

## Syllabus

### ENRE655: Advanced Reliability Modeling

**Five Homework: 30%**

**Project: 40%**

**Final Exam: 30%**

#### **Textbooks:**

- 1 C. M. Bishop Pattern Recognition and Machine Learning, Springer, 2006.
- 2 Prognostics and Health Management in Engineering Systems: An Introduction, Nam-H. Kim, D. An, J-H Choi, Springer, 2017.

### **Course Content**

#### **[LECTURE 1] Advanced Reliability Engineering Methods Survey**

- Simulation methods
- Physics of Failure Methods
- Prognosis and Health Management
- Machine learning and data Analytics methods

#### **[LECTURE 2 & 3] Model Development and Regression**

- Statistical Decision Theory: Optimization solutions
- Classical Probability Theory: Maximum likelihood estimation solutions
- Review of Bayesian estimation methods
- Bayesian Probability Theory: Bayesian estimation solutions
- Multivariate regression
- Kernel-based Methods: Gaussian Process Regression

#### **[LECTURE 4] Thermodynamics and Information Theory**

- Thermodynamics Entropy
- Shannon's Entropy
- Kullback-Leibler Divergence (Relative Entropy)
- Maximum Entropy
- Model Selection (ML, Bayesian Model Comparison, AIC, BIC)
- Bayesian Model Averaging

#### **[LECTURE 5]: Programing Review**

- Matlab
- Python
- Keras and Tensorflow

#### **[LECTURES 6 & 7] Graphical Models**

- Bayesian Networks
- Hybrid Networks

- Naïve Bayes
- Neural Networks
- Convolutional Neural Networks

**[LECTURE 8 & 9] Signals, Prediction and Prognosis**

- Kalman Filter
- Particle Filter
- Vibration Signals
- Acoustic Emission Signals
- Model Updating
- Prognosis

**[LECTURE 10] Feature and Dimensionality Reduction/Data Compression**

- Principal Component Analysis
- Feature Selection

**[LECTURES 11 & 12] Supervised Damage Diagnosis – Classification**

- Support Vector Machines
- K-Nearest Neighbor
- Decision Trees
- Random Forest
- Naïve Bayes
- Neural Networks
- Convolutional Neural Networks
- Recurrent Neural Networks

**[LECTURE 13] Unsupervised Damage Diagnosis – Clustering**

- K-Means Clustering
- Anomaly Detection
- AutoEncoders
- Variational AutoEncoders

**[LECTURE 14] Project Presentation**