

Research on the Application of Digital Twin Technology in Equipment Maintenance

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ABSTRACT

Digital twin technology is to make full use of the data such as physical model, sensor update, running history, integrate the multi-subject multi-physical quantity, multi-scale, multi-probability simulation process, complete the mapping in virtual space, thus reflect the whole life cycle process of the corresponding entity equipment. In this paper, the digital twin of a certain type of equipment system is studied to realize the operation condition monitoring, fault intelligent diagnosis and so on, so as to improve the maintenance efficiency and effect of the equipment.

KEYWORDS

Digital twin; Condition monitoring; Fault diagnosis

1. INTRODUCTION

Countries all over the world vigorously develop computer theory and communication theory technology, With the deep integration and development of social information and industrialization, the traditional single point technology has been unable to meet the needs new generation of production and manufacturing equipment information development and network expansion. With the implementation of "Industry 4.0" and "Mde in China 2025", the information physical system (CPS) [1] has become the current research direction. As a key technology of the information physical system, digital twin technology can be applied to the field of equipment condition monitoring and fault intelligent diagnosis [2-5], improve the maintenance support efficiency, and provide technical support for the subsequent status monitoring and maintenance of unmanned equipment.

Domestic and foreign research institutions and related companies have made a lot of development and research in the field of industrial equipment monitoring, in which a large number of different air survey theories are proposed and applied, but there is little research in the application of military equipment. Combined with the development needs of equipment and the development trend of technology [6-7], this paper explores the application of digital Li Sheng technology to equipment In the field of states monitoring and health management, information modeling, simulation modeling and data transmission of weapons and equipment are carried out through digital equipment. On this basis, the development and the development of equipment health management service system is of great practical significance and application prospects. So as to realize the status monitoring and health management of equipment.

Digital twin technology is to make full use of the data such as physical model, sensor update, running history, integrate the multi-subject multi-physical quantity, multi-scale, multi-probability simulation process, complete the mapping in virtual space, thus reflect the whole life cycle process of the corresponding entity equipment [8]. Digital twin technology can be divided into five-dimensional

structure model, including physical object, virtual model, connection, data and service system. The research focus of digital twin technology should be on model and data. The five-dimensional structural model of the digital twin theory is shown in Figure 1:

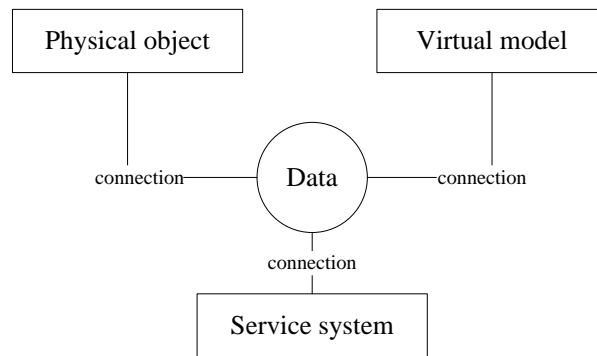


Figure 1. Digital twin five-dimensional structure model

2. DIGITAL TWIN FIVE-DIMENSIONAL STRUCTURE MODEL

According to the digital twin five-dimensional structure model, in order to realize the practical application of digital twin technology, we first analyze a series of characteristics of physical objects, construct a virtual model based on these characteristics, and then complete the data interaction between virtual and real space through connecting channels, and analyze the data. The application of digital twins should follow the following logical criteria:

- (1) The "physical object" is the carrier. Whether it's a virtual model, an optimization process, or a service system, the entire application of digital twins is based on physical objects, while the other parts are subject to physical objects and run along with physical objects to achieve digital twins. Therefore, without physical objects, there is no digital twin application.
- (2) The "virtual model" is the result of the presentation. Virtual model is the core component to realize the major functions such as sample development, actual production, state tracking, and optimal processing. Under the drive of data transmission, virtual model follows the physical object to realize each function. As a result, without virtual models, digital twin applications lack the most critical core.
- (3) "Connections" are arteries. Real-time connectivity connects physical objects, virtual models, and service systems into an organic whole, allowing data to flow freely between parts. As a result, without the connection between the components, the digital twins become a pool of dead water and lose their proper vitality.
- (4) "Data" is blood flow. Data is the central element of digital twins, and the connection of channels drives the operation of the whole digital twin system, which is based on physical objects or virtual models. Therefore, it can be said that without the data of periodic transformation, the digital twins have no source of circulation.
- (5) "Service systems" are calculations and applications. The data report generated by the digital twin application is provided to the user in a very concise and clear form, and the data analysis method is provided to help the staff make timely judgment.

In a word, the digital twin simulation modeling of this project will include kinematics, sensors, user interface, communication, data, so as to realize the state monitoring of equipment. This project selected idle equipment as research sample to verify the feasibility study of the application of digital Lisheng technology in equipment health management. The system composition is shown in Fig2. After successful verification, the feasibility study on the application of digital twin technology in the field of military equipment health management can be carried out.

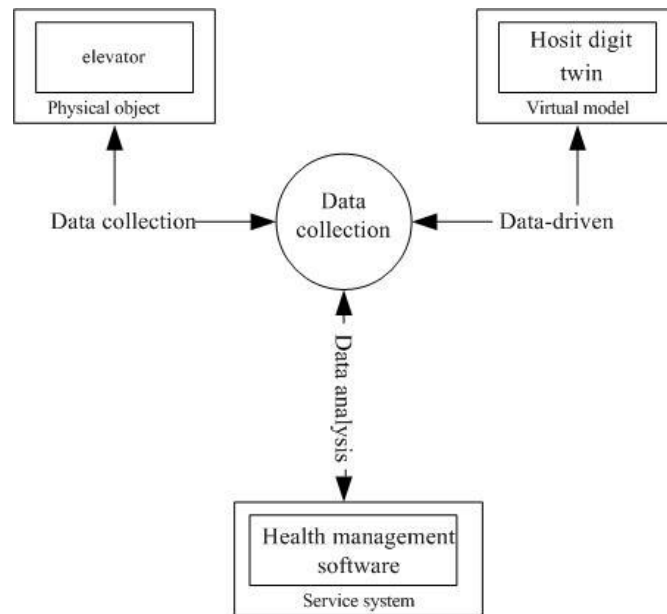


Figure 2. Digital Li Sheng technology application System composition

3. THE DESIGN OF TYPICAL EQUIPMENT HEALTH MANAGEMENT SYSTEM BASED ON DIGITAL TWIN TECHNOLOGY

The equipment health management framework based on digital twin technology mainly includes equipment layer, perception layer, data transmission layer, data analysis layer and service layer, among which the equipment layer is a certain equipment system, which is the main object and carrier of health state prediction, and provides the related operation data of equipment for the perception layer, including voltage, current, contact switch switching time, Rotating sensors encode signals, etc.

Perception layer is the lowest technology to realize health state prediction. It is the link between physical world and information world to collect and process the information of device layer and transmit it to information world.

The data transmission layer is responsible for transmitting the perceptual layer armor equipment to the analysis layer to realize the data access, transmission and storage.

The data analysis layer uses the digital twin technology to realize the real-time state visualization of the device layer, and the on-line data drives the machine learning model to excavate the massive heterogeneous information to realize the health management activities such as state monitoring, fault diagnosis, fault prediction, etc. To realize the qualitative and quantitative analysis of equipment health status by using digital twin technology.

The service layer is the "window" to realize the health status management of armoured equipment. Through the human-computer interaction system, the results of state management are visualized, and the predictive maintenance of armoured equipment is implemented.

4. RESEARCH AND DEVELOPMENT OF EQUIPMENT HEALTH MANAGEMENT SYSTEM BASED ON DIGITAL TWIN TECHNOLOGY

4.1. Equipment Health Management Method Based on Digital Twin Technology

Through the interactive control between the health management system workstation and the portable data acquisition and signal monitoring unit, the resource management analysis is realized. The software of health management platform is used to realize the functions of remote health management,

portable data acquisition and signal monitoring front-end data return, algorithm development iteration and verification, centralized equipment information management and fast logistics support.

Through the establishment of virtual and real mapping equipment digital control platform, virtual simulation armoured equipment weapon system behavior, real-time state visualization of armoured equipment weapon system, provide qualitative analysis basis for weapon system health status prediction; through the health management platform software to complete equipment health management, portable intelligent detection front-end data back-propagation, algorithm development iteration and verification, The realization of centralized equipment information management, fast logistics support and on-line data-driven vehicle key components health management can provide quantitative analysis basis for vehicle health status monitoring.

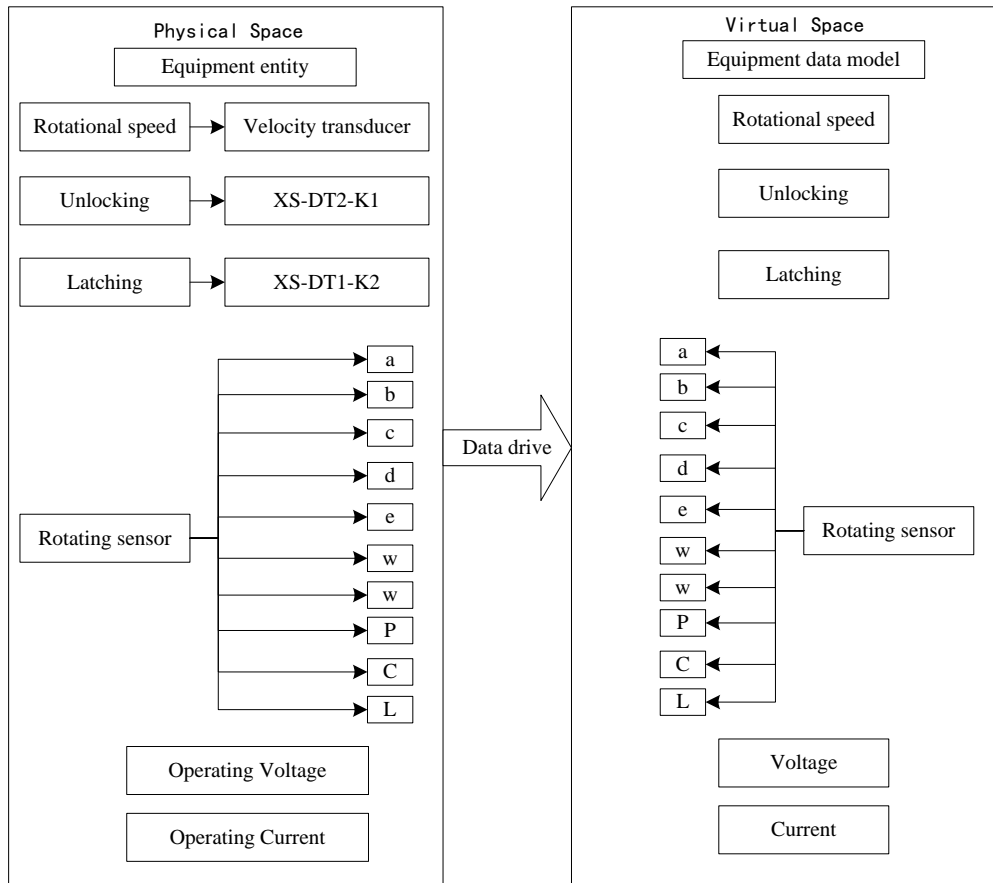


Figure 3. Construction of Equipment System Digital Twins

4.2. Construction of Digital Twins Based on Dynamic Interaction of Virtual And Real Spaces

Based on off-line data such as environment parameters and position parameters, a hyperrealistic simulation environment is constructed in Unity 3D software. Converts the high-fidelity model to Unity 3D identifiable in 3Dmax. fbx format and import Unity 3D software to achieve the fusion of high-fidelity model and hyper-realistic simulation environment. Through real-time updating of digital virtual space model and environment by running data, dynamic parameters and so on, driving high fidelity model to simulate high fidelity behavior in hyper-realistic simulation environment, the real-time state of armoured equipment physical space is mirrored into virtual space, and the real-time state of armoured equipment weapon system is visualized online. It provides decision-making guidance for the predictive maintenance of physical space armor equipment.

4.3. Construction of Equipment Health Management System Based on Machine Learning

Determine the object of study: The research object of this project is to analyze the influence of equipment performance on the working process in the process of equipment use, and then select the turn-off signal as the key modeling object, so as to construct a reasonable digital twin of the rotary projectile conveyor. It directly affects the kinds, methods and algorithms of data collection.

Data collection: Data is the basis of the model. In the health management system of armoured equipment, the types and accuracy of data collected directly affect the accuracy of fault diagnosis and life prediction. The module mainly obtains data from the sensor layer armoured weapon system, and realizes the access, transmission and storage of data.

Model training: A reasonable and effective model is necessary to realize the effective health management of data-driven armoured equipment weapon system. Therefore, using on-line data-driven machine learning model to excavate large amount of heterogeneous information to realize health management activities such as state monitoring, fault diagnosis, fault prediction, etc., the real-time state of visualization and the remaining life of prediction are analyzed synthetically, and the data qualitative and quantitative analysis driven by the fusion of digital twins and machine learning are realized.

Fault prediction and health management: the real-time operation of the equipment is analyzed by the established model, and the health status of the equipment is evaluated. The fault case is iterated to the data construction center to realize the continuous optimization of equipment health state management.

5. CONCLUSION

The virtual model of equipment entity is established through digital Lisheng technology. Continuous interaction and integration between physical real space and virtual digital, continuous upgrading and iteration, helping the intelligent upgrade of equipment number, can realize the efficient control of equipment health, ensure the normal operation of equipment, reduce maintenance costs, can realize the unified and effective management of equipment E, solve the shortage of on-site maintenance, realize real-time combat readiness decision, effective auxiliary combat decision, resource support, etc., equipment combat The performance has been greatly improved, and the equipment combat capability has been continuously improved, which provides new ideas for the health management mode and development planning of the entire army's equipment, and thus has significant military and social benefits.

With digital twinning technology, digital twinning of a certain equipment is established. When the equipment works by using data-driven technology to drive digital twins, the remote monitoring of equipment operation status can be realized by this way, and the fault diagnosis of equipment can be realized. Meanwhile, the technology can be extended to other equipment. digital twins forming the equipment system, in order to realize that parallel battlefield, lay the theoretical and practical foundation.

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