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Support for Artificial Intelligence and PHM in Military Intelligent Equipment Artificial Intelligence

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Abstract:

The implementation framework, key technologies, and guarantee decision-making methods for AI-based military intelligent equipment are studied in order to address the issues of low intelligence and networking in predictive maintenance of military intelligent equipment as well as difficulty in physical model modeling.The PHM system architecture is integrated into the construction of the health management of military intelligent equipment, which benefits from AI's exceptional capabilities of communication throughout the entire network, pan-awareness, and self-learning. The technology makes it possible to manage the health of military intelligent equipment in a data-driven, intelligent, and networked manner. This paper offers references and references for military intelligent equipment support that is appropriate for challenging circumstances, lowers maintenance and operating costs, and consistently raises the bar for military intelligent equipment support. This research paper's goal is to examine how AIT is used in mechanical electrical control systems (MECS). This article first introduces the fundamental theories and concepts of AIT, then develops the core technology of AIT, combines the current state of our nation's modern enterprises' electrical control systems to discuss the issues they are currently facing, and finally studies and analyzes AIT and machinery. Discuss the use of AIT in mechanical electrical orifice subsystems and the combination of electrical control systems.

Keywords: *PHM, Intelligent Equipment, Artificial Intelligence, MECS, AIT*

I. Introduction:

All sorts of equipment with prediction, perception, analysis, reasoning, decision-making, and control capabilities are referred to as "military intelligent equipment" as a whole. On the basis of equipment numerical control, it is a more sophisticated type of equipment that may increase production efficiency and manufacturing precision. The key technologies for their development include defect detection and health maintenance technology, such as high-end CNC machine tools and industrial robots. The direction of development for future military intelligent equipment system support and maintenance is fault prediction and health management technologies. It is exceedingly challenging to develop mathematical or physical models of the parts or systems of complicated military intelligent equipment as it becomes more and more complex. Therefore, using historical data from different points in the component's or system's life cycle for modeling will be more advantageous for the realization of the PHM function than using the physical analysis model . Given that military intelligent equipment is evolving toward informationalization, intelligence, and networking, this necessitates that its maintenance procedures be networked and intelligent as well. In order to create military equipment with intelligence, this essay focuses on the integration of PHM and AI. Support research, improve military intelligent equipment decision-making, force structure, method reform, and effectiveness increase. Also, offer support for the implementation of intelligent and networked maintenance techniques for PHM.

II. A combat mode for militarily sophisticated future technology

The widespread use of sophisticated technology has led to significant modifications in the way that battles are won. Information power has superseded firepower as the most important factor in determining whether a conflict will be won or lost. It has evolved into the favored method to subdue enemies to use control rather than devastation. The impact of clusters in the fighting system is as follows: could be greater than the impact of concentrated forces. Accordingly, on the intelligent battlefield of the future, there will be three types of conflict: the "new type of intelligent warfare" (also known as "coordinated distributed warfare"), the "reactor offensive and defensive warfare" (also known as "cluster offensive and defensive warfare"), and the "cluster joint warfare" (also known as "cluster warfare"), which is based on the conflict in clusters. And the "electromagnetic integrated warfare" developed from new ideas and systems will serve as the fundamental kind of intelligent combat.

III. New clever warfare:

Data analysis warfare, computer power warfare, and intelligent algorithm warfare

The "intellectual power" must be taken in order to engage in intelligent fighting. On the intelligent battlefield, a number of combat actions centered on "intellectual power" have taken center stage. Computing power warfare is used for various computing power battles on the intelligent battlefield, which represents the battle of speed victory. Intelligent algorithmic warfare is used for various source code battles on the intelligent battlefield, which represents the combat mechanism of intelligence winning.

Mechanism; data analysis warfare, employed in a variety of data battles on the intelligent battlefield and representing the big data victory combat mechanism. In the future, intelligent conflict will be planned and drawn out. The three basic components of conventional artificial intelligence are algorithms, calculations, and data. They will also become the focal points of fierce competition for intelligent warfare.

IV. Cooperative distributed warfare

Dispersed warfare, cognitive warfare, and dynamic warfare

Perception, cognition, and decision-making are combat functions produced by the cognitive domain. With the development of new technologies like biotechnology, brain-computer fusion, and nano-weapons, the battlefield will undoubtedly move faster from the physical and informational domains to the cognitive domain. A thorough three-dimensional situational awareness network can be created using distributed coordinated operations that incorporate platforms from the land, sea, air, space, electricity, and other operational domains. Weapon system cluster/division saturation strikes increase the overall battle and strike effectiveness through military communication networks and integrated command and control systems across several domains. In order to achieve an effective situational awareness network, a potent offensive network, and a flexible defense network as well as to fundamentally implement the concept of distributed coordinated operations, "dynamic warfare" constructs a system for integrating manned and unmanned assets.

The application of artificial intelligence technology to achieve a high degree of brain-computer integration in order to realize the complimentary benefits of high-speed computing and logical thinking in the human brain. It is anticipated that intelligent command and control will reach the operational level when commanders are replaced by computer simulations for the purposes of planning combat activities, making combat decisions, and handling emergencies. The concept of "distributed warfare" is built on the collaboration of numerous services and weapons in a challenging setting.To improve the communication, perception, complementarity, and support capabilities in operations, optimize tactics, and exert overall combat effectiveness, it is layered, classified, and classified into decentralized offensive formations, centralized command, distributed organization, and coordinated operations.

VII. Reactionary offensive and defensive tactics:

Three types of network warfare exist: wireless, industrial control, and telecommunications. The conflicts based on professional fields like telecommunications network space, industrial control network space, and wireless network space have jumped into the main battle field and will become a typical form of intelligent network warfare as the integration of the real world and the network world deepens. In order to achieve the goals of communication paralysis, network interruption, or data theft in a broad area, telecommunications network warfare primarily refers to the offensive and defensive struggle initiated in the national backbone communication networks such as international communication networks, mobile communication networks, and metropolitan area networks. The primary targets of industrial control cyber-warfare are large-scale, intelligent, equipment-intensive networks with various industrial and commercial characteristics, such as the national power network, bank financial network, water conservancy engineering network, and so forth.

The industrial control network's core access equipment will behave irregularly or fail to cause overall paralysis or damage to the target system through the use of specialized network attacks. The term "wireless network warfare" refers to offensive and defensive actions carried out on information networks, particularly wireless networking on the battlefield. It is a typical fighting technique and a crucial tool for network warfare on the battlefield in the future. Access to the internal network of the opponent's open connection by brute force deciphering, password intrusion or camouflage infiltration, and other network attacks to achieve the goal of paralyzing, stealing, blocking, misleading, or upsetting the enemy.

VIII. Military intelligent equipment support system architecture that is geared toward the future

The introduction of modular management, dynamic control, and autonomy-oriented concepts to build military intelligent equipment that is integrated with artificial intelligence is based on the PHM system design concept, combined with the complex and high-tech characteristics of military intelligent equipment itself, and guided by actual application and missions. Collecting status data: Single or several detection methods may be utilized, and those for the same piece of equipment are coordinated and complimented, depending on the particulars of the equipment. The information is useful by choosing the right sensors to gather status data indicating whether the system is normal or not. Obtain. In advance, determine the parameters' effective threshold and exclude heterogeneous data. Connect numerous data sources to the military intelligent equipment health management system using cutting-edge communication technology.

IX. Processing and analysis of the data Utilize:

Data analysis techniques to examine the data, make straightforward abnormal judgments about it in accordance with abnormal judgment standards, and then remove or filter out abnormal data. The data is processed using the data preprocessing method into the format needed by the system. It also performs other tasks including data processing and data transport. Health status assessment: This module primarily accepts processed data from the data acquisition and processing module and completes the functions of fault detection, status abnormality analysis, and historical monitoring data query for airborne equipment or systems. Functions for status monitoring and fault detection include tracking and comparing fault features, fault detection and isolation, offline detection of status parameters, and real-time monitoring of status data. To enable the viewing of equipment irregularities and fault detection features, provide a human-computer interaction interface.

X. Predicted state of health:

It primarily completes tasks including identifying health characteristic parameters that exceed the limit, classifying and evaluating health status, managing current health status, sounding the health status warning, and querying previous health status. When a system malfunctions, the diagnosis logs the time it happened, pinpoints the problem's cause, assesses the health status level in accordance with the standards for determining that level's classification, and reports the findings. To implement the tasks of intelligent equipment's status degradation process analysis, equipment status prediction, equipment remaining life prediction, prediction model and algorithm management, health status information is kept in the historical database. You can manage and change the system's built-in predictive model's parameters as well as add user-defined predictive models and algorithms using the module for managing predictive models and algorithms. After the analysis task is finished, the evaluation, prediction, and analysis findings are given to the decision support layer of the system to aid the command manager in making decisions. This layer of the system combines the knowledge base, experience library, and system-encapsulated prediction algorithm.

Making wise support decisions involves reading the findings of condition monitoring, fault diagnosis, and life prediction, combining component data from the equipment management database, business optimization decision elements, and thorough selection based on safety, mission, availability, and significant economic repercussions. In order to arrive at the best guarantee decision, decision objective function, decision optimization model construction, and call decision algorithm are used. The decision's conclusion can be linked to the business department's business process in order to enter the decision deployment of the guarantee process right away. This serves as the foundation for data mining and data synchronization, the exploration of intelligent equipment guarantee rules, the sharing of equipment health management data, and the construction of high-level data integration and research judgment.

XI. Mechanical and electrical control systems using artificial intelligence technology

a. Programmable logic controllers (PLCs) are one of the related technologies.

PLC, or Programmable Logic Controller, is the abbreviation for programmable logic controller. It is now an essential component of industrial automation. The key reasons why programmable logic controllers are so commonly used are their high levels of stability, robust functionality, ease of development, sophisticated user interfaces, good interoperability, and expandable modes.

b. Field bus technology using Modbus

The Modbus protocol's distinguishing feature is its ability to transfer data via a wide range of media, including wireless, twisted pair, optical fiber, and RS-232 and RS-485 electrical interfaces. This guarantees strong scalability and can accommodate up to 200 devices communicating on the same network. This agreement is a part of the master/slave architecture agreement. There is only one master node in the entire communication network; all other nodes are slave nodes, and each slave node has a distinct address. The master node conducts a query operation throughout the communication process, which involves accessing the chosen slave station in accordance with the format, and the slave station device provides response data to complete a full query response cycle.

c. Prediction of failure and health management (PHM)

Prognostics and Health Management, or PHM for short, is the full word for failure prediction and health management in English. In order to save equipment use and maintenance costs, it was first employed in the military to anticipate defects through the gathering and analysis of system status data. It is a product that combines embedded technology, technology for defect detection, and sensor technology. the change from monitoring status to managing health. The two primary components of PHM technology are prediction and health management. The fault prediction uses the current and historical working status data of the system to predict the current health status and possible faults of the system, and to diagnose and address them in a timely manner. The health status is the difference between the current actual working status and the normal working status of the system.

d. Pneumatic system

a. Electrical Control System

The driving device, control element, and executive element make up the system. The two-position, five-way electromagnetic reversing valve in the cylinder allows compressed air from the air compressor (including the air storage tank) to enter after being filtered and decompressed. This causes the piston rod to expand and contract. Control system (2) The station control layer, the communication management layer, and the bay layer are the three equipment levels that make up the control system, which is a distributed data processing system. Each layer carries out a separate set of tasks, and each layer is made up of various devices or subsystems. Although it is not a control system, the process layer is also a service for it. Filtered and decompressed compressed air from the air compressor (including the air storage tank) enters the cylinder through a two-position, five-way electromagnetic reversing valve, which causes the piston rod to expand and contract.

b. System of control

The control system is organized into three equipment layers as a distributed data processing system: the station control layer, the communication management layer, and the bay layer. Every layer has a separate set of tasks it completes, and every layer is made up of various devices or subsystems. There is also a process layer, which serves as a service for the control system even if it is not one.

XII. Evaluation of Current Electrical Control Problems

a. Invalid, unsafe, and unreliable equipment data

Data transmission and processing take a long time because of the outdated communication equipment, and the data is susceptible to interference, which leads to subpar data accuracy and real-time.

b. There is no monitoring network formed by the monitoring point.

A lack of monitoring is the result of certain newly added equipment's electrical amounts not being uploaded to the electrical control system due to equipment modification.

c. Capacity issues with computers

In production since the Cathay Pacific generating set is the TOSMAP-DS system. The control system includes computer technology heavily. The accuracy of the control system is constrained by the dated computer performance as science and technology advance. It now has faster processing times, lower CPU load rates, and higher reliability.

d. The scenario at the operator station is that the operation command fails.

The only way to fix the "program cannot respond" problem that occurred during the procedure is to restart the operator station. This issue occurs more frequently when the unit is started up and shut down frequently, endangering the unit's normal and secure operation.

e. It is difficult to modify the logic configuration.

Modifying function block parameters and logic setup processes on the engineering station requires a lot of work. Maintenance workers are more likely to make mistakes and leave safety concerns because there are so many operation processes. Additionally, due to program function restrictions, online logic configuration cannot be carried out while the system is in operation, making it impossible to promptly fix errors. This makes it difficult to process system errors in a timely manner.

f. As components age, dependability decreases.

The original system's electronic components are at the end of their useful lives because it has been operating for almost ten years. During operation, there were numerous instances of channel damage, communication module damage, and DC power module failure. According to data, electrical control system refusal or malfunction due to module failures have occurred often in recent years. For a variety of reasons, the quantity of replacement parts cannot be efficiently increased.

g. Increased system energy use

There are other requirements for UPS power supplies. The battery pack's performance has gotten worse as it has aged. Moreover, the DC and UPS systems are unable to provide a dependable power supply due to the electrical control system's excessive energy consumption.

h. There is little time for historical database archiving

The archiving period for different historical databases was brief—only approximately one month—due to the performance constraints of computers and software at the time, which made it impossible to meet the demands of accident investigation, data statistics, and temporal recall.

XIII. Design of Artificial Intelligence Technology Application in MECS

When used to address the issues with the current mechanical and electrical control system, A I T can enhance the following functions:

a. Acknowledge automated fault warning

The general installation has the ability to repeat the action and postpone the automatic release of the accident signal and accident sound warning device. The circuit breaker has the ability to immediately transmit the accident sound signal when it mistakenly trips. The matching position indicator flashes simultaneously, and other warning signals are typically attached to the pre-announcement signal system as necessary to alert the operating staff as soon as abnormal conditions of the equipment are discovered.

b. Recognize that electrical devices can operate remotely

In addition to local operation, remote operation and adjustment operations can be performed for electrical equipment with a voltage of 6kV or above and some significant 380V electrical equipment.

c. Possesses specific self-diagnosis and repair capabilities.

The monitoring software's self-checking feature allows for the early detection of electrical control system faults and the provision of appropriate repair advice based on the type of fault, making it simple to perform routine system maintenance and ensuring the smooth operation of the entire system.

d. Recognize the logic's online configuration function

It is convenient for detecting system flaws early on since the logic may be configured online while the system is operating and will not negatively impact the controller's performance when the configuration is downloaded.

XIV. Development of an Asynchronous Motor Mathematical Model

The slip rate s is extremely low when the three-phase asynchronous motor is operating normally.

$$T_n = 3pU^2_{1/}\, 2\pi f_1 R_2\, (1-n_p/n_1)$$

The motor's mechanical motion equation states:

$$T_n - T_L = GD^2 d_n/375 = j_g d_n/d_t$$

Conclusion:

After implementing health management technology, the maintenance support system is evolving toward greater intelligence, automation, and optimization, and the condition assessment is more precise and timely. It directs maintenance in accordance with the results of health management and determines a timely and suitable maintenance mode depending on circumstances. As a result, thorough study on the use of PHM systems and artificial intelligence in sophisticated military intelligent equipment systems provides significant military and national defense benefits. The age of AI T is the twenty-first century. Life is A I T-immersed everywhere. You must demand that businesses be able to appraise the situation if you want to boost productivity and earn large profits. Traditional techniques and technologies are unable to change to accommodate this. The period of science and technology's fast development;The electrical control system can achieve unified automatic management of high and low voltage electrical equipment of the generator set due to its improved real-time performance, stronger communication performance, and greater calculation speed. The application of A I T to mechanical and electrical control systems will enhance the quality of businesses.

References

[1] Qu Ch. Q, (2021) Research on PHM data system architecture for complex equipment. [J]. Computer Measurement and Control, 29(04): 1-4+9.

[2] Shao Sh. G, (2021) Research on the Development Trend of Intelligent Equipment Support Technology. [J]. Flying Missile, (04): 90-94.

[3] Xu W.F, (2021) Application of PHM technology in aircraft assembly unit. [J]. Modern Manufacturing Technology and Equipment, 57(03): 142-144.

[4] Gao M.L, (2021) Research on Urban Rail Transit Vehicle Maintenance Decision-Making Technology Integrating RCM, PHM and Data Mining. [J]. Urban Rail Transit Research, 24(02):64-68.

[5] Jing B, Jiao X. X, (2019) Big data analysis and artificial intelligence application for aircraft PHM. [J]. Journal of Air Force Engineering University (NATURAL SCIENCE EDITION), 2019, 20 (01): 46-54

[6] Hafiz M, Kosuru L, Younis M I. Towards electromechanical computation: An alternative approach to realize complex logic circuits. Journal of Applied Physics, 2016, 120(7):1-10.

[7] Dantas M, Sampaio R, Lima R . Existence and asymptotic stability of periodic orbits for a class of electromechanical systems: a perturbation theory approach. ZeitschriftFürAngewandteMathematik Und Physik, 2016, 67(1):1-14.

[8] Bai W, Chen D, Zheng P, et al. NaNbO 3 templates-induced phase evolution and enhancement of electromechanical properties in grain oriented lead-free BNT-based piezoelectric materials. Journal of the European Ceramic Society, 2017, 37(7):2591-2604.

[9] Lee L C, Sundnes J, Genet M, et al.An integrated electro mechanical-growth heart model for simulating cardiac therapies. Biomechanics & Modeling in Mechanobiology, 2016, 15(4):1-13.

[10] Crozier A, Augustin C M, Neic A, et al. Image-Based Personalization of Cardiac Anatomy for Coupled Electromechanical Modeling. Annals of Biomedical Engineering, 2016, 44(1):58-70.

[11] Yin Z Q. Quantum superposition, entanglement, and state teleportation of a microorganism on an electromechanical oscillator. Science Bulletin, 2016, 61(2):163-171.

[12] Liu L L, Feng W J, Ma P. A penny-shaped magnetically dielectric crack in a magnetoelectroelastic cylinder under magneto electromechanical loads. ZAMM - Journal of Applied Mathematics and Mechanics / ZeitschriftfürAngewandteMathematik und Mechanik, 2016, 96(2):179-190.

[13] Demir K, Avci A, Kaya Z , et al. Assessment of atrial electromechanical delay and P-wave dispersion in patients with type 2 diabetes mellitus. Journal of Cardiology, 2016, 67(4):378-383.

[14] Dantas M, Sampaio R, Lima R . Existence and asymptotic stability of periodic orbits for a class of electromechanical systems: a perturbation theory approach. ZeitschriftFürAngewandteMathematik Und Physik, 2016, 67(1):1-14.

[15] Kiseleva M A, Kuznetsov N V, Leonov G A. Hidden attractors in electromechanical systems with and without equilibria. IfacPapersonline, 2016, 49(14):51-55.

[16] Lin S, Xu J. Effect of the Matching Circuit on the Electromechanical Characteristics of Sandwiched Piezoelectric Transducers. Sensors, 2017, 17(2):329.

[17] Esmaeilian A, Kezunovic M. Fault Location Using Sparse Synchrophasor Measurement of Electromechanical Wave Oscillations. IEEE Transactions on Power Delivery, 2016, 31(4):1-1.