Model-based Diagnosis
Tutorial PHM-E 12

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Outline

1 Introduction: Model-based Systems
2 Component-oriented (Qualitative) Modeling
3 Consistency-based Diagnosis
(4 Test Generation)
5 Other Tasks during the Product Lifecycle
6 Summary and Perspectives
Knowledge-based Systems

- Model-based systems are knowledge-based systems

**are not simply**
- Systems based on knowledge

**but**
- Systems grounding their solution on a knowledge base

Problem solver

Knowledge base
Knowledge Base and Problem Solver

**Problem solver:**
- A usually task-specific,
- possibly domain-independent
- algorithm which can process the represented knowledge

**Knowledge base:**
- an explicit
- declarative
- formal representation
- of knowledge about a certain domain and/or class of tasks
Knowledge Base and Problem Solver: „What“ and „How“

Separate:
• How (a certain class of problems is solved)
• What (is the individual problem to be solved)

Advantages:
• Transparent, maintainable, extensible solution
• Re-use of (parts of) knowledge base and problem solver
For instance: diagnosis

Observations:
- “When braking with ABS, car is yawing to the right, and brake pedal feels harder than normally”
- “Yawing”:
  - under-braking at left side
  - over-braking at right side
Diagnose: „Was“ und „Wie“

Wissen über das Objekt
- „Wie ist es strukturiert?“
- „Wie funktioniert es?“
- Wissen über
  - Struktur
  - Komponentenverhalten

Diagnose-Algorithmus
- Aus Wissen über das Objekt
- und Beobachtungen des Systemverhaltens
- und schließen Diagnosehypothesen
Task:
• Determine, based on a set of observations:
• What`s going on in the system?
Task:
• Determine system models
• that are consistent with the observations
Iterative Diagnosis

Task:

- Incremental modification of fault hypotheses
- Initial hypothesis: correctly designed device
Key Idea: Generation of Diagnosis Systems

- User: specifies structure only
- Diagnosis system is generated automatically
- The same for FMEA, Testing, ...

Library: Component Models

Component Behavior

System Model

Structure

CAD Data

Generic FMEA Engine

Specific FMEA Generation

Test Generation Engine

Generic Diagnosis Engine

Specific Diagnosis System

• User: specifies structure only
• Diagnosis system is generated automatically
• The same for FMEA, Testing, ...
Models

• explicit conceptual and structural model
• Behavior models
• Compositional („context-free“)
• (possibly) qualitative models
Simple Example – Diagnostic Reasoning

- Inconsistent partial models: „conflict“
- combined evidence from several conflicts
- Pump or pressure sensor or container defect
- OR mechanical drive and flow sensor
- logical theory: consistency-based diagnosis
Demonstrator: Turbo Charger System

- On-board detection and localization of
- faults related to black smoke
- under realistic conditions (e.g. sensors)
- with model-based techniques from Artificial Intelligence
Demonstrator Vehicle Set-Up

MAC 2

serial line

ETK

ECU

VS100

RAZ’R
Demonstrator Car (Volvo) with RAZ’R
Demonstrator Car (Volvo) Switchboard for Fault Injection
Demonstrator Turbo Control Subsystem

Scenario 1
Leakage

Scenario 2
Air flow sensor

Scenario 3
Boost pressure
VMBD Demonstrator: Leakage in Air Intake