INL/EXP-22-68377-Revision-0

Multi-Kernel Support Vector Machine based Predictive Maintenance of Circulating Water Pumps in Nuclear Power Plants

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Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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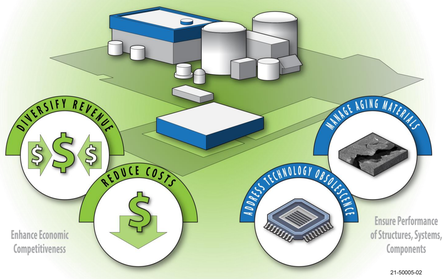
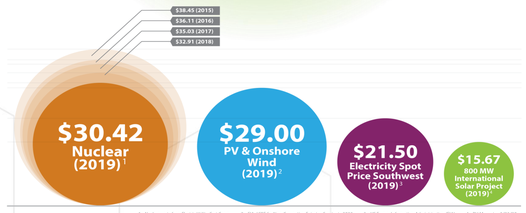
Motivation

Reduce maintenance costs by adapting a predictive maintenance strategy in nuclear power plants



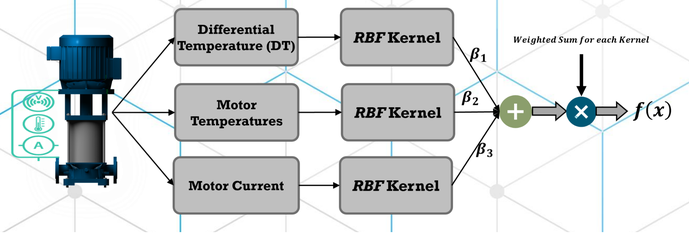


Total average operating costs ($/MWhr) for different energy sources.

Predictive Maintenance in Nuclear Power Plants

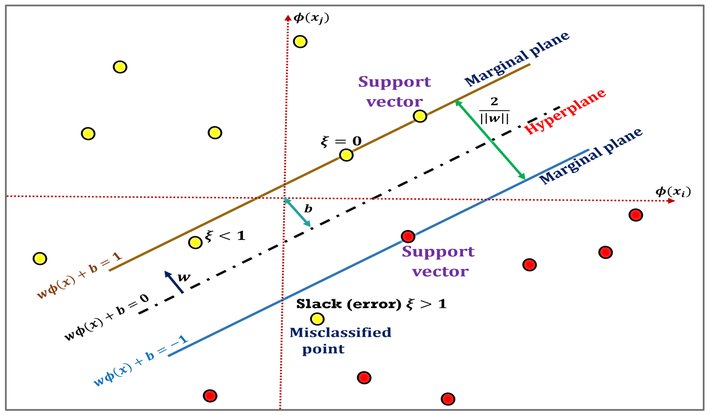
- Predictive maintenance monitors the condition of assets through sensor devices
- Predict health of the circulating water pump (CWP) considering:
  - Healthy and unhealthy (in this work only waterbox fouling fault) data
  - Use fault signature data from measurements and predict using a machine learning model

Objective: Utilize a Multi-Kernel Support Vector Machine (MK-SVM) to determine the operational health of a CWP



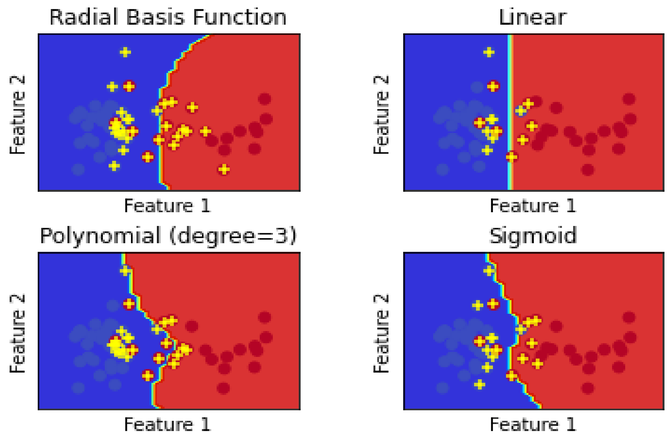
Feature selection for MK-SVM

Multi-Kernel Support Vector Machine



Visualization for SVM

- SVM is a classification-based machine learning algorithm that divides data into two or more classes based on the formation of a decision boundary
- This algorithm utilizes multiple "Kernels" which impact the formation of the decision boundary, Kernel types include:

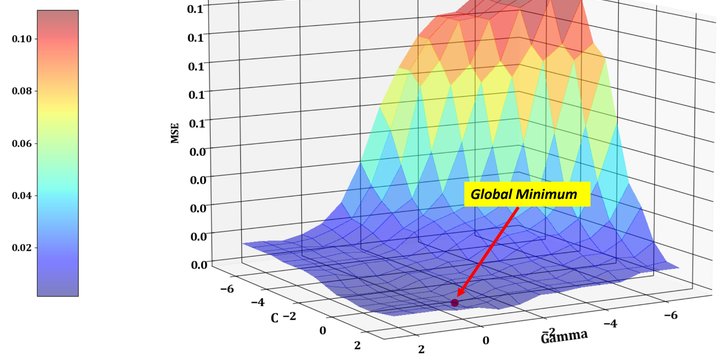


Representative diagram for decision boundaries for each kernel

- MK-SVM will have feature specific kernels
  - Decision will be a weighted sum of all the kernels
  - Helps to deal with missing features during prediction
  - Kernels specific to missing features can be turned off

SVM Hyperparameter Optimization

- Grid search utilized to find the optimal kernel parameters (C and γ) to train the MK-SVM
- Optimal parameters selected based on minimum mean squared error



MSE surface plot for C and γ

CWP Health Prediction Results

- With optimized parameters: C = 2.6827, γ = 0.7197
  - Training Accuracy = 99.85%
  - Testing Accuracy = 99.63%

	Actual\Predicted	Healthy	Unhealthy
Training	Healthy	4287	11
	Unhealthy	2	4292
Testing	Healthy	529	4
	Unhealthy	0	541

- The adoption of predictive maintenance strategy would drive automation, efficiency gain, enhanced reliability of plant systems, and substantial cost savings
- Future work: Validation and optimization of the models

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LWRS LIGHT WATER REACTOR SUSTAINABILITY

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Acknowledgments
This work is supported by the U.S. Department of Energy Office of Nuclear Energy's Nuclear Energy University Program.

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