BIG DATA ANALYTICS FOR PLANT PERFORMANCE IMPROVEMENT

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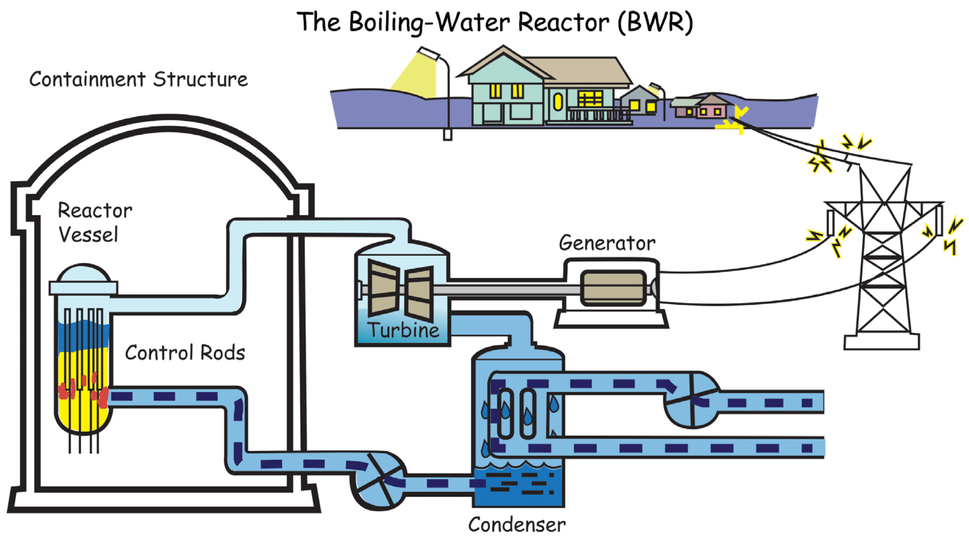
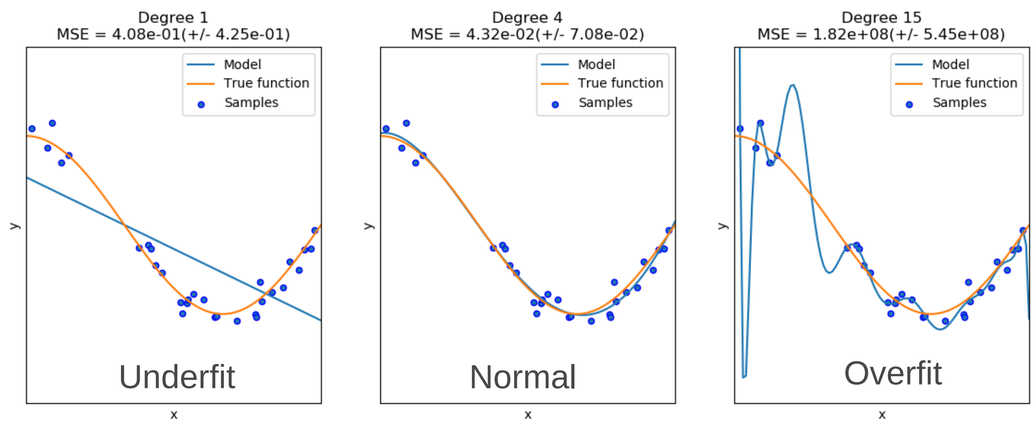
MOTIVATION

- In commercial light water reactor systems, moisture must be removed from the steam before supplied to the turbine. However, in some boiling water reactors the moisture content of steam was elevated at the end of power generating cycles, known as a problem of moisture carryover (MCO).
- With undesirably high MCO:
  - The liquid droplets in the steam may adversely impact the steam line and turbine resulting in system degradation;
  - Meanwhile, the elevated dose levels in the plant during high MCO may have negative effects to worker health.
- In order to avoid high MCO in the power-generating cycle:
  - Identify the parameters closely related to MCO;
  - Develop a model to predict the MCO before a cycle starts, in order to evaluate the operating plan.

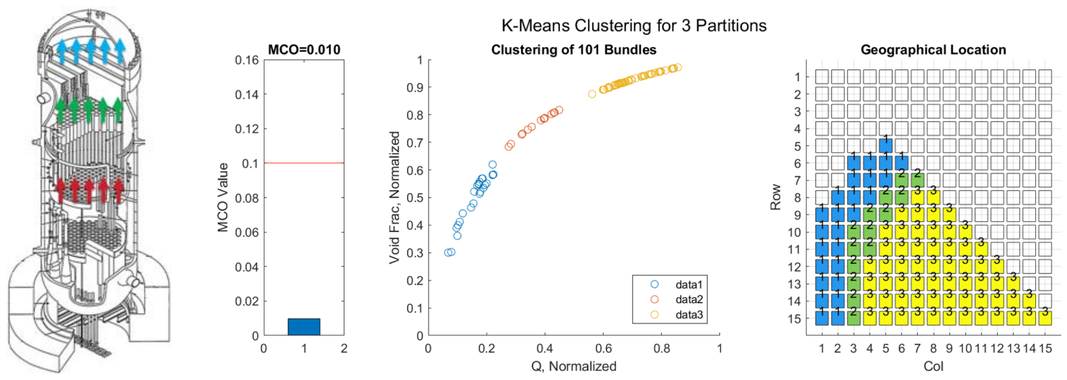


METHODOLOGY: BIG DATA AND MACHINE LEARNING

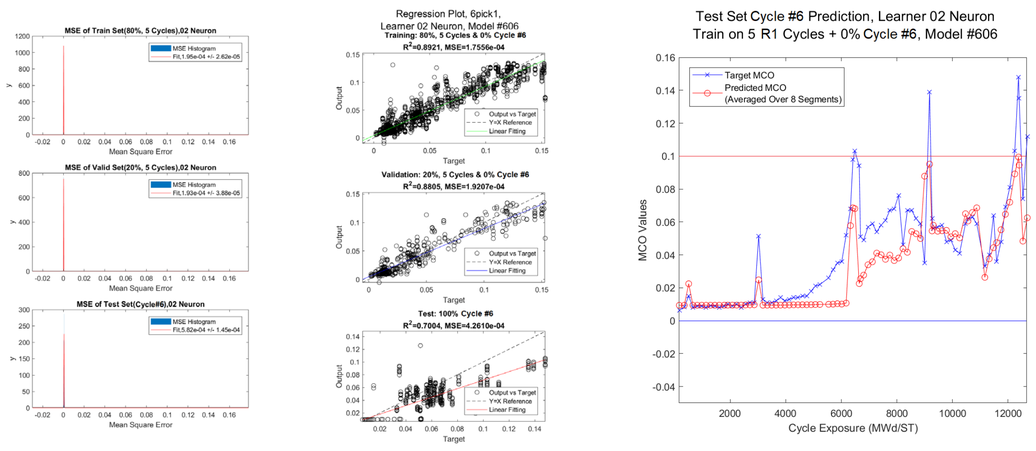
Machine learning could assist us to link the predictors to the desired outputs by training models using observed data. In this project, a model is desired to take the reactor core parameters as input, and return the modeled MCO as output.



- Avoiding Either "Underfit" or "Overfit":
  - Machine Learnings can only interpolate within the scope of training data;
  - Normal: Model catches the variation of data within error bar;
  - Underfit: Model is too simple to catch the variation of data;
  - Overfitting: Model is too complicated to generalize.



- Select the Appropriate Input Variables:
  - Engineering analysis: Identify what the steam separator can see;
  - Correlation analysis and k-means clustering: Combining bundles with similar performance;
  - Genetic algorithm: Find the most promising combination of core parameters.



- Neural Network Model Training, Validation and Independent Test:
  - Use observed data to train a model minimizing loss function;
  - Use set-aside validation data to stop training, avoiding overfit;
  - Use independent test data to measure the performance of this model.

IMPACT

- The models could predict the general MCO trend for an entire power-generating cycle, which was never used in the model training or validation process.
- The related findings were fed back to the nuclear power companies for improvement;
- Models are being improved to predict high MCO better.

FUTURE DIRECTIONS

- Other machine learning techniques will be applied:
  - Deep convolutional neural network;
  - Unsupervised learning, etc.
- Other reactor optimization topics to discover:
  - Power-converting efficiency;
  - Steam line equipment fault prediction, etc.

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