



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

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*Changing the World's Energy Future*

Matthew Stephen Scott, Vivek Agarwal, Koushik Araseethota Manjunatha



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**Idaho National Laboratory  
Idaho Falls, Idaho 83415**

**<http://www.inl.gov>**

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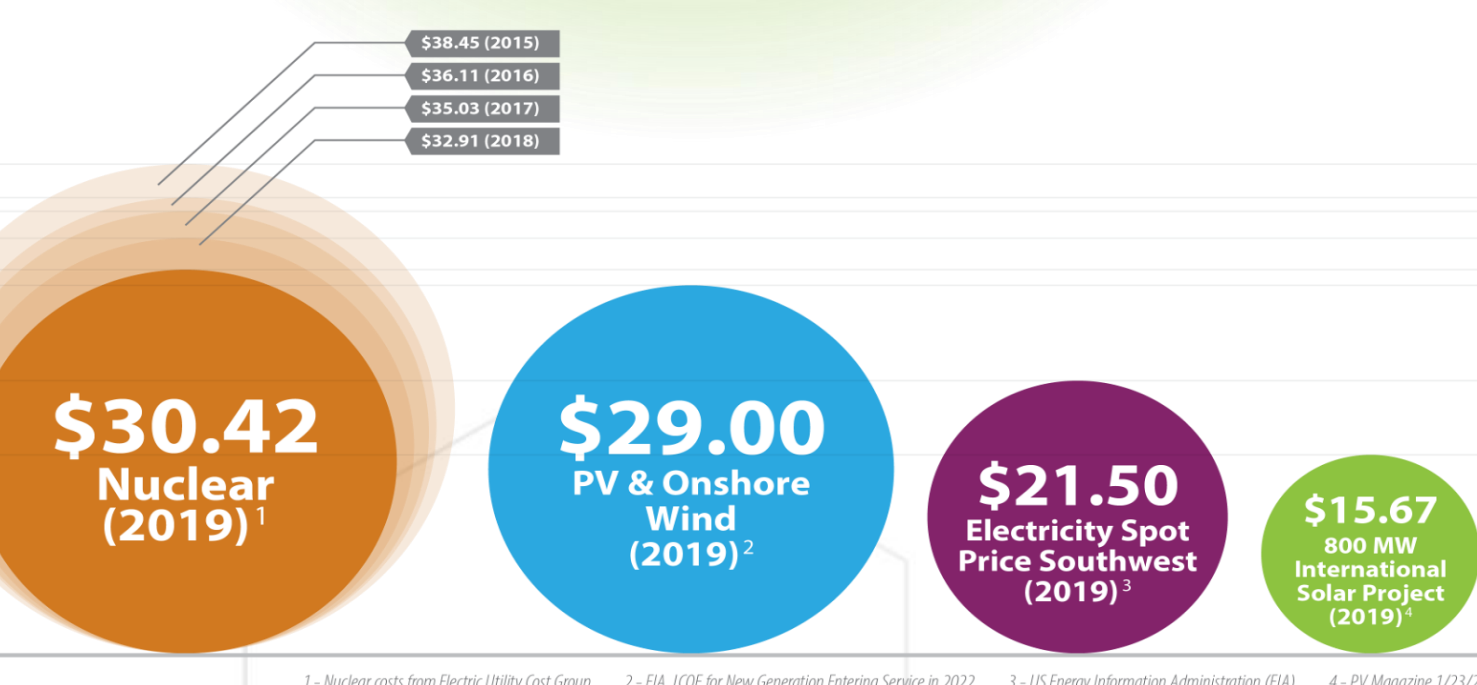
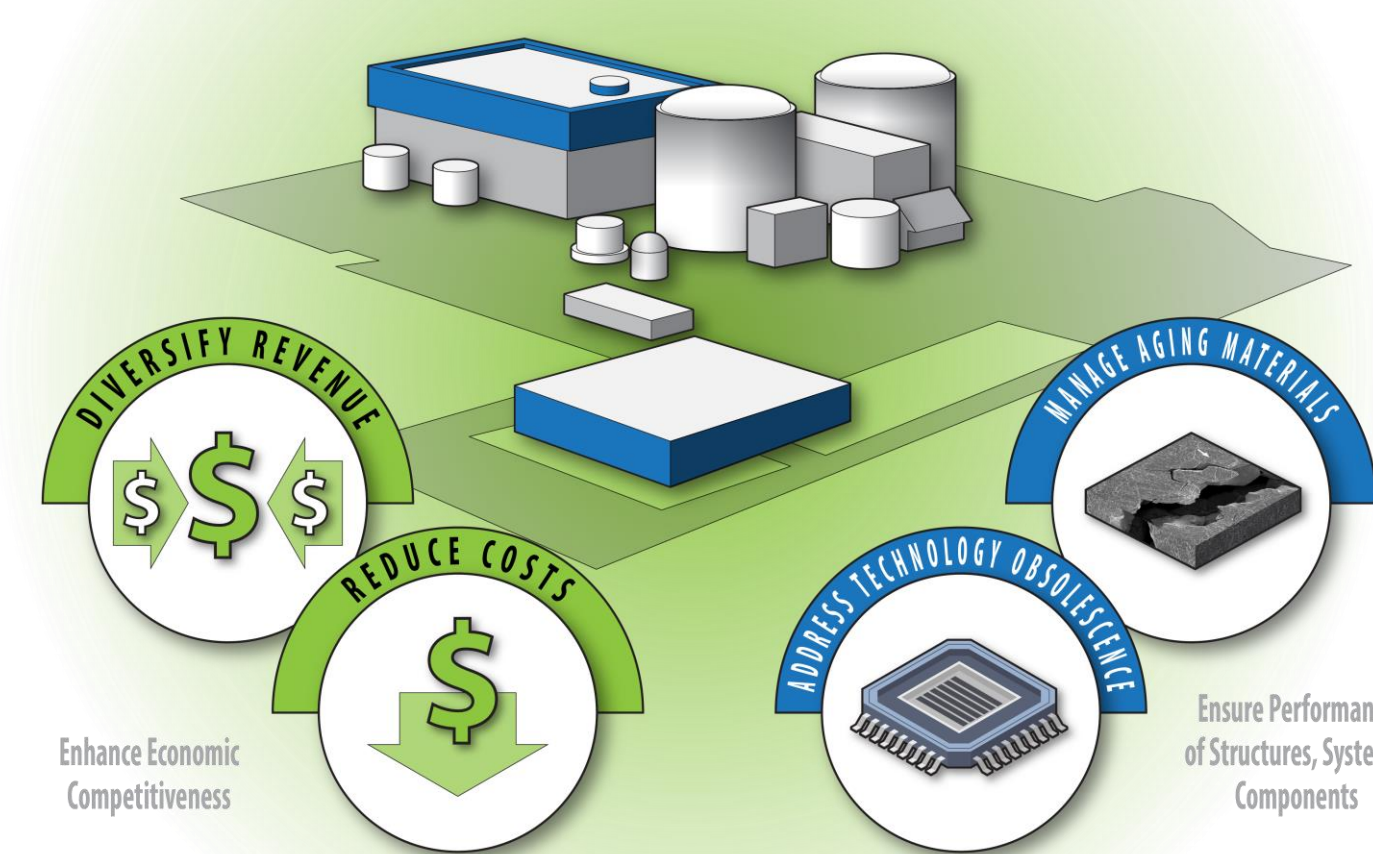


# Multi-Kernel Support Vector Machine based Predictive Maintenance of Circulating Water Pumps in Nuclear Power Plants

Matthew Scott – University of Tennessee. Mentors: Koushik A. Manjunatha, and Vivek Agarwal

## Motivation

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

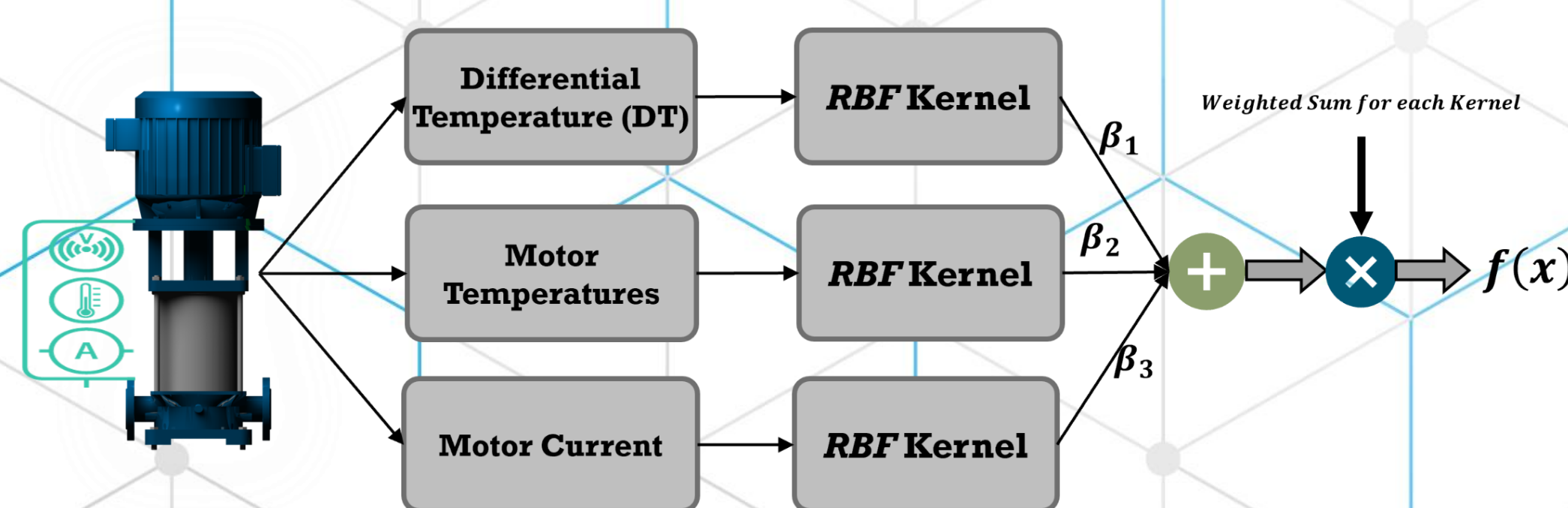


Total average operating costs (\$/MWhr) for different energy sources.

## Predictive Maintenance in Nuclear Power Plants

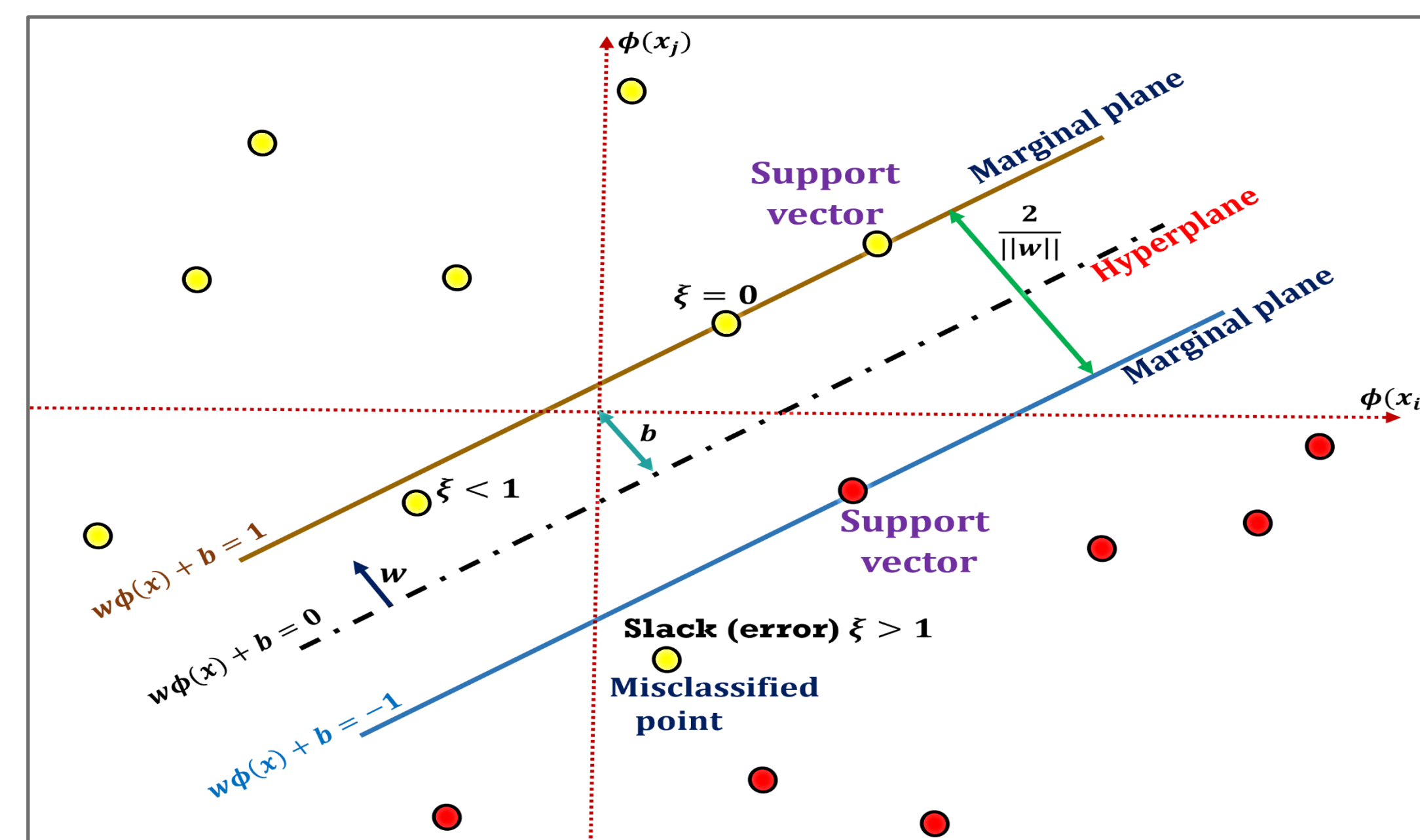
- Predictive maintenance monitors the condition of assets through sensor devices
- Predict health of the circulating water pump (CWP) considering:
  - Healthy and unhealthy (in this work only waterbox fouling fault) data
  - Use fault signature data from measurements and predict using a machine learning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

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



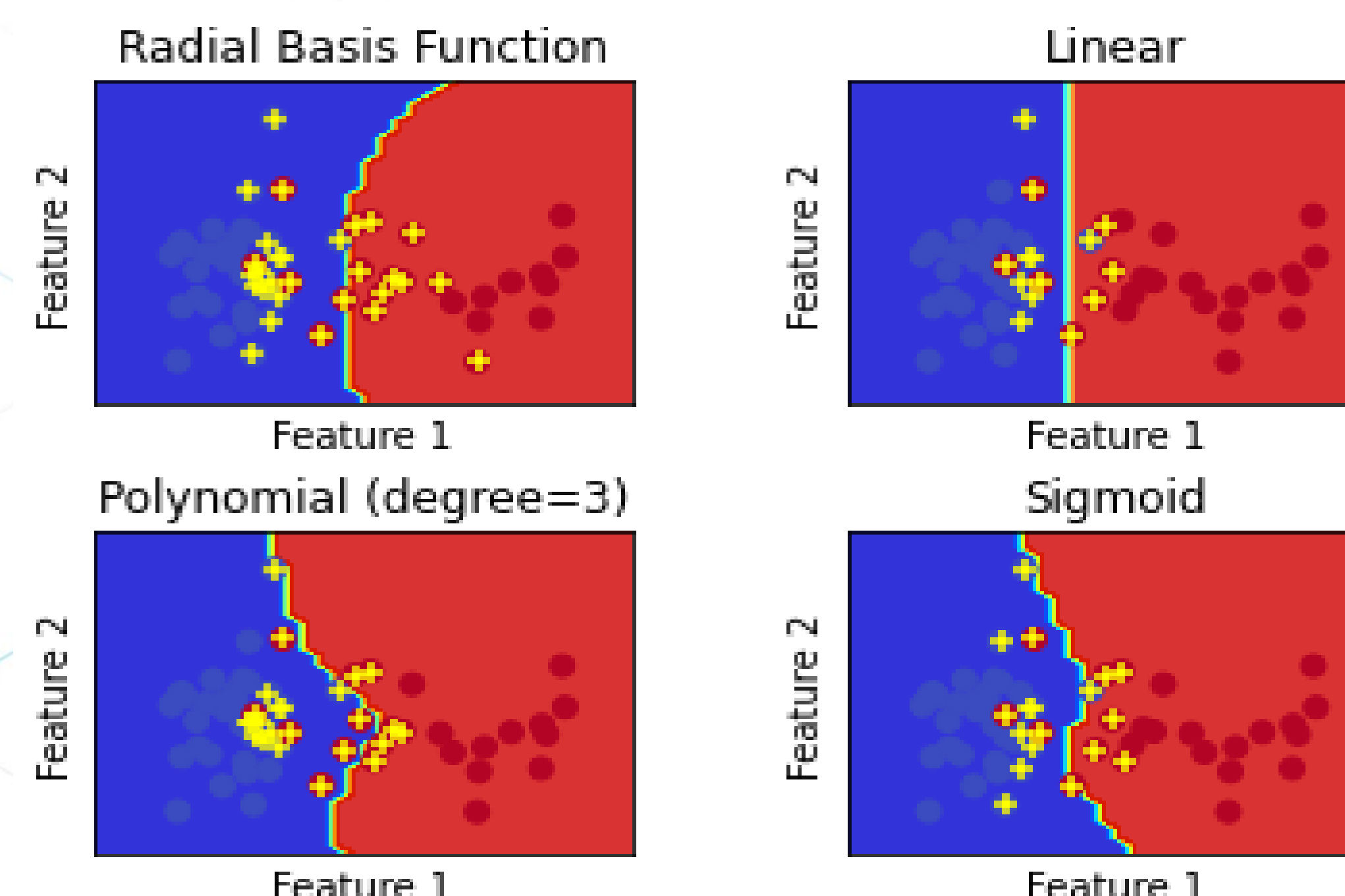
Feature selection for MK-SVM

## 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:

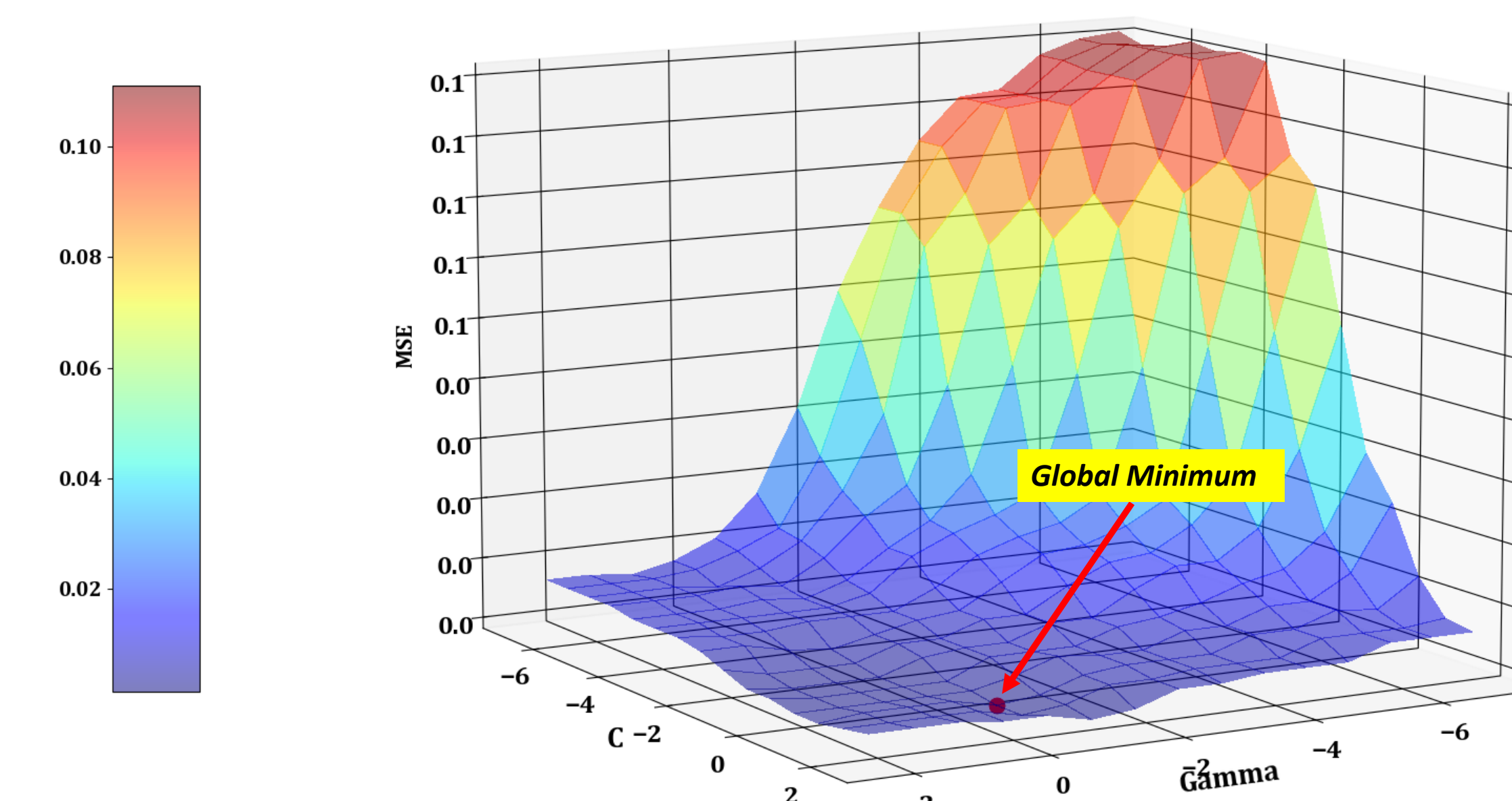


Representative diagram for decision boundaries for each kernel

- 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  $\gamma$ ) to train the MK-SVM
- Optimal parameters selected based on minimum mean squared error



MSE surface plot for C and  $\gamma$

## CWP Health Prediction Results

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

	Actual\Predicted	
	Healthy	Unhealthy
Training	Healthy	4287
	Unhealthy	2
Testing	Healthy	529
	Unhealthy	0

- 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

## Acknowledgments

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