Hybrid Modelling and Reasoning in Measuring Systems

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Measuring systems are a special form of information systems. The aim of their design is to extract some important information about the measured entities. The information flow begins at the sensors, then the measurement information is carried by complex signals to the information processing components, and to the user. Identifying or even detecting faults in such systems requires well based knowledge about the goal and the functionality of the measurement equipment. Traditional model-based diagnostic approaches cannot cope well with this problem, because of the complexity of the components of such systems. This paper introduces a novel approach to the modelling and diagnosing of measuring systems.

The first question to be answered is how to reason about the flow of information in measuring systems, i.e. about analog signals and systems. Planning the measurement provides high level knowledge about the role of the components in the measurement set-up and this knowledge should be exploited. Traditional theory of signals and systems provide a way to describe relations between parts in form of complicated mathematical formulas, e.g. convolution. Information about the measurement system is represented partly numerically and partly symbolically. The proposed approach introduces a multilevel abstract modelling scheme, where reasoning is possible at different levels of abstraction, using all the information available.

At the highest level of abstraction a functional description of the measuring system can be formulated. It describes certain teleological information about the system, introducing subtasks done by the components. At in-between levels qualitative knowledge can be used to describe the signals. Symbolical reasoning is still possible at this level. The lowest level are pure numerical signals.

The important point of the investigation is the reasoning about signal flow. Measurement takes place at numerical level, but reasoning is usually confined to symbolic information. Generally neither of the representation levels is fully available. Abstraction and refining support the transformation between representation levels. Several diagnostic reasoning strategies can be applied to this scheme depending on the completeness and presence of different kinds of description.

A central issue of the approach is thus knowledge representation. There is a need to have a formal way of symbolically reasoning about signals and systems, that will respect the mathematics of the system theory. This reasoning approach has several requirements to fulfill: (1) It has to ensure that the mathematical foundations wont be violated. (2) It has to grasp the essence of signals: enough, but not too detailed information has to be expressed. (3) Effective reasoning has to be supported by the representation.

The paper discusses the main problems of the topic, mainly concentrating on the problems of reasoning. The proposed system aim to provide a general representational method, that supports several fields of measuring, including e.g. measurement planning.