高速列车故障预测与健康管理技术研究

Research on Prognostics and Health Management of High Speed Trains

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摘要/Abstract

随着高速铁路的快速发展，安全、舒适、可靠的高速列车越来越成为乘客首选的快捷交通服务载运工具。如何确保大规模车辆集群的运行安全性、可用性及运维经济性，已成为高速铁路行业协作创新与可持续发展的重要方向。本文首先介绍了故障预测与健康管理技术手段及应用现状。其次，结合故障预测与健康管理技术、大数据技术等新兴技术的应用，阐述了高速列车安全保障技术的创新。最后，文章展望了未来高速列车故障预测与健康管理的发展与协作方向。

With the rapid development of high-speed railway, high-speed trains with safety, comfortability and reliability has become the most preferred choice for more and more passengers. How to ensure the operation safety and to improve the maintenance economy of large-scale train fleet has become one of the most important directions for innovation and sustainable development in high-speed railway industry. Firstly, the technology and application of prognostics and health management has been reviewed. Then, the innovation on safety and security for high speed trains is introduced based on PHM and Big Data technology. Finally, the future development on PHM for high speed trains is discussed.

前言/Introduction

With the rapid development of China's high-speed railway, ‘four vertical and four horizontal’ main skeleton has been basically completed. And the total high-speed railway mileage in China has exceeded 22,000 km by the end of 2016. Meanwhile, the EMUs on operation have reached to 2586 standard groups [1]. How to ensure the operation safety and to improve the maintenance economy of large-scale train fleet has become one of the most important directions for innovation and sustainable development in high-speed railway industry. An effective way is to promote the change for the manufactures from product manufacturing mode to manufacturing plus service mode by applying the intelligent O&M Technology [2].

故障预测与健康管理技术发展/Development of Prognostics and Health Management

Prognostics and Health Management is a multi-disciplinary domain technology

consisted of three application scenarios, enhanced diagnostics, prognostics and Health Management [3-4]. There are two objectives to conduct PHM, one is to enable products and systems to achieve and sustain near-zero breakdown performance, and one is to transform maintenance data to useful information for improved productivity and asset life-cycle utilization [5].

The industry applications of PHM are quite diverse, starting from the aerospace and defense applications [6], extended to automotive and electric vehicle application [7], power generation application [8], manufacturing applications [9], railway applications [10], etc.

Actually, PHM is one core application of industrial big data technology, as well as the core technology of the CBM and predictive maintenance [2].

高速列车故障预测与健康管理系统架构/System architecture of PHM system for high speed trains

In order to conduct the application of intelligent maintenance technology, CRRC has launched a PHM project for high speed trains. And there are several objectives by constructing the PHM system. The first one is to monitor the real-time conditions of EMUs and to conduct the fault diagnosis and alarming, which can help to avoid the possible safety problems. The second one is to facilitate the development from CBM to health management of EMUs, which is effective to improve the O&M economy. Besides，the service ability can be promoted to create service revenue. Finally, by the application of PHM system, the manufactures can construct the linkage between the design, production and the maintenance.

The proposed PHM system architecture of high speed trains is illustrated by Fig.1. And the whole system is defined by four parts, including the train-based system agent, the wayside sensing system, the transmission system and the ground data center.

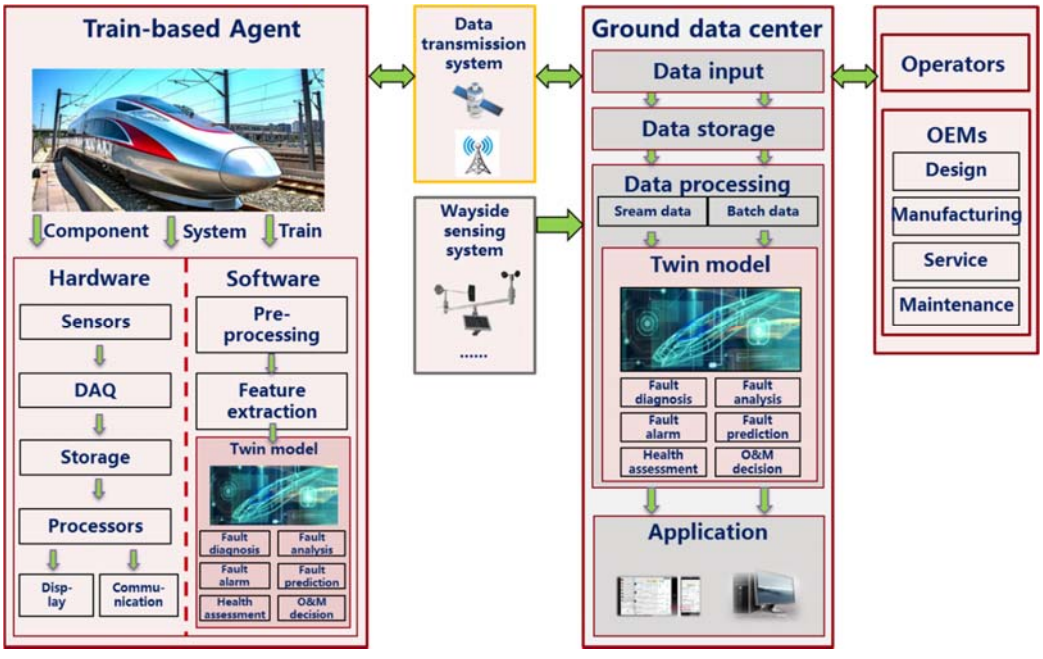

Figure 1. The architecture of PHM system for high speed trains

(1) On-board system agent

Train-based agent can collect the real-time information from the component level to the subsystem level and then to the vehicle level. The software operating in the corresponding hardware can implement the data fusion, data cleaning, feature extraction, information storage and so on. The intelligent twin model can achieve the fault diagnosis; fault alarming, health assessment, fault prognostics and decision support.

(2) Wayside sensing system

Ground sensing system is to combine the environment information and the wayside sensing data, which can support the multidimensional analysis in the ground data center.

(3) Data transmission system

Satellite or 2G/3G/4G networks will be chose to implement the real-time data transmission. WIFI or copy will be chose to conduct the original data transmission.

(4) Ground data center

All kinds of data are input to the ground data center. After the data fusion, data cleaning and data storage, the streaming data processing and batch data processing will be achieved with the ground-deployed intelligent twin model. Finally, all the decisions can be output to support the OEMs and the operators.

结论/Summary

There are several challenges in PHM development for high speed trains. The first one is data communication and peer variance due to the large number and distributed fleets. The second one is that it is too costly to build intelligent models for each component or complicated subsystem. And another one is to implement machine learning and data-driven PHM techniques for varying patterns. However, PHM is of great significance for the safety guarantee of high speed trains. The first one is to improve the inspection efficiency by providing diagnosis information and decision support for operators. The second one is to improve the security and comfort experience for passengers.

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