Chapter 16
Component Models Based Approach for Failure Diagnosis of Discrete Event Systems

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ABSTRACT

This chapter addresses the problem of diagnosing Discrete Event Systems (DESs), specifically manufacturing systems with discrete sensors and actuators. Manufacturing systems are generally composed of several components which can evolve with the course of time (new components, new technologies …). Their diagnosis requires the computation of a global model of the system. This is not realistic due to the great number of components. In this chapter, we propose to perform the diagnosis by using component models. Each component model is constructed using different information sources represented by sensor-actuator spatial structure (plant model), controller specifications (desired behaviour) and temporal information about the actuators reactivity. In addition, components' technological constraints and characteristics are considered for this construction. For each model, a local diagnoser is computed. Its complexity is polynomial because the diagnosis is computed only for the faults that it can diagnose. Limited information about the global system functioning is required to synchronize the functioning of local diagnosers. This synchronisation is considered using a set of expert rules representing the symbolic information about the global desired behaviour. The local diagnosers are then used to perform diagnosis online. They validate, in the case of normal functioning, the transmission of control signals and incoming sensor data between the controller and the plant.

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INTRODUCTION

In this chapter, a decentralized diagnosis approach is proposed to realize the diagnosis of DESs, specifically manufacturing systems with discrete sensors and actuators. We treat the case of a system composed of disjoint components, *e.g.*, they do not have any transition labelled with common synchronisation events. In this case, a failure occurred on a component dose not propagate its consequences to any other component. Therefore, the local diagnosis is independent and no need to construct a global model which is in this case complex because it is a Cartesian product. However, the components' models need to be synchronized in order to keep the links between their initial states. This needs limited information about the system global functioning. Each local diagnosis is calculated based on a local diagnoser. The latter is computed using the component model, the control specifications or constraints and actuators reactivity. This enhance the local diagnosis efficiency by exploiting all the available information about the system functioning. Only the faults that can be diagnosed within a finite time are computed for each local diagnoser. The goal is to perform local diganosis by a polynomial complexity computation. Finally, the synchronisation is performed based on the expert knowledge. Indeed, the expert can provides an interesting information about the global system functioning. This information is represented by some rules used to synchronize the functioning of the different local diagnosers.

The chapter is organized as follows: firstly, the proposed approach for the diagnosis of DESs is proposed. All the steps necessary to compute the local diagnosers are then detailed and followed by an illustration example. Finally, the advantages and the drawbacks of this approach and the perspectives for the future work are discussed.

BACKGROUND

The increasing complexity of processes rises their potential to fail regardless how safe the control design is and how better trained the operators are (Perrow, 1984). Thus, diagnosis of industrial systems is a subject that has received a great attention in the past few decades (Boel & Jiroveanu, 2004), (Boufaïed, 2003), (Genc & Lafortune, 2003), (Holloway & Krogh, 1990), (Klein et al., 2005), (Lafortune et al., 2005), (Su & Wonham, 2000). It is defined as the process of detecting and isolating faults. Fault detection is the operation of deciding weather a failure has occurred or not. It is followed by the fault isolation in order to determine the kind and the location of the failure. Any abnormal change in the system's behaviour is caused by a fault whereas a complete operational breakdown is denoted as a failure. In this chapter, the two terms are used synonymously.

Discrete Event Systems (DESs) are dynamic systems equipped with a discrete state space and a state-transition structure (Cassandras & Lafortune, 1999), (Ferrier & Boimond, 2004), (Wonham, 1995). They are discrete in time and in state space. They can be derived by the tick of a clock and may be nondeterministic, *e.g.*, they have several transitional choices due to internal events or other mechanisms that are not necessarily modelled by the system analyst. Manufacturing systems are one of the major applications of DESs. They are a collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts. DESs are often modelled using a finite-state automaton (IEC, 2002), a GRAFCET (David, 1992), a Petri net (Cassandras & Lafortune, 1999) or process algebra (Console, 2002, Wang, 2000).

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