Using Fault Augmented Modelica Models for Diagnostics

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We propose a model-based diagnosis framework in which Modelica models of faulted behavior are used in combination with a Bayesian approach. The fault augmented models are automatically generated through a process developed as part of our Fault Augmented Model Extension (FAME) work. Fault diagnosis using a Bayesian approach is based on computing a set of probability density functions, a process that is usually intractable for any reasonably complex system. We use Approximate Bayesian Computation (ABC) to bound the numerical and computational complexity. The basic idea is to use fault augmented Modelica models to create probability distributions of possible outcomes and then compare those distributions against actual observations to perform parameter estimation. The detection of faults is treated as a model selection problem and the inference of their severity levels is treated as parameter estimation. The diagnostic precision of this approach is evaluated on a Modelica vehicle drive line model.

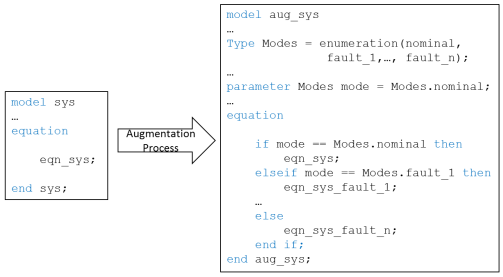

Figure 1: Alternative dynamics are enabled for each operating mode.

In addition to predicting behaviors through numerical simulations of Modelica models, we propose to use the same simulation models for diagnosis. Modelica's focus on simulation would seem to make it a poor choice for diagnosis. After all, diagnosis is the inverse of simulation. Simulation predicts the behavior of a system given a (correct) model. Diagnosis must infer how the model has changed (i.e., faulted) from observed behavior.

Most model-based diagnosis algorithms perform inference on declarative models. Although Modelica supports the writing of declarative models, too many Modelica models (including many in the MSL) contain imperative constructs making direct application of existing model-based diagnosis algorithms problematic. RODON is a Modelica inspired approach to modeling, but Modelica models first have to be re-written by hand in qualitative declarative form. We know of no system identification or FDI technique that applies for DAE models with boolean constraints (as Modelica models translate into). Our approach, on the other hand, applies on Modelica models directly no matter what types of constraints they contain.