Sandia National Laboratories

Sandia Information Sciences Initiative

PRESENTED BY

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Manager, Complex Systems for National Security

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COMPUTING CONVERGENCE

The Nation is asking for a computing convergence to enable the ability to address increasingly complex questions at the "speed of mission."

National-Level Strategies Emphasize Paradigm Shift in Information Sciences

Pioneering The Future Advanced Computing Ecosystem: A Strategic Plan

National Strategic Computing Initiative Update: Pioneering The Future Of Computing

Earth System Predictability Research And Development Strategic Framework And Roadmap

DOE Strategies and Budget Justifications Reiterate this Shift

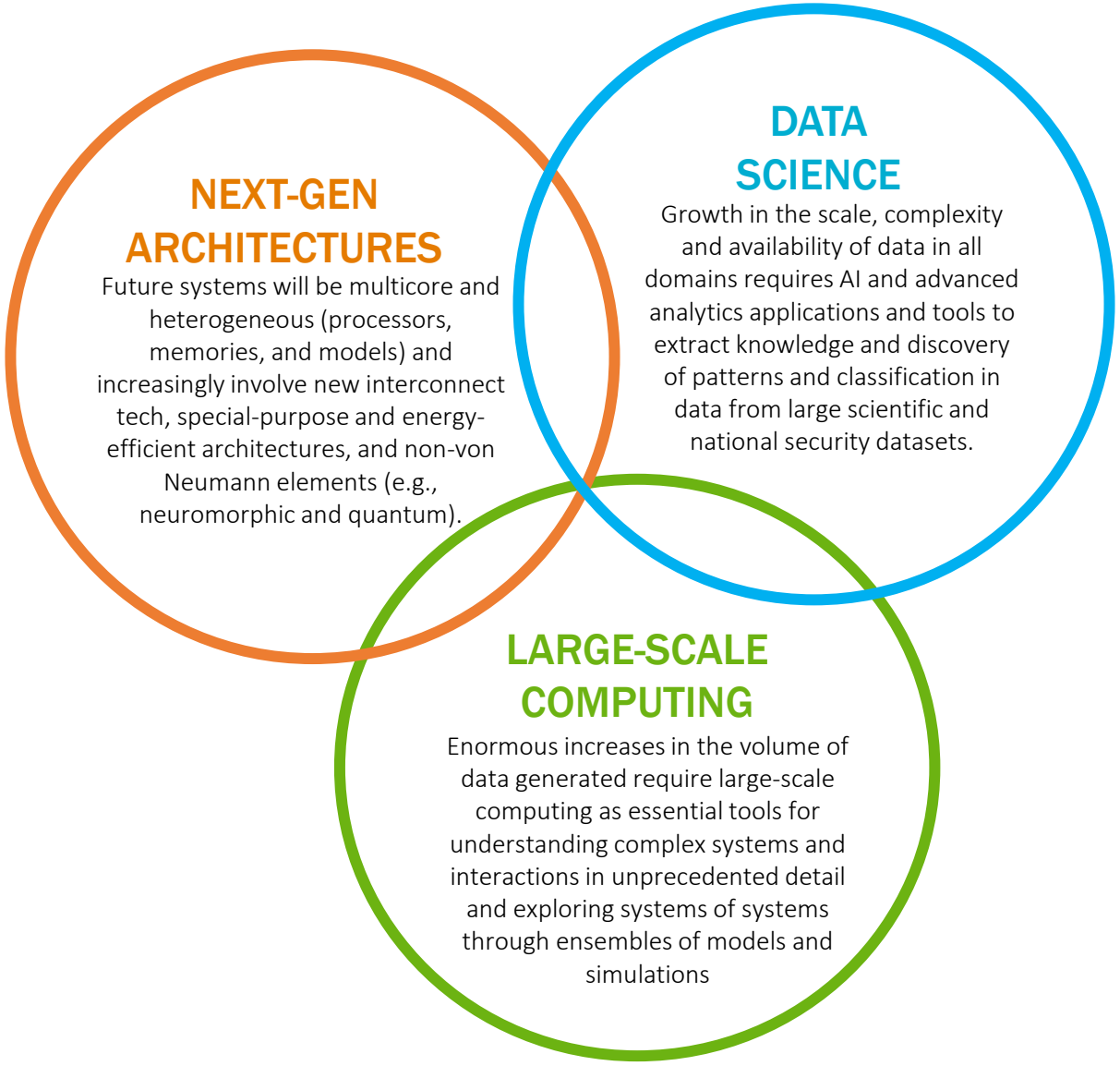
SEAB Report on AI and Machine Learning
"With the given existing and planned investment… Opportunities range from AI-designed workflow… to AI-enabled scientific 'comprehension'…"

Office of Science… **NNSA…**

All Agencies Have a Need to Capitalize on Future Advanced Computing and AI

DOE, NASA, NIH, NNSA, DoD, IC, DHS

Strategic computing could address
Unprecedented scale, reducing cost & schedule, increased complexity, real-time data and decision making



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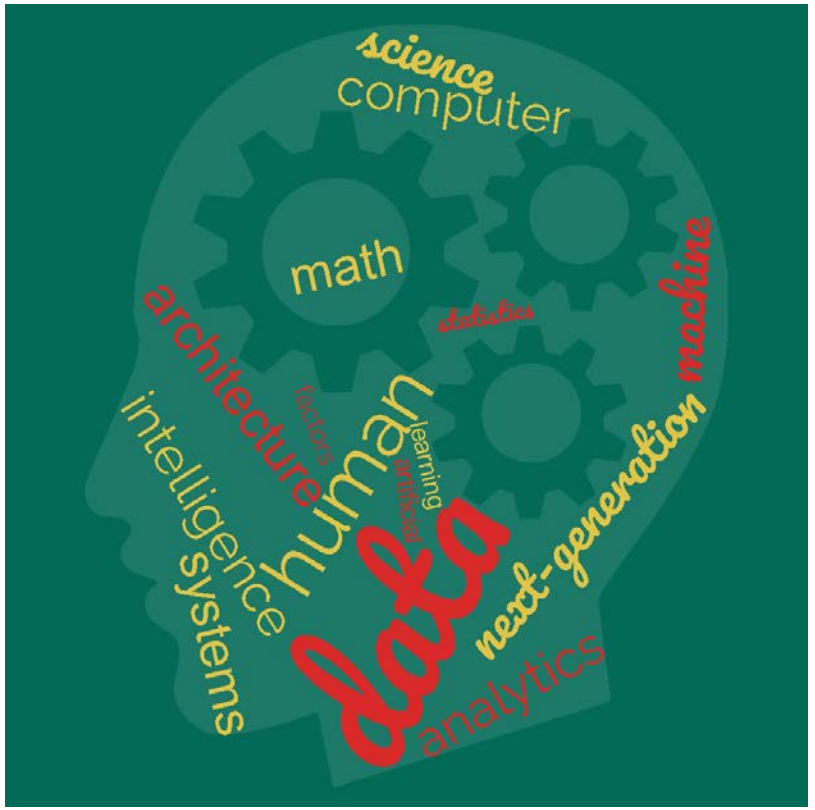
Applied Information Sciences Center, 5500

SANDIA DEFINITION OF INFORMATION SCIENCE

The integration of:

- data science/analytics
- artificial intelligence
- machine learning
- associated math and statistics
- human systems/human factors
- next-generation computer architecture



INFORMATION SCIENCES INITIATIVE

Initial Objectives

- Bridging fundamental IS research to high consequence applications
- Creating new IS programmatic opportunities to develop and apply IS techniques, tools, workforce, and infrastructure
- Enhancing Sandia's IS capabilities to:
  - benefit of NNSA and other clients
  - increasing Sandia's IS leadership
  - attracting and retaining critical skills in the workforce

APPLIED INFORMATION SCIENCES (AIS) CENTER

- Develop a new Laboratory Directed Research and Development (LDRD) area
  - National Security Information Science & Technology (NSIST)
- Facilitate bridging between fundamental R&D and application
- Focus on institutional technical road mapping, planning, and investments
- Identify critical skills and needed *infostructure*
- Assist existing mission areas in the development of new program opportunities

ALPHAGRID PROJECT OVERVIEW AND OBJECTIVE

When a power grid becomes unstable there are currently no methods to walk it back to a stable state. Can Machine Learning assist grid operators to restore the system to a safe condition in real-time?

- There are six Stability Margins which create a six dimensional space that is too computationally expensive to navigate in real-time using traditional methods
- Reinforcement Learning has shown itself to perform well on similar problems and through LDRD funds, Sandia demonstrated Reinforcement Learning is a strong candidate for this problem, which led to the DOE/OE funding
- Three year project funded by DOE Office of Electricity, Advanced Grid Modeling Program

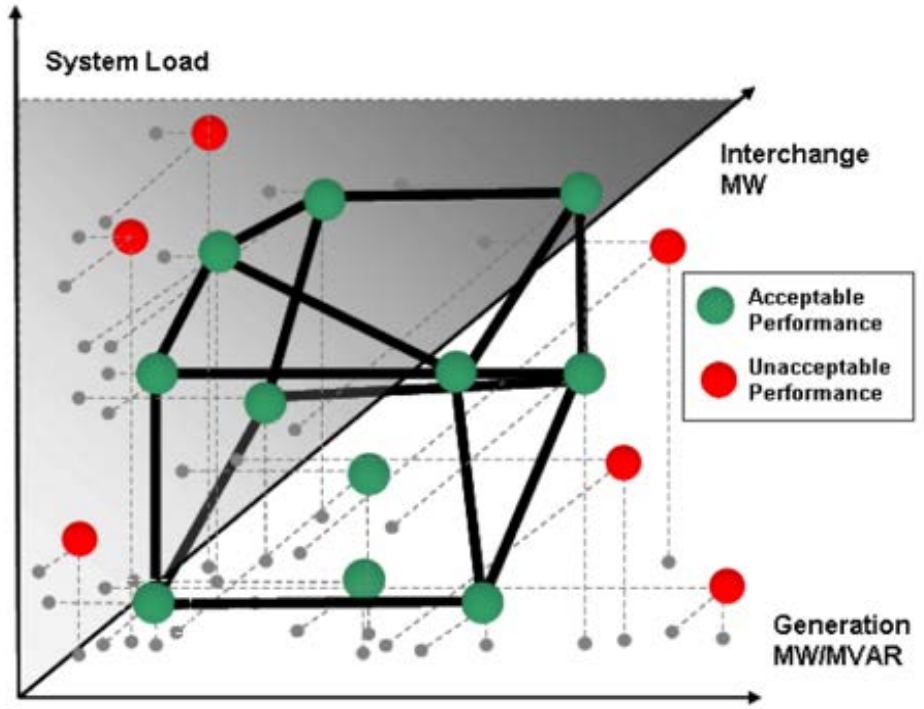


Figure 9 - "Scatter" plot of planning scenarios.

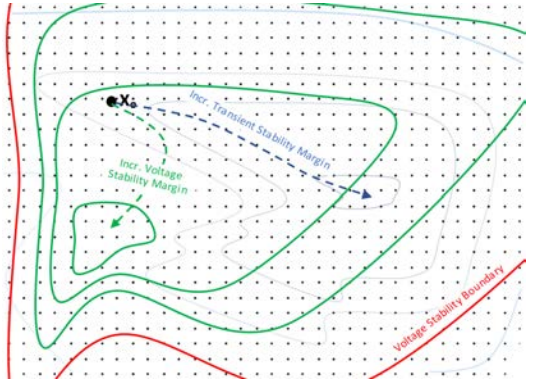
Image from North American Electric Reliability Corporation (NERC), Reliability Concepts document, pg 40.

ALPHAGRID: RESULTS TO DATE

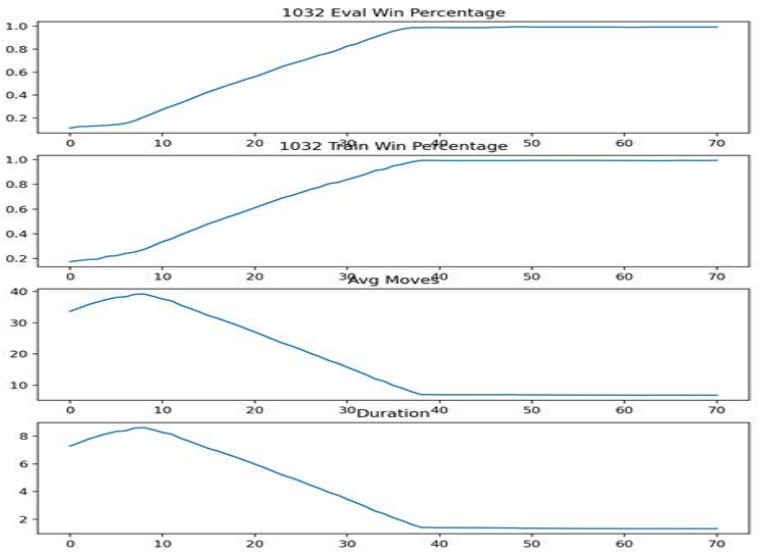
- First year
  - Developed mini-WECC grid model with 20 control dimension to navigate stability space
  - Understand how to navigate stability space using static data from the mini-WECC model
  - Sponsor funding result of LDRD investment

- Second year
  - Implemented Reinforcement Learning (RL) approach to navigate stability space on a simple grid, random player safely navigates ~8%, RL ~100%

- Third year (current year)
  - Advanced RL to navigate stability space on a complex grid, random player safely navigates ~.01%, RL converging towards 100%
  - Apply RL to navigate space, not memorize, dynamic grid
  - Publish results
  - Follow-on funding anticipated



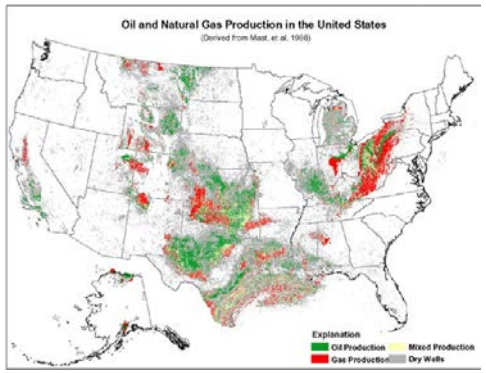
Transient Stability and Voltage Stability Level Curves
(Plot Sandia generated)



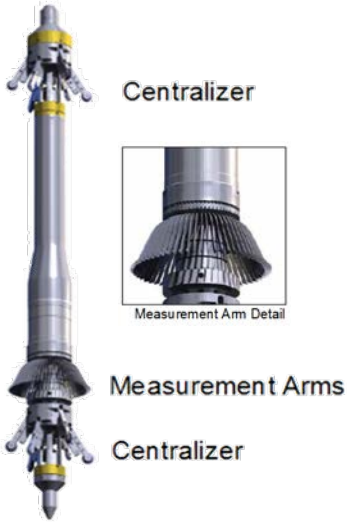
Reinforcement Learning plots
(All plot Sandia generated)

Machine Learning for Early Wellbore Failure Detection

- Problem: 93% of US total energy supply is dependent on wellbores in some form. Current approaches to evaluating wellbore risk focus on manual grading and site specific physics-based models. Need an automated approach.
- Sponsor: Geosciences LDRD
- Approach: Use Deep Neural Networks and Random Forests
- Outcome: Good results in automating wellbore failure detection, pursuing follow-on sponsors



https://www.usgs.gov/media/images/map-united-states-oil-and-gas-wells-2017



Weatherford Multi Sensor Caliper Tool Pamphlet 3725.01

NLP for Document Classification

- Problem: Large quantities of documents need to be categorized with rational, effectively and efficiently, with limited human resources.
- Sponsor: DOE Office of Classification (in collaboration with LLNL, ORNL, PNNL, Y-12)
- Approach: Ontologies, Machine Learning, Bayesian Networks
- Outcome: Developing a suite of NLP tools that aid derivative classifiers.

https://www.dreamstime.com/photos-images/messy-file-storage.html

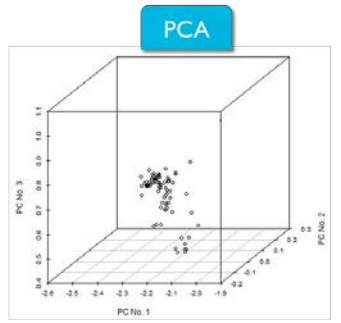
Machine Learning for Outlier Detection

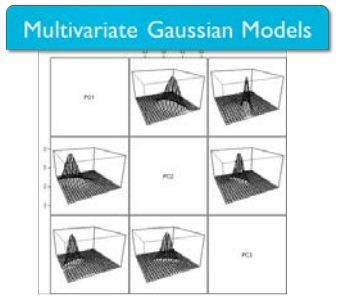
Problem: Develop a method of detecting outliers in the acoustic data from electromechanical devices that produce a sound

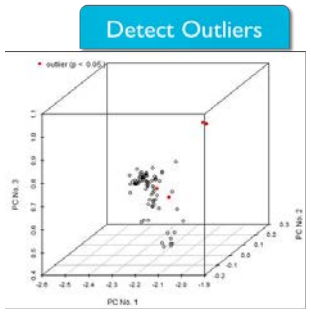
Sponsor: NNSA/ND Program

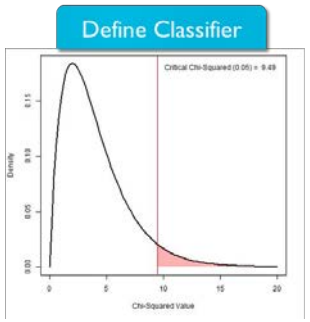
Approach: Statistical machine learning

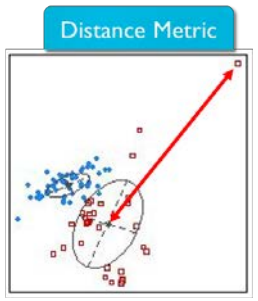
Outcome: Deployed tool to Component Engineers for testing











(All plot Sandia generated)

Machine Learning for Detecting Technological Maturity

- Problem: Identifying emergent technologies based on open source indicators (publications, new releases, patents, etc.)
- Sponsor: Airforce Research Lab
- Approach: Artificial Neural Networks, Data Augmentation
- Outcome: Performs with 90.4% accuracy, can be scaled, can be automated