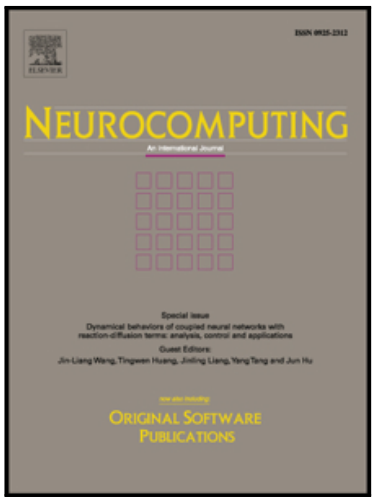

A novel adaptive fault detection methodology for complex system using deep belief networks and multiple models: A case study on cryogenic propellant loading system

Ren Hao , Chai Yi , Jianfeng Qu , Ye Xin , Tang Qiu

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A novel adaptive fault detection methodology for complex system using deep belief networks and multiple models: A case study on cryogenic propellant loading system

Renhao[a,b,c],Chaiyi[a,b,c*], Jianfeng Qu[a],Yexin[c], Tangqiu[a],

a.School of Automation, Chongqing University, Chongqing City, China, 400030.

b.State Key Laboratory of Power Transmission Equipment and System Security and New Technology, Chongqing University, Chongqing City, China.

c.Key Laboratory of Space Launching Site Reliability Technology, Haikou City, China, 570100.

Abstract

A novel methodology based deep belief networks and multiple models (DBNs-MMs) is presented to accomplish fault detection for complex systems. And firstly, historical datasets are collected and processed to train the DBNs, so that DBNs can be constructed to learn the nonlinear dynamic characteristics of complex system, and so a model with a specific architecture and some initial intelligence will be built up. Secondly, the operation condition and real-time measurement data are employed in DBNs-MMs to get a series of network outputs. Finally, the residuals can be obtained by comparing the measurement output and each DBN output. Then, the fault detection can be achieved by employing a properly adaptive threshold for each residual. Some faulty cases of the complex cryogenic propellant loading system have been used to demonstrate the effectiveness of the proposed fault detection methodology, and the result has shown its excellent performance.

Keywords: Fault detection, Complex system, Deep belief networks, multiple models, Adaptive threshold, Cryogenic propellant loading system

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1. Introduction

With the increase demand in terms of quality, safety and service, researchers and engineers have to pay more and more attention to develop and integrate more and more complex industrial systems, so that they can become or remain the market leaders [1]. In these complex industrial systems, large number of equipment, facilities, and subsystems are coupled together. This is bound to bring a series of challenges. Under these circumstances, all concerns must be taken into consideration, explicitly. Fault detection in complex systems is therefore becoming an extremely important issue to obtain high control performances.

The mathematical mechanisms of complex systems are hard to elucidate by the reasons that large number of simple components can produce some dynamic behaviors with great complexity and nonlinearity when they act together [15]. Complex systems have been characterized by a high level of nonlinearities, uncertainties, and huge amount of variables, which makes it hard to build an simple model to achieve the fault detection. Furthermore, due to the granularity of the model and the availability of the measurements to the complex systems have often impacted the performance of fault detection, which makes efficiency and scalability become the key consideration to accomplish the fault detection, particularly with large-scale nonlinear multimode systems [4]. Therefore, the