Discovery of Incomplete Diagnostic Model based on Learning

Wang Xiaoyu, Li Chuang and Ye Liang

***Abstract*—**The model-based diagnosis uses the common reasoning of offline model and online observation to obtain whether and why faults occur. However, the diagnosis is based on the premise of complete model. Once there are unknown behaviors in the diagnosis process, the diagnosis results will not be obtained. In this paper, a method of incomplete model discovery based on online diagnosis process is proposed: In the online diagnosis process, the data of the complete model are learned and the model is trained and adjusted. When the incomplete behavior is found, the nature of the incomplete behavior is determined according to the historical diagnostic data and online observation data, and the corresponding transition/state/event is generated and added to the model to further obtain the definite diagnosis results.

***Keywords*—**mode based diagnosis; incomplete model; model discovery

I. INTRODUCTION

Model-based diagnosis method is a cross branch of both artificial intelligence and control field[1-3]. Through the common reasoning of model and observation, the conclusion of whether the system is faulty or not is obtained. Model-based diagnosis is initially a static method, which can obtain the diagnoses when the system is down[4-5]. As the modern system is becoming larger and larger, the behavior is more and more complex, and the cost of system downtime is higher and higher, a dynamic model-based diagnosis method is produced. In the process of system operation, system faults are judged by off-line models and on-line observations. Dynamic diagnosis method can not only get faults, but also get the way of system gets bad[6-7]. However, the above diagnosis process is very dependent on the model. Once the model can not fully correspond to the actual behavior, it will produce blind expansion, or even can not get the diagnoses. At the same time, the premise of traditional model-based diagnosis is that the model established by abstraction or approximation can completely correspond to the actual behavior. The advantage of off-line complete model is that it can improve the diagnostic efficiency by pre-compiling the model, while the disadvantage is that if there are incomplete behaviors, the diagnostic results cannot be obtained.

Incomplete model refers to undefined behavior in the process of mapping from real world to logical model. In the diagnosis based on complete model, undefined behavior will not be able to get results[8]. And in another case, the failure cannot be completely eliminated[9]. In the diagnosis of incomplete model, the basic complete diagnoses is obtained by synchronization through the existing complete model and online observations, and the incomplete diagnosis problem is defined by temporal and causality[10]. Although this diagnosis breaks the premise of the traditional diagnosis method which assumes that the model is complete, it has some drawbacks: When the event is incomplete, it cannot accurately distinguish the location of incomplete events, and when defining the nature of incomplete events, it is not accurate to rely only on the judgment of the trajectory before and after.

In order to solve this kind of problem, the concept of incomplete model is proposed[8,11] to solve the situation that the expected behavior is different from the model. On this basis, more researchers pay attention to this problem and propose a series of methods[12-14]. Context of model is used to deduce the faults[15], or knowledge is compiled to dianogsis[16]. In this paper, decision tree is used to infer online incomplete events, further characterize the attributes of events, and more accurately locate the location and context of events in the model. At the same time, it defines a corresponding diagnostic model that can use learning method, and carries out complete or incomplete online diagnoses simultaneously.

II. MODEL

A. A Framework of Diagnosis

Complete system diagnostic methods for discrete event are usually based on automata models.

Definition 1 (complete model)[17]: The complete model is represented by a five tuple automata $G = (Q, E, T, I, F)$

And Q is a finite state set; E is a finite event set; T is a finite transition set: $T \subseteq Q \times E \times Q$, $I \subseteq Q$ is an initial state set; $F \subseteq Q$ is a final state set. According to the nature, event set can be divided into three subsets, observable event set E_o ,normal non-observable event set E_n ,and fault non-observable event set E_f , and satisfy $E = E_o \cup E_n \cup E_f, E_o \cap E_n = \emptyset, E_o \cap E_f = \emptyset, E_n \cap E_f = \emptyset$.

In a complete model, the process of system behavior is defined as a path.

Definition 2 (path)[18]: Path s is the transition sequence of states triggered by events $s =< q_0, e_0, q_1 \dots q_n >$, and $\forall t, t = q_i \times$

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Wang Xiaoyu is with the College of Computer, Jilin Normal University, Siping, Jilin, China (e-mail: wxyjldx@163.com)

Li Chuang is with the College of Computer, Jilin Normal University, Siping, Jilin, China (e-mail: lichuang12@mails.jlu.edu.cn)

Ye Liang is with the College of Computer, Jilin Normal University, Siping, Jilin, China and the Siping Highway Administration Office, Siping, Jilin, China (e-mail:caocaovb@163.com)