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Edge Detection System Based on Digital Twin Technology

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Abstract: An edge detection system based on digital twin technology is an advanced technological solution that combines the concepts of digital twin and edge computing. The main goal of the system is to improve the efficiency and accuracy of industrial manufacturing processes, especially in complex and dynamic environments.

Keywords: Digital twin; Technology; Edge detection system

1. Introduction

1.1 Research Background.

With the rapid development of industry 4.0 and smart manufacturing, digital twin technology has become a research hotspot in the industrial field. Digital twin technology can realize real-time monitoring, prediction and maintenance of physical devices or systems by simulating their operating states. However, it is still a challenge to detect and process data accurately and efficiently in complex industrial environments. Edge detection, as an important technique in image processing and machine vision, can recognize and extract the edge information in an image, providing a basis for subsequent analysis and processing. Therefore, the edge detection system based on digital twin technology has become a worthy research direction.

Digital twin technology can obtain a large amount of data in real time, and efficient edge detection algorithms can quickly process this data, improve the data processing efficiency disturbed and lead to inaccurate detection results. Edge detection system based on digital twin technology can utilize digital twin technology. Due to the presence of noise and other disturbing factors in the industrial environment, traditional edge detection algorithms may be subjected to dry high-precision simulation capabilities, preprocessing and screening of data to improve the reliability of the detection results.

The edge detection system based on digital twin technology can be applied to intelligent manufacturing, intelligent monitoring and other fields to promote the development of industrial intelligence. At the same time, the research and development of the system also help to promote the further application and promotion of digital twin technology. The research of the system involves many fields such as digital twin technology, image processing, machine vision, etc., and the research and development of the system can help to promote scientific and technological innovation and technological progress in these fields.

1.2 Explanation of Terms

DIGITAL TWIN: Digital twin is an interaction between the physical world and the digital world that creates a virtual model corresponding to a real object or system. In this model, the behavior and performance of the object can be simulated, predicted and optimized. Digital twin technology allows us to monitor, analyze and optimize manufacturing processes in near real-time.

Edge Computing: Edge computing is a technology that relocates computing resources (such as data storage, processing and analytics) from a central location to a device or endpoint. This reduces latency in data transmission, improves responsiveness, and allows for real-time decision making. In manufacturing environments, edge computing can enhance automation and intelligence to improve productivity.

Edge Detection System: Edge detection is a critical step in image processing for recognizing shapes, objects and features in an image. Edge detection system based on digital twin technology utilizes digital twin modeling and edge computing techniques to perform fast and accurate edge detection on real-time images.

Application Advantage: this system shows its superiority in many aspects. For example, it can monitor the production process in real time to identify and solve potential problems; optimize production schedules by predicting equipment performance through digital twin models; reduce the load on data centers and increase the speed of data processing; and enhance safety and reliability.

2. System Introduction

Edge detection systems based on digital twin technology are expected to evolve further as technology continues to advance. For example, more accurate model predictions, more powerful edge computing capabilities, and integration with other advanced technologies such as machine learning, IoT, etc.

2.1 System Model

With the rapid development of technology, digital twin technology has gradually become a research hotspot in several fields. In image processing and machine vision, edge detection is one of the core tasks, the purpose of which is to identify the contours in the image and provide a basis for subsequent analysis and recognition.

Digital twin technology, in simple terms, is to realize dynamic, real-time, bi-directional simulation and monitoring of physical entities by establishing their digital mirrors. In this model, we apply this technique to the edge detection of images. First, the image data to be processed are acquired through high-precision sensors or other data acquisition devices. These data are then fed into the digital twin model.

In the digital twin model, we apply advanced algorithms and mathematical models to deeply learn and process the image data. This includes, but is not limited to, steps such as filtering, binarization, and edge detection. Through these processes, we are able to accurately recognize edges and contours in an image.

It is worth mentioning that the digital twin technology not only provides high-precision simulation and detection capabilities, but also powerful real-time performance. This means that our edge detection system can quickly process new input images in real time, providing real-time edge detection results.

In addition, the model is robustly scalable and flexible. With the continuous progress and optimization of the technology, we can upgrade and improve the model to make it more adaptable to a variety of complex and changing image processing needs.

2.2 Performance Analysis

In today's digital era, digital twin technology is gradually becoming an important tool in various industries. Especially in the field of detection and prediction systems, digital twin technology provides new perspectives and methods for solving complex problems. Among them, the edge detection system, as a key part of this technology, plays a crucial role in improving the performance and efficiency of the whole system.

Digital twin technology is a technology that realizes real-time data interaction and analysis by establishing the correspondence between the physical world and the virtual digital world. Edge detection, as an important part of this technology, focuses on analyzing the collected data and identifying the parts, i.e. edges, that are significantly different from the surrounding environment. These edges may be anomalies, malfunctions, or other situations that require attention in the physical system.

The core of an edge detection system is to accurately identify edges in the data. If the system does not accurately detect edges, then subsequent analysis and prediction may be biased. Therefore, accuracy is an important metric for evaluating the performance of an edge detection system. For many application scenarios, especially industrial control and monitoring systems, real-time availability of data is critical. A good edge detection system should be able to process a large amount of data in a short time and give timely analysis results. The quality and characteristics of data may vary greatly from different data sources and under different acquisition conditions. An excellent edge detection system should be able to maintain stable performance in all situations. With the continuous advancement of technology and the growth of data volume, a good edge detection system should be able to be easily upgraded and expanded to meet future needs.

3. Application of edge detection system based on digital twin technology

3.1 Application Scope

With the rapid development of technology, digital twin technology has become a hot topic in today's industry. Digital twin technology can simulate the operating state of a physical device or system, providing a new perspective for monitoring, diagnosis and maintenance of equipment. Especially in the edge detection system, the application of digital twin technology has far-reaching significance. Edge detection system is an important technology in image processing, which is mainly used to identify and locate edges in images. Edge detection plays a key role in many fields such as industrial automation, security monitoring, and medical diagnosis. However, traditional edge detection methods are often affected by factors such as environmental noise and light changes, resulting in unstable detection results.

Edge detection systems based on digital twin technology can effectively solve these problems. By establishing a digital twin model of a physical device or scene, various environmental conditions and device states can be simulated so that the edge detection algorithm can be accurately verified and optimized. This not only improves the accuracy and stability of detection, but also provides the possibility of real-time monitoring and predictive maintenance.

In practice, edge detection systems based on digital twin technology first collect real-time data from devices or scenes through sensors. This data is transferred to the digital twin model for updating and calibrating the model's operational state. Subsequently, edge detection algorithms are run on the digital twin model to identify edge information that corresponds to the actual scene. Finally, this information is used to monitor the operational status of the equipment, predict potential failures, and optimize the maintenance schedule of the equipment.

3.2 Fault Detection

Fault detection for edge detection system based on digital twin technology is an advanced technology that utilizes digital twin models for real-time monitoring and fault detection of physical systems. This technique can be widely used in various fields such as manufacturing, aerospace, medical etc.

In the 5G era, in order to meet the needs of different application scenarios, the 5G network is characterized by structural diversity, functional diversity, and intelligence, and network slicing technology to meet the quality of service assurance of different application scenarios. The intelligence of the 5G network edges, and the access to software control and virtual control allow the original network functions and the composition of the network to be dynamically configured according to the needs, which causes great complexity, and therefore requires a new network management method to achieve dynamic adaptive. tremendous complexity, and therefore a new network management approach is needed to achieve dynamic adaptivity. Effective prediction and diagnosis of real-time network failures is of great significance in modern network development as it can provide early warning of abnormal networks and avoid huge losses caused by network paralysis.

Network failure is a phenomenon in which the network is working abnormally, manifesting itself in many abnormal states. In order to troubleshoot the network failure, the first step is to analyze the abnormal phenomenon, then determine the point of failure, then diagnose that failure, and finally eliminate the failure and return to the normal state. Among them, after determining the type of network failure, it is also necessary to monitor the geographic location of the fault in real time, the fault will inevitably spread dynamically in the network, in the traditional network fault diagnosis needs to be constantly on-board monitoring, which consumes huge human and material resources, so the intelligent network fault diagnosis is a very important part of the network fault diagnosis.

In traditional network troubleshooting, constant on-board monitoring is required, which consumes huge human and material resources, so the exploration of intelligent network troubleshooting is the most important task in the development of modern networks.

Intelligent network troubleshooting can reduce the huge consumption of human and material resources. The introduction of intelligent network troubleshooting algorithms can better reduce network monitoring costs. At the same time, intelligent algorithms can effectively improve the efficiency of fault diagnosis. Finally, there is a huge improvement in the diagnosis accuracy. Intelligent algorithms, based on historical states, historical data, etc., can continuously learn the necessary characteristic laws when the network fails, which greatly reduces the difficulty of analyzing network failures.

The detection system requires the construction of a digital twin model that simulates the operational state and behavior of the physical system. The digital twin model can be constructed using the basic physical information and dynamic sensing information of the physical system, including geometric model, rule model, and sensor data. The digital twin model can simulate the operating state of the physical system in the virtual space and generate the corresponding data.

The system failure detection mainly relies on the data analysis of the digital twin model. Data analysis can perform feature extraction and pattern recognition on the data generated by the digital twin model to detect anomalies and faults. By comparing historical and real-time data, anomalous changes and trends can be detected to predict and diagnose potential faults. Data analysis can also pass the results to the digital twin model to update the model's parameters and rules to improve the model's accuracy and reliability. The technology can monitor the operational status of physical systems in real time, detecting anomalies and failures in time to avoid major losses. At the same time, the technology can also improve the reliability and stability of equipment and reduce maintenance costs and downtime. In addition, the edge inspection system based on digital twin technology can also improve productivity and product quality, providing strong support for the sustainable development of enterprises.

Edge detection system fault detection based on digital twin technology is a technology with a wide range of applications. It can monitor the operating status of the physical system in real time, detect abnormalities and faults in a timely manner, improve the reliability and stability of equipment, and reduce maintenance costs and downtime. In the future, with the continuous development and improvement of digital twin technology, it is believed that this technology will be applied and promoted in more fields.

3.3 Diagnostic Process

Digital twin technology makes it possible to accurately simulate and monitor equipment status, operating parameters and other information by establishing a real-time, dynamic mapping relationship between physical equipment and virtual models.

Through the sensor acquisition of equipment operation data, digital twin technology can reflect the working status of the equipment in real time, providing a basis for edge detection. When an abnormality occurs in the equipment, the digital twin model can quickly capture the abnormal data and provide support for fault diagnosis. By analyzing the historical data of the equipment, the digital twin model can predict the future operating status of the equipment and help formulate a reasonable maintenance plan.

Based on systematic feedback, the credit ability of the rules is adjusted to enable systematic self-learning. The method can realize the rapid identification of network faults, but it is less effective in terms of accuracy.Some scholars proposed a fuzzy set-based fault diagnosis model, which characterizes the state of network faults, simplifies the neural network structure, reduces the cost of the system, speeds up the diagnostic speed, and efficiently carries out the diagnosis of network faults and improves the accuracy. Meanwhile, it not only has good scalability and fault tolerance, but also improves the false alarm rate of fault diagnosis.

Key parameters including temperature, vibration, pressure, etc. are collected through sensors deployed on the equipment. The collected data is transmitted to the edge computing platform in real time. On the edge computing platform, the data is processed and analyzed using digital twin technology to extract key information.

4. Summary

Edge detection systems with digital twin technology have a wide range of applications in many fields, and their performance directly affects the effectiveness of the whole system. Through an in-depth analysis of the performance of the edge detection system and effective optimization suggestions for the existing problems, it helps to promote the further development and application of digital twin technology. In the future, with the continuous progress of technology and in-depth research, we expect to see more efficient and accurate edge detection systems with digital twin technology applied in various fields.

References

[1] Digital twin-driven visualization and monitoring method for ship loading and welding production line[J]. TIAN Guizhong; QU Pengfei; TANG Mingming; LIU Jinfeng; JING Xuwen. Journal of Jiangsu University of Science and Technology (Natural Science Edition), 2021(06)

[2] A review of research on ship digital twin and its service full life cycle[J]. YANG Shaolong; SUN Yanhao; XIANG Xianbo; WANG Zhuo; PAN Xinxiang. Ship Science and Technology, 2020(21)

[3] Interactive simulation design of engineering ship Kringle crane based on Unity3D[J]. Zhang Xiaoxi; Yin Yong. Marine Engineering, 2018(01)

[4] Development of digital asset management system for shipyard segment yard based on VR technology[J]. WANG Zhen; ZHENG Pengfei; DING Weijie; YU Lingyun; HE Di; QIU Yuzhou. Ship and Ocean Engineering, 2017(02)

[5] Research and implementation of visualization construction method based on interaction model[J]. LU Feng, CHEN Chuanbo, LU Zhengding. Computer Engineering and Science, 2003(04)

[6] Framework and key technologies for integrated development of complex product design and manufacturing based on digital twin[J]. LI Hao; TAO Fei; WANG Haoqi; SONG Wenyan; ZHANG Zaifang; FAN Beibei; WU Chunlong; LI Yupeng; LI Linli; WEN Xiaoyu; ZHANG Xinsheng; LO Guofu. Computer Integrated Manufacturing Systems, 2019(06)

[7] Research on generalized data model for intelligent control of knitting production[J]. ZHOU Yaqin; WANG Junliang; Bao Jinsong; ZHANG Jie. China Mechanical Engineering, 2019(02)

[8] Research and realization of configurable monitoring system for 3C non-standard testing equipment[J]. LI Baochao; WU Zhiqiang; ZHANG Chengrui; HU Tianliang. Combined machine tools and automated processing technology, 2018(09)

[9] Research on modeling of aerospace structural parts manufacturing workshop based on digital twin[J]. GUO Dongsheng; Bao Jinsong; SHI Gongwei; ZHANG Qiwan; SUN Xiwu; WENG Haihong. Journal of Donghua University (Natural Science Edition), 2018(04)

[10] Theory and technology of information-physical fusion in digital twin workshop[J]. Tao Fei; Cheng Ying; Cheng Jiangfeng; Zhang Meng; Xu Wenjun; Qi Qinglin. Computer Integrated Manufacturing Systems, 2017(08)

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