New Approach of Diagnosis by Timed Automata

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ABSTRACT

The Discrete Event Systems (DES) is a nonlinear dynamic system with discrete state and event evolution. In this article, we are interested in the diagnosis of failures with Timed Automata. The proposed approach is based on the operating time and it is applicable to any system whose dynamic evolution depends not only on the order of discrete events but also on their periods as in industrial processes. The most important part of this work is the construction of a diagnoser which uses observables events to detect and locate the faults. We present on the last part of this work results of the study of the performance of the diagnosis showing the power of this diagnostic approach. An implementation on a hydraulic system is made to illustrate the proposed steps. It put in evidence the effectiveness of this approach. The model of the simulation phase is done using Matlab / Simulink / stateflow.

KEYWORDS

Detection, Diagnosis, Discrete Event System, Localization, Timed Automata

INTRODUCTION

Industrial systems become progressively complex. The complexity of systems and the increasing requirements in terms of performance and reliability impose the necessity of developing new diagnosis techniques. Diagnosis plays an important role in improving the operational availability of equipment and it contributes to the increase of the production and the reduction of maintenance costs. In industry, a significant part is dedicated to the maintenance, testing and diagnostic systems. It is a main key to improve the performance of industrial feature.

Fault detection and diagnosis is an important problem in process engineering. It is the central constituent of Abnormal Event Management (AEM) which has attracted a lot of interest recently. AEM deals with the timely detection, diagnosis and correction of abnormal conditions of faults in a process. Early detection and diagnosis of process faults while the plant is still operating in a controllable region can help avoid abnormal event evolution and reduce productivity loss. For example, the petrochemical industries lose an estimated 20 billion dollars every year, they have rated AEM as their number one problem that needs to be solved. Hence, there is considerable interest in this field now from industrial practitioners as well as academic researchers, as opposed to a decade or so ago. There is an abundance of literature on process fault diagnosis ranging from analytical methods to
artificial intelligence and statistical approaches. From a modeling perspective, there are methods that require accurate process models, semi-quantitative models, or qualitative models. At the other end of the spectrum, there are methods that do not assume any form of model information and rely only on historic process data. In addition, given the process knowledge, there are different search techniques that can be applied to perform diagnosis.

Diagnosis approaches developed in recent decades can be classified into two broad categories: Approaches with models based on the existence of a model of the system to monitor and approaches without models based on the analysis of variables monitoring. Methods with models are based on a comparison of the expected behavior of the model with the actual observed behavior of the system. Any difference between these two behaviors will mean failure.

Automatic systems can be characterized through their dynamic operation. According to the considered objective, there are three possible ways to model this dynamic: continuous systems, discrete event systems and hybrid systems. Continuous systems are constituted by elements characterized by one or more measures that can take real values when the weather is changing. We can mention magnitudes, the position, the velocity, the acceleration, the level, the pressure, the temperature, the flow rate, the pressure, etc. DES are the systems with discrete state space, which transitions between states are associated with the occurrence of asynchronous discrete event (Cassandra & Fortune, 1999). These systems cover a wide range of situations such as vehicle traffic, machine operation, etc. The Hybrid Dynamical Systems (HDS) covers simultaneously continuous and discrete aspects. These systems evolve over time and combine continuous variables and discrete variables. A discrete state system can be seen as a continuous process with continuous variables connected by constraints.

We consider the diagnosis of model based Discrete Event Systems that works from a presentation of the system. Discrete Event Systems (DES) is the class of active systems whose transitions and states are modeled in a discrete manner, for example by a finite state automaton. So all performances of the system are represented by a path on the Automata.

The concept of diagnosis of DES was introduced in the mid - 1990s by (Sampath, 1995), which inspired many extensions (Debouk, 2000), (Tripakis, 2002), (Silveira, 2003), (Lunze, 2004), (Zad, 2005) and (Thorsley, 2005). This reference approach is based on the compilation of a controller called diagnostician, from a finite state machine modeling the behavior of the system. The dynamics of the DES in this approach is described by a sequence of events that characterize the state transitions of the system. Thus, consideration of time is performed only by the order of occurrence of events. This results in a considerable loss of information, essential for identification of defects. Indeed, the occurrence of events dates can play a significant role in the discrimination of the defects.

In general, the diagnosis is made up of two closely related parts: detection and default localization. Diagnosis of the discrete events is the problem to detect and identify certain unobservable events that occur during operation of the system, based on the model of system and observable sequences of events obtained from the sensors connected to the system. The detection returns to determine if it is behaving normally or not, based on observations and knowledge of the industrial system. The localization needs more to locate failed components to perform the repair. To make a diagnosis based on a reliable model, we must have a complete system model, which describes both normal and faulty behaviors of the system. The normal behavior of the system corresponds to the operating modes and planned trajectories, while bad behavior corresponds to deviations from normal behavior, because of failures called faults.

The proposed approach is based on timed automata which are widely used for modeling, analysis and supervision of Discrete Event Systems (DES). The automata caught our attention because of its ability to model the temporal constraints. The following application enables the implementation of a
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