AIM-DEEP

UNIVERSITY of HOUSTON

PETROLEUM ENGINEERING

Artificial Intelligence, and Data Analytics for Exploration and Production

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UH Energy Virtual Seminar

February 4, 2020

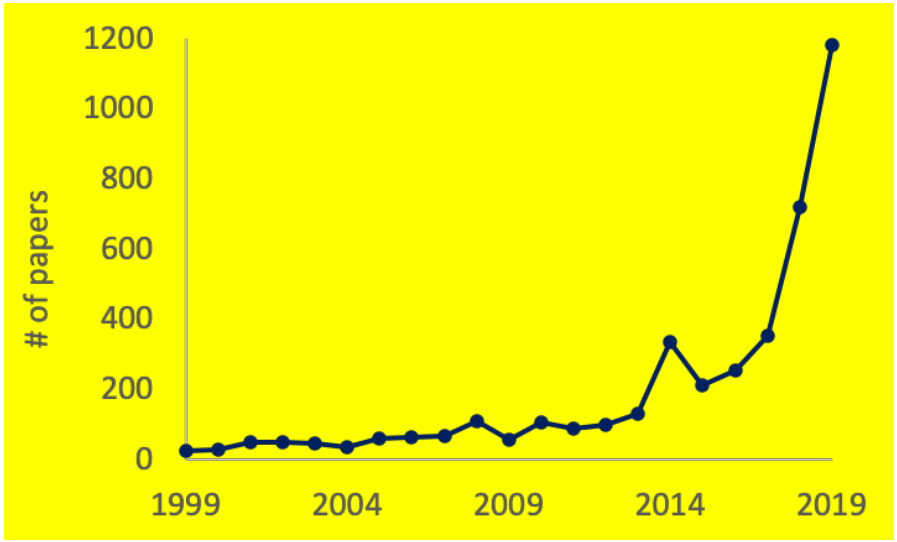
Is Artificial Intelligence, & Data Analytic the Next E&P breakthrough after Hydraulic Fracturing?

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.

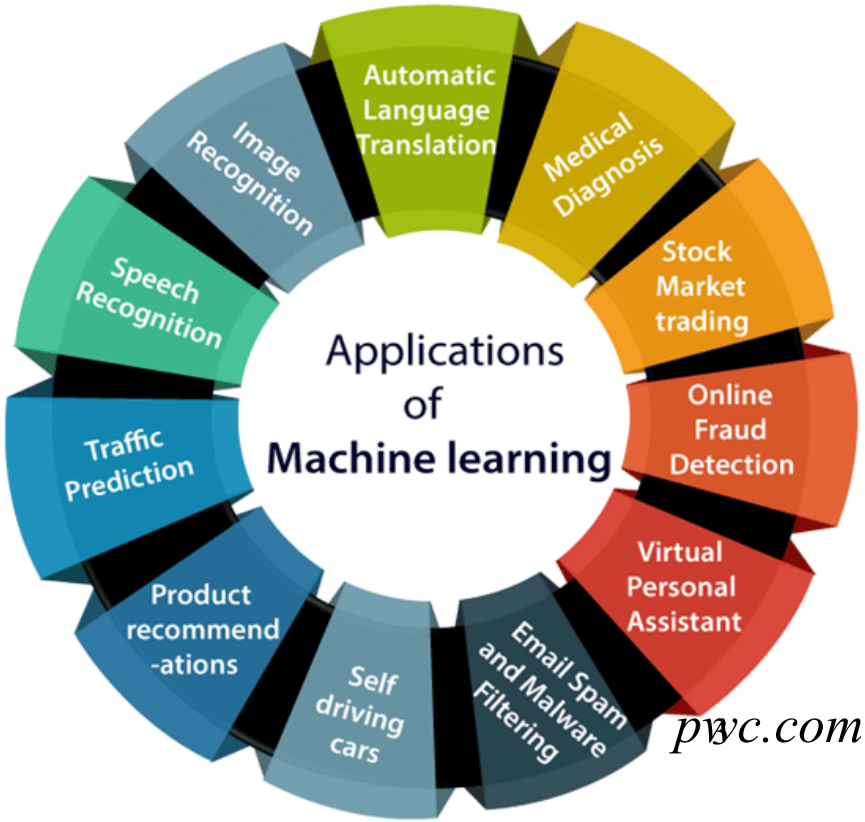
New Challenge: What is the next transformative energy related technology for the next two decades? Is Effective use of Artificial Intelligence (AI) and Data Analytic (DA) for exploration, drilling, production and sustainability of energy resources is the possible answer?

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.

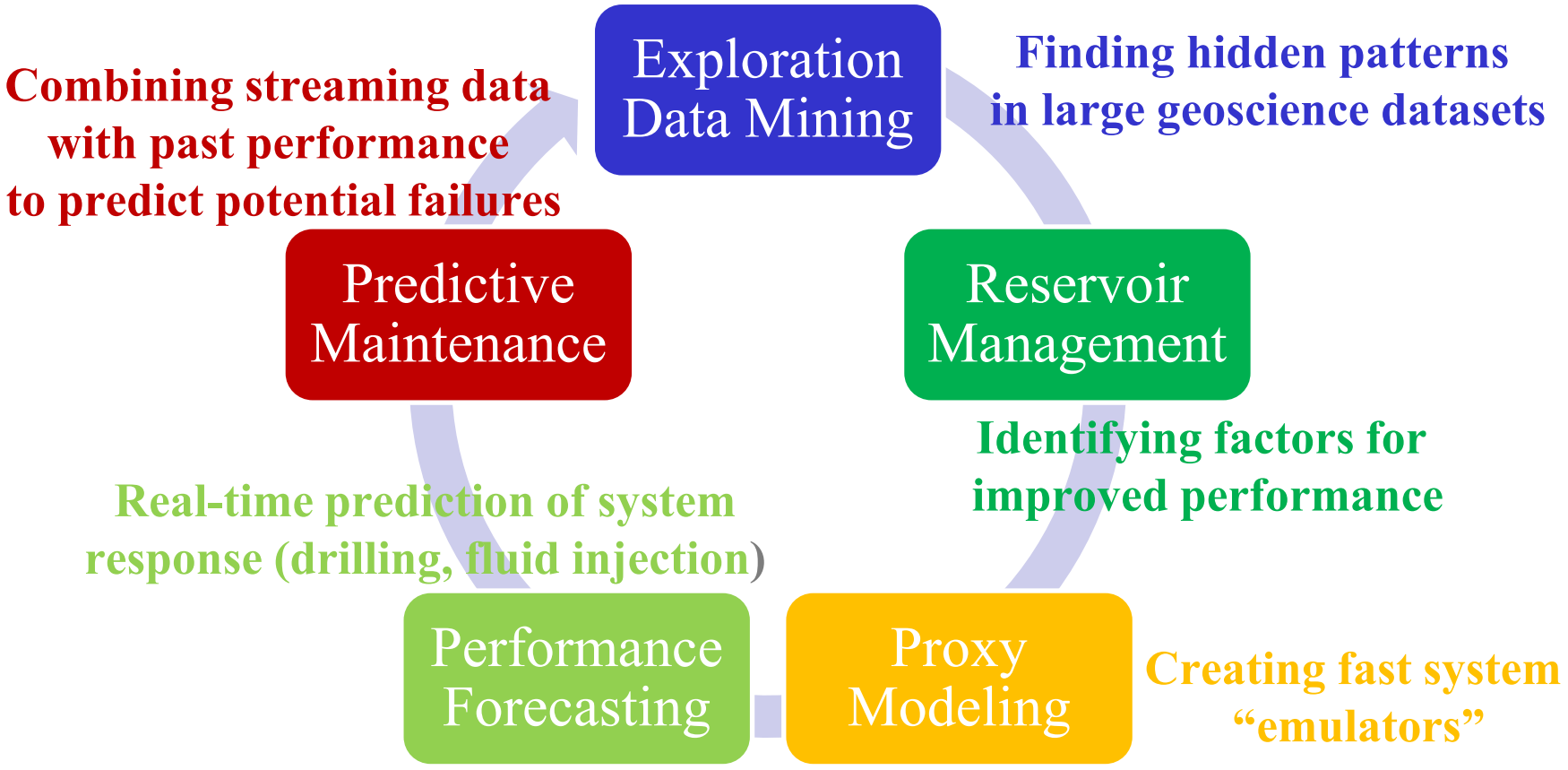


OnePetro- SPE



pwc.com

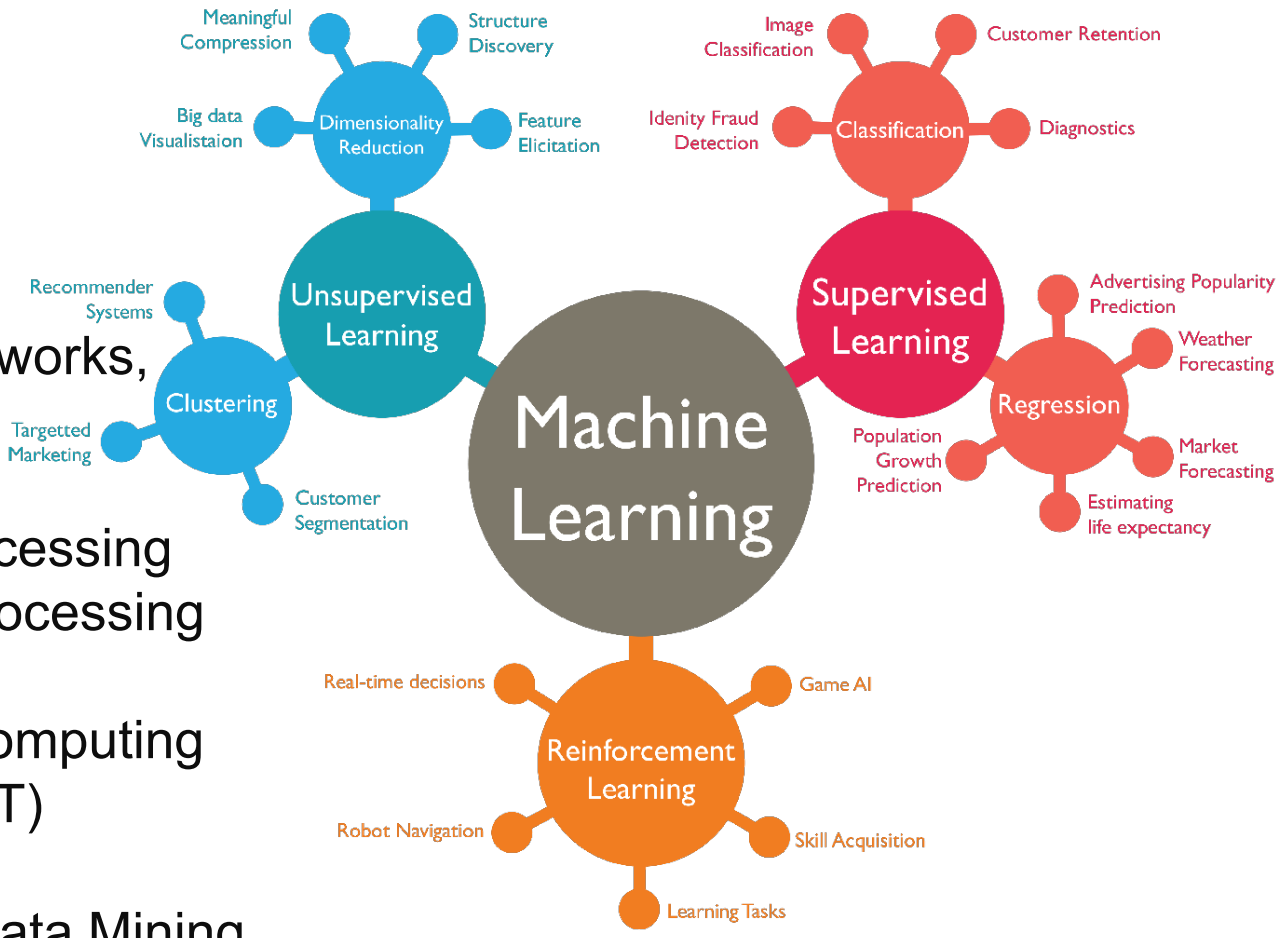
AI- Data Analytics Application Areas in E&P



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

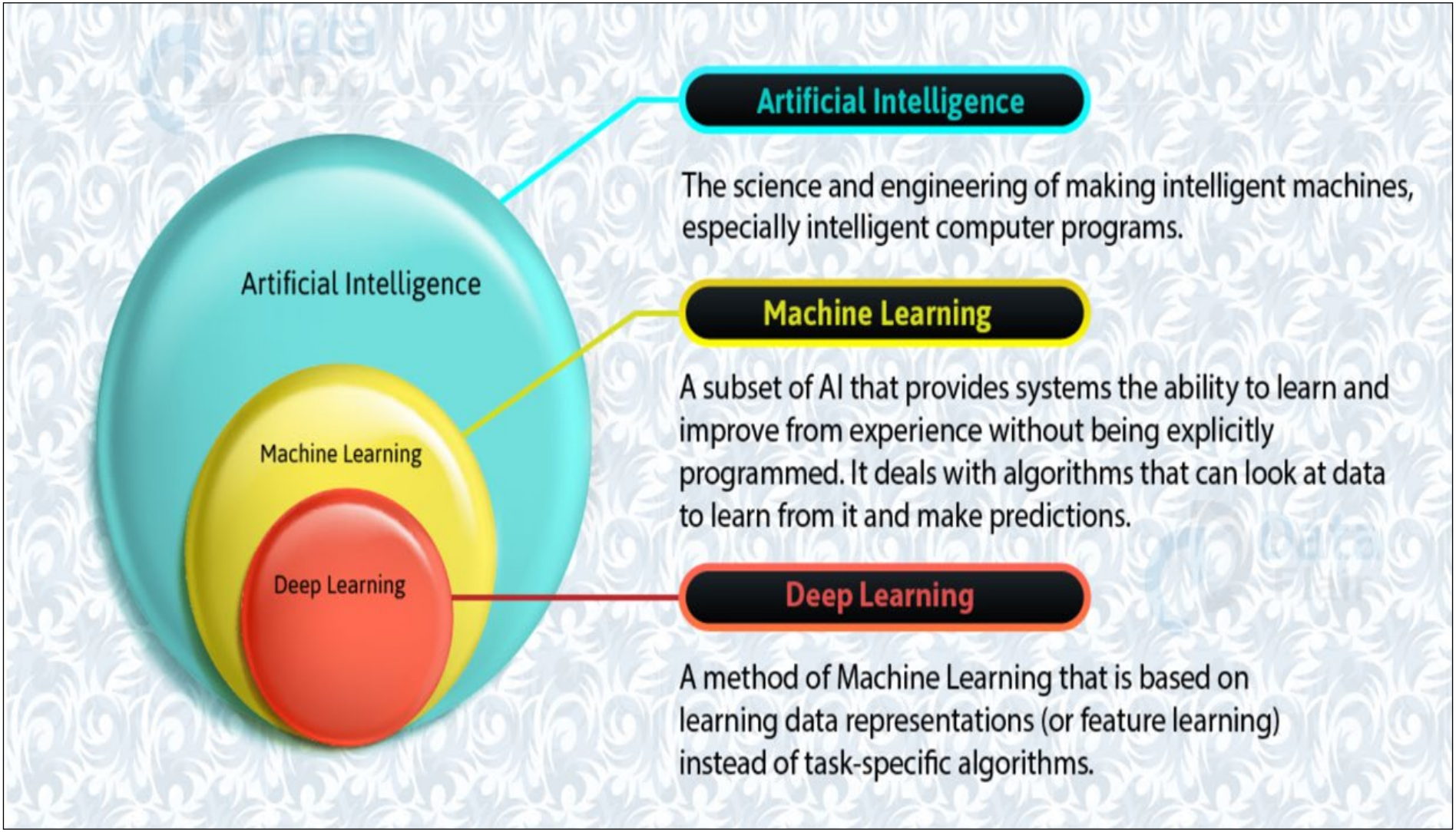
Artificial Intelligence and Related Topics

- Artificial Intelligence
- Machine Learning
- Deep Learning
- Expert Systems
- Soft Computing
  - Artificial Neural Networks,
  - Fuzzy Logic,
  - Genetic Algorithms
- Intelligent Signal Processing
- Natural Language Processing
- Pattern Recognition
- Cloud / Fog/ Edge Computing
- Internet of Things (IoT)
- Big Data
- Data Analytics and Data Mining
- Man-Machine Interface



Lorberfeld (2019):
https://wordstream-files-pr od.s3.amazonaws.com/s3fs-public/machine-learning.png

Artificial Intelligence /ML/DL



Data Flair Company (2020) Machine Learning Tutorials: https://data-flair.training/blogs/machine-learning-tutorial/

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

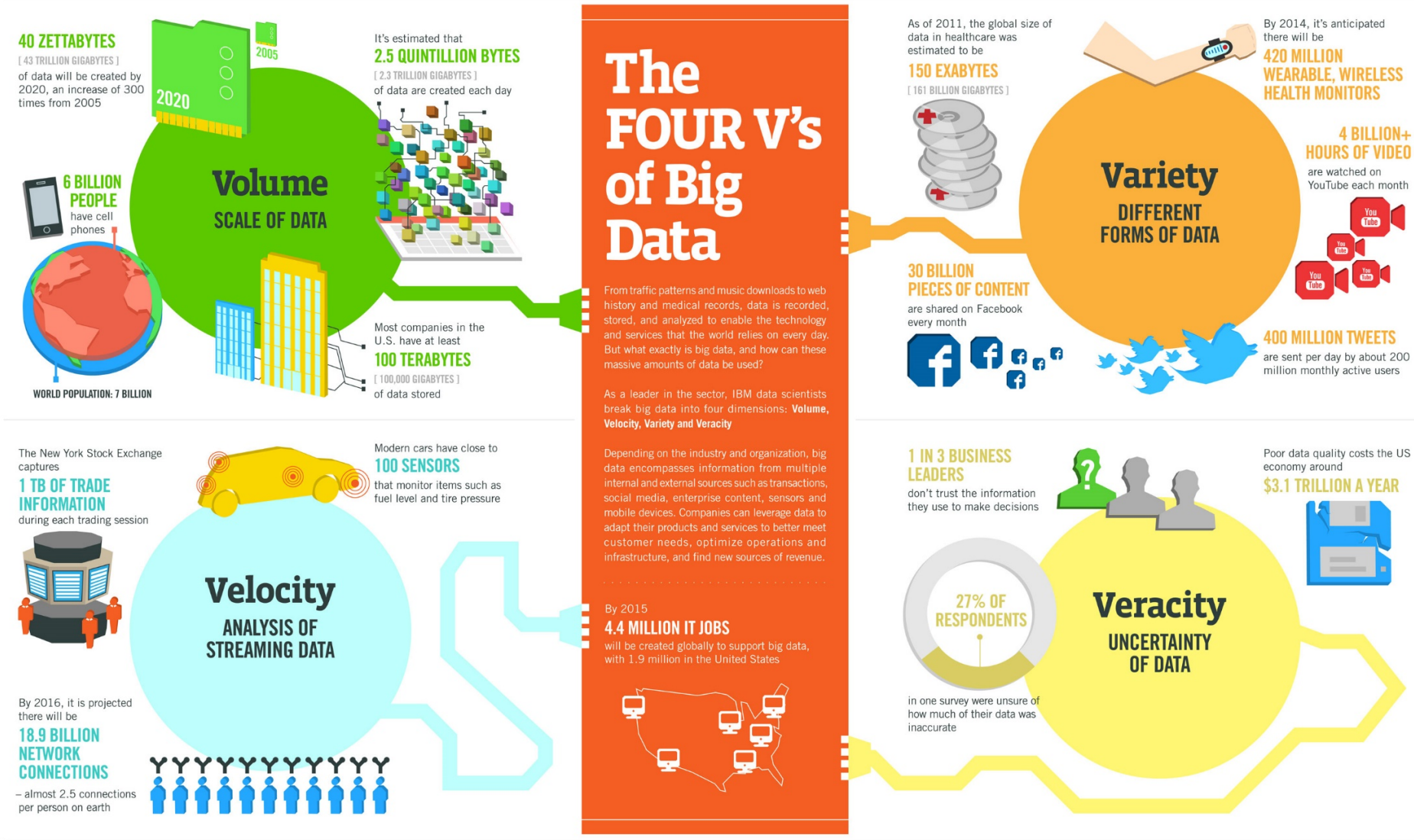
Drilling/Development **D**

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 Concept



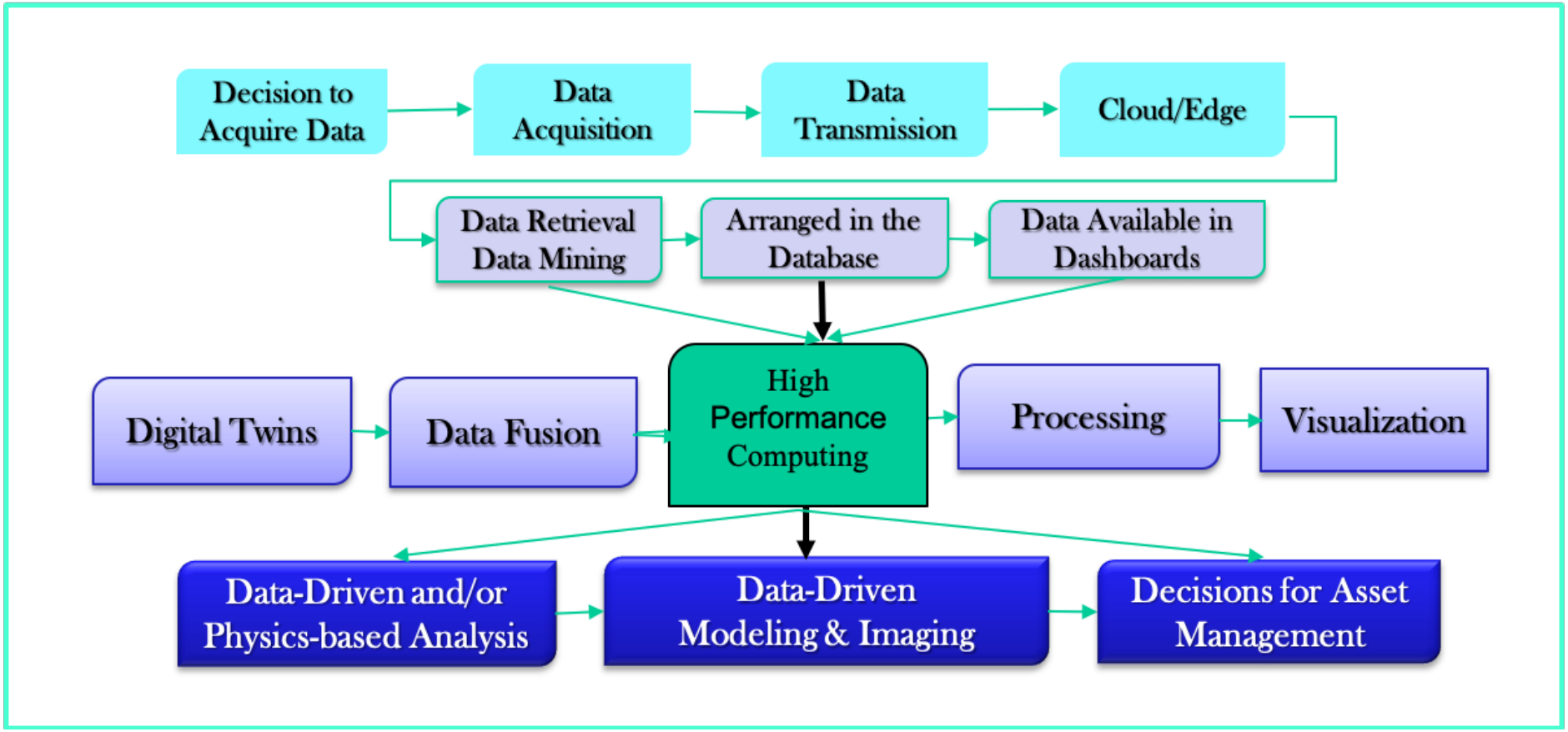
Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS

IBM

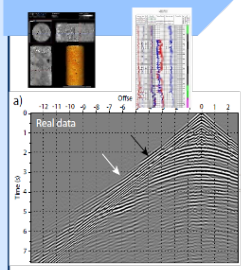
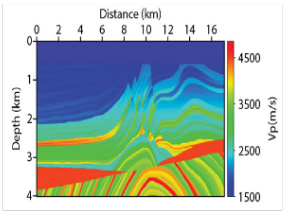
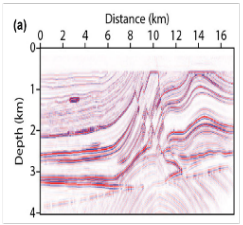
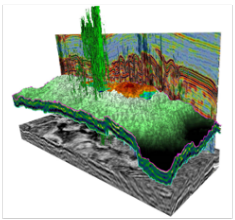
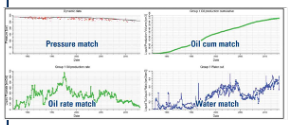
Big Data 4V in Oil and Gas

Exploration	Drilling/ Development	Production
3D Seismic Real-time Visualization Subsurface Imaging Reservoir Characterization	MWD, LWD, SWD Data transfer from drill bit Geo-Steering Reservoir Simulation	4D Seismic Reservoir Surveillance Production Optimization Enhanced Oil Recovery

Workflow for Data Driven Analysis



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

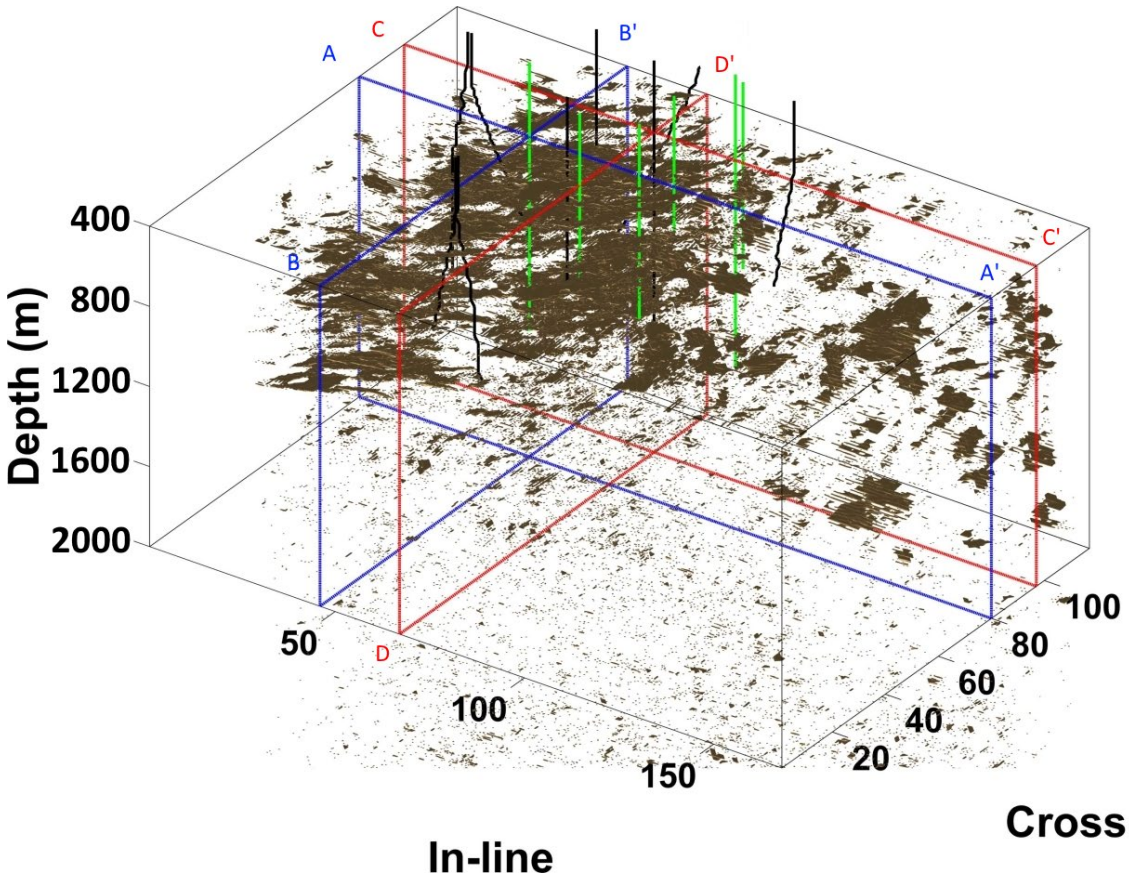
HPC+AI-DA Reduces Exploration Cost and Improves Recovery Factor

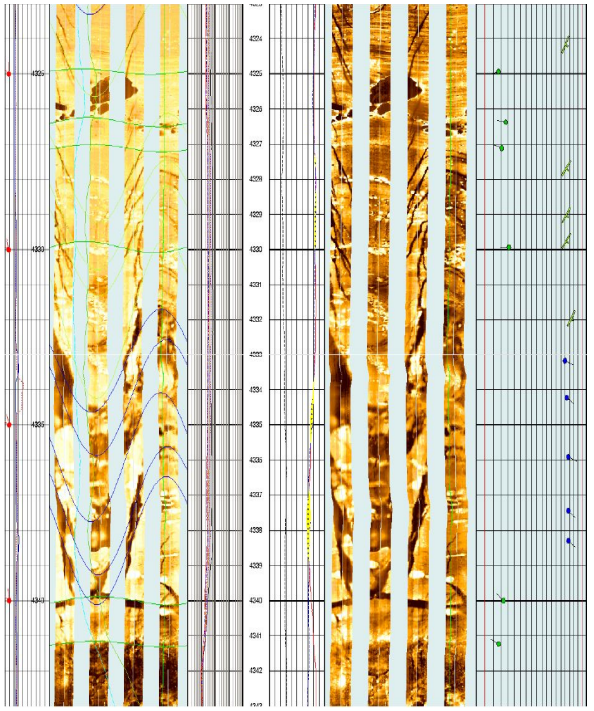
Courtesy of NEC Corporation
Aminzadeh and Ikuta, (2021)

A FEW EXAMPLES OF USE OF AI-DA IN E&P

E&P

Determining Fracture Distribution





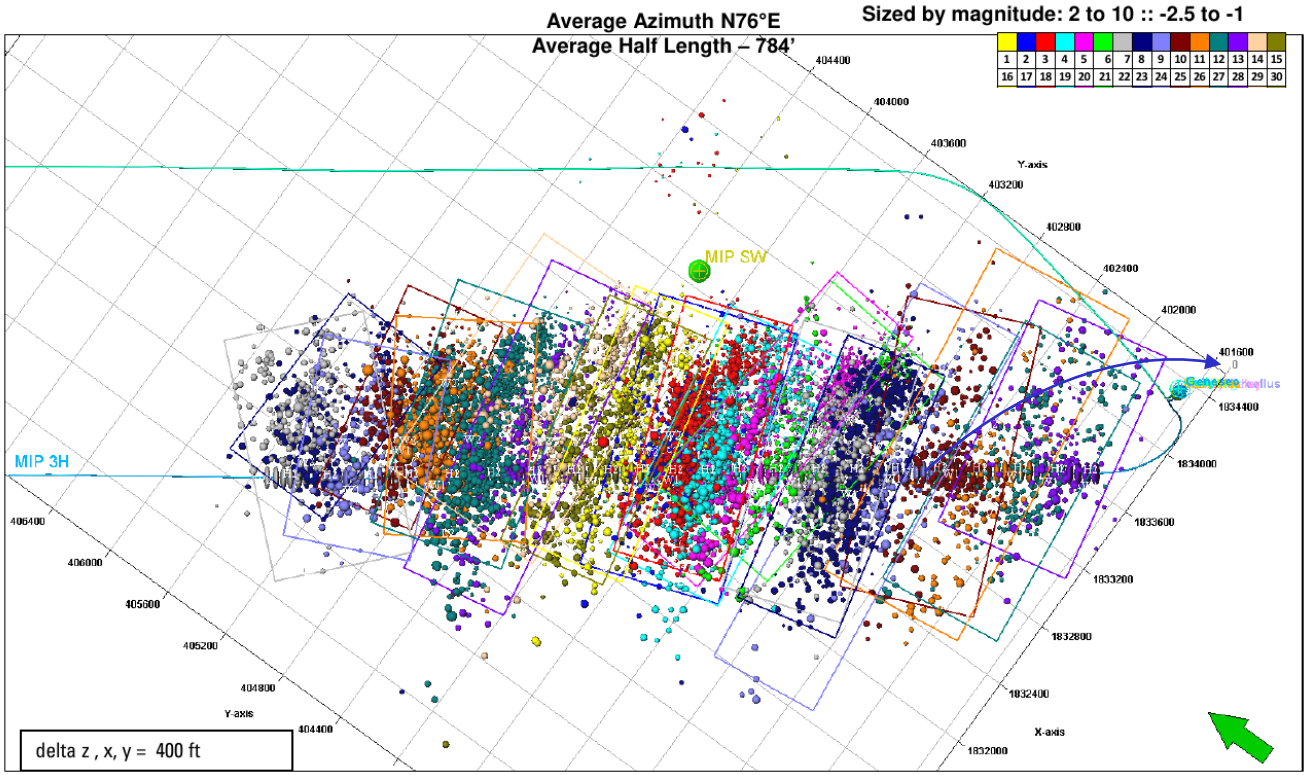
Identify fractures & generate fracture logs

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

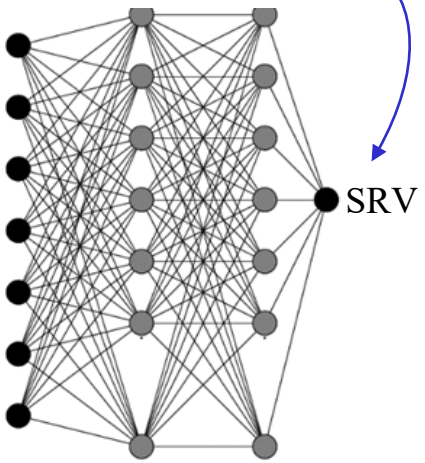
Injected fluid volume

Recorded pressure

….

Stress

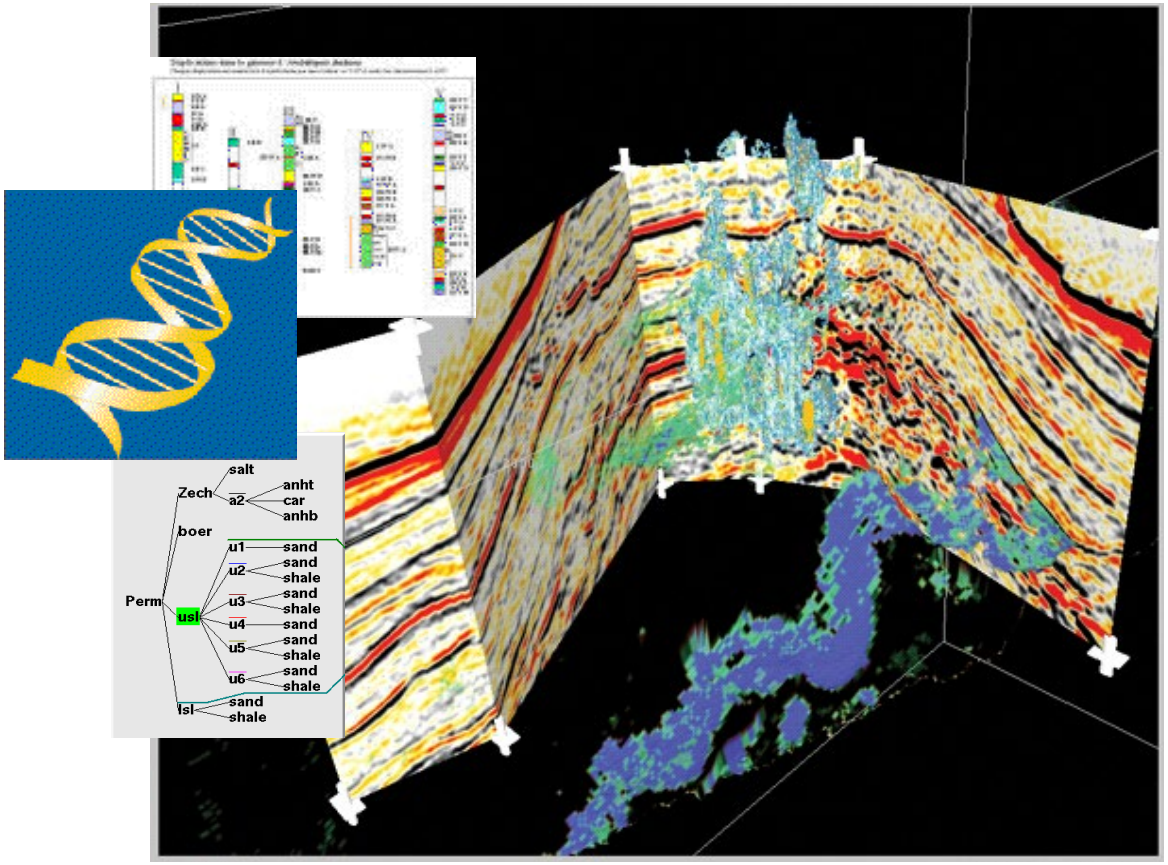
Mineralogy



Rezaei et al. (2021)

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

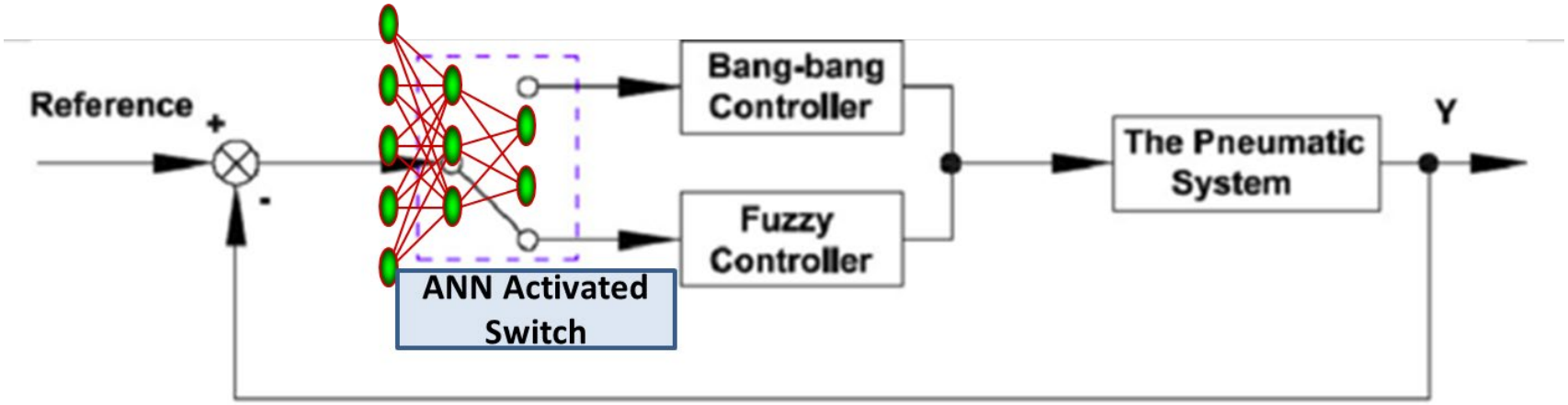
- Correlating DNA fingerprinting logs is useful for DNA stratification.
- By forming such pairs, we can pictorially represent a DNA sequence to specific oil type for stacked reservoirs
- The first step in DNA Fingerprinting is isolating the individual microorganisms from the bacterial colonies.



(from Aminzadeh, 2005)

Cyclic Neuro - Fuzzy Water-Steam Flooding

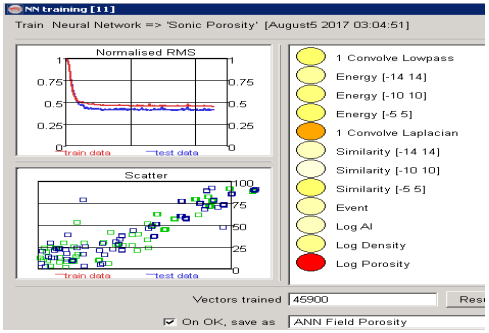
- Bang–bang fuzzy controller requires soft fuzzy engine, and a hardware relay to accomplish Bang–bang control action.
- The controller has fuzzy decision-making capability in its inputs and normally have two fixed levels Bang–bang output*



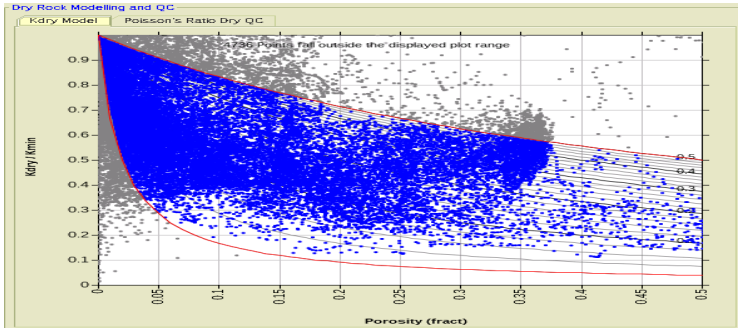
Provisional patent filing pending, Cyclic Fuzzy Water-Steam Flooding, Aminzadeh, 2017

CO_2 Sequestration using Integrated Physics based and Machine Learning

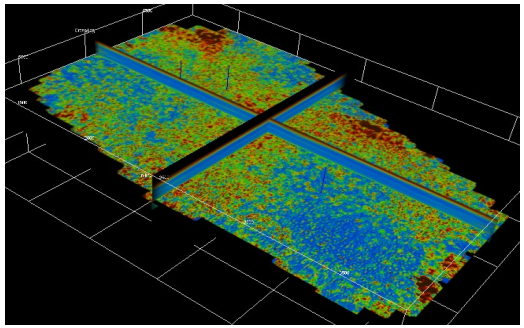
1. To model and identify effective and low-cost monitoring techniques for CO_2 Carbon Capture and Storage.
2. To derive geophysical techniques (seismic) and attributes for an accurate and robust CO_2 monitoring system.
3. To evaluate geophysical monitoring ideas for safe CO_2 storage, and identify any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



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



QC of the applicability of Gassmann equation.

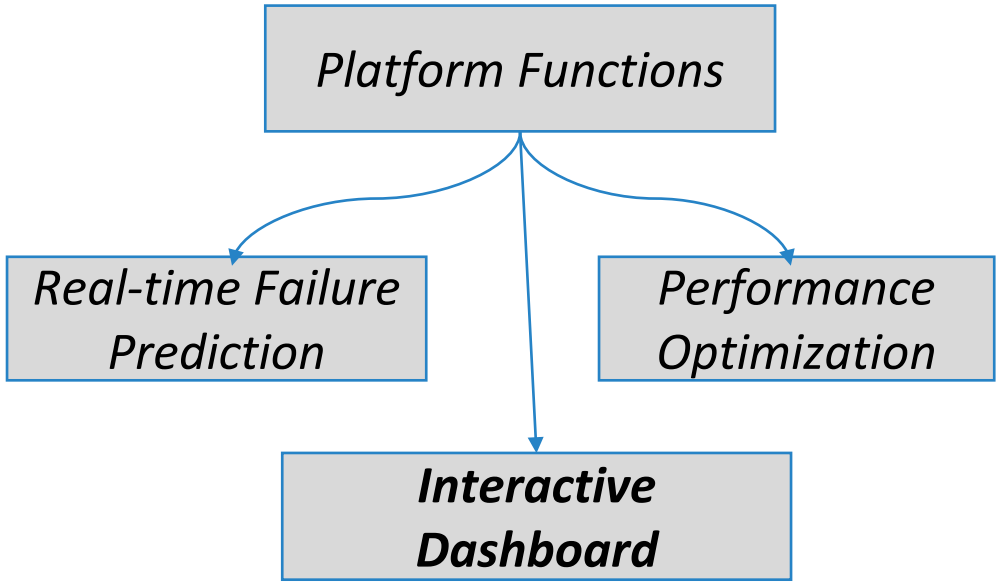


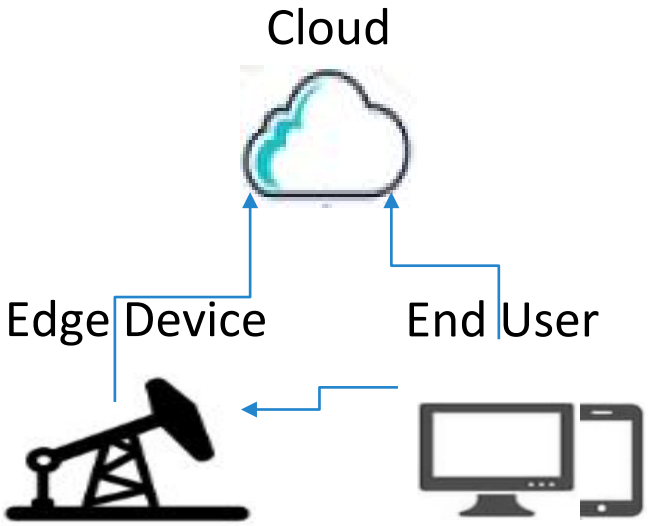
Porosity Prediction Results- Farnsworth Unit (FWU) oilfield .

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

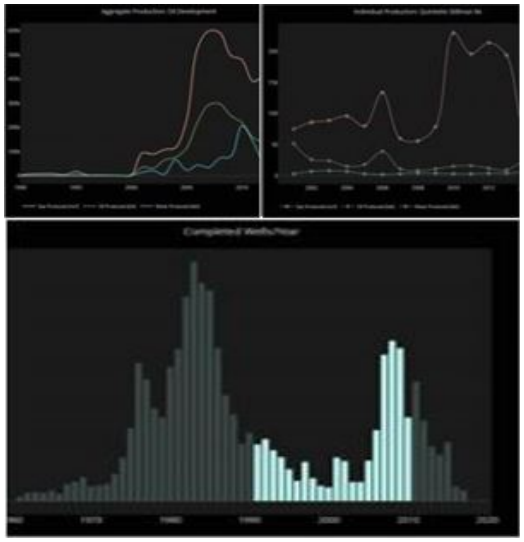
http://www.energy.psu.edu/ucfer/sites/default/files/files/images/files/summaries/5551-Aminzadeh-RFP01.pdf

AI-Biased Failure Detection via an IoT Platform





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

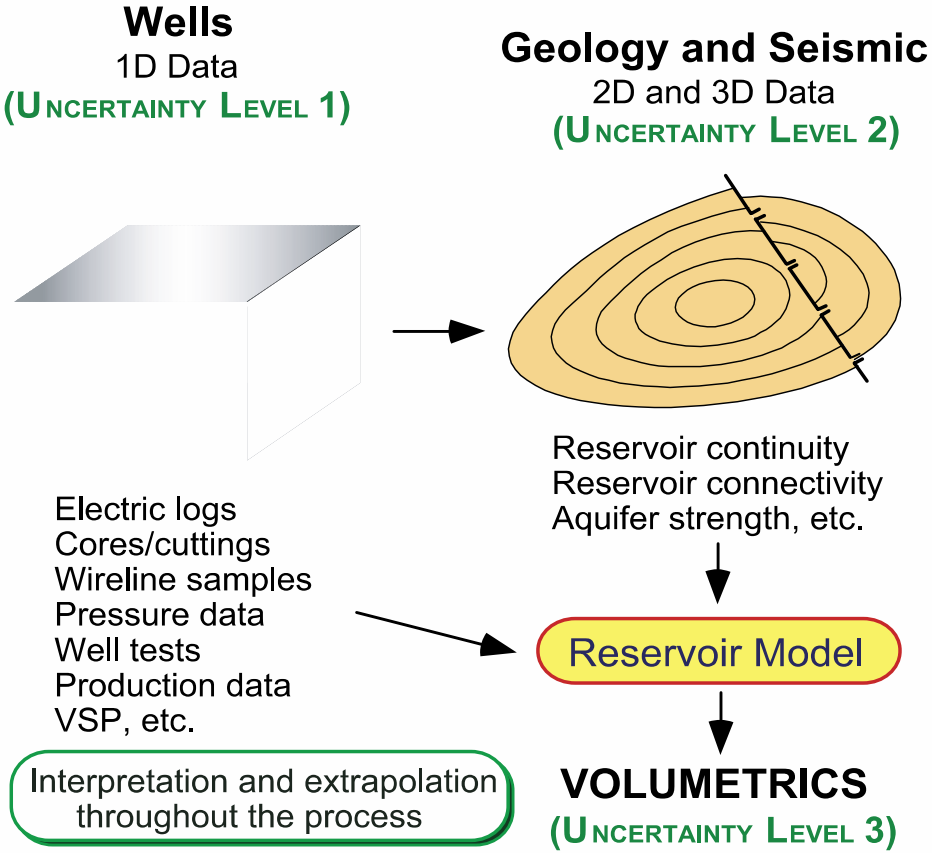


Interactive Dashboard

Ranjit, Suhag, Aminzadeh (2019)

AI for Uncertainty in Reserves (EUR) Prediction

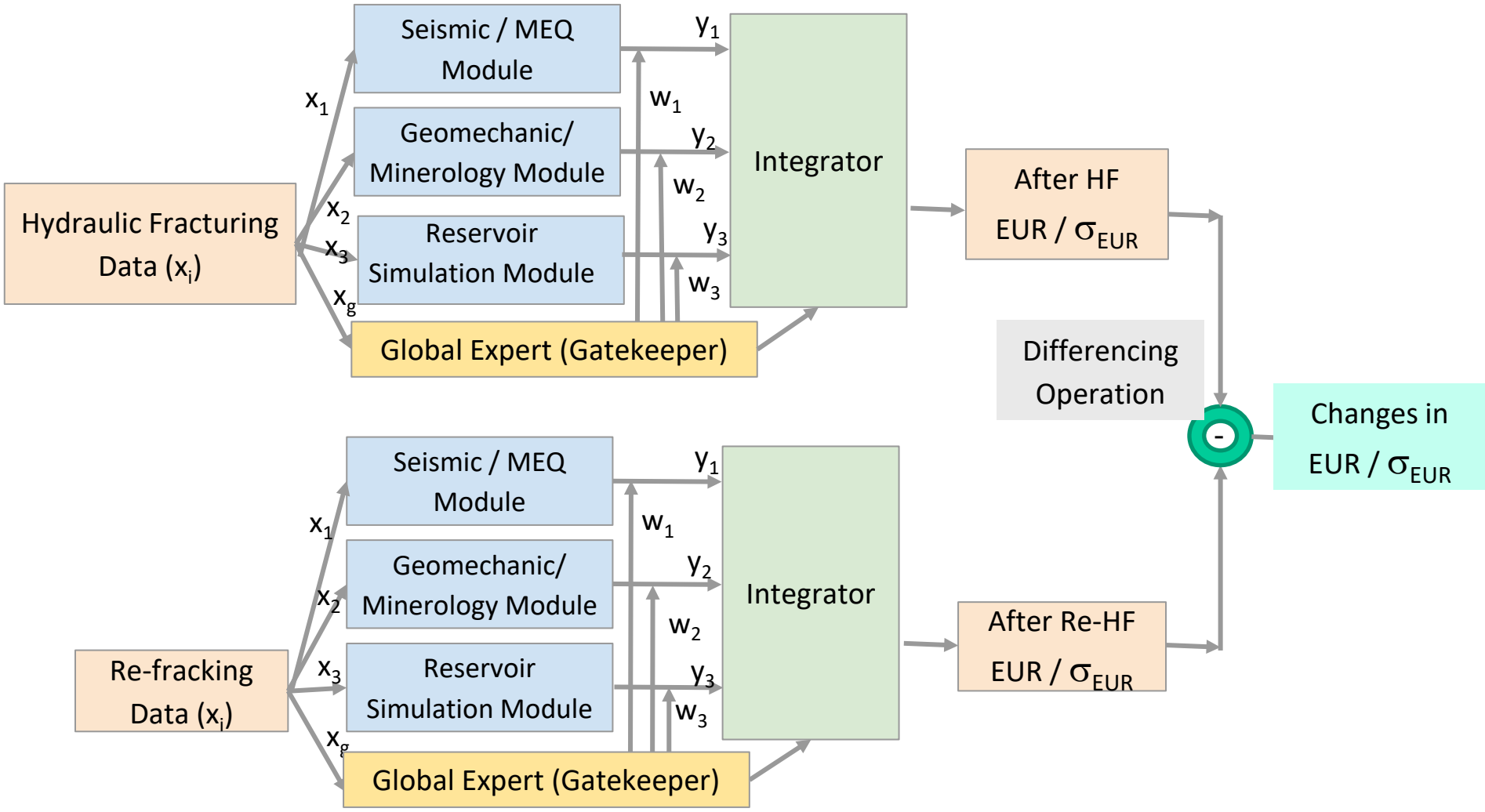
A. 1D data for reservoir properties such as porosity, saturation, oil viscosity
B. As 1D reservoir properties are extrapolated to 2D and 3D with the help of geology, seismic, and production data, simplifying assumptions are made and errors are incurred
C. EUR estimation process involves many complications,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

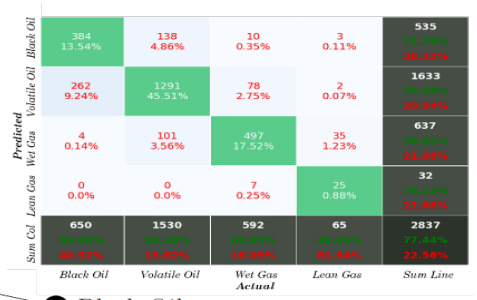


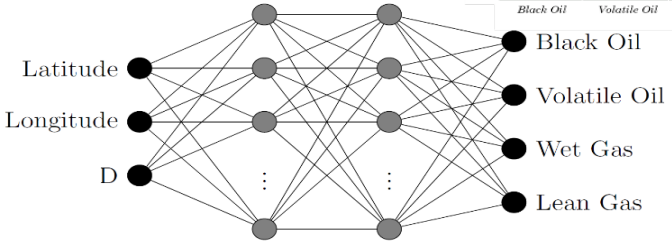
Adopted from Aminzadeh. (2020)

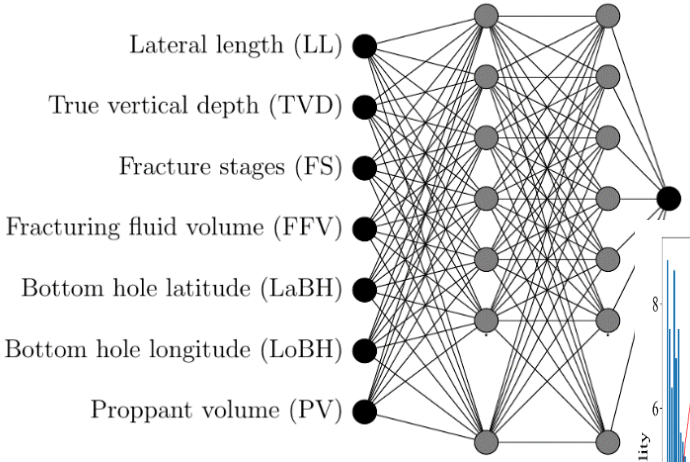
Production Optimization

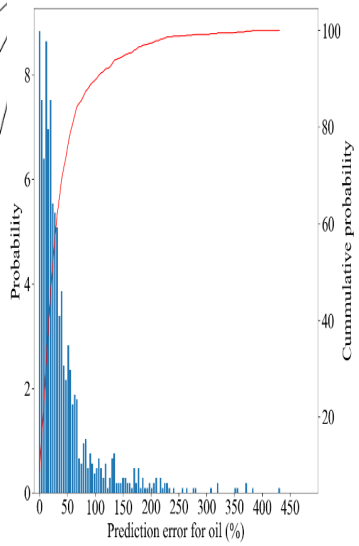
Different ANNs for Prediction of

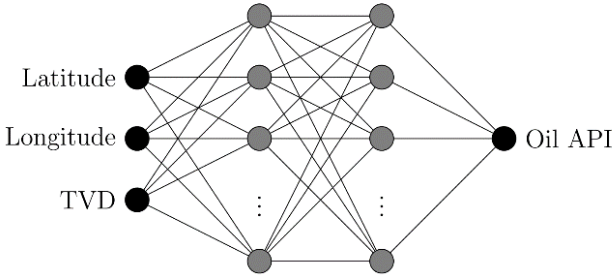
- Oil API
- Fluid Type
- Production Prediction

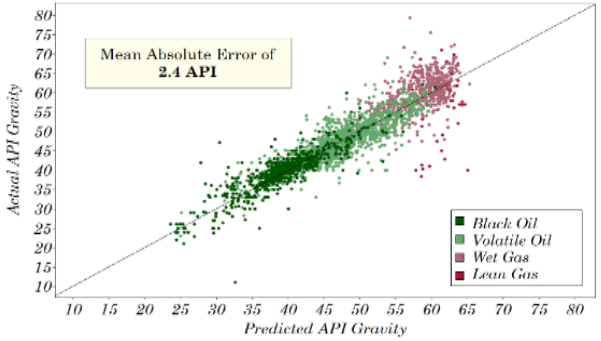












Rezaei et al. (2020)

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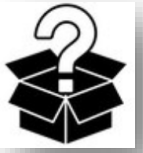


What: New UH program aimed at bridging the gap between the needs and related capabilities in Artificial Intelligence, Machine Learning and Data Analytics (AIM-DEEP) for Energy Exploration and Production.

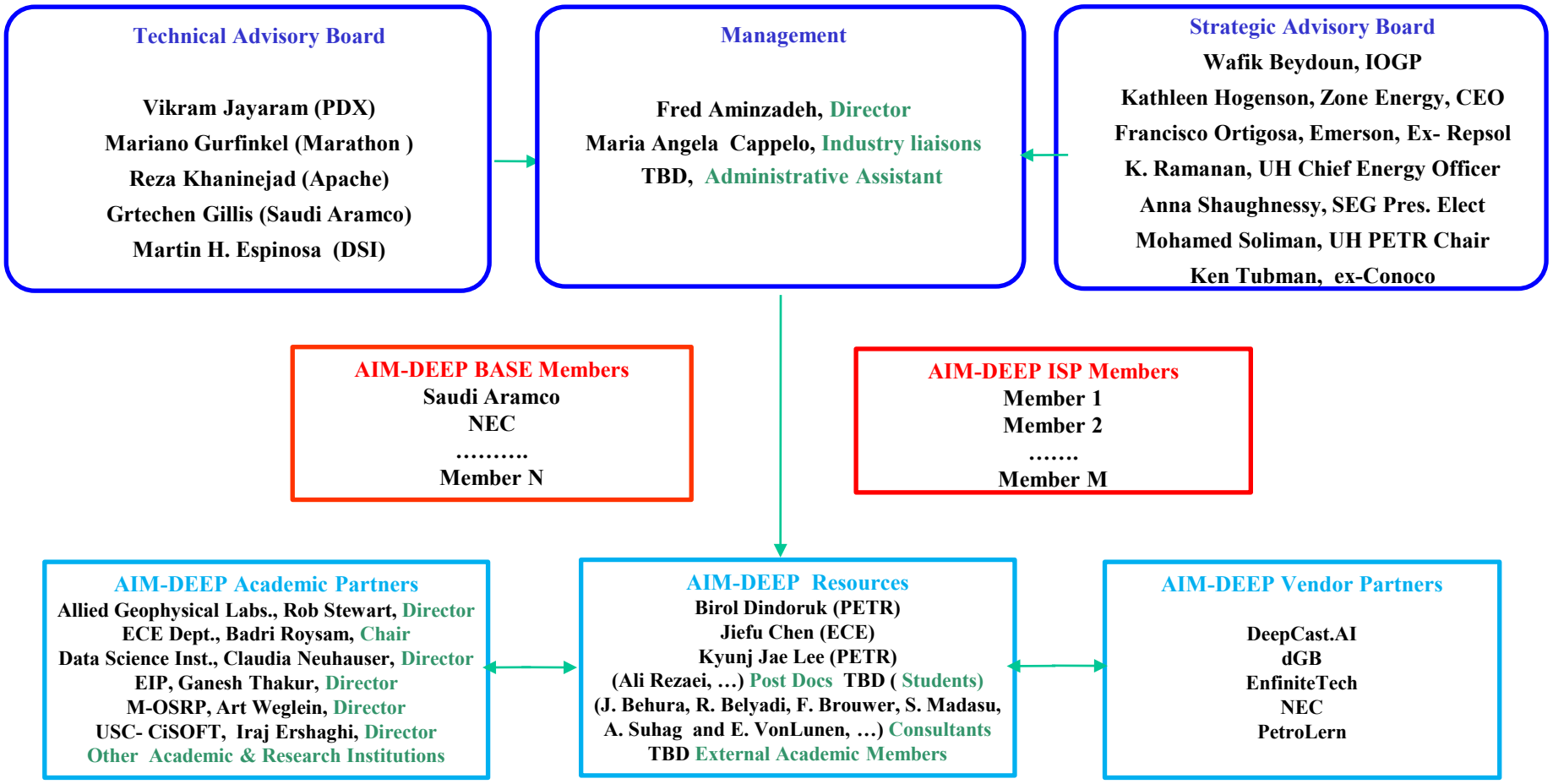
Why: AI-ML-DA have the potential of reshaping E&P operations, strategy and competition. AIM-DEEP intends to accelerate this transformation by creating a symbiotic AI platform where select people (students, faculty, experts) are immersed in E&P technologies (exploration, drilling, development and production)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

From Wafik Beydoun's posting: https://www.linkedin.com/feed/update/urn:li:activity:6726997299681206272/

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 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 here 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. **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. **Determining "Sweet Spots" in Unconventional Reservoirs with Machine Learning**
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?**

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.