From: AAAI-94 Proceedings. Copyright © 1994, AAAI (www.aaai.org). All rights reserved.

Model-Based Sensor Diagnosis: When Monitoring Should Be Monitored

Joël MILGRAM

Électricité De France, DER-IMA-TIEM
1, avenue du Général De Gaulle
92141 Clamart Cedex FRANCE
Joel.Milgram@der.edf.fr

Abstract

A complex industrial plant, such as a nuclear power plant, is monitored thanks to a number of sensors. The instrumentation may be itself a complex system liable to failures. We propose a model-based sensor diagnosis system which relies on the topological description of the plant and on a set of component models. This model implicitly conceals relations involving only sensor data. Such relations must always be verified if components behave normally; thus, the detection task consists of verifying these relations. So, this work is a first step in extending the scope of model-based diagnosis, since we question here the information stemming from the plant and normally considered as safe. As further studies, we wish to monitor this detection system itself; i.e., whenever the instrumentation is supposed to behave correctly, non-verified constraints point out to errors in the plant model.

Questioning the model-based diagnosis

A model-based diagnosis (Reiter 1987) relies on structural and behavioural knowledge and on observations. Observations in a plant stem from sensors. Since the instrumentation is liable to failures, sensor data are questionable. On the other hand, component models in a thermohydraulic circuit are very crude and the topological database describing the plant must be updated after each human intervention on the plant. So, when a model-based reasoning system provides a result, three assumptions must be taken into account: there is no sensor failure, component models are accurate enough, and the topological database rigorously describes the plant.

Sensor failure in a thermohydraulic circuit

Fluid behaviour is described by a set of equations of different kinds stemming from the plant model. As some of the variables are measured by sensors, we seek to exhibit, when they exist, algebraic relationships between them by eliminating the variables which are not measured. Such constraints should be verified at each step if every component behaves properly. Constraint violation is equivalent to a malfunction and is seen as a sensor failure.

Constraints can be found in two steps. First, a qualitative model of constraint existence is set up by means of structural analysis. Secondly, models are formally handled as according to the structural analysis results in order to establish the constraints on sensor data.

The set of equations is turned into a structural matrix (Iwasaki & Simon 1986) in which each variable v is characterized with respect to each equation E by only two pieces of information: whether v is involved in E and whether E can be solved with respect to v. Constraints are found by triangulation of a part of this matrix.

Further research direction

Whereas the operator may check the installation thanks to the instrumentation, the present system aims at providing a diagnosis on the instrumentation itself, rather than on the installation. We wish to check the sensors with their own values. Sensor data, thus validated, may be used in other monitoring systems. Sensor diagnosis may be seen as a part of the diagnosis of a monitoring system. On the other hand, this sensor diagnosis system may itself be faulty, and should also be monitored. This system is based on four sources of knowledge and data, namely: the topological database describing the installation (TDB), the models library (ML), the research and generation algorithm (A), and sensors data. If no sensor is assumed to be faulty, then constraints violation is seen as a set of malfuctions of (TDB), (ML), or even (A).

Conclusion

The system proposed here relies on structural analysis and generates constraints on sensor data. Presently, for each circuit, a monitoring program is automatically generated from the model. This application uses resources which must themselves be monitored. When the sensors behave normally, we wish to diagnose the topological data base or the component model; this is still under study.

References

Reiter, R. 1987. A theory of diagnosis from first principles. *Artificial Intelligence*, 32:57-95.

Iwasaki, Y., and Simon, H. A. 1986. Causality in device behavior. *Artificial Intelligence*, 29:3-32.