An Information Theoretic Framework for Health and Condition Monitoring of Power Plant Equipment Names
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I. Introduction

Power plants are composed of many subsystems and components. These subsystems possess their own individual dynamics, and contributing to overall system dynamics through their interactions. Sensors are used to help a human plant operator to detect and track anomalous behaviors. While sensor data from directly connected elements are related, it is also possible that other elements may be related via the intrinsic dynamics of the overall system.

II. Relationship between Information Measures and Power Plant Equipment Monitoring: A Control Theory Perspective

Mathematical Model of Power Plant:

- Correlation measures can perform poorly for nonlinear correlation.
- Correlation measures are insufficient to capture nonlinear underlying dynamics of power plants.
- We propose mutual information to capture this nonlinear interconnection.

III. Computation of Mutual Information

A. Continuous-Valued Representation

- Underlying dynamic of complex plant are continuous.
- Sensor data generally treated as continuous-valued.
- Use Hidden Markov Model (HMM) to capture coarse approximation of underlying dynamics.
- Data under HMM with Gaussian emission is Gaussian Mixture (GM) approximate large class of probability distributions.
- Model construction performed in two steps:
  - Model order selection and parameterization for given data.
  - Computation of mutual information given HMM.
- Interpretation of information measure for continuous PVI’s can differ from original definition in discrete-valued space.

B. Discrete-Valued Representation

- Results from computational algorithms upon violation of strict assumptions, can have completely different interpretation.
- Mathematically proven that Shannon mutual information gives meaningful result even if i.i.d. assumption is not satisfied.
- We focus on this simpler method for mutual information computation.

B.1 Shannon Mutual Information and Quantization

- Discrete-valued representation requires quantization.
- Selecting methods for quantization can be challenging.
- Simulations show that computation of mutual information is not overly sensitive to quantization method.
- Simulations also suggested that normalized mutual information can be used to reduce the effect of different number of bins.

B.2) Simulation Results on Varying Parameter Dynamical Systems

- Simulation results show that Shannon mutual information can detect the change in the parameter of coupling chaotic systems.
- We propose the use of adjacency matrix for health condition monitoring.

- Due the symmetric property, mutual information cannot be used to detect the direction of influence.
- We are currently investigate the new alternative quantity which emerges from mutual information in order to detect the directionality.

IV. System Structure Representation

V. Conclusions and Future Work

- Theoretically, information measure can be used to detect change in the structure of the systems.
- We propose study and compare the computation approach for mutual information.
- Simulation results show that Shannon mutual information can detect the change in the parameter of coupling chaotic systems.
- We propose the use of adjacency matrix for health condition monitoring.

VI. References