To simulate Health Indicators distributions with variations of Parameters and Degradations

Surrogate Modeling
Sensitivity analysis: Morris Method
Surrogate Modeling: Latin Hypercube + Kriging

A. Sensitivity Analysis
- Morris Method
- 225 simulations
- Original: 45 parameters
- Reduction: 120

B. Kriging
- Kriging Model: \( f(x) = f_0(x) + Z(x) \)
- \( f_0(x) \): regression model
- \( Z(x) \): Gaussian process
- mean zero
- variance \( \sigma^2 \)
- with \( k \) correlation function
- \( R(x,y) = \sigma^2 \exp(-d/\theta) \)
- Exponential correlation: \( R(x,y) = \sigma^2 \exp(-d/\theta) \)

Software: Co-simulation AMESim/Matlab-Simulink

Health Indicators Construction
Parameters + Degradations

Input

Parameters + Degradations

Central Concept: W-model

New Proposal: Integrated PHM
To optimize PHM system capabilities at each stage of the development process

Difficulty 1: managing multiple parameters
- Sensitivity Analysis for parameters prioritization
- Morris Method
- One at the time method
- B. Sobol Indices
- Based on Variance Decomposition
- More precision but more simulations needed

Solution: Numerical Modeling
To create the data needed for the validation of the PHM Framework

Expensive Numerical Model

High Pressure Fuel Pump PHM

Numerical Key Performance Indicators
- Health Indicator: Engine Rotation speed at BSV, TBV and HPSOV Opening
- wBSV, wTBV and wHPSOV
- HP Pump Internal Leakage

Surrogate Modeling
- Based on semi-logarithmic ROC curves
- Common Criteria: TP > 0.5 & FP < 1.4
- Compliance Points (CP): (TP, FP)
- Neyman’s: Winnow detection, class = 1 if the curve is above the CP, 0 if the curve is under the CP