Research on Framework of Fault Prognostics and Health Management System for Complex System

Shi Junbin1*, Cai Huanxi2, Jiang Xianming3
1 Army Academy of Armored Forces, Changchun, China
2,3 31700 Army, China

*Corresponding author e-mail: jilijilu@163.com

Abstract. This paper studies the framework of fault prognostics and health management for complex systems. Aiming at the problems of lack of effective organization and management of fault diagnosis resources and low resource sharing rate, this paper analyzes the characteristics of complex system and the shortcomings of traditional diagnosis mode, puts forward the service-oriented PHM system architecture, studies the system service mode and characteristics, analyzes the key technologies and main function modules of establishing the system, and carries out public PHM system service level for complex equipment field Taiwan research provides a new way of thinking.

1. Introduction
A large number of knowledge resources, software resources and hardware resources are involved in the process of fault prognostics and health management of complex systems. A large number of research results have been accumulated in the fields of fault diagnosis data acquisition, data processing, pattern recognition, and decision support. Manufacturing enterprises and user units have a large number of diagnostic resources such as testing equipment, diagnostic instruments, and software tools. However, the lack of a resource sharing and application model makes it difficult for these methods and diagnostic resources to be effectively shared and reused, resulting in low resource utilization and serious repetitive research. The development of emerging technologies such as cloud computing, the Internet of Things, and cloud manufacturing has brought new challenges and opportunities to equipment fault diagnosis.

Based on emerging technologies and concepts such as cloud computing, the Internet of Things, and cloud manufacturing, and building a service-oriented PHM system, group companies can realize equipment diagnosis, maintain centralized management and sharing of maintenance resources, and enhance their core competitiveness. And SMEs can perform equipment maintenance according to third-party service brands, and obtain related service resources from the platform as needed. The software and hardware resources of the platform are maintained and updated by third parties, which can save the cost of SME equipment maintenance.

This paper takes the research objects of group companies to build an open, collaborative, on-demand service fault prognostics and health management platform architecture, and integrates fault diagnosis resources. Users only need to submit fault diagnosis service requests to the platform as required, and the platform automatically performs service decomposition. Service composition, and service invocation to meet user needs.
2. Cloud service-based PHM system architecture

The cloud service-based PHM system architecture is shown in the figure. It includes a physical resource layer, a service interface layer, a virtual resource layer, a supporting technology layer, a service layer, and a user layer.

Physical resource layer: It mainly provides knowledge resources, software resources and hardware resources for fault prognostics and health management. Among them, knowledge resources include various structured, unstructured, and semi-structured resources such as historical data, failure cases, expert experience, document knowledge, model knowledge, and technical standards. Software resources include various software tools, intelligent algorithms, optimization models, diagnostic models, and prediction models in the field of fault diagnosis. Hardware resources include various test equipment, diagnostic equipment, testing equipment, IT equipment, and so on.

Service interface layer: This layer provides data and knowledge resource interfaces, software and hardware resource interfaces, and network communication interfaces for the PHM platform. This layer contains the physical support technology of the system platform and provides an information channel for the diagnosed equipment from the operating site to the cloud service platform.

Virtual resource layer: This layer transforms resources into a platform-recognizable form by cloudizing physical resources and virtualizing them, and provides the basis for subsequent service calls, including virtual databases, knowledge bases, algorithm libraries, model libraries, virtual software resources, and virtual hardware. Resources. The database mainly stores historical data and status information of equipment status monitoring, the knowledge base mainly stores unstructured knowledge such as failure cases, empirical knowledge, and standard specifications, the algorithm library mainly stores various artificial intelligence algorithms, and the model library is used to store various diagnostic models, Prediction models and optimization models.

Supporting technology layer: This layer provides technical support and guarantee for platform operation. It mainly includes various modeling technologies (system modeling, method modeling, process modeling, etc.), and platform management techniques (such as user management, rights management, resource management, process management, etc.) , Knowledge service technology (knowledge modeling, knowledge management, knowledge application, ontology modeling), service management technology (service packaging, service composition, service search, etc.).

Service layer: This layer contains the main service content of the PHM platform. Some services can be called independently, and some services have a certain logical sequence. They need to be used in combination, such as knowledge services, software tool services, and algorithm optimization services., Model optimization services, expert consulting services can be independently transported. Data processing, condition monitoring, health assessment, performance prediction, and decision support services can be combined.

1) Data processing: The input of this service comes from the data source of the data acquisition layer and its signal processing module, or the offline data provided by the user. Data processing is performed through methods such as data cleaning and feature extraction algorithms, and its output includes filtered sensor data, spectrum and other feature quantities.

2) Condition monitoring: The service receives real-time data, processed data or offline data, compares the characteristic values with expected values, and outputs the detection results, and can alarm according to certain rules and methods.

3) Fault diagnosis: This service can receive real-time status data, or offline data provided by users, and perform fault diagnosis services through various diagnostic models and methods.

4) Health evaluation: This service receives data from condition monitoring services or other health evaluation modules. When a component or system of a device degrades, it determines its health status. If the performance is degraded, it is based on historical trends, working conditions and maintenance. Diagnose history and generate diagnostic records.

5) Performance prediction: This service can receive data resources from the above services, predict the future status, performance changes and health status based on the current status of the device, and can predict the remaining life of the device.
(6) Decision support: The input of this service comes from the data and information of the health assessment service and performance prediction service. Based on the current status, operation history and other information, the maintenance plan and recommendations are changed to provide users with decision support services. Users can query related knowledge to assist decision-making as required, and the system can also actively and intelligently provide users with decision-making knowledge according to user needs.

User layer: this layer provides human-computer interface, mainly for various users in equipment maintenance activities, mainly including equipment users, equipment manufacturers, equipment supporting enterprises and other participants. All kinds of users can call fault diagnosis service, fault prognostics service, knowledge retrieval service, knowledge push service, knowledge consultation service and other service contents through the service platform, and use all kinds of platform resources to meet user needs. Users can also provide their own knowledge resources to the platform. The platform encourages users to share knowledge resources and enrich the system knowledge base through knowledge evaluation and other ways.

3. System service mode
In the business activities of fault prognostics and health management, the resource types and demands are different. For example, in the fault diagnosis stage, not only all kinds of data resources, fault case knowledge, design standard knowledge, but also relevant fault diagnosis algorithm are needed. In this paper, according to the characteristics of different resource requirements in the process of fault prognostics and health management, resource services are divided into three types: knowledge service, software service and hardware service.

3.1. Knowledge service
The process of fault diagnosis is a process of using knowledge synthetically and generating knowledge, which may involve knowledge resources in all stages of product life cycle. Knowledge service is mainly to extract and organize multi-disciplinary knowledge hidden in historical data, drawings, models, fault cases, description documents, parameters of previous products and the minds and experiences of experts in related fields through comprehensive management and application of various knowledge resources of different enterprises or individuals, so as to provide timely and accurate knowledge resources for users in the process of diagnosis. Knowledge service can be divided into static knowledge service and dynamic knowledge service. Static knowledge service is mainly used to query, browse and assist users to diagnose. It is a kind of application mode of resultant knowledge resources. Dynamic knowledge service aims to complete a diagnosis task directly. It can call related knowledge service components through parametric input to complete related analysis and diagnosis tasks.

3.2. Software services
Software service refers to that the platform provides software resource services related to fault diagnosis field, virtualizes and encapsulates application software through service interface to realize SaaS of software. Enterprise users do not need to purchase relevant software, but can rent or purchase software services in the platform on demand to complete their own business needs and software resources are managed by service providers.

4. Characteristics of system services
Service oriented PHM system application mode is a new mode of fault prognostics and health management in the information environment, which has the characteristics of sharing, opening, collaboration, knowledge and service.

4.1. Sharing
The service-oriented PHM system unifies the software resources, hardware resources and knowledge resources involved in the process of fault prognostics and health management into a service platform,
and the platform can obtain relevant resources on demand. As the openness of the platform is conducive to the relevant units, individuals and groups in the field of fault diagnosis to provide advanced technology and services in accordance with the needs of the platform, it is conducive to the effective sharing and reuse of fault diagnosis resources, to achieve positive interaction, and to improve the utilization rate of resources.

4.2. Openness
In the process of complex equipment fault prognostics and health management, a large number of knowledge resources and technical tools are needed, which are usually difficult to meet the needs of users by relying on the strength of a single diagnosis system and equipment manufacturers. The PHM system based on cloud service publishes the user needs in the form of services, which can form an open system platform to obtain the information from equipment manufacturers, equipment users and equipment suppliers. Provide technical support and services from manufacturers and relevant experts. The platform can introduce advanced diagnosis methods and theories from research institutions or other enterprises, and other units can also provide targeted diagnosis services to the platform.

4.3. Synergy
Due to the complexity of complex equipment, the process of fault solving often needs multi-party cooperation and common completion. In the PHM system platform based on cloud service, the resources in the platform can be fully utilized to solve the problem of equipment fault through a variety of collaboration mechanisms (such as resource collaboration, management collaboration, online collaboration, offline collaboration).

4.4. Knowledge
The process of fault prognostics and health management involves multi domain, distributed and heterogeneous knowledge resources, which are the basis and basis for users to make diagnosis and decision. In the process of fault prognostics and health management, it is necessary to mine knowledge from the historical operation data of the equipment to obtain the operation status of the equipment. In the process of fault diagnosis, we need to find and reason from a large number of historical data, empirical knowledge and fault cases. Even some equipment failures are caused by product design defects, so it also involves product design knowledge. The open and integrated PHM system service platform can provide users with diversified knowledge resources to meet the needs of diagnosis and maintenance knowledge.

4.5. Service
Service is the main feature of the system price. The software resources, hardware resources and knowledge resources in the platform are packaged in the form of services and released to the system platform. Users provide service requests to the platform according to their own needs, while the platform provides services for users through service decomposition, service scheduling, service composition, etc. The platform resources are provided by a third-party organization or Specialized departments manage and maintain, users do not need to purchase relevant software and hardware equipment separately, only need to pay the service provider on demand, and can use relevant diagnosis and maintenance resources.

To sum up, PHM system architecture and mode based on cloud service can integrate distributed diagnosis resources and provide users with comprehensive, timely and intelligent service resources. Through an open way, it can rely on advanced software and hardware resources and historical resources to continuously enrich the knowledge base, widely absorb new diagnosis methods and build a public project service platform, which can effectively improve the performance of PHM system Fault prognostics, fault diagnosis efficiency, reduce the cost of enterprise personnel, enhance the process of enterprise.
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