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Innovative Application of Emerging Sensing Technologies in Mechatronics Systems

Jianming Feng*

Xinjiang Industry Technical College, Urumqi 830021, Xinjiang, China

**Author to whom correspondence should be addressed.*

Abstract: With the rapid development of science and technology, new sensing technology has been used increasingly in mechatronics system, for the system of intelligent, automation and efficiency, provide strong support. Emerging sensor technology in electromechanical integration system of innovative applications not only promote the system of intelligent upgrade, also for its wide application in the field of multiple provides a strong support, and along with the advance of technology and application scenario development, emerging sensor technology in electromechanical integration system to play a more important role. In this regard, this paper first expounds the overview of emerging sensing technology, then analyzes the innovation and integration of emerging sensing technology and mechatronics system, and finally further explores the practical application of emerging sensing technology in mechatronics system, in order to provide some reference for relevant researchers.

Keywords: Emerging sensing technology; Mechatronics system; Innovative application

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1. Introduction

In recent years, with the rapid development of modern science and technology, the deep integration of electronic technology and mechanical technology constitutes the mechatronic system, and it is widely used in industrial manufacturing, intelligent transportation, medical health and environmental protection and other fields. In addition, the public requirements for the automation and intelligence of the mechatronic system are getting higher, and the challenges to be met are relatively complex. The emerging sensing technology has the advantages of multi-function, high sensitivity, and high accuracy, which can not only properly respond to the challenges faced, but also continue to improve the performance of the mechatronic system [1]. Depth, therefore, to explore how emerging sensor technology innovation applied to electromechanical integration system, in addition to better meeting the diversified demand from all walks of life, and promote the development of high-quality electromechanical integration systems, to promote the development of the social economy achieve high quality [2].

2. Overview of emerging sensing technologies

2.1. Classification and characteristics of emerging sensing technologies

The types of emerging sensor technologies are relatively rich, and each type has its own special features. Optical fiber sensing technology, for example, the technology is the main external physical quantity change perception by light in the optical fiber transmission characteristics, because the electromagnetic interference is not easy to affect the optical signal, and the optical fiber has strong scalability, flexibility, even under the complex electromagnetic environment of bad work environment, the optical fiber sensing technology can still stable work, Optical fiber sensing technology has high precision and sensitivity, to ensure its accurate measurement and sense tiny changes [3]. Biological sensing technology, the technical principle is the specificity of the interaction between biological molecules, such as the specificity of the enzyme and substrate combination, which can convert the biological molecular recognition information into characteristics of the light signal that can be detected. At the same time, biosensing technology has certain selectivity, specificity and can accurately and quickly detect biomolecules, which is widely used in biological detection, medical diagnosis, and other fields. Quantum sensing technology, which measures through the special properties of quantum states, can break through the limit of traditional measurement accuracy, measure weak physical quantities such as magnetic fields and electric fields with high precision, and promote the field of precision measurement to achieve new development [4].

2.2. The development process and trend of emerging sensing technologies

At present, emerging sensing technology has experienced multiple stages of development. Traditional sensor technology is mostly built on the basis of ordinary physical laws, such as capacitance sensing, resistance sensing, and other technologies, whose functionality and accuracy are limited. With the rapid development of information technology, microelectronic technology, and new materials, emerging sensing technology has begun to change in the direction of intelligence, and the research and development of emerging sensing materials, such as nanomaterials and semiconductor materials, has significantly improved the performance of sensors. Micro-electro-mechanical system (MEMS) makes the sensor show the characteristics of integration and miniaturization. At present, emerging sensor technology presents a networked and intelligent situation. Small sensors are easier to embed into various devices or combine. Multi-function sensors combined with micro-processing systems can realize intelligent, self-management, and analysis of data information. In addition, with the development of the Internet of Things becoming more and more mature, emerging sensors are realizing online data transmission and sharing, which has brought some help to the wide application of emerging sensors [5].

2.3. Application fields of emerging sensing technologies

Emerging sensing technologies are playing a more active role in all walks of life. For example, in the field of industrial manufacturing, emerging sensing technology can be applied to equipment condition monitoring, such as temperature sensors, vibration sensors, etc., to monitor the operation of equipment in real time, find out potential risks and faults in the first time, and maintain the equipment, so that the maintenance cost and time can be reduced. In the field of quality control, the accuracy of sensors can be improved, and the quality, shape, and size of products can be detected online to ensure that the products produced can meet the quality standards, so that the competitiveness and productivity of products can be further improved [6]. In the field of intelligent transportation, as an important part of automatic driving technology, cameras, laser radar, and other terminals can obtain real-time information such as road state and obstacle direction near the vehicle, provide accurate information and data to the

automatic driving vehicle, and improve the safety and driving speed of the automatic driving vehicle. On the other hand, these vehicles themselves have the ability to monitor traffic flow, road conditions, and other information in real time, which can be used for auxiliary decision-making in traffic control and vehicle routing design. In the field of health care, biological monitoring technology can be used to monitor body conditions and diseases. For example, blood glucose sensors can dynamically monitor the blood glucose concentration of the human body in real time and provide targeted treatment plans for diabetes patients. Biochips can detect a variety of biomolecules at the same time, detect diseases in time and carry out personalized treatment, and improve the level of disease treatment and diagnosis as a whole [7].

3. Innovative integration of emerging sensing technologies and mechatronics systems

3.1. Integration at the structural level

When new sensing technology is applied to the mechanical and electrical integration of system development, it increases the intelligence of the mechatronics system and fully improves precision. Taking mechanical structures as an example, fiber optic sensors embedded in structures such as Bridges and aircraft wings can detect compression deformation in real time. Once the compression mutation or deformation occurs, the new sensors will immediately respond and feed back the information to the relevant personnel, providing an important basis for the improvement and maintenance of bridge and aviation machinery safety. For precision production equipment, the use of position sensors and Angle sensors of the device to monitor the direction and attitude of the cutter can ensure the quality of high-precision cutting products. At the same time, the mechatronic system architecture is relatively simple due to the use of emerging sensor technology. For example, the use of miniaturized sensors and an integrated design scheme, the organic combination of sensors and mechanical structures, reduces the volume and weight of the system, making the mechatronic system more flexible and portable [8].

3.2. Integration at the functional level

The application of emerging sensor technology in mechatronics systems can expand the functional range and application field of sensing technology. For example, in the field of medical instruments, the biosensing technology is integrated into the sensor, which can accurately monitor the physiological indicators of the human body in real time. For example, active biosensors in wearable devices can record life indicators such as heart rate, blood pressure, and oxygen content in the blood in real time, and give health advice or reminder instructions accordingly. In the factory automation manufacturing process, a variety of sensors are paired with each other to monitor and control the whole production process in real time, and the parameters of the production process can be measured in real time through temperature, pressure, flow, and other sensors, and combined with advanced control algorithms, the production process can be optimized and adjusted, so as to improve production efficiency and product quality. Produce products that meet the needs of the public [9].

3.3. Integration at the control level

In the control link of mechatronic systems, the application of emerging sensing technologies provides strong support for achieving more accurate and intelligent control. The high-precision measurement ability of quantum sensing technology enables the control system to obtain more accurate parameters such as position, velocity, and acceleration, so as to realize the precise control of moving parts. For example, in CNC machine tools, sub-micron

precision control of tool position can be achieved by using quantum sensing technology, and machining accuracy and surface quality can be improved. At the same time, the fusion of sensing technology and control systems can also realize the real-time monitoring and adaptive adjustment of the system's operation state. The real-time operation data of the system is collected by the sensors, and the control system automatically adjusts the control parameters according to these data to adapt to different working conditions and task requirements [10].

4. Practice and exploration of emerging sensing technologies in mechatronics systems

4.1. Practical application in the field of industrial manufacturing

With the application of emerging sensing technologies in industrial manufacturing, mechatronics systems are gradually developing towards intelligence. For example, in the automotive field, the emerging sensor technology has been widely used in various production links, for example, in the body welding, the introduction of laser sensor, vision sensor and other technologies, real-time monitoring of the body welding quality, and in the presence of defects immediately adjusted to ensure the qualification and high quality of the body welding. Another example, in the assembly link, the application of a force sensor and a position sensor makes the manipulator more accurate in grasping and assembling parts, to avoid quality defects due to splicing errors. At the same time, the emerging sensors can also be used for high-quality management of enterprise operations and production. For example, by deploying energy consumption sensors to observe the energy usage of equipment in real time, the data results are used with optimization algorithms to realize energy allocation and utilization, reduce production costs, realize energy saving, and effectively improve the production level and quality of industrial manufacturing [11].

4.2. Practical application in the field of intelligent transportation

In the field of intelligent transportation, various emerging sensors are also indispensable auxiliary technologies for building intelligent traffic control systems and realizing unmanned driving modes. All kinds of sensors integrated in unmanned vehicles, such as laser radar, millimeter wave radar, camera, and so on, cooperate with each other to continuously collect and reflect the surrounding environment information to the vehicle in real time. Lidar can accurately capture the distance and position between the vehicle and the obstacles, and reflect clear topographic map information to the unmanned vehicle in real time. The role of cameras is to detect road signs, traffic lights, and other moving cars or pedestrians, so as to have a 360-degree understanding of the current road conditions. Through the comprehensive processing of the collected information, driverless cars can make corresponding decisions to realize automatic positioning, navigation, and obstacle avoidance, etc., which also makes a large number of sensors applied to intelligent transportation infrastructure to continuously improve the convenience of intelligent transportation [12].

4.3. Practical application in the field of medical health

In the field of health care, emerging sensor technologies also play an important role. Sensors are widely used in medical devices to improve the accuracy of diagnosis and the effectiveness of treatment [13]. For example, in an electrocardiogram instrument, sensors are able to accurately measure the electrical activity of the heart, helping doctors accurately determine the health status of the heart. In the glucose meter, the sensor can quickly detect the glucose concentration in the blood, providing timely blood glucose monitoring for diabetic patients. In addition, with the popularity of wearable devices, sensors are also applied to health monitoring bracelets, smart clothing,

and other products to monitor users' physiological indicators in real time, such as heart rate, blood pressure, and step count, and provide users with personalized health management programs. These applications not only improve the efficiency and quality of medical services, but also bring more convenience to people's healthy lives, and further show the application advantages of emerging sensing technologies in mechatronic systems [14].

4.4. Practical applications in the field of environmental protection

Emerging sensor technologies also have great development prospects in the field of environmental protection. In the environmental monitoring system, many types of emerging sensor technologies are added for real-time monitoring, which can monitor atmospheric conditions, water quality conditions, and land pollution degree in real time. For example, in the air monitoring station, the relevant environmental sensors are used to monitor the pollution degree of $PM_{2.5}$, PM_{10}, SO_2, and NO_2 in the air in real time, and the corresponding monitoring data is reported to the environmental protection department, so that it can grasp the air pollution status in time and improve it. In water quality monitoring section, the sensor can monitor the dissolved oxygen and pH value of water quality, turbidity and heavy metal content, monitoring personnel according to the corresponding data can be found that the pollution of water bodies in time, and processing; In the field of land pollution monitoring, using soil sensor to toxic substances content in the soil, which will provide a scientific basis for soil restoration and protection, so the APP to improve the accuracy and efficiency of the environmental monitoring, also will improve the effectiveness of the environmental monitoring task, constantly enhance the level of environmental protection.

5. Conclusion

In a word, this paper systematically discusses the innovation and integration of emerging sensor technology in mechatronics systems. Because of the unique advantages of emerging sensor technology, its function is fully embedded in the mechatronics system, which can improve the functionality and efficiency of the system as a whole. Moreover, the new sensor technology is directly applied to industrial manufacturing, intelligent transportation, medical health, environmental protection, and other fields, which not only reflects the great potential but also has great use value, and promotes the development of these fields in the direction of intelligence [15]. With the continuous development of science and technology, the application and improvement of emerging sensing technology will be more full and extensive, and I believe that there will be more and more innovative sensing technology applied in the mechatronic system in the future, so as to make the production of various industries more efficient, people's lives more intelligent, higher quality of life, and make outstanding contributions to the sustainable development of society.

Disclosure statement

The author declares no conflict of interest.

References

[1] Yu Y, 2020, Application of Intelligent Control Technology in Mechatronic System. Paper Equipment & Materials, 54(04): 110–112.

[2] Gao R, 2025, Application of Mechatronics Intelligent Monitoring System in Coal Mine Safety Production, China

Mechatronics Technology Application Association. Selected papers of the 8th National Petroleum and Chemical Electrical Design and Application Paper Competition. Xinjiang Research Institute of China Coal Science and Engineering Group Co., LTD., 784–785.

[3] Dang H, 2020, Research on Mechatronics Intelligent Control System Based on Digital Modeling Technology. Modern Manufacturing Technology and Equipment, 61(02): 184–186.

[4] Yu Y, 2025, Design and Research of Mechatronics System in Cloud Computing Environment. China Strategic Emerging Industries, (06): 20–22.

[5] Jiang J, Si D, 2024, Monitoring Application of Coal Mine Mechanical and Electrical Equipment Based on Optical Fiber Sensor Technology. Inner Mongolia Coal Economy, (23): 157–159.

[6] Lu R, 2024, Design and Stability Analysis of Mechatronics System for Robot Mobile Platform. Smart China, (11): 71–72.

[7] Wang L, 2024, Research on Design and Application of Mechatronics System Based on Intelligent Manufacturing Technology, China Intelligent Engineering Research Society. Proceedings of 2024 Engineering Technology Application and Construction Management Exchange Conference (II). Zhejiang Yazhixing Auto Parts Co., LTD., 129–131.

[8] Feng Y, 2024, Design and Implementation of Digital Intelligent Control System for Mechatronics Based on Digital Modeling. Automation Application, 65(20): 75–77 + 81.

[9] Lu R, 2024, Design and Research of Mechatronics Control System Based on Machine Vision. Technology & Market, 31(10): 40–42 + 46.

[10] Liu X, 2024, Design of Automatic Control System for Electromechanical Equipment Based on Laser Sensor. Modern Manufacturing Technology and Equipment, (S1): 97–99.

[11] Luo X, 2024, Teaching Design of Mechatronics System Course Based on Digital Twin. Science Consulting, (14): 132–135.

[12] Yao X, 2024, Research on the Application of Intelligent Sensor Technology in Monitoring and Protection of Mechanical and Electrical Systems, Guangxi Network Security and Information Technology Federation. Proceedings of the First Academic Exchange Conference on Engineering Technology Management and Digital Transformation. Shaanxi Beidou Xingxing Technology Development Co., LTD., 120–123.

[13] Tang S, Tian B, 2024, Monitoring Method of Mine Electromechanical Equipment Running State Based on Multi-Sensor Information Fusion Technology. Mining Equipment, (05): 147–149.

[14] Li S, 2024, Design of Mechatronics System Based on Multi-Sensor Information Fusion. China New Technology & Products, (08): 40–42.

[15] Zhang J, 2024, Automated Control System for Mechatronic Equipment Based on Laser Sensors. Automation and Instrumentation, 39(03): 103–106 + 125.