Hybrid Diagnosis: Fault Detection, Isolation, and Identification for Complex Embedded Systems[1]
Summary of Features

This project addresses the problem of designing and implementing online monitoring and diagnosis systems for complex hybrid systems. Hybrid systems are common in the avionics, spacecraft, automotive, and robotics domains, where behavior is characterized by continuous plant dynamics and discrete supervisory control. Therefore, hybrid system analysis has to seamlessly integrate discrete and continuous techniques using multiple system models. As a result, tasks like monitoring, fault diagnosis, and control require model selection and switching to be performed online as system behavior evolves. Our work focuses on faults that occur in plant components. We develop parameterized models where faults are represented by changes in system parameters.
Our model-based approach to hybrid diagnosis involves three primary tasks:

- A unified topological modeling methodology based on hybrid bond graphs (HBGs), from which models (state space and temporal causal graph) geared toward the different steps of the diagnosis task are derived. The modeling work is supported by the FACT tool-suite.
- Observers based on hybrid automata and Extended Kalman Filters for tracking system behavior online, and robust fault detectors that quickly and reliably identify discrepancies in observed system behavior. The innovation in this work is that models are generated online from HBGs when mode changes occur.
- Fault isolation and identification schemes to determine the faulty component or parameter and the magnitude of the change. The innovation in thus work is the combined qualitative and quantitative reasoning schemes for isolating parameter deviations across model changes using the TCG, and estimation techniques for computing fault magnitudes.

The figure below shows the computational architecture of the hybrid diagnosis scheme, and screenshots of our run-time system tracking system variables, performing fault detection, isolation, and identification.

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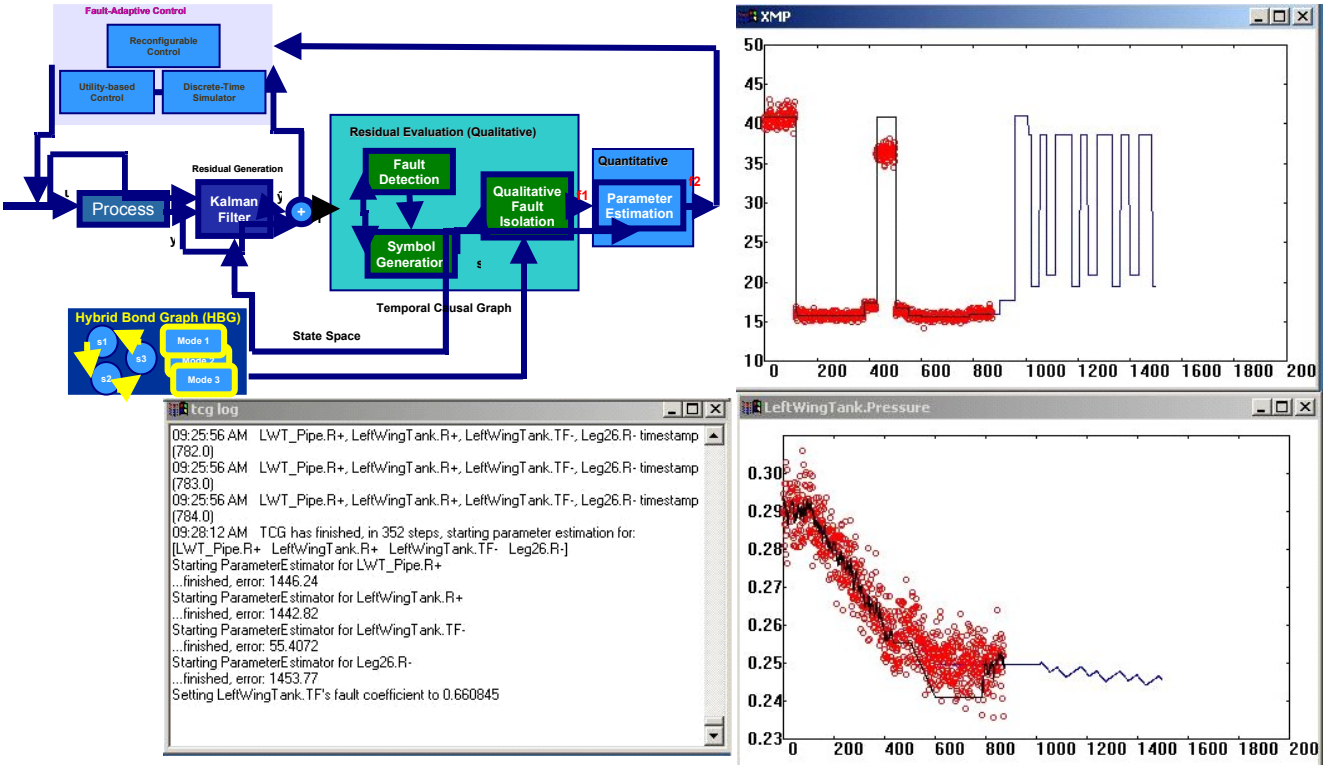

The hybrid diagnosis scheme has been applied to diagnosis of aircraft fuel systems for Boeing Phantom Works and subsystems of the Advanced Life Support Systems for NASA.

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