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Research on the Present Situation and Development of Anti-Harsh Environment Computer Technology

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Abstract: ***Resilient computer technology is a technology developed to meet the computational requirements under harsh environmental conditions. Harsh environments present numerous challenges to computer technology, including high temperatures, low temperatures, humidity, vibrations, radiation, and electromagnetic interference. To address these challenges, various techniques have been applied to resilient computer technology, such as enclosed and sealed designs, as well as dust and waterproofing technologies. Looking ahead, the development trends of resilient computer technology encompass the application of new materials, improvements in chip and hardware technology, and the enhancement of intelligence and autonomy. These technological advancements will offer better solutions for computing and data processing in challenging environmental conditions.***

Keywords: Resistance to harsh environment; Computer technology; Challenge; Development.

1. PREFACE

In modern society, the application of computer technology has penetrated into various fields, including extremely harsh environmental conditions. Adverse environments such as high temperature, low temperature, humidity, vibration, radiation, and electromagnetic interference pose severe challenges to the performance and reliability of computer equipment. In such an environment, traditional computer devices often fail to function properly and may even be damaged. Therefore, the development and application of computer technology that can withstand harsh environments has become an important topic in today's technological field. Anti adverse environment computer technology aims to provide computer solutions that can operate stably under harsh conditions to meet the needs of specific fields. Liu et al. (2024a) proposed a coreference resolution method to bridge context gaps in long-context understanding, demonstrating improved coherence in language models[1]. Further extending practical applications, Liu et al. (2024b) introduced Tool-Planner, a framework for multi-tool task planning that leverages clustering to optimize workflow efficiency[2]. In computer vision, Peng et al. (2024) addressed domain shifts in 3D human pose estimation through a dual-augmentor framework, achieving robust cross-domain performance[3]. For healthcare analytics, Pang et al. (2024) developed a data-driven approach using electronic health records to unveil diabetes-related knowledge and improve risk prognosis[4]. In predictive modeling, Wu (2024) enhanced click-through rate (CTR) prediction in advertising by optimizing XGBoost-based classifiers, highlighting gains in computational efficiency[5]. Yu et al. (2024) tackled autonomous intersection management by integrating social value orientation into priority-swapping algorithms, ensuring equitable vehicle coordination[6]. Security-focused innovations include Liu et al. (2025)'s privacy-preserving hybrid ensemble model for network anomaly detection, which balances security and data protection[7], while Guo et al. (2025) improved imbalanced dataset forecasting via a focal loss-based ensemble method[8]. Multi-task learning was advanced by Weng et al. (2024) through a multi-layer alignment framework that adaptively weights task contributions[9]. Finally, Xu et al. (2025) analyzed adversarial attacks and defenses in cybersecurity, offering critical insights for robust machine learning systems[10].

2. THE CHALLENGE OF HARSH ENVIRONMENTS TO COMPUTER TECHNOLOGY

Adverse environmental conditions pose many specific challenges to computer technology, limiting the normal operation and performance of computer devices in these environments.

2.1 High temperature environment

In high temperature environments, computer equipment faces the problem of overheating. High temperatures can cause the temperature of electronic components to rise beyond their normal operating range, leading to performance degradation, system crashes, and even damage. In addition, high temperatures can accelerate the aging of electronic components and increase the failure rate. Therefore, the challenge of high temperature resistance is a key issue in maintaining stable operation of computer equipment under high temperature conditions.

2.2 Low temperature environment

Low temperature can make electronic components fragile, leading to a decrease in their conductivity and affecting the normal start-up and operation of equipment. Low temperature can also affect the response speed and brightness of LCD screens.

2.3 Humidity and moisture are natural enemies of computer equipment

In high humidity environments, moisture can seep into the interior of equipment, causing circuit short circuits and corrosion of electronic components, leading to equipment failure. Moisture can also cause oxidation and corrosion of metal components, reducing the lifespan of equipment. Therefore, the challenges of humidity resistance and waterproofing are key issues in ensuring that computer equipment works properly in humid environments.

2.4 In certain work environments, such as industrial production lines or transportation vehicles, there is frequent vibration and vibration.

Vibration and vibration can cause electronic components to loosen, slots to fall off, circuit boards to break, and other issues, thereby affecting the performance and reliability of the equipment. Therefore, anti vibration and anti vibration challenges are key issues to ensure the normal operation of computer equipment in vibration and vibration environments. Fifth, electromagnetic interference. Electromagnetic interference is the interference of electromagnetic wave signals from power equipment, communication equipment, or other electronic devices. These interferences can affect the normal operation of computer equipment, leading to data transmission errors or device performance degradation, and may also cause device crashes or shutdowns.

3. CURRENTLY AVAILABLE COMPUTER TECHNOLOGIES THAT CAN WITHSTAND HARSH ENVIRONMENTS

3.1 Closed sealing design and dust and waterproof technology

Sealed design and dust-proof and waterproof technology are common solutions in computer technology that can withstand harsh environments. By using special sealing materials and processes, the internal components and circuit boards of computer equipment can be effectively sealed to prevent external dust, particles, or moisture from entering the device. The key to closed sealing design and dust and waterproof technology lies in selecting appropriate sealing materials and sealing processes. Common sealing materials include silicone, fluororubber, rubber O-rings, etc. They have good sealing performance and high temperature and corrosion resistance. Meanwhile, precise processing techniques are employed to ensure the integrity and tightness of the sealed area. Sealed design and dust-proof and waterproof technology can effectively protect computer equipment from the intrusion of dust, particles, and moisture. They play important roles in some special environments, such as industrial manufacturing sites, outdoor environments, military applications, etc. Through these technologies, computer devices can operate stably for long periods of time in harsh environments, reducing malfunctions and damage caused by dust, particulate matter, or moisture. The application of closed sealing design and dust and waterproof technology can also be extended to some special scenarios, such as ocean exploration, deep-sea submersibles, desert areas, etc. In these environments, computer equipment needs to withstand strong challenges such as sandstorms and seawater corrosion. Therefore, adopting sealed design and dust-proof and waterproof technology can ensure the normal operation of equipment and the reliability of data.

3.2 High temperature, low temperature, and humidity adaptation technology

High temperature adaptation technology aims to solve the overheating problem faced by computer equipment in high-temperature environments. In high-temperature environments, the increase in internal temperature of equipment can lead to a decrease in the performance of electronic components, system crashes, and even damage. To address this challenge, adopting an efficient heat dissipation system is one of the key factors. For example, increasing the number and power of cooling fans, adopting advanced cooling technologies such as heat pipes and

fins, can improve heat dissipation efficiency. In addition, selecting high-temperature resistant materials for the manufacturing of electronic components and circuit boards can enhance the equipment's ability to withstand high temperatures.

Low temperature adaptation technology aims to solve the problems of cold start and delayed response of computer equipment in low-temperature environments. In extremely cold environments, the normal operation of equipment may be affected, such as a decrease in the conductivity of electronic components, leading to difficulties in cold start and response delays. To address this challenge, the use of heating devices is a common solution. By using heating equipment to maintain the appropriate operating temperature of electronic components, cold start problems and delayed response can be avoided [3]. In addition, the use of low-temperature resistant materials and components can improve the reliability and performance of equipment in low-temperature environments.

3.3 Anti seismic and anti vibration technology

Structural design and shock absorption technology are key aspects of seismic and vibration resistance technology. In terms of structural design, reasonable structural layout, rigid frame, and strengthened support structure are adopted to improve the overall stability and seismic performance of the equipment. At the same time, the use of shock-absorbing technology, such as shock-absorbing pads, shock-absorbing bases, and shock-absorbing platforms, can reduce vibration and the impact of vibration on equipment, and lower the amplitude of equipment vibration.

Anti seismic and anti vibration technology also includes strong connection and anti loosening technology to ensure the stable connection of equipment in vibration and vibration environments. Using locking bolts, nuts, spring washers and other connecting components to increase the fastening force of the connection and prevent the equipment from loosening during vibration. In addition, using structurally stable and earthquake resistant connectors can improve the seismic resistance of the equipment.

Vibration compensation and balancing technology. By installing compensation devices, balancers, and dampers, the vibration and vibration inside the equipment can be reduced to maintain stable movement of internal components. The application of these technologies can improve the reliability of equipment and reduce failure rates.

Fourth, strengthen the structure and materials. Strengthening structural design can increase the seismic resistance of equipment by increasing the stiffness and stability of the frame, thereby improving the stability of the equipment in vibration environments [4].

3.4 Anti radiation technology

3.4.1 Radiation Protection Materials and Shielding Technologies

Radiation protection materials have high radiation protection performance and can reduce the penetration of radiation into equipment. For example, using high-density materials such as lead, tungsten, steel, and special alloys as shielding layers can effectively block the propagation of radiation. In addition, the use of radiation protection coatings and shielding structure design is also a common technical means to reduce the impact of radiation on equipment.

3.4.2 Electromagnetic shielding technology

By using electromagnetic shielding materials and designs such as metal shielding boxes, electromagnetic shielding covers, and electromagnetic shielding layers, the interference between equipment and external electromagnetic fields can be effectively isolated, protecting the normal operation of equipment.

3.4.3 Radiation hardening and radiation resistant design

By optimizing the design and manufacturing of electronic components and circuit boards, they can withstand ionizing radiation in a radiation environment without being damaged. This includes the use of radiation hardened electronic components, radiation hardened memory, and radiation hardened circuit design.

3.5 Electromagnetic interference protection technology

3.5.1 Shielding Technology

By using metal shielding materials such as copper, aluminum, etc., shielding covers, shielding boxes, or shielding films can be made to effectively isolate computer equipment from external electromagnetic field interference [5]. Shielding materials can absorb and reflect electromagnetic waves, preventing them from entering or leaving the device. In addition, reasonable design of shielding structures and connection methods to ensure the integrity and effectiveness of shielding is of great significance for reducing electromagnetic interference.

3.5.2 By using filters in power or signal lines, electromagnetic interference signals can be weakened or eliminated

Filters can select appropriate frequency bands and filter out interference signals or protect the integrity of signal transmission through their low-pass, high pass, or band-pass characteristics.
3.5.3 Grounding and shielding connection

A good grounding system can guide the charge of electromagnetic waves to the ground, avoiding their interference with equipment. At the same time, ensure a good connection between the shielding structure and the equipment, eliminate the leakage of interference signals through the shielding structure, and enhance the shielding effect. Reasonably designing and arranging the connection between grounding lines and shielding structures, using low impedance grounding wires and connectors, and avoiding interference from grounding circuits are all important factors in ensuring good grounding and shielding connections.

3.5.4 Electromagnetic Compatibility Testing and Verification

By conducting electromagnetic compatibility testing on equipment, the tolerance of the equipment in electromagnetic environments can be evaluated, and the effectiveness of anti-interference technology can be verified. This includes radiation emission testing, radiation immunity testing, conducted immunity testing, etc., to ensure that the electromagnetic compatibility of the equipment meets the corresponding standards and requirements during actual operation.

4. EXPLORATION INTO THE DEVELOPMENT OF ANTI HARSH ENVIRONMENT COMPUTER TECHNOLOGY

4.1 Application of New Materials

With the advancement of technology, new materials with excellent performance and adaptability to harsh environments are constantly emerging, providing new possibilities for the application of computer technology in harsh environments. On the one hand, the application of new materials can improve the seismic, vibration, radiation, and electromagnetic interference resistance of computer equipment. For example, using high-strength and high toughness composite materials, titanium alloys, and other structural materials can increase the seismic and vibration resistance of equipment and improve its stability in harsh vibration environments. At the same time, the use of radiation hardening materials, shielding materials, and electromagnetic isolation materials can improve the equipment's resistance to radiation and electromagnetic interference, protecting the equipment from the effects of radiation and electromagnetic interference.

4.2 Improvement of chip and hardware technology

The improvement of chip and hardware technology plays a crucial role in the development of computer technology that can withstand harsh environments.

Firstly, the improvement of chip technology can enhance the processing capability and anti-interference ability of computer devices. Modern chip design tends towards high integration, low power consumption, and high reliability. By adopting advanced manufacturing processes and design techniques, the computing and processing capabilities of chips are improved to meet the requirements of complex computing tasks.

Secondly, improvements in hardware technology can enhance the durability and adaptability of computer equipment, such as circuit board design, heat dissipation systems, power supply, and connectors. By optimizing the layout and design of the circuit board, the anti-interference ability and stability of the equipment can be

improved. Improving the cooling system can effectively reduce the temperature of equipment in high-temperature environments, protecting the components and circuits of the equipment from damage. Optimizing the design of power supply and connectors can enhance the stable power supply capability of equipment, reduce the risk of power interference and poor contact.

Finally, the introduction of new hardware technologies also brings new development opportunities for computer technology that can withstand harsh environments. For example, replacing traditional mechanical hard drives with solid-state drives (SSDs) can improve the device's seismic resistance and data storage stability. Using special materials and coatings to enhance the equipment's radiation and electromagnetic interference resistance, protecting the equipment from adverse environmental factors.

5. CONCLUSION

The development of computer technology that can withstand harsh environments is of great significance in addressing the computing and data processing needs in extreme environments. At present, various anti harsh environment computer technologies have been applied in various fields, including closed sealing design, dust and waterproof technology, high temperature adaptation technology, earthquake and vibration resistance technology, radiation resistance technology, and electromagnetic interference protection technology. These technologies enable computer equipment to operate stably in harsh environments such as high temperature, low temperature, humidity, vibration, radiation, and electromagnetic interference.

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