**	**Synthetic model Inversion**	**Subsurface Imaging**	**Interpretation / Characterization**	**Simulation / History Matching**	**Infill Drilling Production / EOR**
						
Application	Compressive sensing	Elastic / Anisotropic Full Wave Inversion	Reverse Time Migration	Data Integration/ Digital Twins /Visualization	Production forecasting Economics	Reservoir Monitoring Real Time Dec. Making
Challenge	Expensive	5 days with CPU Memory limitations	Takes time and effort	Nonunique Solutions	Trial and error	Optimize well location increase recovery factor
HPC Value	Real time	Less than a day	Seamless	Collaborative Intr. Char.	Efficiency	Real time feedback
AI/DA Value add	Intelligent sensing Smart processing Utilize experience	Pattern Recognition Ability to create alternative models fast	Image updating with Data Mining Deep Learning	Data Mining method Big Data / 4V concept	Model Validation Digital Twins, Proxy models	Reservoir surveillance/ Visualization

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

Courtesy of NEC Corporation
Aminzadeh and Ikuta, (2021)

Determining Fracture Distribution





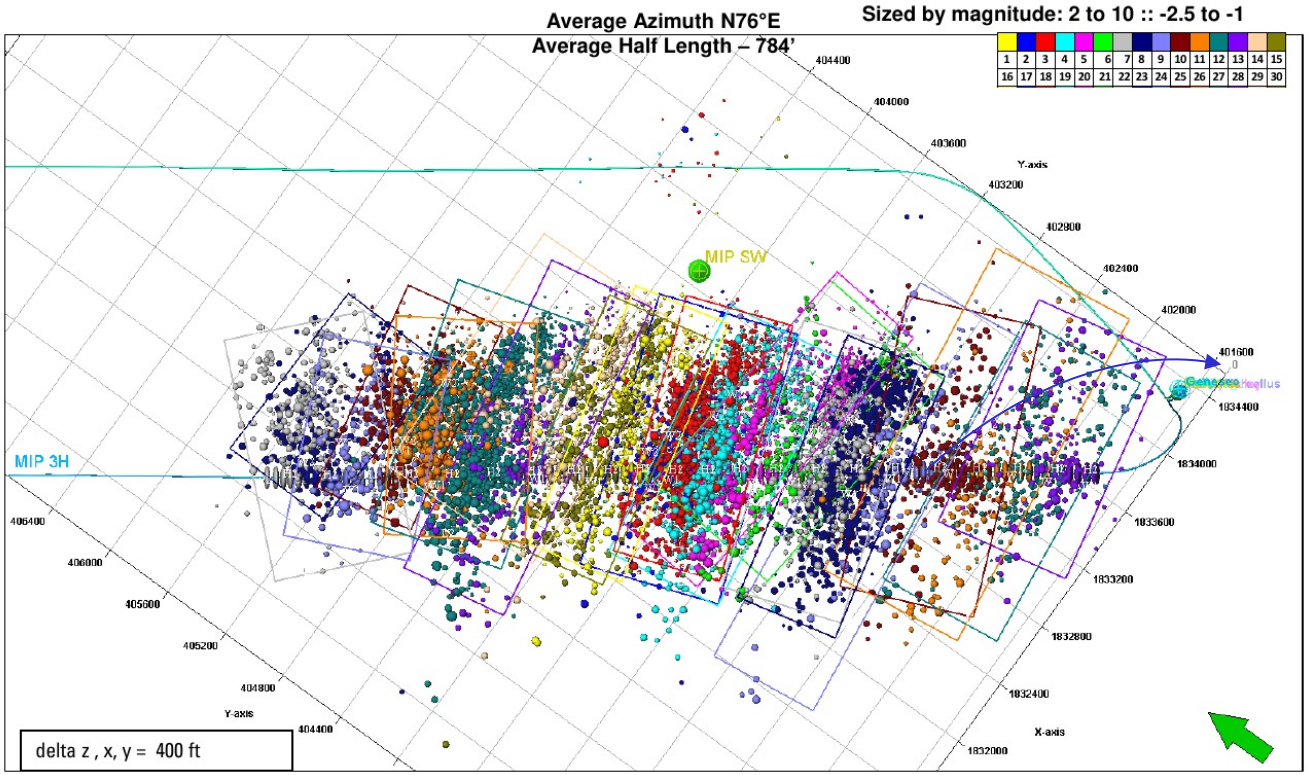
Identify fractures & generate fracture logs

HYBRID FZI ATTRIBUTE MAPPING (ANN)

$$FZI_n = F\{\phi_n, Z_n, V_{Pn}, V_{Sn}, \rho_n, V_{En},\}$$

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

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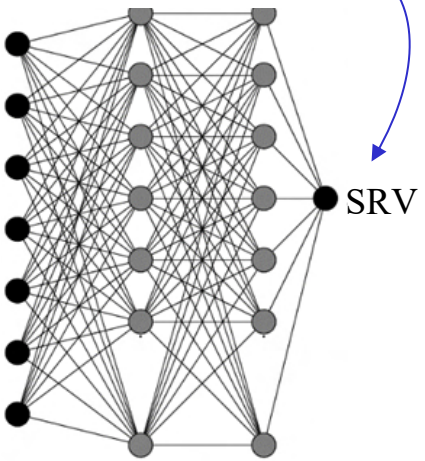
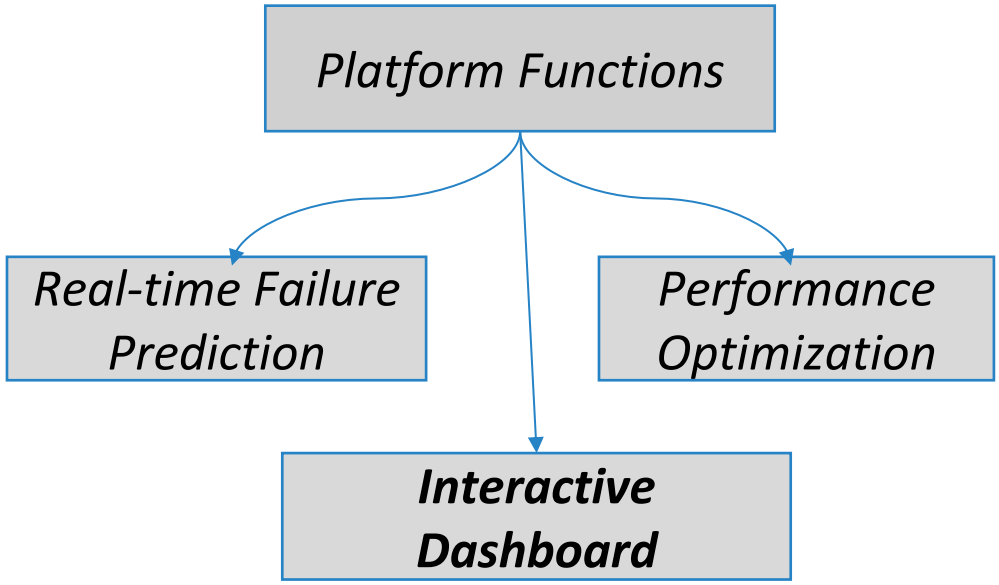
Stress

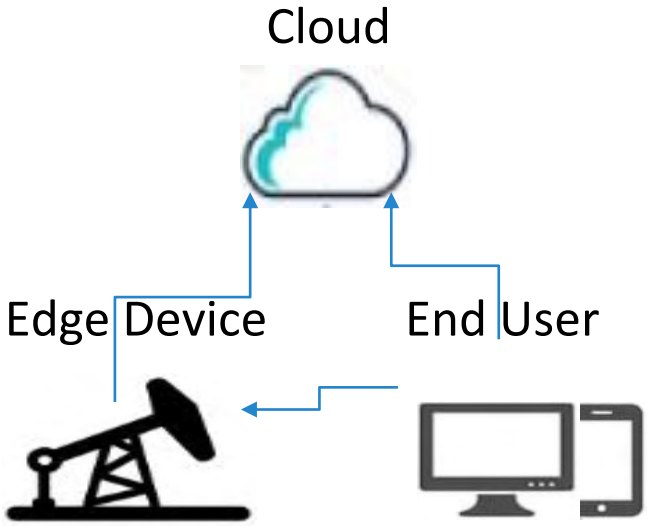
Mineralogy



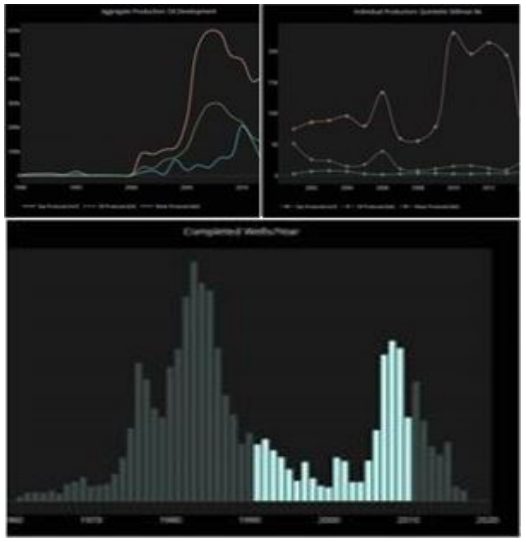
Rezaei et al. (2021)

AI-Biased Failure Detection via an IoT Platform





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

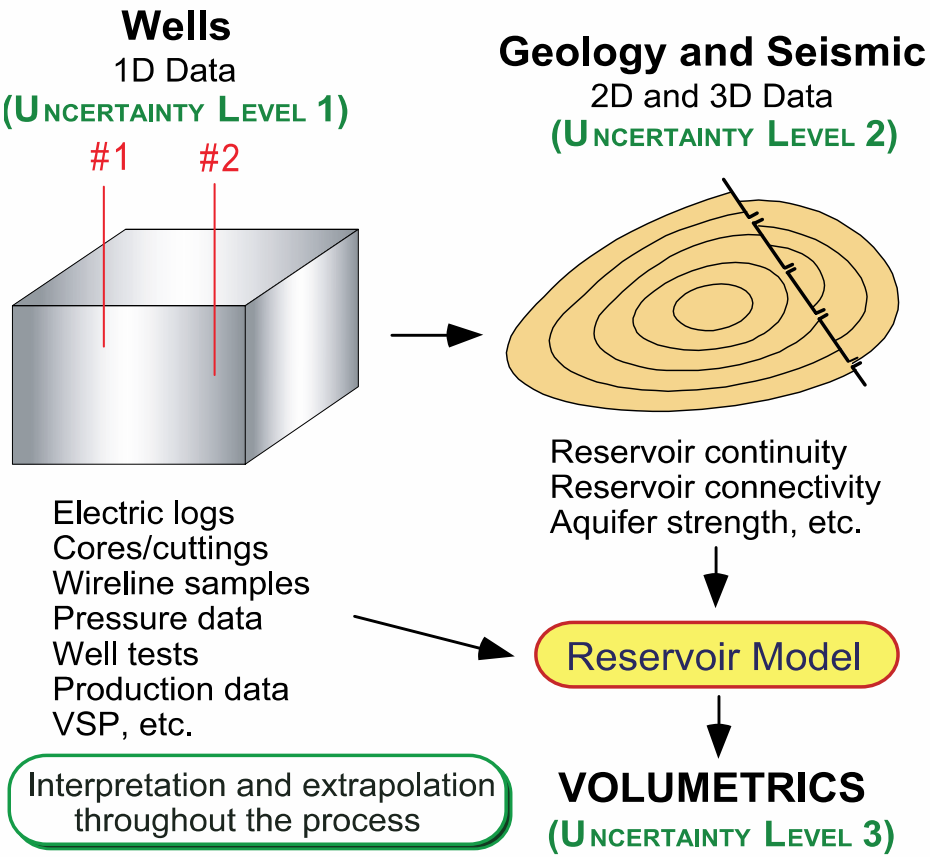


Interactive Dashboard

Ranjit, Suhag, Aminzadeh (2019)

AI for Uncertainty in Reserves (EUR) Prediction

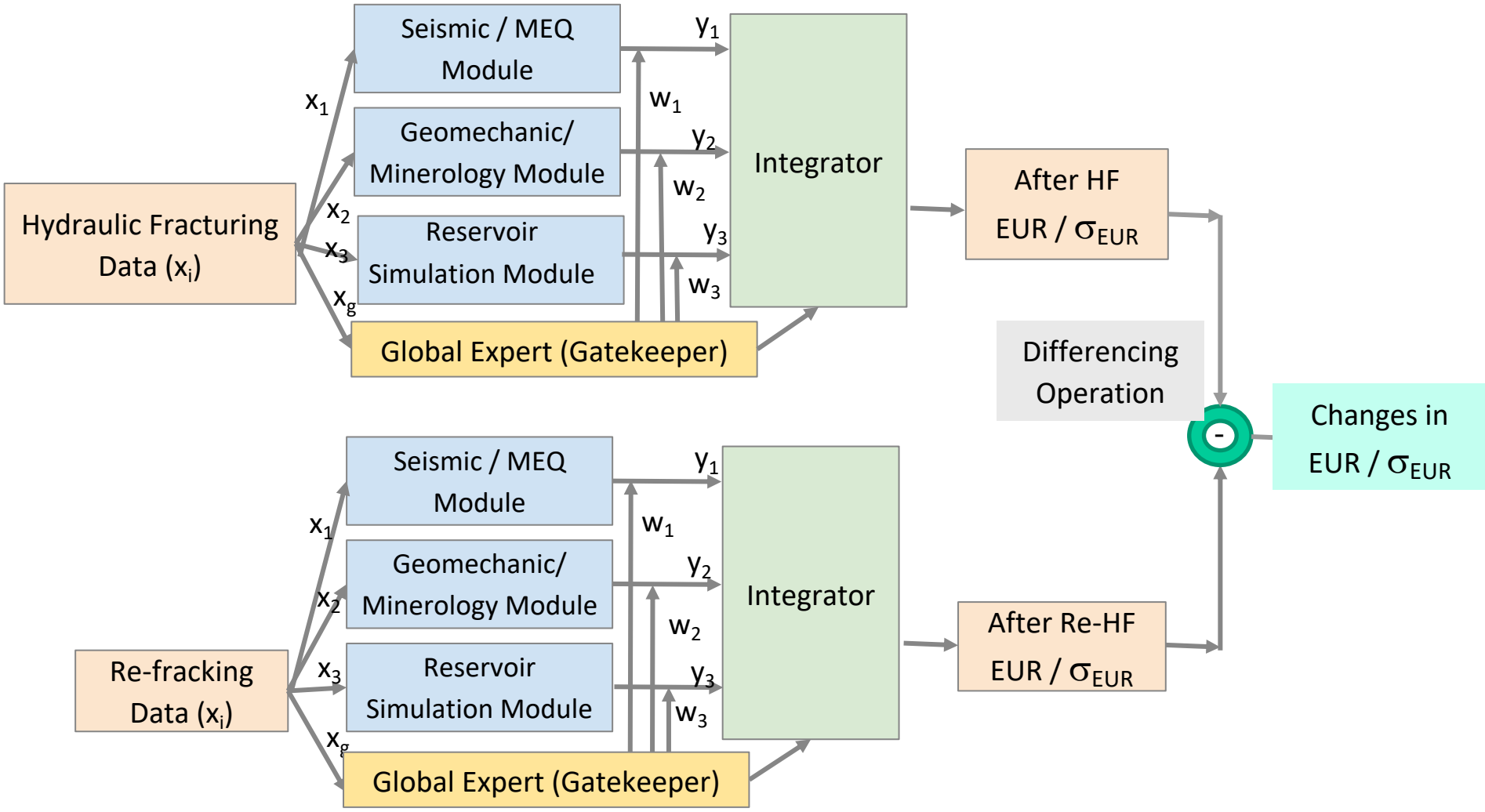
A. 1D data for reservoir properties such as porosity, saturation, oil viscosity
B. As 1D reservoir properties are extrapolated to 2D and 3D with the help of geology, seismic, and production data, simplifying assumptions are made and errors are incurred
C. EUR estimation process involves many complications,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



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

Aminzadeh (2016)

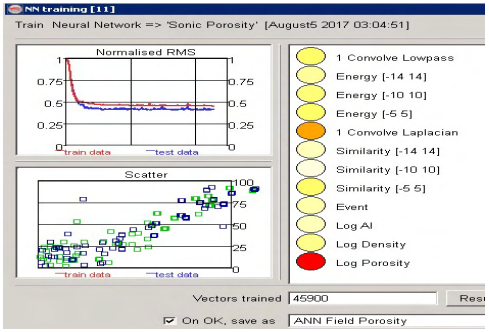
Prediction of EUR and its Uncertainty Using Modular Neural Networks (MNN)



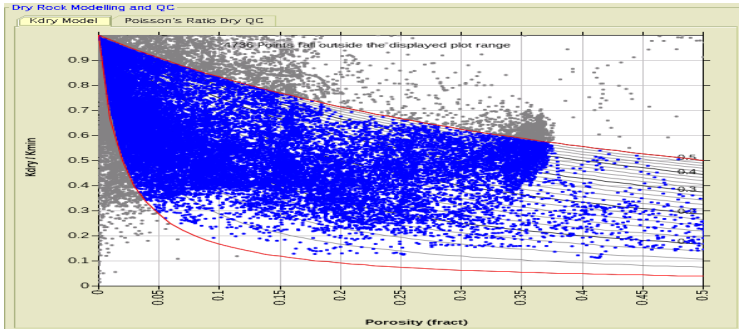
Adopted from Aminzadeh. (2020)

CO_2 Sequestration using Integrated Physics based and Machine Learning

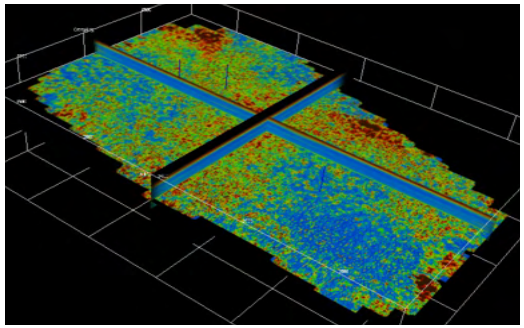
1. To model and identify effective and low-cost monitoring techniques for CO_2 Carbon Capture and Storage.
2. To derive geophysical techniques (seismic) and attributes for an accurate and robust CO_2 monitoring system.
3. To evaluate geophysical monitoring ideas for safe CO_2 storage, and identify any 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 .

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

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.