



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

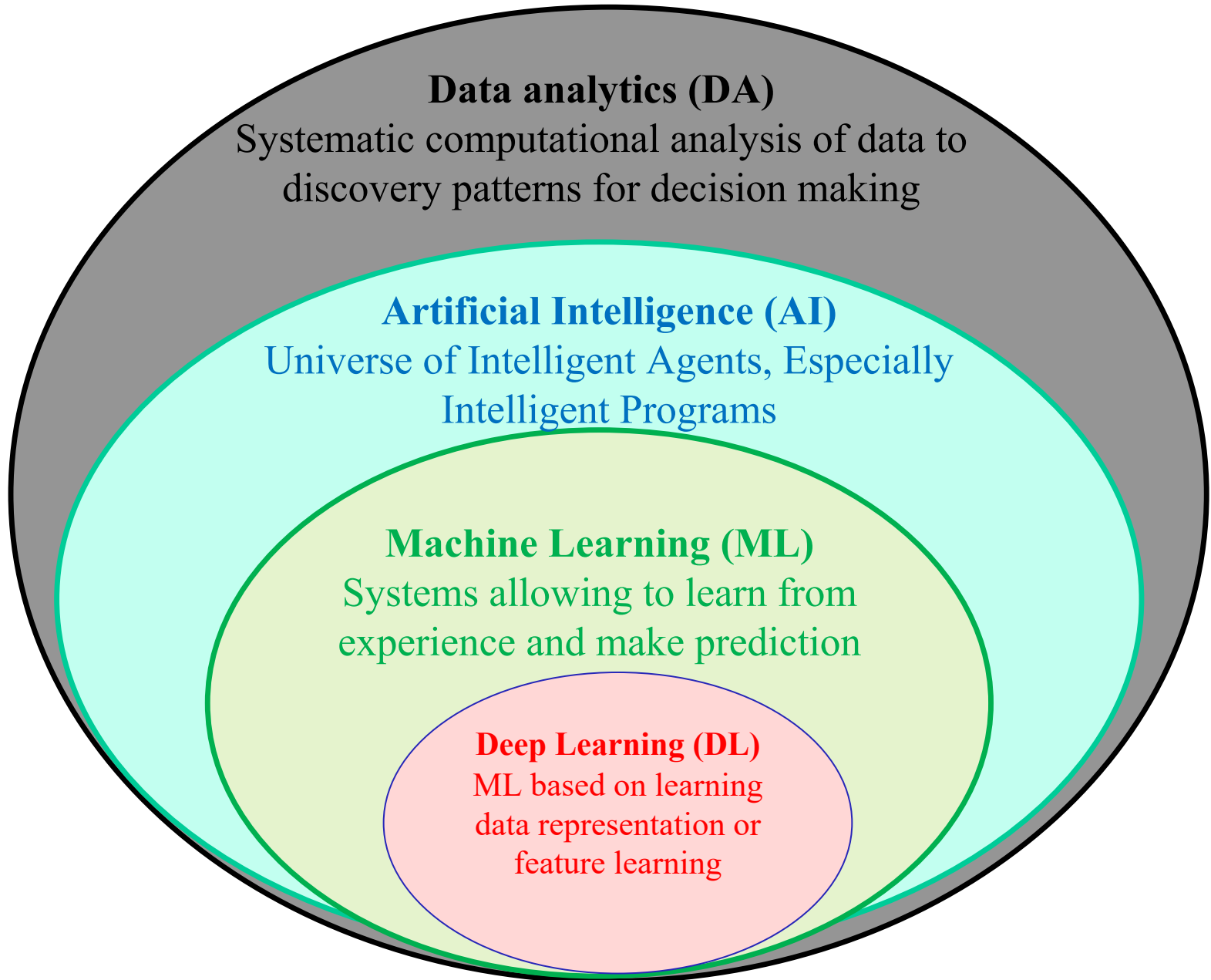
Fred Aminzadeh,  
Professor, & Director of AIM-DEEP

# 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.

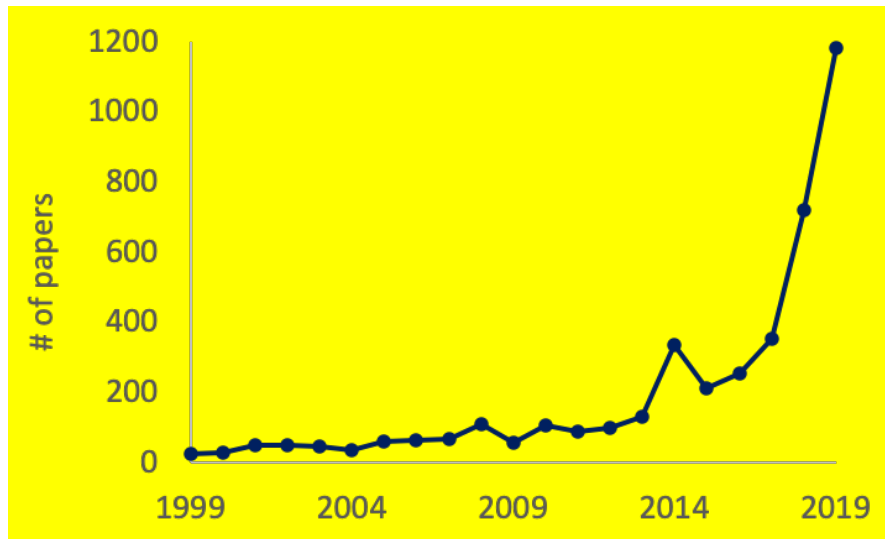
**New Challenge:** What is the next transformative energy related technology for the next two decades? Is Effective use of Artificial Intelligence (AI) and Data Analytic (DA) for exploration, drilling, production and sustainability of energy resources is the possible answer?

# DA and AI-ML-DL

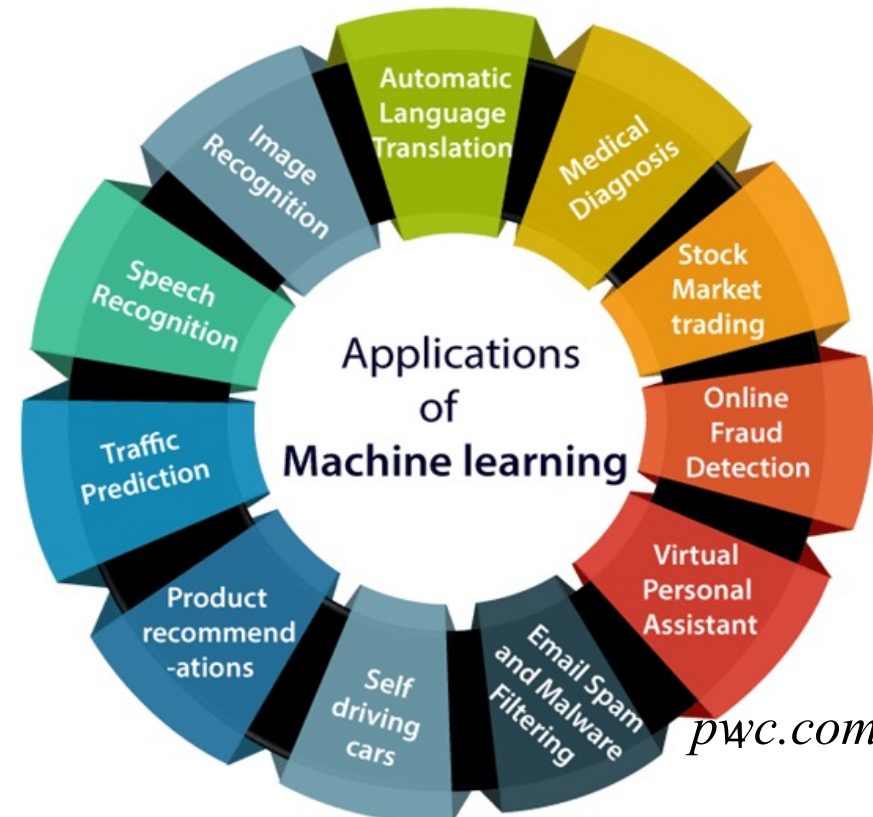


# Why AI-DA is Transformative Technology for E&P?

- 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 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.

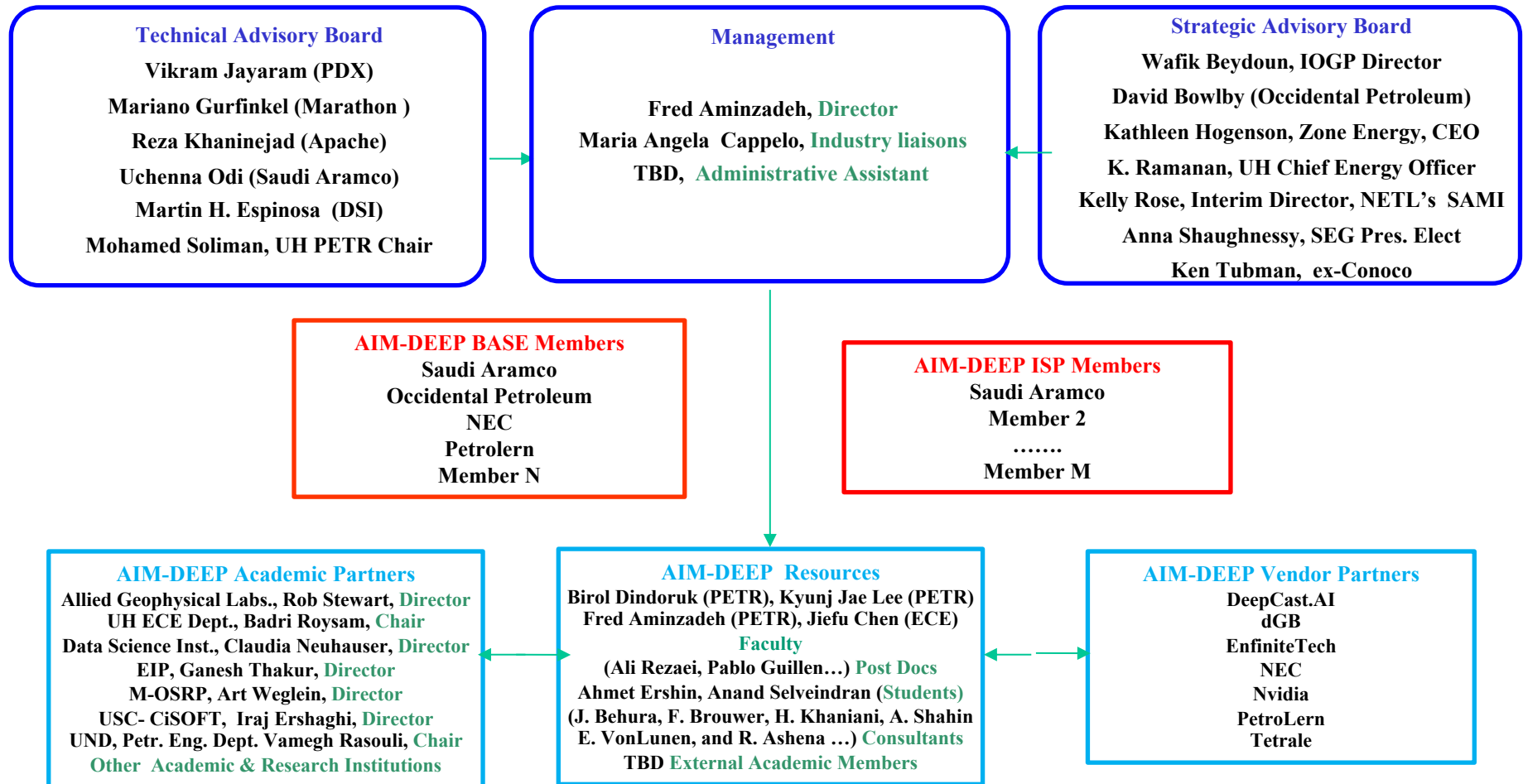


*OnePetro- SPE*



*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

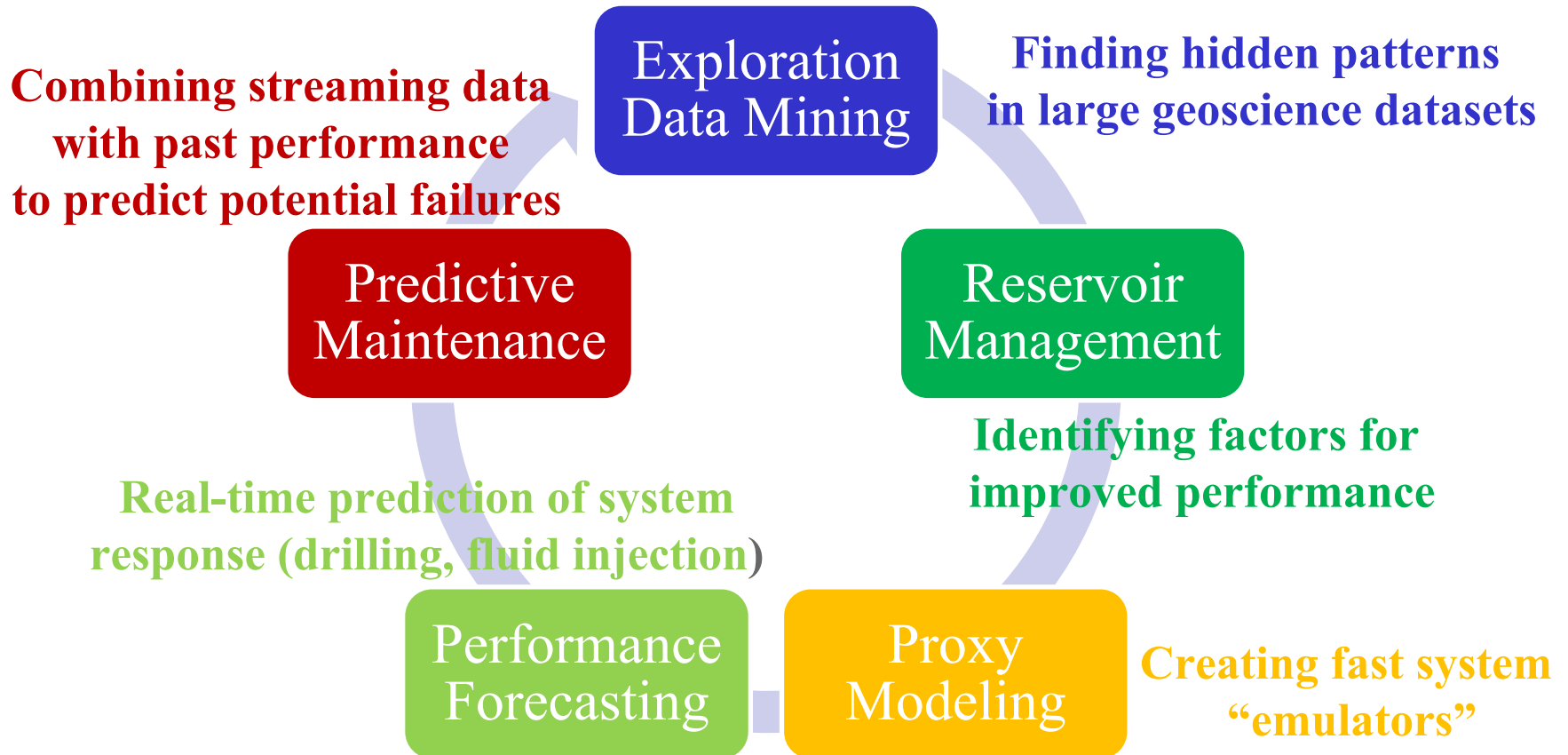


## Leveraging Opportunities: Research and Training

- 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.

[illegible]

# 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**

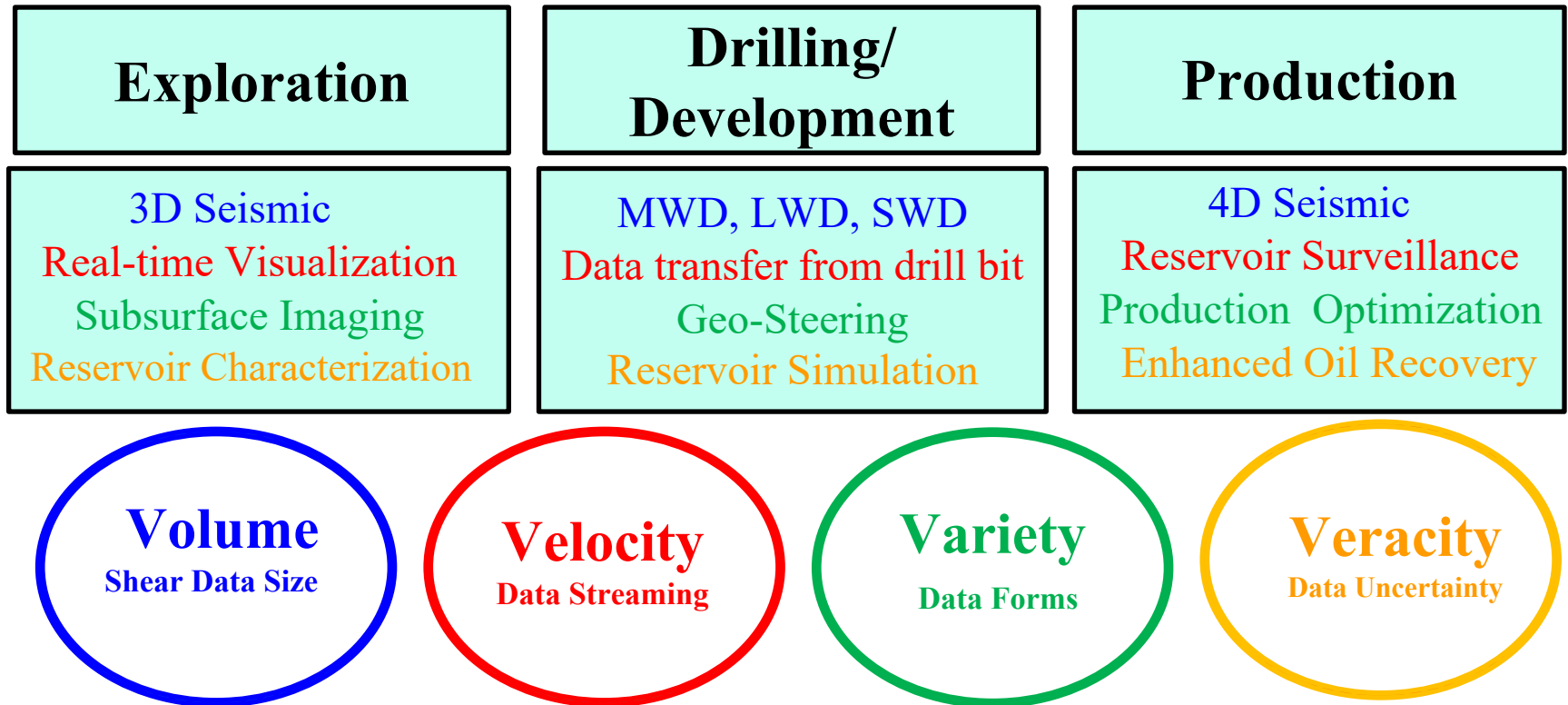
**Well Path Design**  
**Optimum Mud weight**  
**Geo-steering**  
**Reservoir Pressure Mon.**  
**Kick Monitoring**  
**MWD / LWD / SWD**  
**Completion**



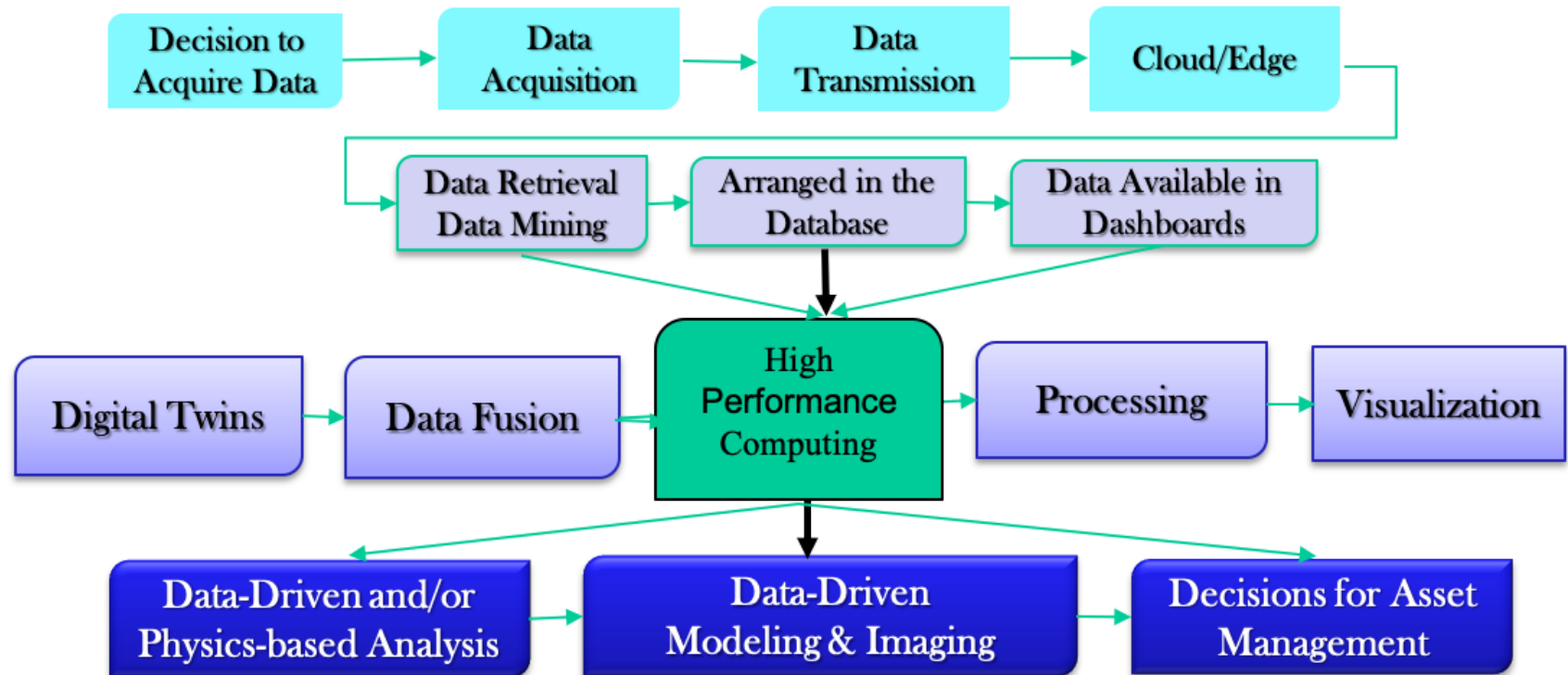
Production / EOR **P**

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

# Big Data 4V in Oil and Gas



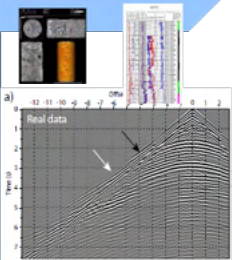
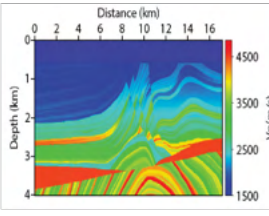
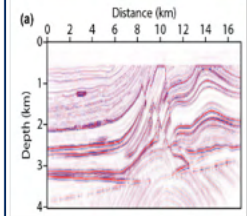
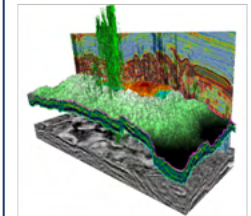
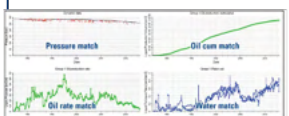

# Workflow for Data Driven Analysis



# 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

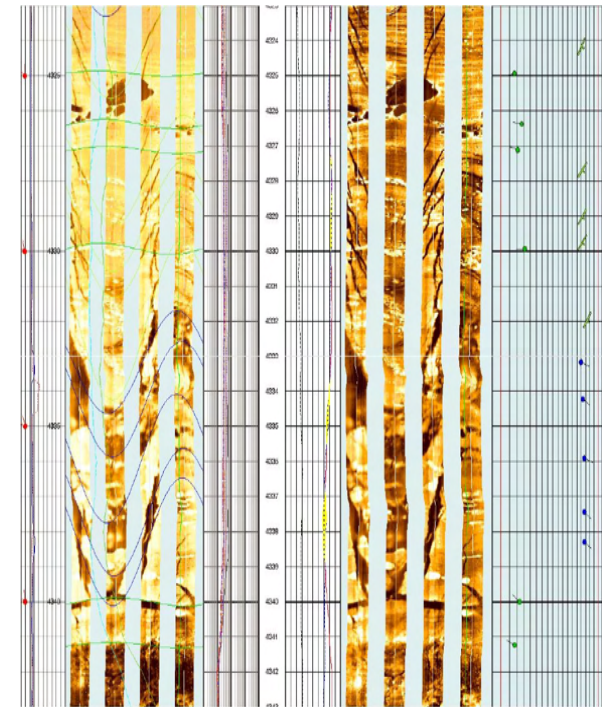
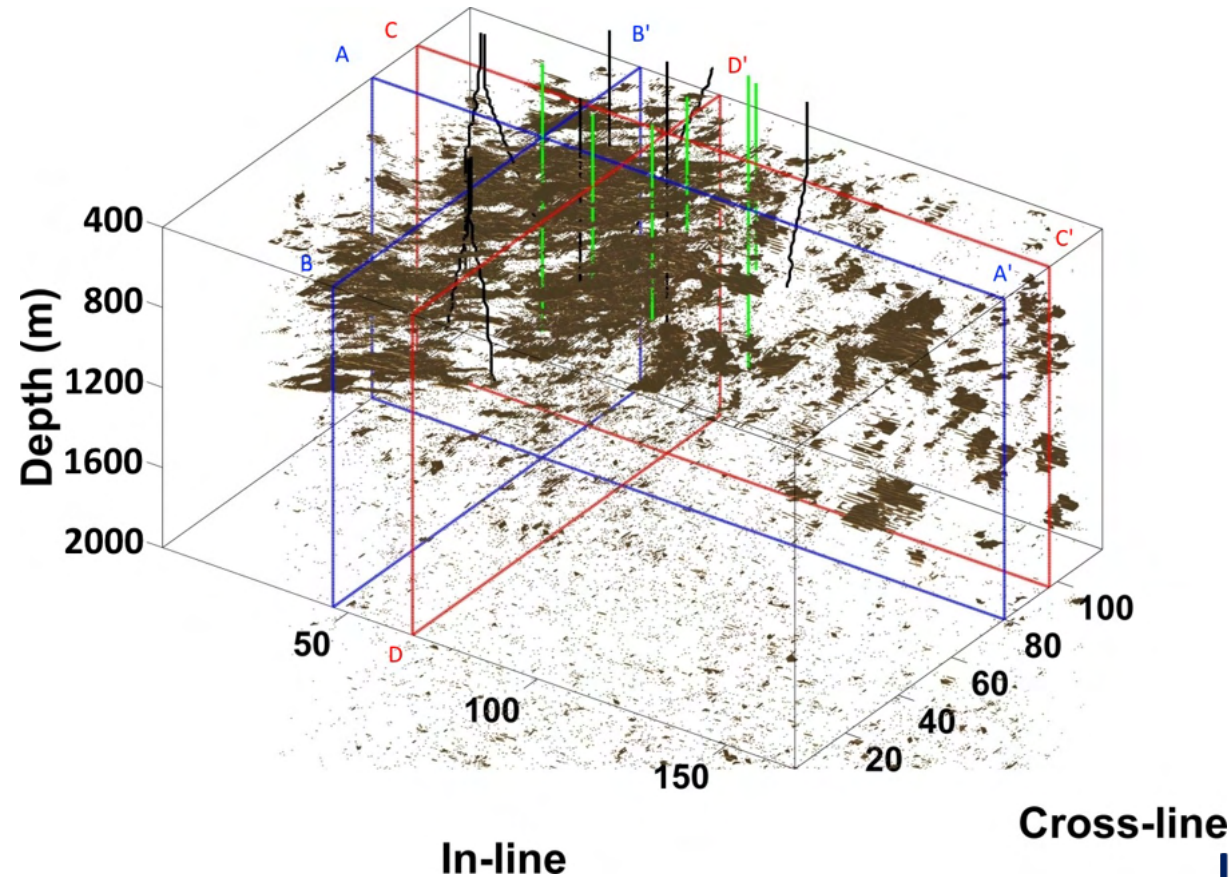
	3D Seismic / Well Logging /				Reservoir Simulation	Surveillance/ 4D Seis
Work	Measurement 	Synthetic model Inversion 	Subsurface Imaging 	Interpretation / Characterization 	Simulation / History Matching 	Infill Drilling Production / EOR 
Application	Compressive sensing	Elastic / Anisotropic Full Wave 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

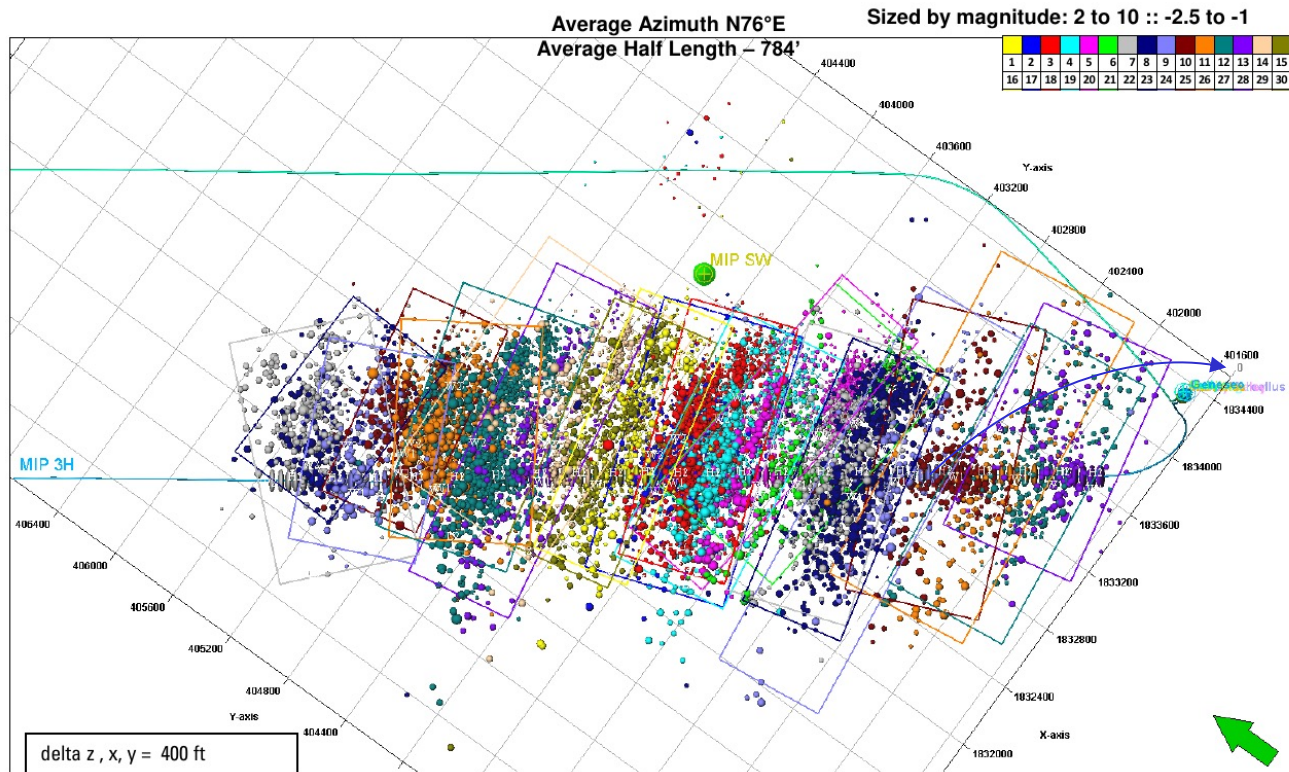
HYBRID FZI ATTRIBUTE MAPPING (ANN)

$$FZI_n = F\{\phi_w Z_n, V_{Pn}, V_{Sn}, \rho_w V_{En},\}$$

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

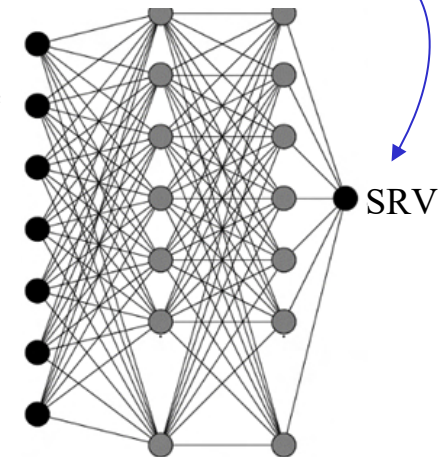


# Stimulated Reservoir Volume (SRV) Prediction



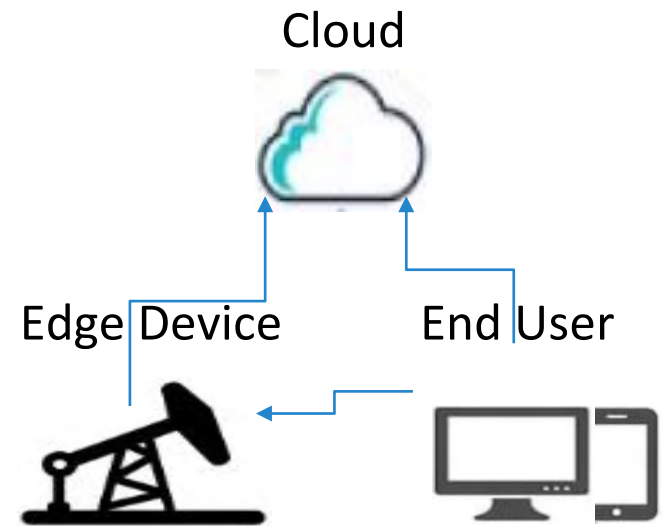
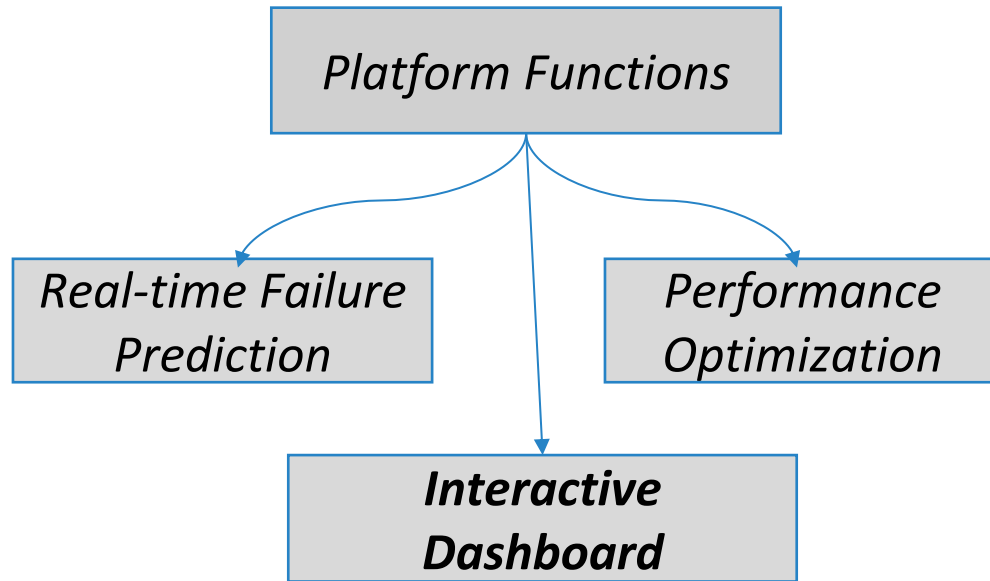
Area (or volume of the stimulated reservoir) as a scalar representing SRV

Proppant volume  
Injected fluid volume  
Recorded pressure  
....  
Stress  
Mineralogy

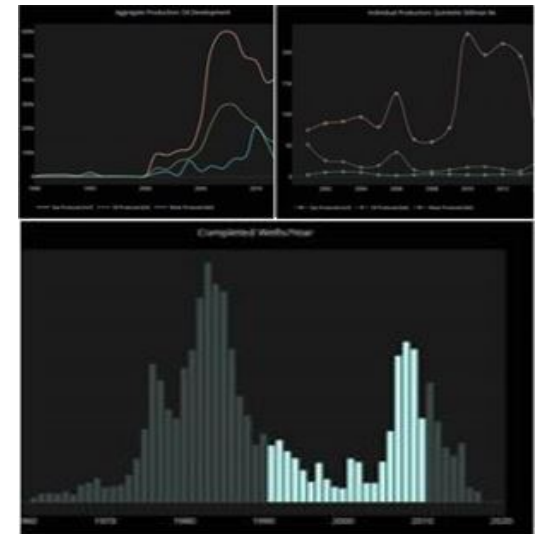


Rezaei et al. (2021)

# AI-Biased Failure Detection via an IoT Platform

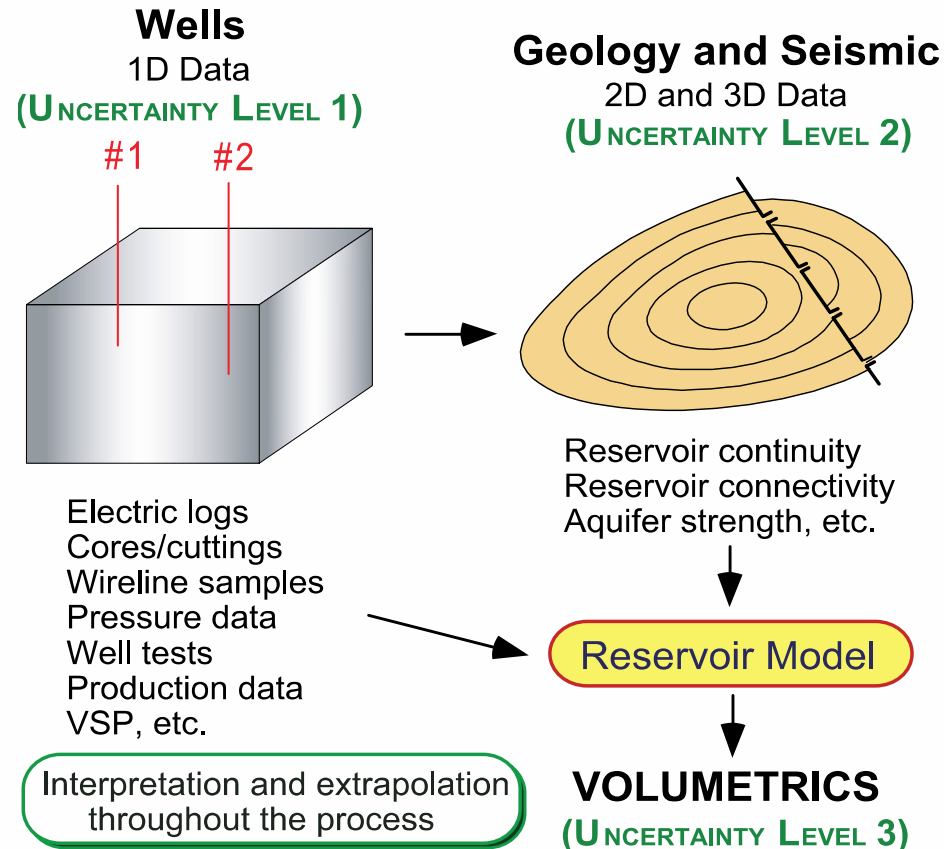


End-to-end visibility and control of artificial lift assets, devices and reporting



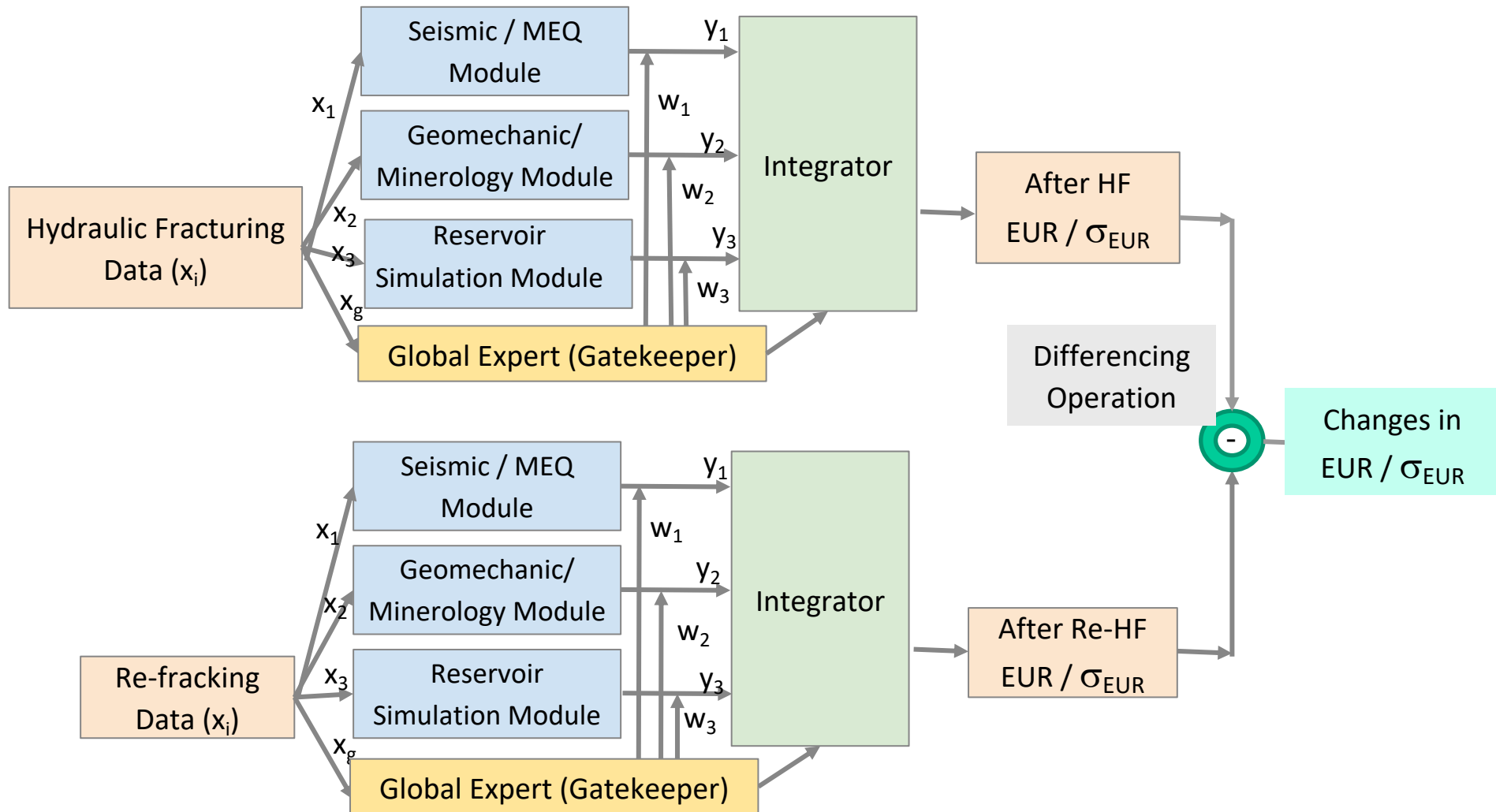
# AI for Uncertainty in Reserves (EUR) Prediction

- 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



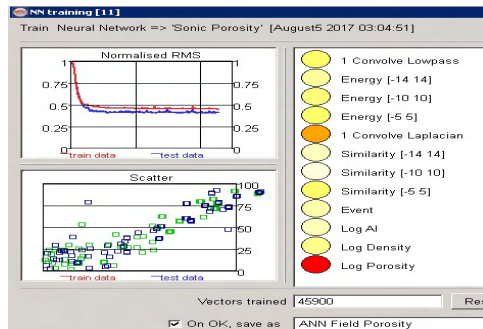
$$\text{Effective Volume} = \text{Area} * \text{Thickness} * \Phi * (1 - S_w) * RF / FVF$$

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

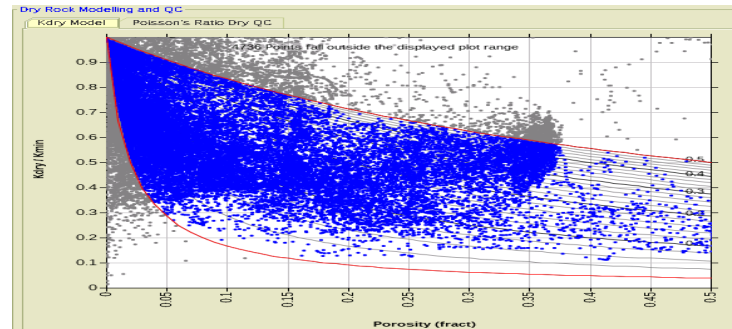


# CO<sub>2</sub> Sequestration using Integrated Physics based and Machine Learning

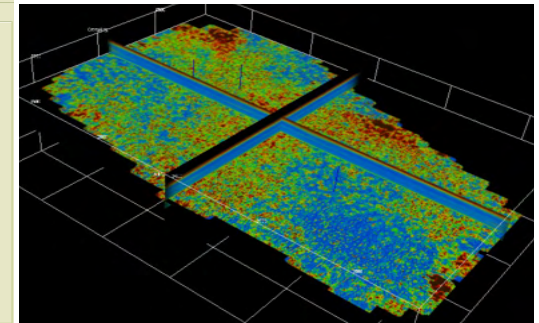
1. To model and identify effective and low-cost monitoring techniques for CO<sub>2</sub> Carbon Capture and Storage.
2. To derive geophysical techniques (seismic) and attributes for an accurate and robust CO<sub>2</sub> monitoring system.
3. To evaluate geophysical monitoring ideas for safe CO<sub>2</sub> 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.