UNIVERSITY of HOUSTON

PETROLEUM ENGINEERING

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

AIM-DEEP

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PETROLEUM ENGINEERING

AIM-DEEP Consortium

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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.

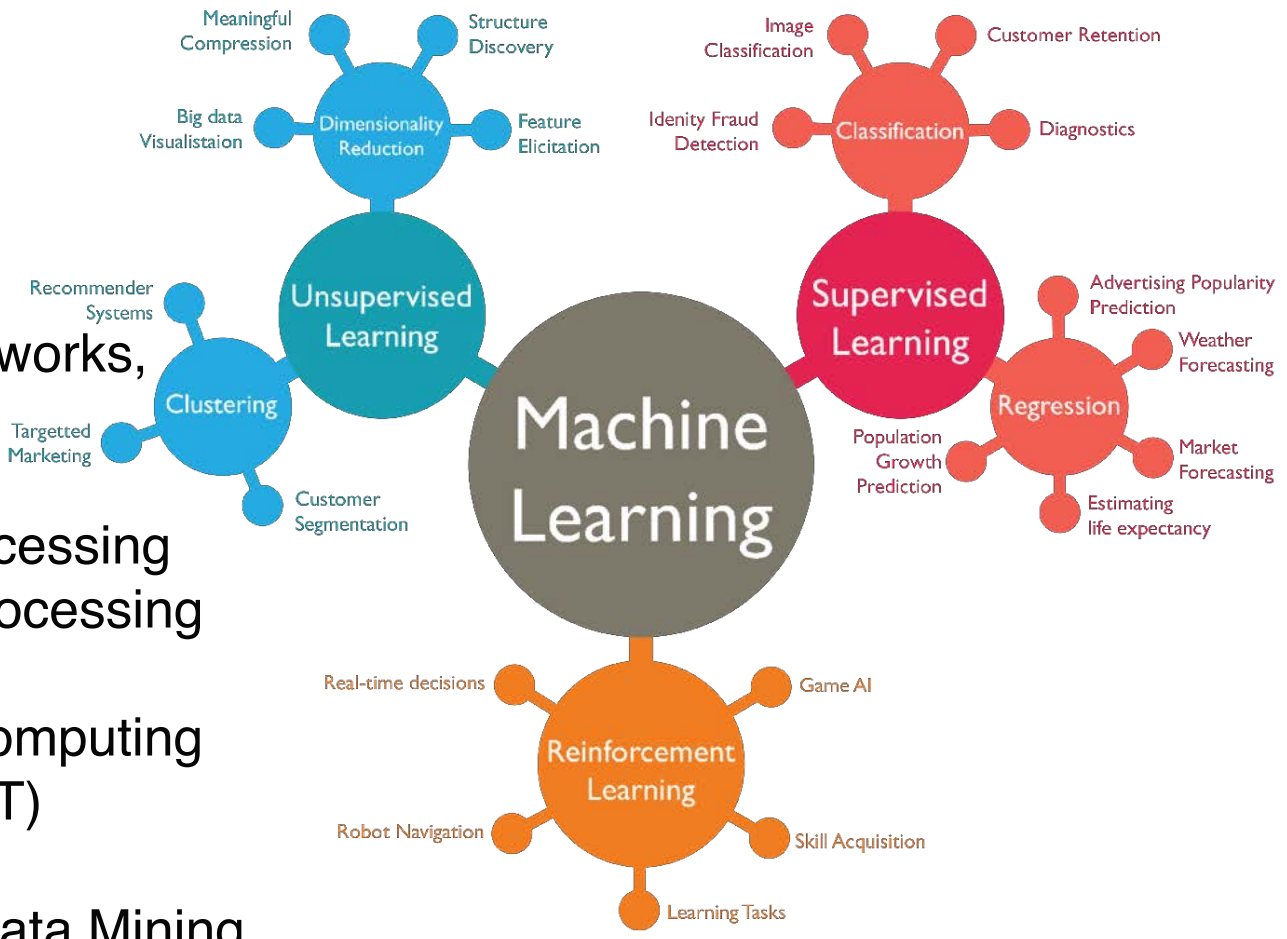
Unique benefits:

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

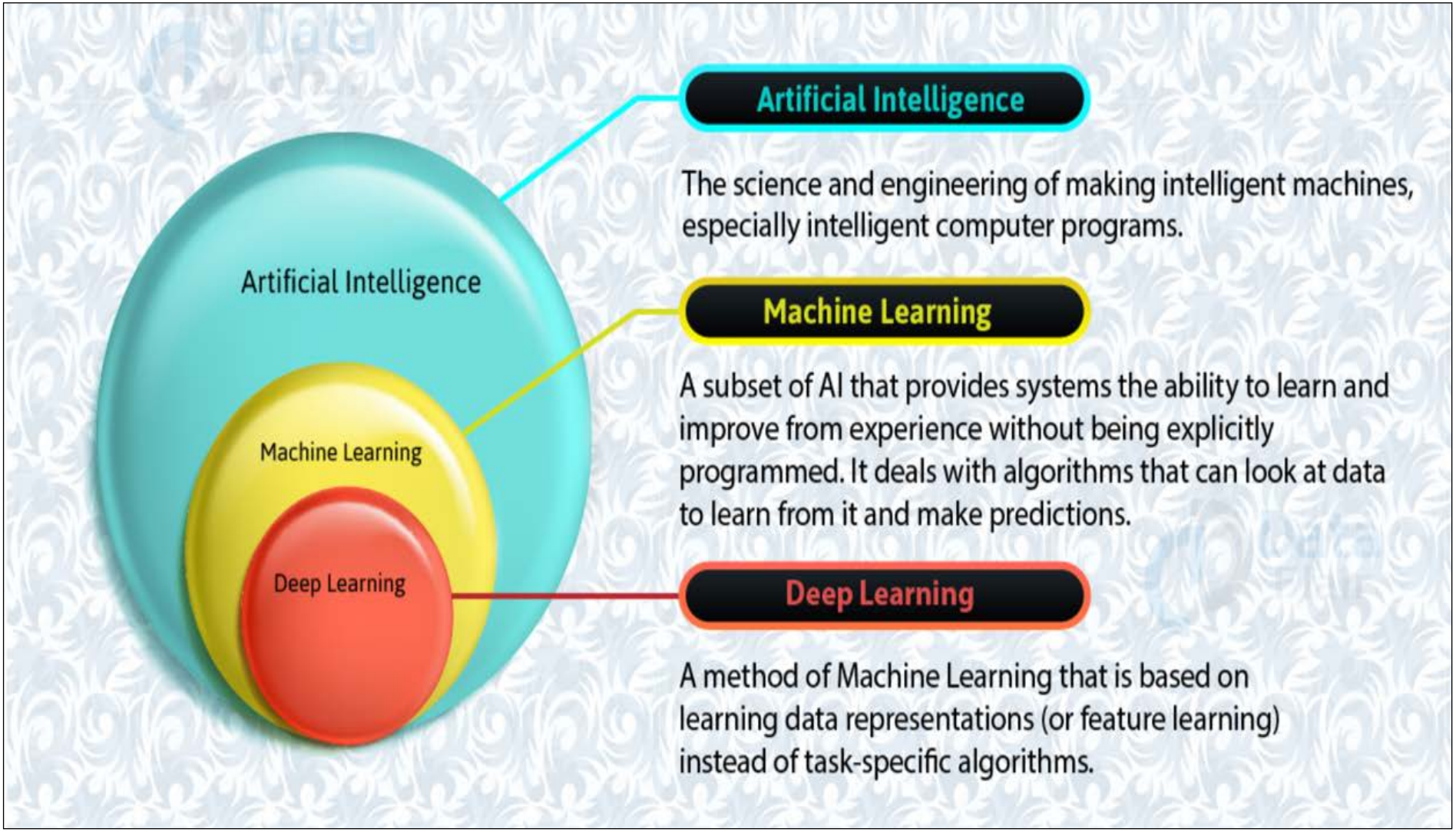
Artificial Intelligence and Related Topics

- 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

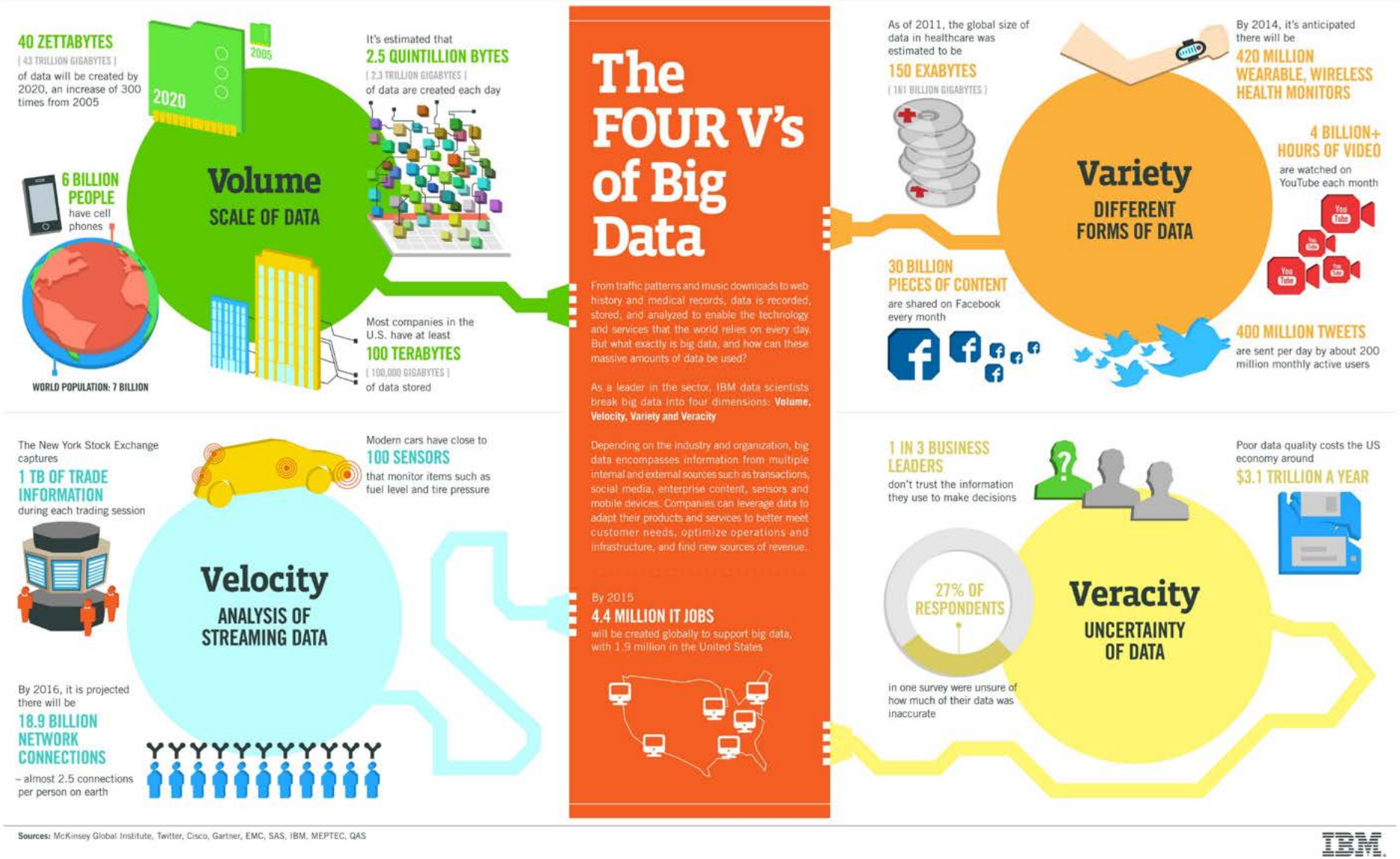
Development D

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

Production P

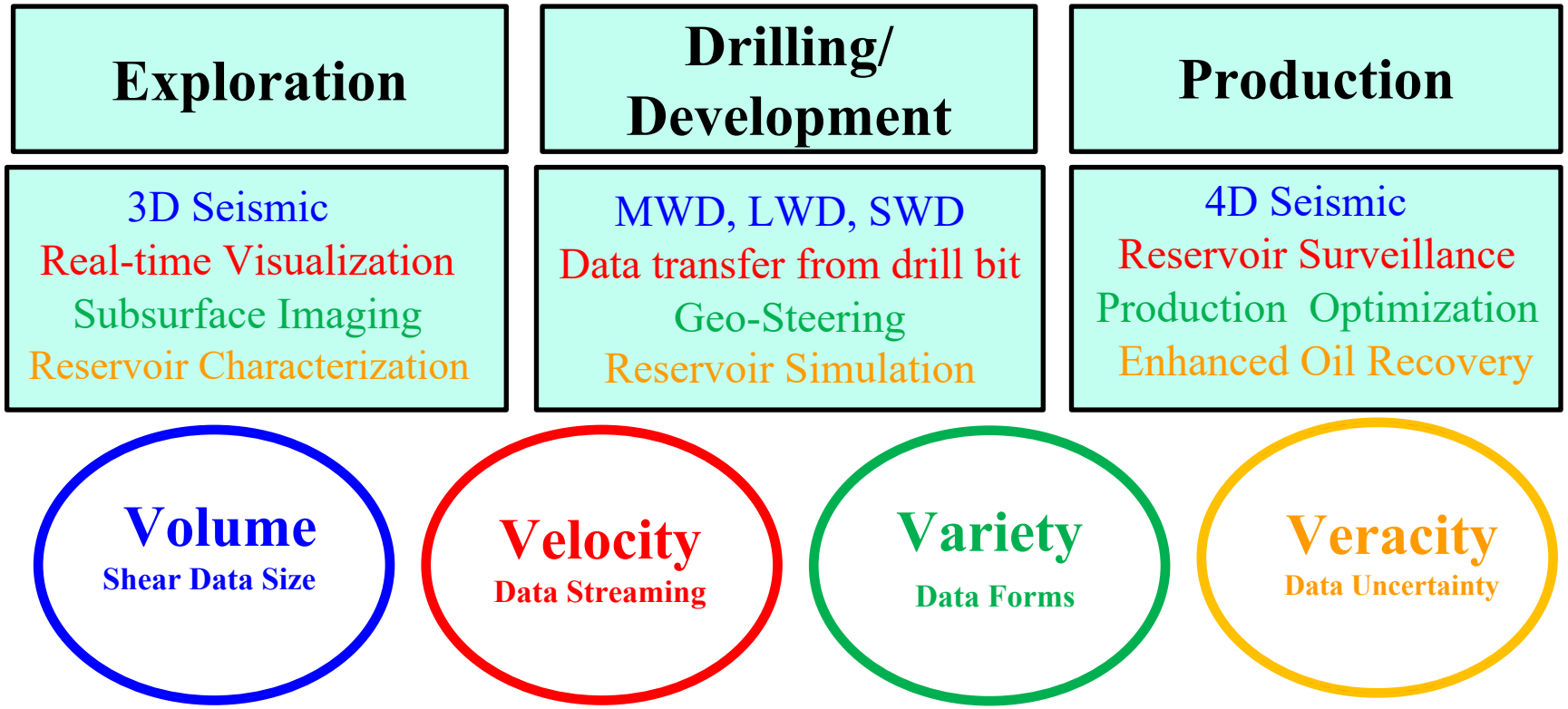
Res. characterization
Production Optimization
Reservoir Surveillance
Optimizing EOR
Hydraulic Fracturing
Economic Forecasting

Big Data (4V)

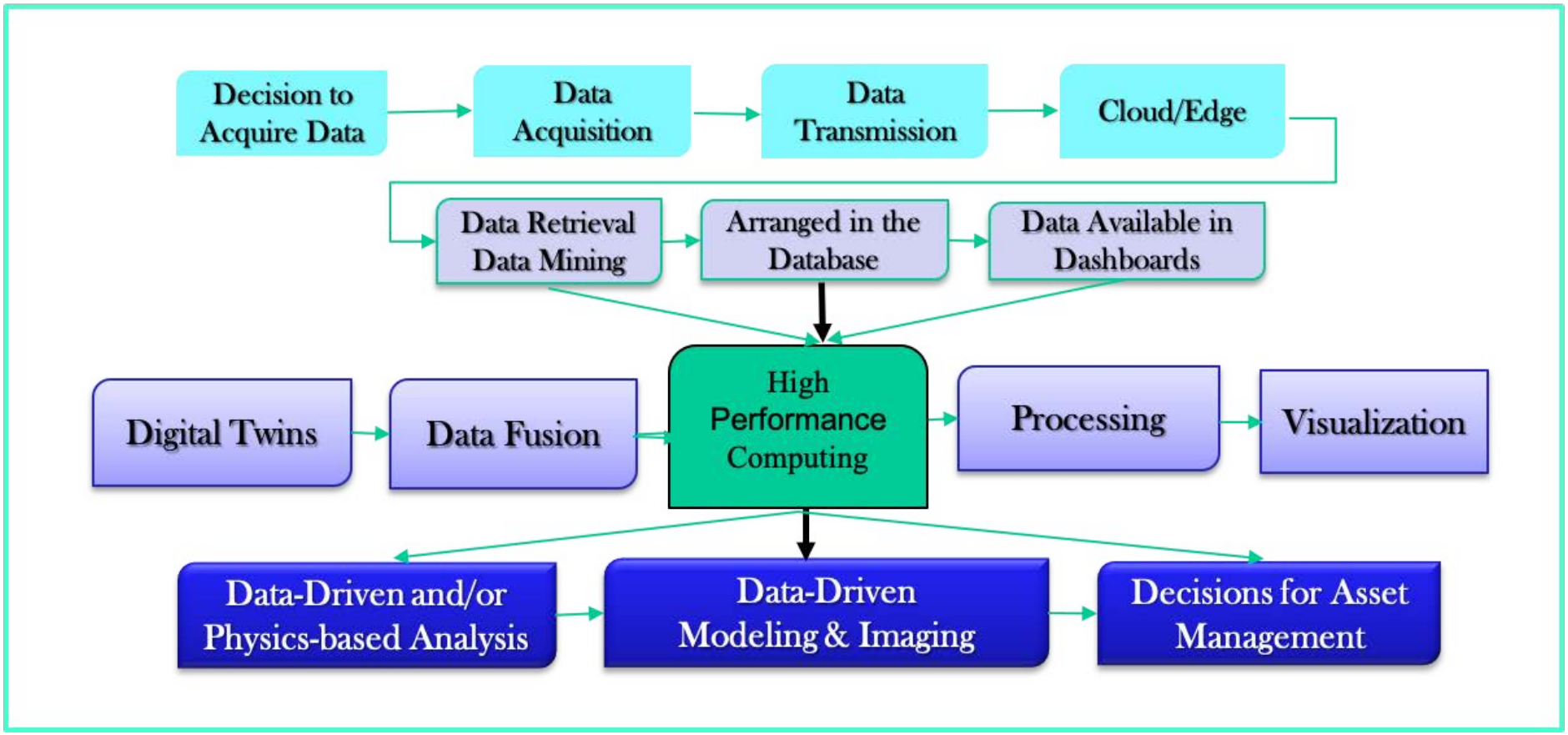


https://www.ibmbigdatahub.com/sites/default/files/infographic_file/4-Vs-of-big-data.jpg

Big Data 4V in Oil and Gas



Workflow for Data Driven Analysis

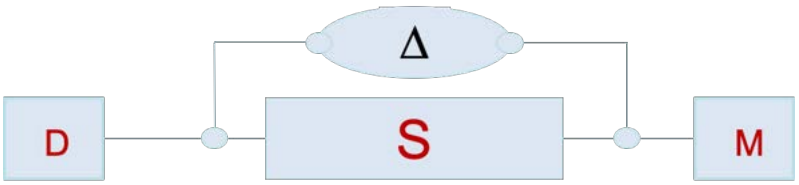


Characteristics of Smart Systems

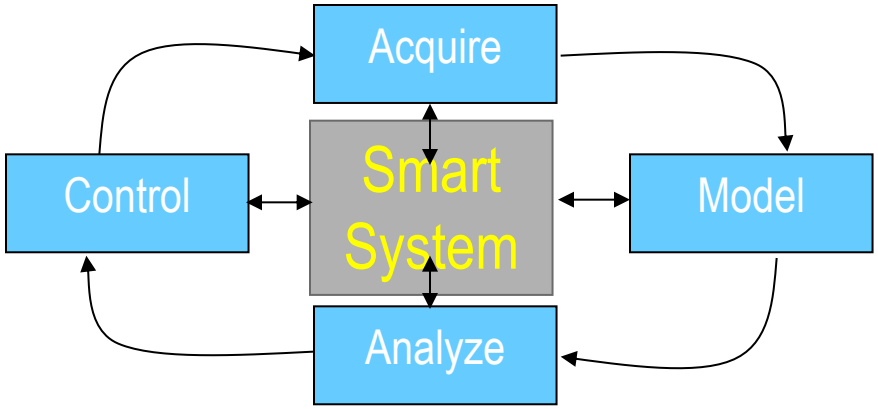
The key components of "smart system":

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



$M_{new} = S(M_{old}, D_{new}, \Delta)$



Integrated Operations

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

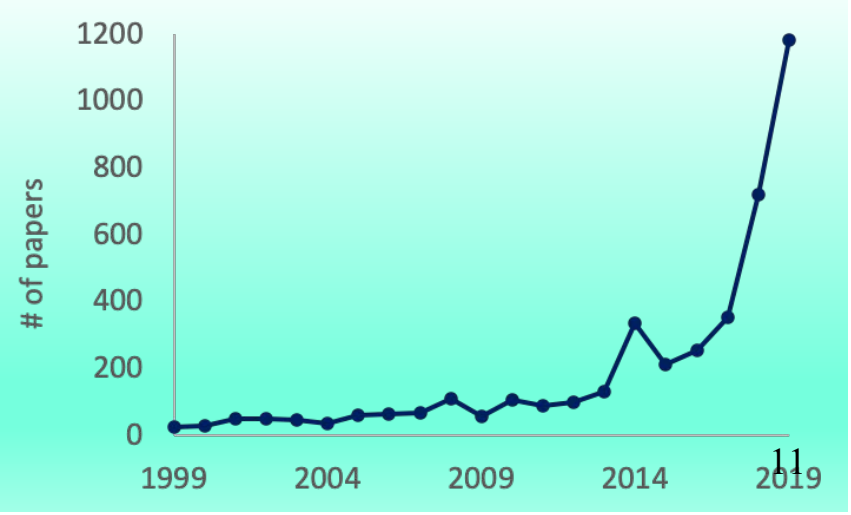
Narrative: About 20 years ago advances in Hydraulic Fracturing (HF) and horizontal drilling helped exploit the massive shale resources and ensuring energy security for the US.

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?

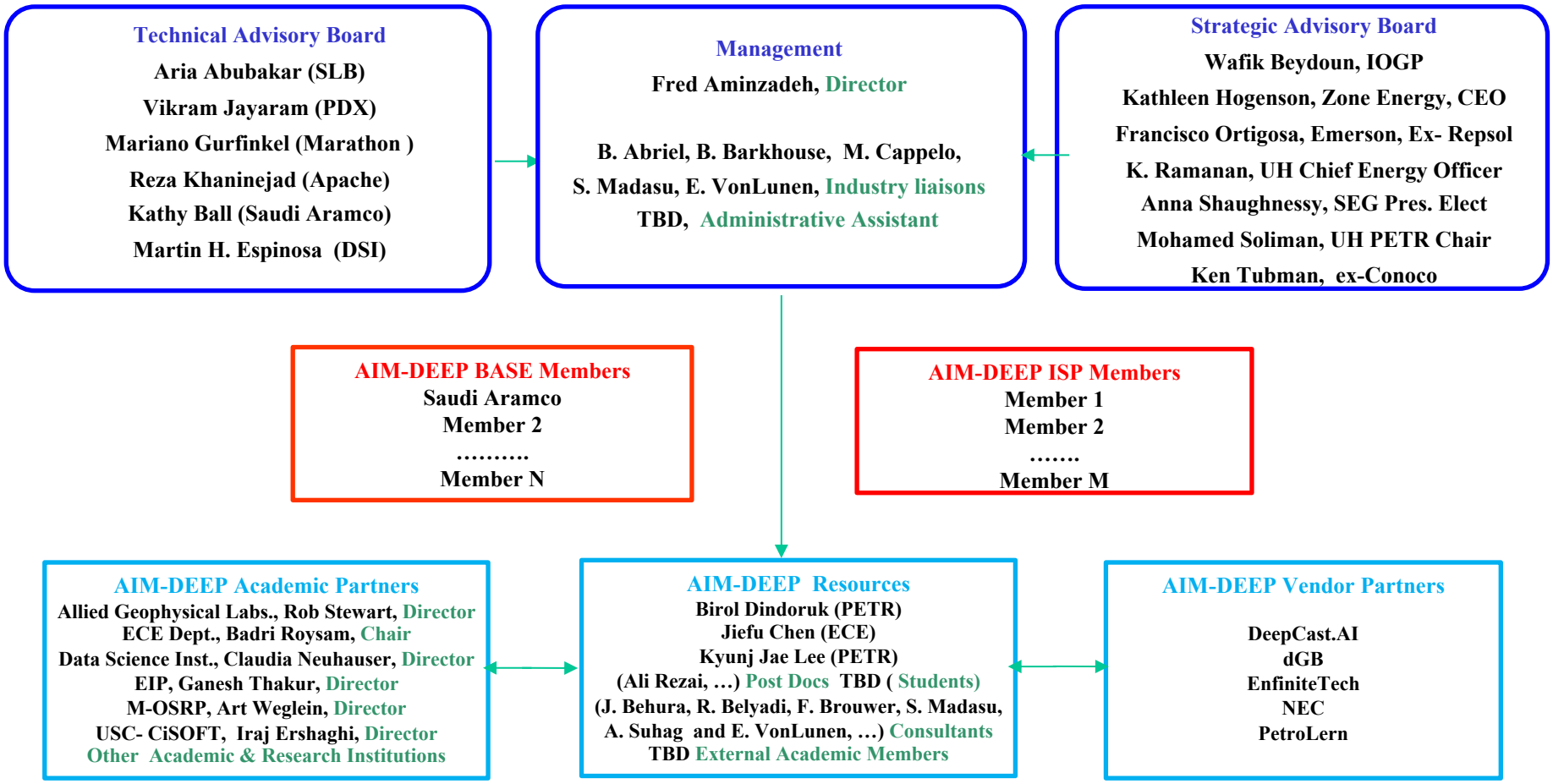
Why AIM-DEEP

- 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.

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
- 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

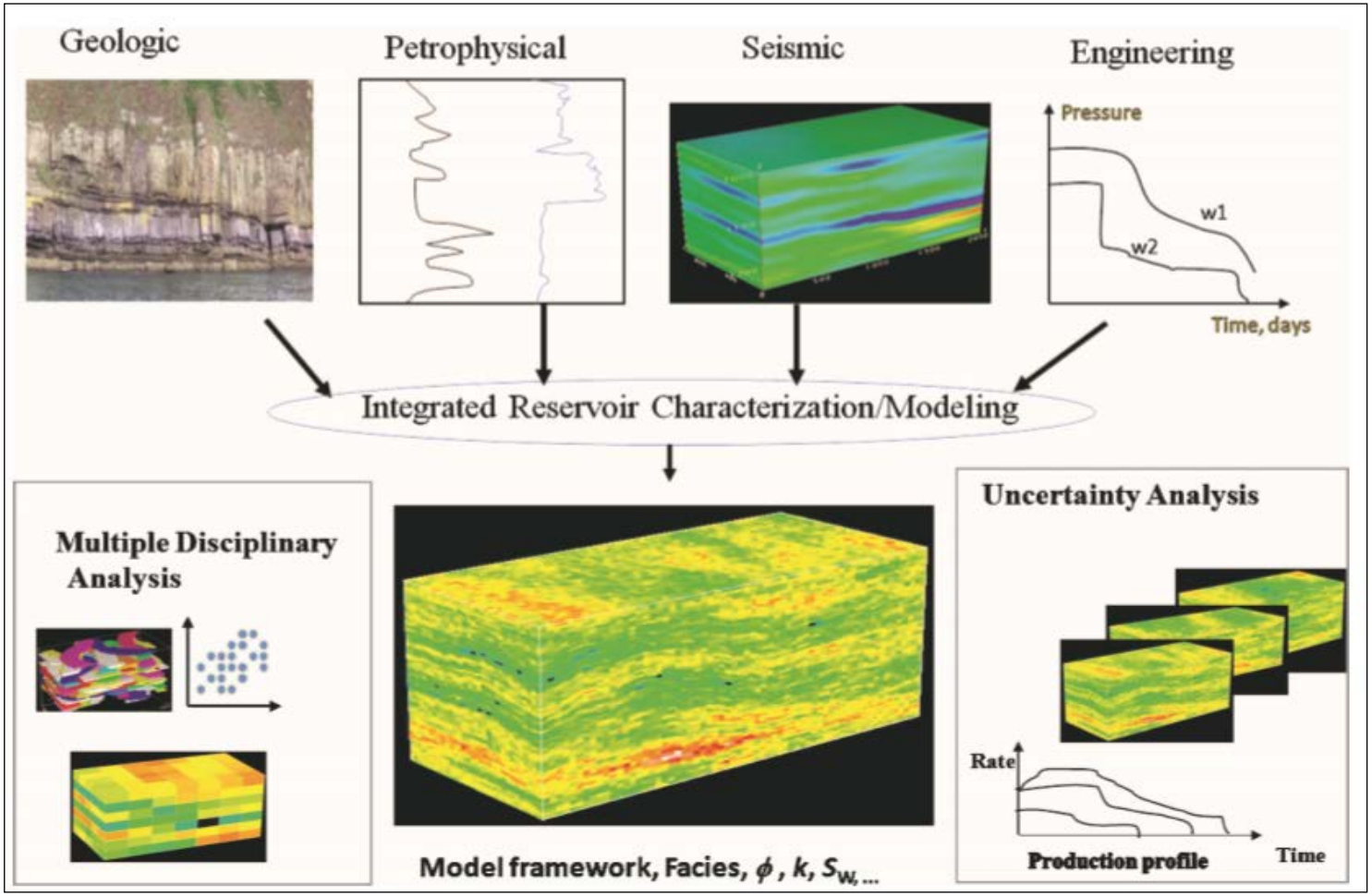
Possible AIM-DEEP Project Focus Areas

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. **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?**

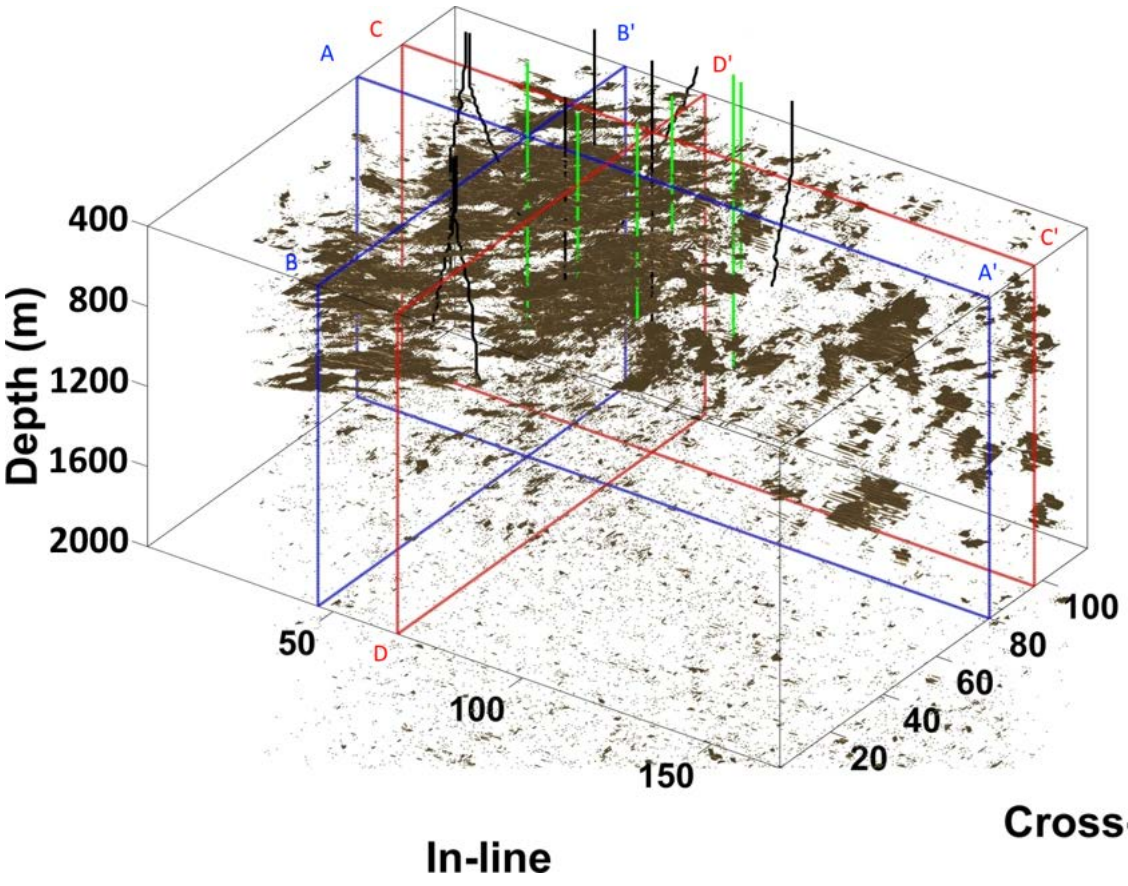
A Few Examples of Use of AI-ML-DA in E&P

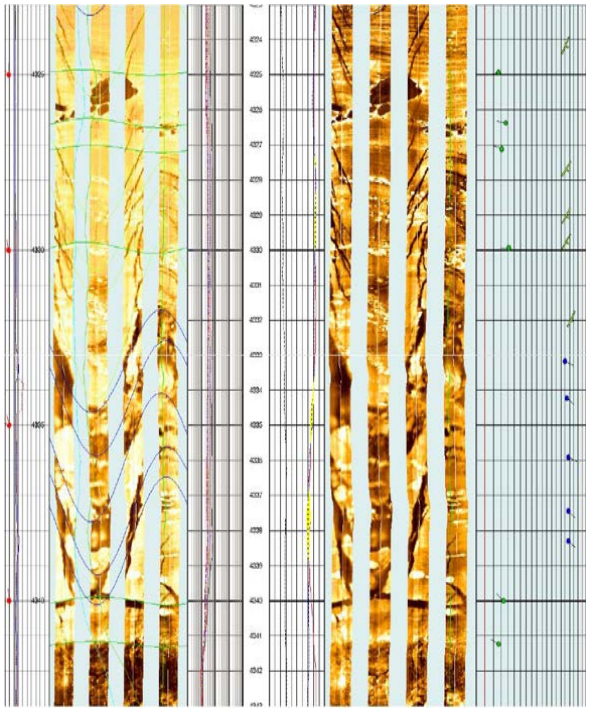
Reservoir Characterization



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

Determining Fracture Distribution





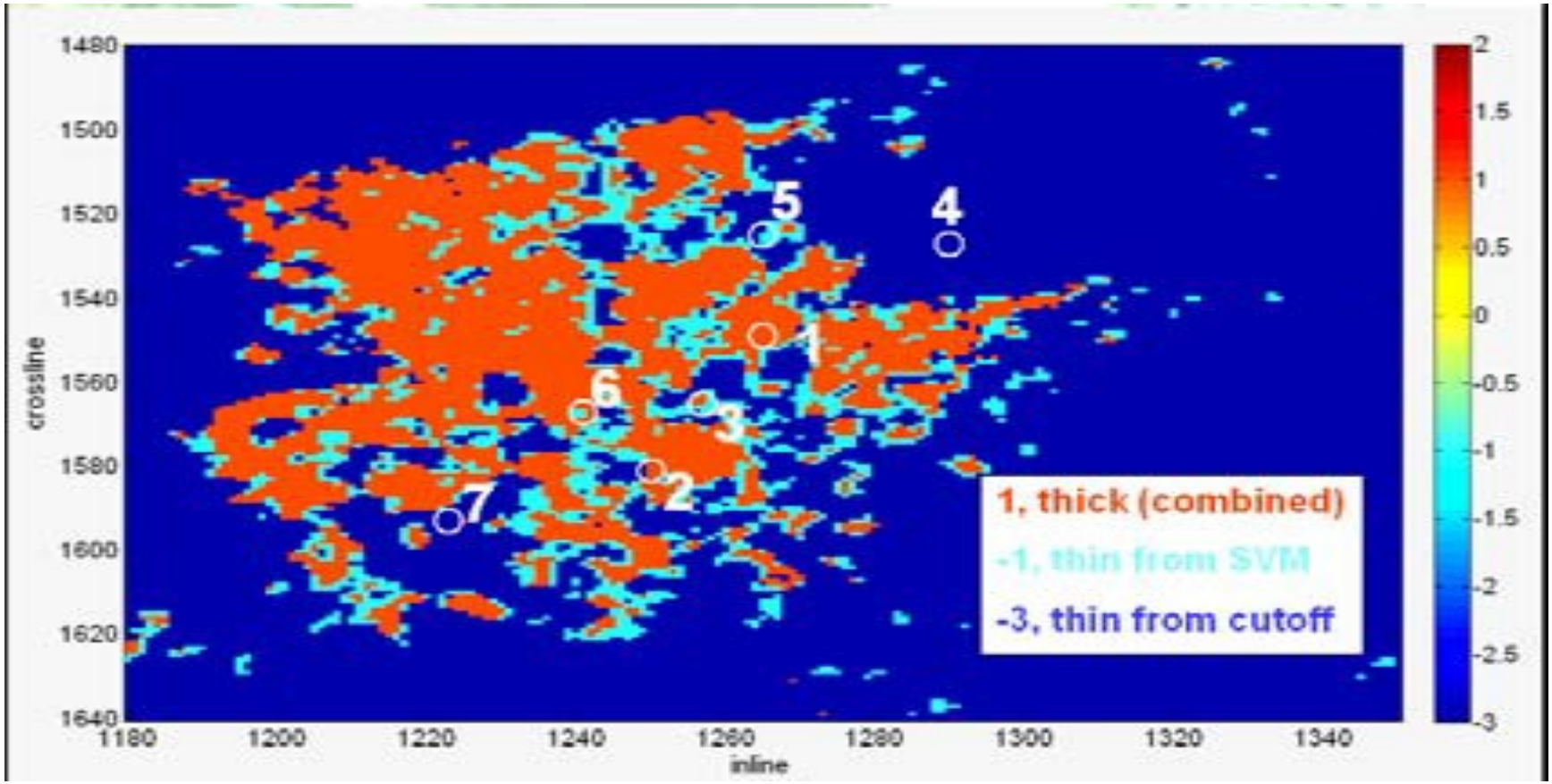
Identify fractures & generate fracture logs

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.

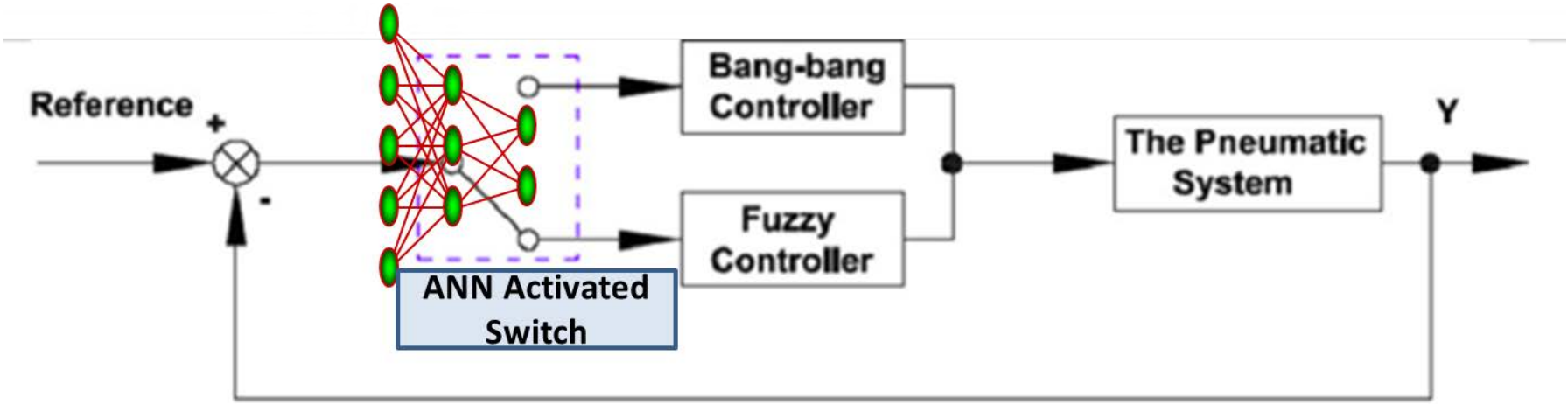
Sand Thickness Prediction



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

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

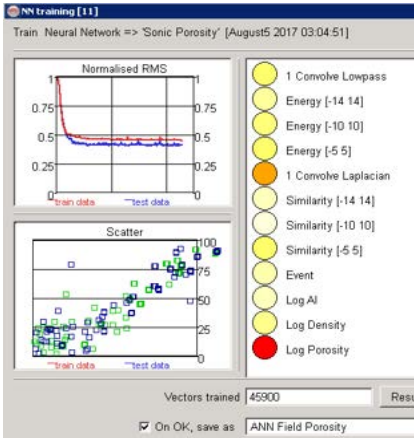
- Bang–bang fuzzy controller requires soft fuzzy engine, and a hardware relay to accomplish Bang–bang control action.
- The controller has fuzzy decision making capability in its inputs and normally have two fixed levels Bang–bang output*



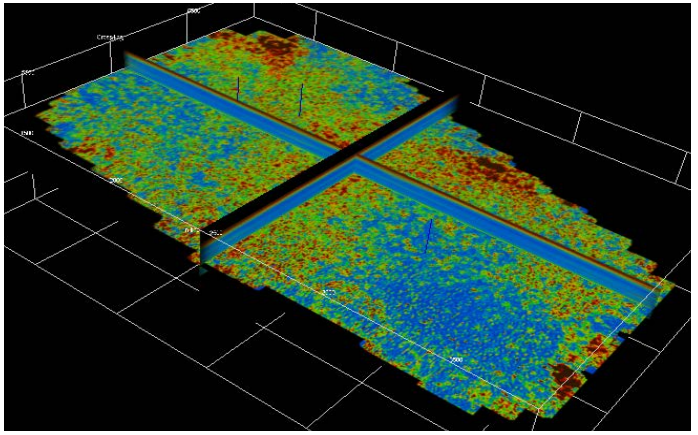
Provisional patent filing pending, Cyclic Fuzzy Water-Steam Flooding, Aminzadeh, 2017

CO_2 Sequestration using Integrated Physics based and Machine Learning

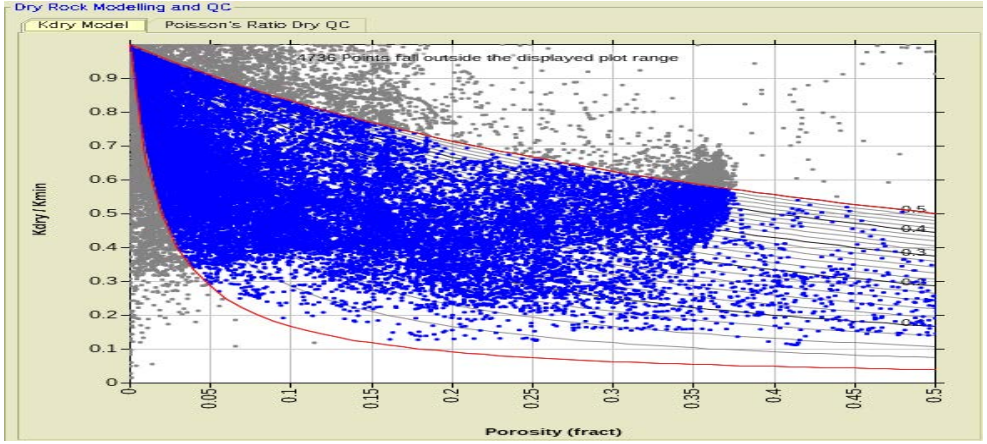
1. To model and identify effective and low-cost monitoring techniques for CO_2 Carbon Capture and Storage.
2. To derive geophysical techniques (seismic) and attributes for an accurate and robust CO_2 monitoring system.
3. To evaluate geophysical monitoring ideas for safe CO_2 storage, and identify any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



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



Porosity Prediction Results- Farnsworth Unit (FWU) oilfield .



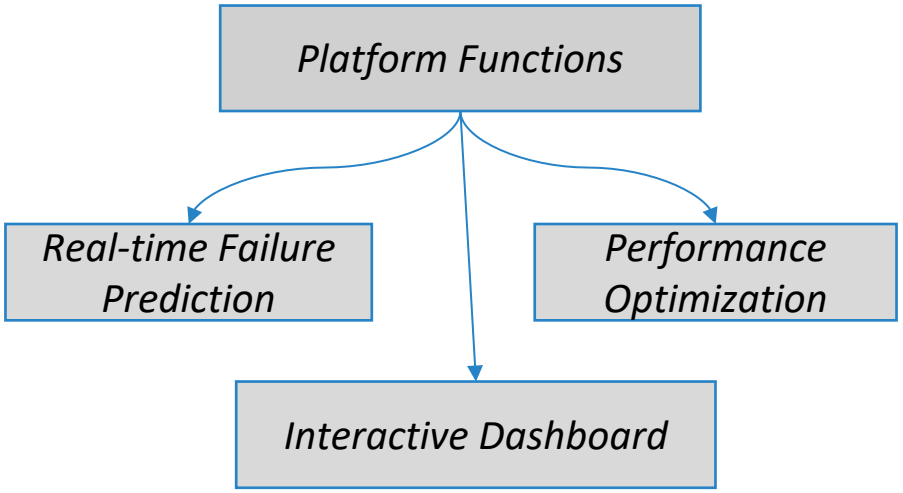
QC of the applicability of Gassmann equation.

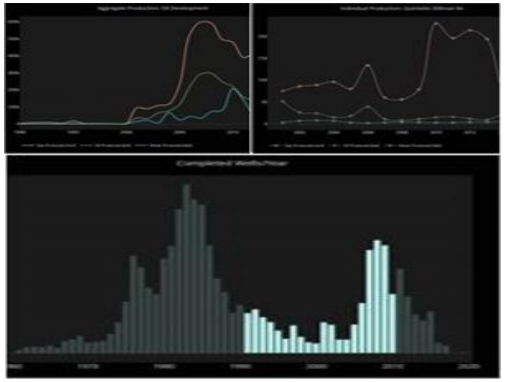
Aminzadeh (2018) DOE / NETL DE-FE0026825 Final Report

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

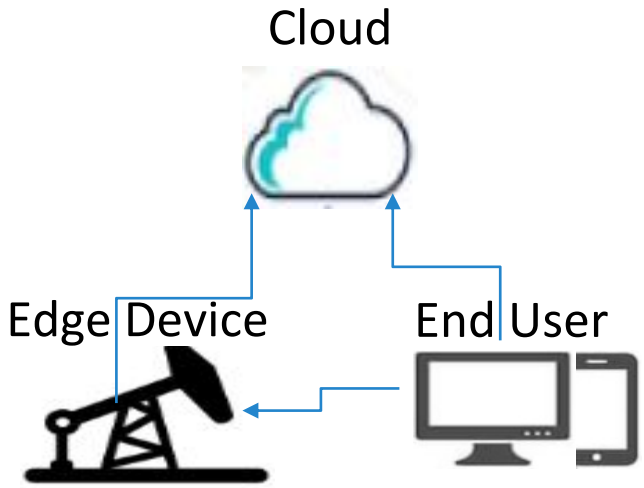
AI-Based Failure Detection via IoT & Edge Computing

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



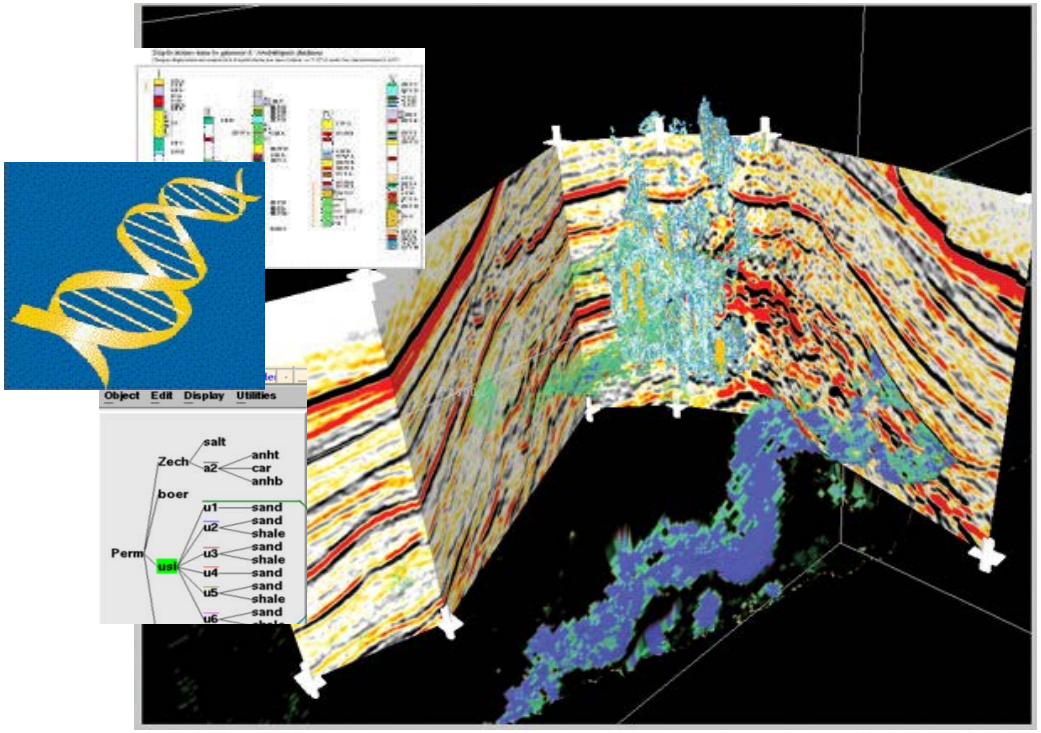


Interactive Dashboard



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.