Chapter 11

APPLICATION OF FUZZY LOGIC TO DIAGNOSTICS

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11.1. Introduction

The basics of fuzzy logic as well as fuzzy modelling and control are described, for example, in the monographies by Czogała and Łęski (2000), Yager and Filev (1994), Drinkov et al. (1996), Rutkowska (2002), and Piegat (2001). An interesting overview of fuzzy logic application to fault detection and isolation can be found in Frank and Marcu (2000). This chapter presents the application of fuzzy logic to fault detection and isolation.

A growing interest in the development and industrial applications of methods to the fuzzy modelling of systems has been observed during the last couple of years. It is visible in both the number of the papers published, as well as the number of software packages developed for such applications. Fuzzy models, similarly as neural ones, are suitable not only for the control, optimisation and estimation of variables that cannot be measured, but also for fault detection and isolation. A vital advantage of fuzzy techniques is the ability of modelling non-linear systems. Models of systems in the state of complete efficiency are obtained on the grounds of data from experiments, with the use of various training methods. A fuzzy system description in the form of a network (fuzzy neural network) makes the application of learning methods developed for neural networks possible.

In automated industrial processes, both current process data and archived ones are attainable. This creates an advantageous situation for building models on the grounds of process measured data as well as an expert’s

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knowledge about the relationship which exists between the variables (i.e., the model structure). On the other hand, the rapid development of computer techniques has eliminated a vital barrier related to significant calculation efforts required for tuning fuzzy model parameters with the use of large data sets.

Fuzzy logic is a very efficient tool for the conversion of uncertain and inaccurate information. Most data obtained in industrial practice have such a character. Disturbances and measurement noise exist in the process. Measurement data contain errors. The models of the system are not quite accurate, so the calculated residual values are not precise. Uncertainties exist also when experts try to establish the diagnostic relation. Fuzzy logic is a natural way of taking these uncertainties into account, therefore it can be successfully applied to diagnosing algorithms for residual values evaluation, description of the relation between faults and symptoms, and for inference.

11.2. Fault detection

Fuzzy logic is applied to fault detection mainly through methods based on the use of models. The models make it possible to calculate process variable values. Signals calculated in this way are redundancies of measured signals. Redundancy which consists in comparing the measured signals with the calculated ones is called information redundancy.

Different kinds of models can be applied, including fuzzy ones, which are an alternative to analytical ones. They allow us to describe the operation of a system in a way which is natural for the system operator, i.e., in the form of if-then rules. The basics of fuzzy modelling are described, for example, in (Babuška and Verbrugen, 1996; Czogała and Łęski, 2000; Piegat, 2001; Rutkowska, 2002; Wang and Mendel, 1992a; 1992b; Yager and Filev, 1994).

Figure 11.1 presents a general diagram of residual generation with the use of a fuzzy model. A residual $r$ is obtained as a result of a comparison between the model output $y_M$ and the real measured signal $y$. In the normal state, the residual value is close to zero, but it is different than zero when a fault appears in the controlled part of the system. It is assumed that the process

![Diagram of residual generation with the use of fuzzy models](image-url)