Background

Real applications are often complex and model-based techniques for diagnosis are therefore often faced with a general, large- scale, and non-linear differential-algebraic model, possibly in high level languages like Simulink or Modelica consisting of hundreds or thousands of equations. Such complex models often require specialized techniques for specific classes of systems. One successful way to manage the complexity is to utilize the model structure using graph based algorithms. Structural analysis has proven to be a powerful tool for generating detection signals and early determination of fault isolability properties.

Methodology will be supported by freely available software (faultdiagnosistoolbox.github.io) provided to the tutorial participants, supporting analysis, design and a tool-chain from modeling a system to generating C-code for residual generators.

Main themes

1. Formally introduce structural models and fundamental diagnosis definitions
2. Derive algorithms for analysis of models and diagnosis systems
   - Fundamental graph-theoretical tools, e.g., Dulmage-Mendelsohn decomposition of bipartite-graphs
   - Fault isolability of a model
   - Fault isolability of a diagnosis system
   - Finding sensor locations
3. Algorithms for design of residual generators
   - Find minimal submodels with redundancy
   - Generating residuals based on submodels with redundancy
4. Interactive Matlab sessions
   - Analysis and design for provided use-case
   - Analysis and design on own laptop (optional)
   - Illustration on an industrial sized example

Tutorial outline

Time	Description
09:00-10:30	Formal introduction of fundamentals; definitions, theory, and models
10:30-10:45	Short break
10:45-12:30	Algorithms for analysis of models and diagnosis systems - Some fundamental graph-theoretical tools - Determination of fault isolability properties of a model - Determination of fault isolability properties of a diagnosis system - Finding sensor locations for fault diagnosis
12:30-13:30	Lunch
13:30-15:15	Algorithms for design of residual generators - Finding all minimal sub-models with redundancy - Generating residuals based on sub-models with redundancy - Code generation, state-observers, and detection algorithms
15:15-15:45	Short break and time for discussions
15:45-17:00	Interactive session in Matlab – analysis and design for a provided use-case

17:00-17:30 Concluding discussion and demonstration of use-case

Biographies

Erik Frisk *was born in Stockholm, Sweden in 1971 and now is an associate professor at the Department of Electrical Engineering, Linköping University, Sweden. His research interest include model based fault diagnosis in general, and structural methods, observers for fault detection, statistical signal processing, and fault prognosis in particular. Design of diagnosis algorithms based on industrial sized models, e.g., described in Simulink or Modelica has been a key driver for his research, especially in the automotive domain.*

Mattias Krysander *was born in Linköping, Sweden in 1977 and is an associate professor at the Department of Electrical Engineering, Linköping University, Sweden. His research interests include model based diagnosis and prognosis. As a way to cope with the complexity and size of industrial systems, mainly vehicle systems, he has used structural representations of models and developed graph theoretical methods for assisting design of diagnosis systems and for fault isolation and sensor placement analysis.*