DOE/OE Transmission Reliability Program

Discovery Through Situational Awareness (GMLC0070)

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Project Scope

Create a tool that applies statistical and machine-learning algorithms in context of big data analytics to investigate and implement anomaly and event detection algorithms in near real-time

Current Focus

- Working with the Eastern Interconnect
- Initial focus on phase angle pair analyses
- Provide the EI partners with a frequent (i.e. daily or weekly) report of the findings

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Power Grid Statistical Analytics: Our Historical Journey

Aircraft safety Morning Report w/ NASA

Analytics Using State Estimator Data w/ EI

Data Investigations Using PMU Data (uncovering data quality issues, etc.)

DISAT

Data **I**ntegrity **S**ituational **A**wareness **T**ool (PMU Data Analytics w/ BPA)

GMLC and Beyond
Machine learning basis
Many additional data streams
Predictive analytics

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What Makes This Unique?

- More and more “machine learning” functionality is being added to software, but this software often lacks direction and feature extraction, and is often univariate.
- Research is needed to determine proper ways to use the algorithms (exploration, prediction, etc.), features to include, and how much and what time period to include.
- Multivariate approaches are needed and baseline testing necessary.

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Recent Accomplishments

- Processed 8 months of PMU data (western grid data)
  - Investigated data quality and anomalies
  - Focused on wide area phase angle pairs
- Created a plan with EPG and our Eastern Interconnect partners (facilitated by Joe Eto) to build a prototypical tool containing:
  - Multivariate anomaly detection algorithms
  - Oscillation detection and analysis algorithms
  - Plotting and reporting algorithms
- Presentations at JSIS, NASPI, and the GMLC Industry Workshop; poster presented at recent GMLC review
- Lead organizer and author of the Data Mining EATT (NASPI) white paper

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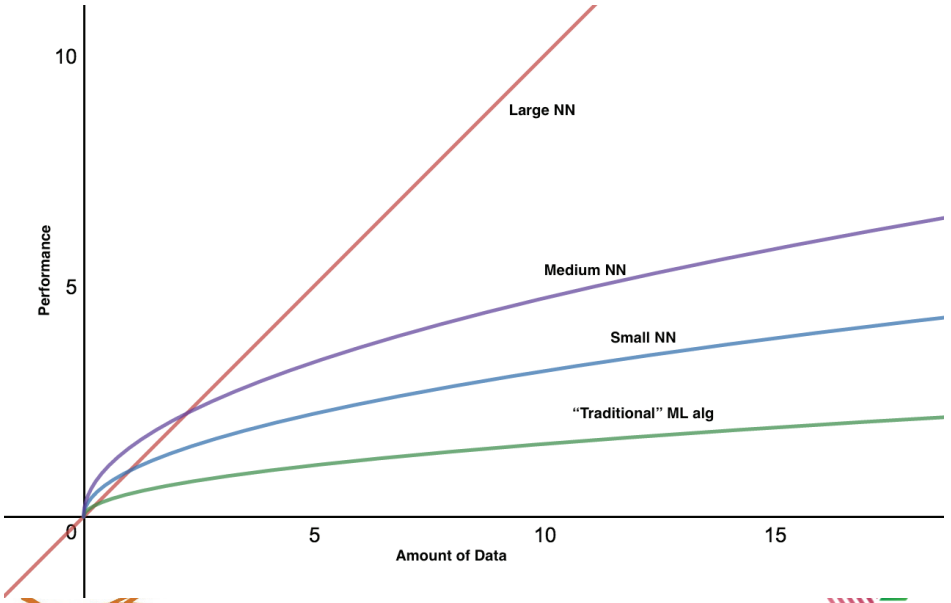
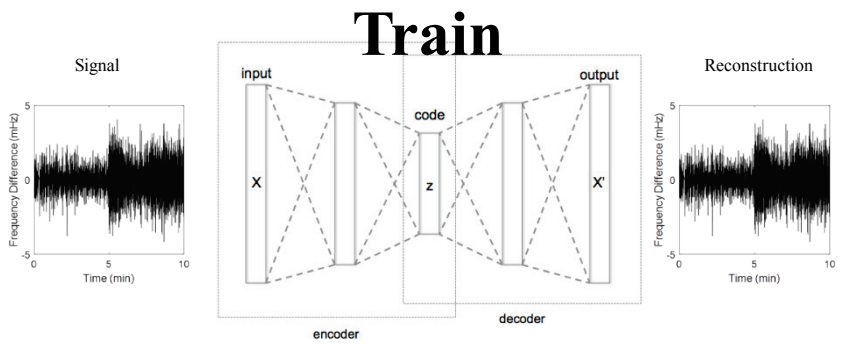
Applying Neural Networks

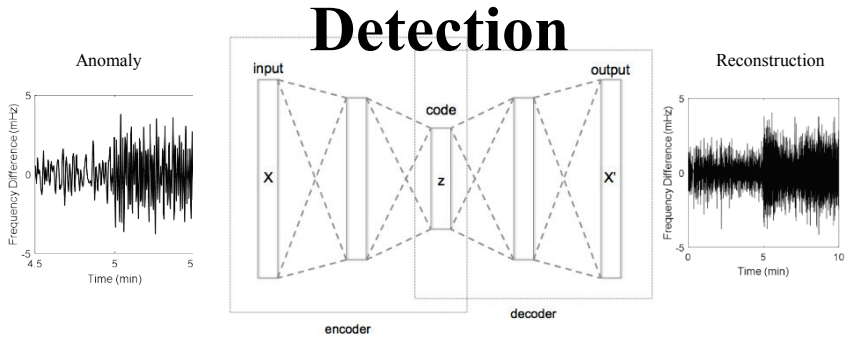
- **What** are neural networks?
  - Machine learning models that can learn highly non-linear behavior
- **Why** we need neural networks?
  - For sufficiently large networks, performance becomes a function of the amount of data



Neural Networks for the Power Grid

- Neural networks are a perfect fit for **power grid** applications because:
  - We have access to a lot of data (volume, high frequency).
  - Power grid behavior is highly non-linear.
- **Approach**: Train a neural network (called **autoencoder**) to learn when the grid is stable.





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Current Collaborations

- Previously mentioned work with EPG and the Eastern Interconnection to develop ESAMS (Eastern Interconnect Situational Awareness Monitoring System) including our anomaly detection methods
  - Prototypical tool hosted by PJM
  - Initial focus will be wide-area phase angle pairs
- Summer interns: Tianzhixi Yin from University of Wyoming (John Pierre & Shaun Wulff) & Shikhar Pandey from Washington St. University (Anurag Srivastava)

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Current Investigations

- Comparing anomaly detection methods developed by our summer interns at their respective universities to methods developed at PNNL
- Investigating optimal baselining parameters (i.e. length of time, variables and features to include, etc.)
- Compare our detected events to actual events on the western grid

Remaining Deliverables

Deliverable	Schedule
Provide investigation results to industry partners for feedback	Aug 25, 2017
Technical report summarizing methodologies and findings	Oct 27, 2017
Prototypical Situational Awareness Tool Working with real-time streaming PMU data at PNNL	Dec 29, 2017

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Beyond FY16

- Finish building ESAMS with EPG and the Eastern Interconnect
- Review ESAMS findings and tune algorithms accordingly
- Continue machine learning approach to find events and patterns, including other power grid data and other data streams like weather, social media, etc.
- Employ predictive analytics
- Use spatial statistical techniques to take advantage of spatial relationships