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# *Application of Mechanical Electronic Engineering Technology in Sensor Measurement System*

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***Abstract:*** With the development of the times and technological progress, sensor measurement technology is also constantly developing. Mechatronics engineers are different from traditional mechatronics engineers. They utilize the manufacturing technology of mechatronics and the power of mechatronics engineers to stand at the forefront of the mechatronics technology revolution. New mechatronics engineers have been fully developed and gradually become mechatronics engineers. Today, the rise of mechanical Electronic engineering technology undoubtedly brings opportunities and challenges to sensor measurement systems. While replacing the technology and methods of old sensor measurement systems, it also brings important innovations. This paper mainly introduced the current situation, evolution and future prospects of mechanical and Electronic engineering technology, aiming at promoting its development and evolution, and discussed the application of mechanical and Electronic engineering technology in sensor measurement systems. Finally, the experimental analysis verified that the sensor measurement system based on mechanical Electronic engineering technology was 0.0785, 0.03%, less than 2um and less than 0.04% higher in sensitivity, linearity, return error and repeatability than the sensor measurement system with traditional technology, which showed the superiority of its overall performance.

## 1. Introduction

With the continuous development of science and technology, mechanical Electronic engineering technology has been widely used in the field of sensor measurement systems. Sensors can perceive physical quantities and convert them into electrical signals for output, thereby achieving monitoring and control of various parameters in mechanical engineering.

A large number of scholars have conducted relevant research on sensor measurement systems. GeX first discussed in detail the application of mechanical Electronic engineering technology in sensor measurement systems. Some major issues related to the design of distributed estimators were discussed, such as estimator structure, communication constraints and design methods. Secondly, Ge X emphasized the latest development of event based distributed estimators, which have received widespread attention in recent years. Then, Ge X described the basic principles of event based incentive mechanisms and summarized recent results obtained under different event based incentive conditions. Thirdly, Ge X introduced the application of event based distributed estimators in practical sensor network-based control systems, such as networked distributed manufacturing and object tracking systems. Finally, Ge X raised some challenging issues that require further research [1]. Abdulkarem M. proposed a Structural health monitoring system based on wireless sensor networks, and reviewed the latest progress in Structural health monitoring using wireless sensor networks. He outlined wired and wireless sensor system technology, the structure and functions of wireless sensor nodes, communication technology, and their common operating systems. Subsequently, he comprehensively summarized and described the latest academic and commercial wireless platform technologies for laboratory and field testing of Structural health monitoring applications. Finally, he discussed the outstanding research challenges of wireless sensor networks in Structural health monitoring [2]. Duan Z introduced a multifunctional paper humidity sensor with many advantages. This humidity sensor is made of smooth printing paper and flexible conductive tape using a simple bonding method, where paper is both the material and substrate of the humidity sensor. Due to the moderate hydrophilicity of paper and the design of the paper humidity sensor, the sensor has good sensitivity and linearity (R2=0.9549) for humidity above 103 in the range of relative humidity of 41.1% to 91.5%. In addition, paper humidity sensors have high universality and compatibility, allowing them to be used for measuring respiratory rate, infant diaper humidity, non-contact transfer, skin humidity, and spatial position monitoring. Although paper humidity sensors have relatively high impedance, the sensor's response to humidity detection can be easily processed by the proposed signal processing system. Easy to obtain starting materials and convenient manufacturing methods are a useful strategy for developing multifunctional humidity sensors [3]. The technology used in the above research is relatively outdated.

Mechanical and electrical engineering is a broad field with a broad knowledge base, rich theories, and extensive applications, which is why it plays an important role in China's higher education field and is closely related to other technologies. Mechanical and electrical engineering has enormous potential, driving early innovation in mechanical and electrical engineering by introducing high automation to replace traditional human labor and improve efficiency while reducing costs. This paper discusses the application of mechanical Electronic engineering technology in sensor measurement system. The perfect combination of mechanical Electronic engineering technology and sensor measurement system can save a lot of manpower and realize the automation of measurement system.

## 2. Mechanical Electronic Engineering Technology in Sensor Measurement System

### 2.1 Mechanical Electronic Engineering Technology

Mechanical and electronic technology belongs to a relatively broad discipline, which has a common term, that is, mechatronics. In daily life, mechanical and electronic technology has been widely applied, and it has been developing, conducting research and development, and constantly innovating technology [4-5]. Through continuous development, research and development, innovation, and reform, electromechanical technology has become a relatively mature discipline [6]. Mechanical Electronic engineering includes three aspects of mechatronics theory, mechatronics design and mechatronics manufacturing. It is a comprehensive system containing theoretical knowledge, design and manufacturing, covering all aspects of life [7]. Whether in theory, design or manufacturing, mechanical and Electronic engineering is a relatively general discipline, not limited to a certain discipline [8]. Fundamentally, mechanical Electronic engineering is a comprehensive field combining electronics, machinery and information technology. It has a certain connection with intelligent technology. Since then, it has formed its own technical and academic support system [9]. Compared with traditional engineering, mechanical Electronic engineering has the advantages of flexibility, scientificity, efficiency and so on. To some extent, it has raised the production efficiency of related products to a new height and applied it to people's daily life [10]. Therefore, mechanical Electronic engineering can be regarded as an optimized comprehensive engineering. Its industrial products include: Ticket machine, photocopier, automobile airbag, automatic loading and unloading equipment [11]. Compared with traditional mechanical engineering, electromechanical technology has higher efficiency. The important reason is that it integrates methods and technologies from various fields in a reasonable manner, and applies them scientifically and rationally to its own field. In other words, its development direction has no limitations [12].

In the context of the multidimensional development strategy of electromechanical engineering technology, the importance of some independent technologies is inevitably overlooked. The phenomenon of "light electricity heavy machinery" has always been a core feature of university courses, let alone the widespread application of electromechanical engineering technology in companies and factories [13]. Alpha Go defeated South Korean players in 2016, marking the entry of computer technology into a new era of information technology and artificial intelligence. At present, machine and computer technology have been widely applied in enterprise production, but there are still some challenges in the use process, such as low efficiency, long cycles, and high error rates. Technology should be used to reduce errors, and artificial intelligence should be used to improve and monitor operations to partially overcome these problems.

### 2.2 Sensor Technology

#### 2.2.1 Introduction to Sensor Technology

Since its inception, sensor technology has aroused great interest among people. Sensors have solved the problem of physical quantities that cannot be measured using conventional methods, thereby promoting the development of related research fields [14-15]. The concepts of magnetic field and electromagnetic induction are closely related to electrical physics, so the development of electromagnetic instruments is a natural result of technological progress. Electromagnetic method has unique advantages in measurement. Firstly, electromagnetic waves are a continuous signal that can be used for continuous measurement of physical quantities. Secondly, an electromagnetic measuring instrument is used to establish a distance between the measuring instrument and the object being measured, thereby eliminating measurement errors caused by the measuring instrument itself. Transforming non electrical physical quantities into electrical physical quantities is a promising testing method [16].

#### 2.2.2 Application of Wireless Sensor Technology in Non Highway Cranes

When the hook tilts, the lifting energy exerts uneven force on the crane, which may lead to safety related accidents. There are significant safety hazards when lifting large objects. There is a high risk of injury when moving the hook up and down. Wired sensors should not be used for detection. A wireless sensor scheme can be used to detect the position of the hook, that is, connect the wireless angle sensor to the hook, and the wireless angle sensor determines the angle of the hook plate in real-time. The block diagram of the control system is shown in Figure 1. The PLC (Programmable Logic Controller) input of the crane controller can be connected to the wireless sensor transmitter and communication mode through the CAN (Controller Area Network) bus. The output of the PLC is connected to the solenoid valve through a 4-20mA current signal to control the opening speed of the solenoid valve, thereby controlling the speed of the crane. At the initial alignment, the tilt angle feedback from the wireless sensor must be used to ensure that the hook is in a horizontal position before lifting. During the lifting process, wireless sensors detect the tilt angle of the hook plate in real-time. When the tilt angle reaches a certain value, the PLC controls the actuator by releasing the flow of the solenoid valve.

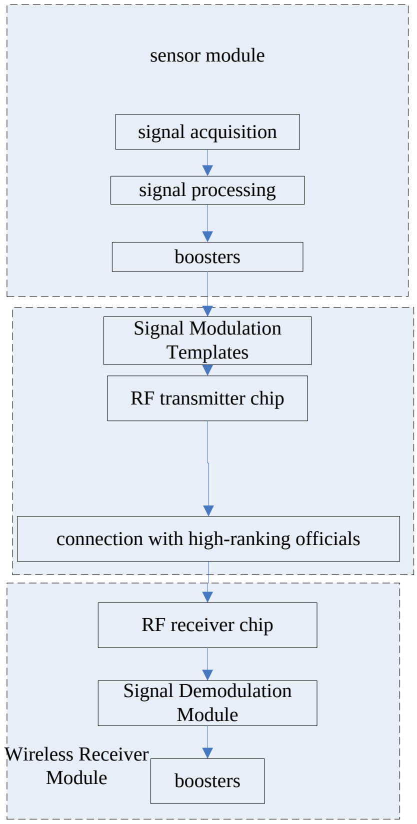


Figure 1: Control system composed of wireless sensors

### 2.3 Practice and Application of Sensor Technology in Electromechanical Technology

Sensing technology is used in the manufacturing and production operations of sensing equipment, playing an important role in various stages of production. Especially, automatic sensing equipment and its automation technology can fully control production operations, provide timely feedback on production problems, and enable workers to solve certain problems faster and more accurately, so that machines and equipment can resume normal operation as soon as possible, thereby reducing the possibility of problems occurring [17].

Compared to old-fashioned machines, modern machines with automatic detection capabilities have more advantages. Automatic detection technology also plays an important role in the production control of key components. Compared with traditional control, it can reduce labor costs and make automatic information processing faster and more effective. It can also reduce errors caused by human intervention, reduce the likelihood of errors, and help effectively control and manage production operations [18]. In automated industrial production, with the development of advanced technology, safety requirements are becoming increasingly strict, leading to an increase in the level of automation of sensing and process monitoring at all levels. Sensors are widely used in steel, paper, petrochemical, pharmaceutical, food, and other industries [19]. For example, differential pressure sensors are used in medicine, and infrared sensors are used in hazard warning systems. Eddy current sensors are used to measure the thickness of printed materials, and distance sensors are used to determine vehicle speed, and so on. Humidity sensors are widely used in the textile and printing and dyeing industries [20]. In industries such as textiles, printing and dyeing, accurate measurement of environmental humidity is often required due to the high requirements for environmental humidity. Humidity sensors convert moisture into electronic signals through sensitivity to moisture. Humidity sensors have the advantages of fast response speed and high measurement accuracy, making them increasingly used in the printing and dyeing industry.

## 3. Testing System Software Testing

### 3.1 Experimental Preparation

Based on LabVIEW, this system collects, analyzes and processes the data measured by Linear encoder. The system mainly includes two aspects: data collection and processing. The data collection section configures the hardware of the data collection channel of the data collection board, configures the sampling frequency, sampling mode, and sampling quantity, and configures the data collection format. The data acquisition module obtains data from four acquisition channels and inputs it into the upper processor. The data processing section is responsible for analyzing, storing, and visualizing the received data.

Data processing mainly involves converting raw linear action data into multi-dimensional actions and domain actions. In the time domain, the filter is analyzed and calculated. Then, every 100 sampling points are filtered to obtain the corresponding linear motion sensor measurement values. The effective, maximum, and minimum values of each channel are compared at these 100 points. Frequency domain analysis can be applied in real-time to the spectral data of each channel, as well as to the spectral analysis of historical and recorded data to verify the frequency composition of the measured signal and ensure the accuracy of the measured and recorded data. When the analysis button is pressed, historical data is defined as 100 data points, and when the record button is pressed, recorded data is defined as all data points.

In the "Save Data" section, the "Save" button is clicked, and the test data is saved to a file. The path and file name are entered, and the "Open" button is clicked. The saved data is opened, and the previous data is viewed. The "Data and information visualization" part includes displaying the set parameters, displaying the original data waveform and the data of the two sensors tested, displaying the time and data waveform for analysis, and displaying the frequency domain data waveform for analysis.

### 3.2 Measurement and Results

The developed measurement system is used, and data is obtained from sensors 1 and 2. Sensor 1 is a sensor based on traditional technology, and Sensor 2 is a sensor based on mechanical Electronic engineering technology. The least squares method is used to fit the outputs of all linear displacement sensors and obtain corresponding theoretical curves. Figures 2 and 4 provide the true outputs and fitting results of sensors 1 and 2, resulting in the following theoretical curves:

$$y_{1f} = 4.4306x_{1f} - 5.233 \tag{1}$$

$$y_{2f} = 4.409x_{2f} - 4.941 \tag{2}$$

The basic error curve obtained from the difference between the fitted curve and the actual measurement is shown in Figures 3 and 5.

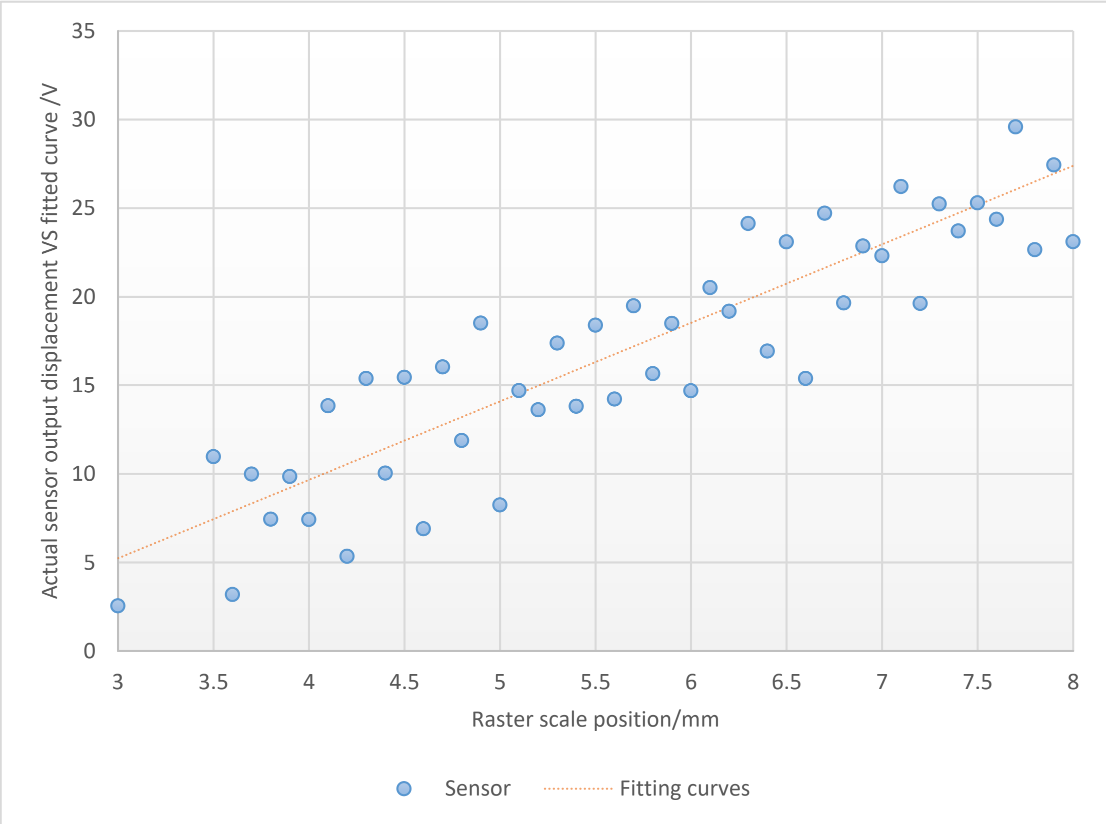


Figure 2: Actual output and fitting curve of sensor 1

As shown in Figure 2, the voltage displacement of sensor 1 shows a linear relationship throughout the entire range. The distribution of actual output data is relatively scattered. The distribution of the actual output data distance fitting curve is relatively scattered.

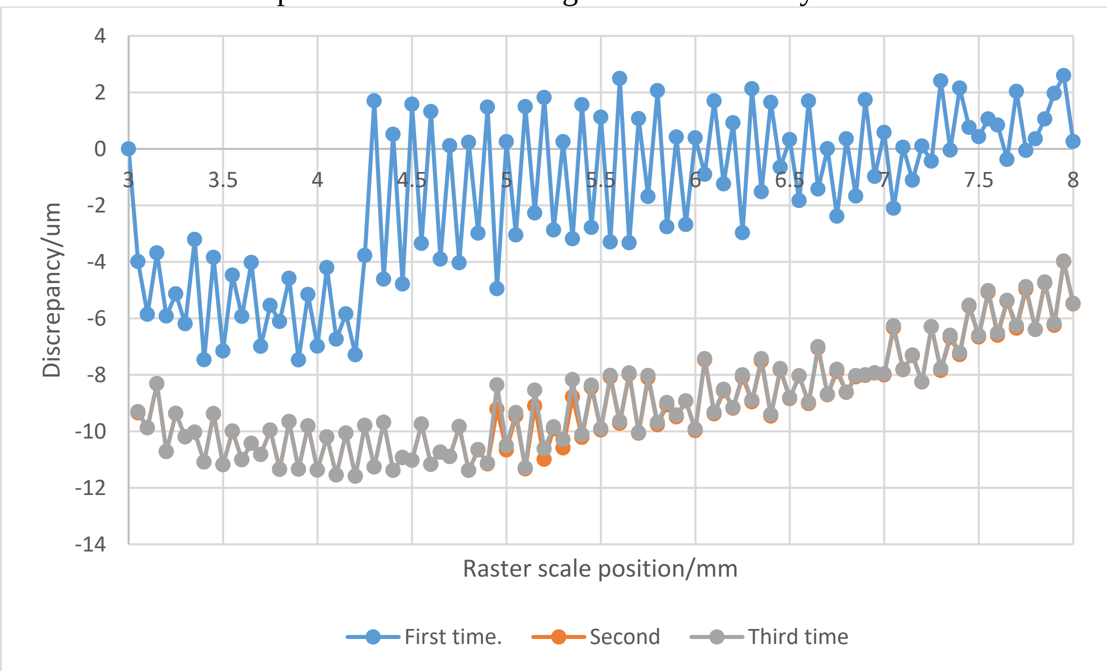


Figure 3: Difference between the fitted curve of Sensor 1 and the actual difference

As shown in Figure 3, the actual output displacement and fitting difference of the sensor are significantly different in the first, second, and third orders. The absolute values of the differences in the first experiment are relatively small, while the absolute values of the differences in the second and third experiments are relatively large. However, the fluctuations in the differences in the three experiments are not significant and are basically controlled between 0 and 10um.

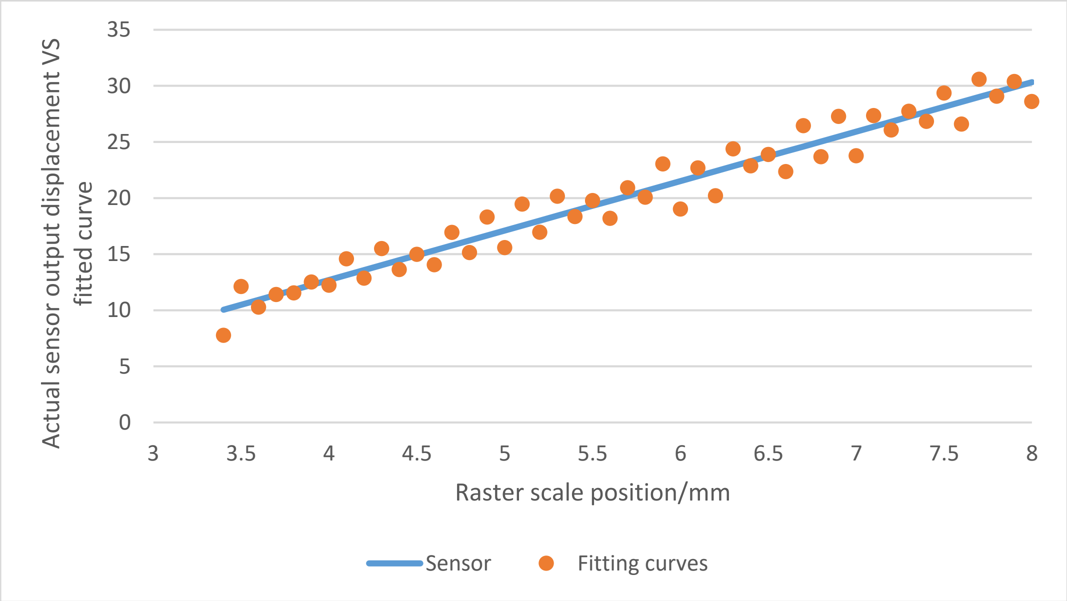


Figure 4: Actual output and fitting curve of sensor 2

As shown in Figure 4, the actual displacement data output by the sensor is basically linearly correlated with the position of the grating ruler, and the output data of sensor 2 is more closely distributed from the ideal fitting line, resulting in higher linearity.

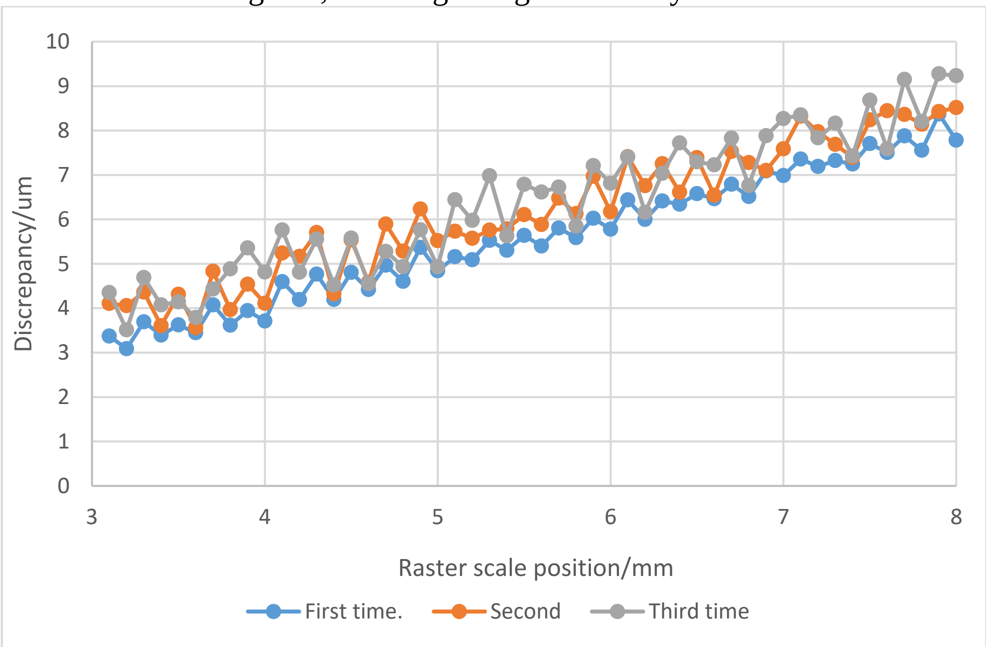


Figure 5: Difference between the fitted curve of Sensor 2 and the actual difference

As shown in Figure 5, the voltage deviation characteristic of sensor 2 is linear throughout the entire region, with a basic error of 3-10μ m for three measurements. The basic error is relatively stable in the center, but there are significant fluctuations near the upper and lower limits.

After analyzing the measured data, the results obtained are shown in Table 1. From the table, it can be seen that the important values for sensor 1 and sensor 2 and 5 are all within this range.

Table 1: Various indicators of sensor 1 and sensor 2

| Sensor number | Sensitivity | Linearity | Maximum fundamental error/μm | Return Error/μm | Repeatability |
|---|---|---|---|---|---|
| 1 | 4.4306 | 0.14% | 11 | 6 | 0.14% |
| 2 | 4.5091 | 0.17% | 11 | 4 | 0.1% |

From the five indicators in Table 1, it can be seen that the performance of sensor 2 is better than sensor 1. In terms of sensitivity, linearity, return error, and repeatability, sensor 2 has better indicators.

## 4. Conclusions

With the advancement of technology and the mutual penetration of various disciplines, the application range of sensors is constantly expanding, closely linking wireless technology, automation technology, and the performance of sensors themselves, thereby making the functions of sensors more reliable. In the development process of new technologies, in order to achieve higher production levels, enterprises can also control automatic sensing equipment to achieve higher production levels. This article explored the use of automation technology in mechanical and electrical engineering to reduce manual operation of sensor equipment, save resources, and increase testing accuracy, which is of great research significance.

## References

*[1] Ge X, Han Q L, Zhang X M. Distributed event-triggered estimation over sensor networks: A survey. IEEE transactions on cybernetics, 2019, 50(3): 1306-1320.*

*[2] Abdulkarem M, Samsudin K, Rokhani F Z. Wireless sensor network for structural health monitoring: A contemporary review of technologies, challenges, and future direction. Structural Health Monitoring, 2020, 19(3): 693-735.*

*[3] Duan Z, Jiang Y, Yan M.Facile, flexible, cost-saving, and environment-friendly paper-based humidity sensor for multifunctional applications. ACS applied materials & interfaces, 2019, 11(24): 21840-21849.*

*[4] Chen X. Application of Intelligent Control in Mechatronics System. Engineering Advances, 2022, 2(2): 182-185.*

*[5] Najeh L M, Ala B. The Need for System Approach and Mechatronics for Agricultural Applications. Journal of Computer Science and Control Systems, 2021, 14(1): 26-29.*

*[6] Kustija J, Ana A, Jayanto N. Web-based and thinvnc remote laboratory implementation to support students skills in mechatronics course to face the industrial revolution 4.0. Journal of Engineering Science and Technology, 2021, 16(2): 1800-1813.*

*[7] Oluwatimilehin A S, Chimezia U K, Danladi M. Integration of automobile mechatronics technology into the curriculum of automobile trades programmes at the technical colleges in Nigeria. Britain International of Linguistics Arts and Education (BIoLAE) Journal, 2021, 3(1): 1-9.*

*[8] Gao H, Liang B, Oboe R.Guest editorial introduction to the focused section on adaptive learning and control for advanced mechatronics systems. IEEE/ASME Transactions on Mechatronics, 2022, 27(2): 607-610.*

*[9] Despa V, Badea F, Badea S I. Progressive Conceptions of the Future in Cyber-Mix Mechatronics Industry and Claytronics Engineering (II). Scientific Bulletin of Valahia University-Materials and Mechanics, 2022, 18(19): 43-46.*

*[10] Wu J, Zhang H, He R. A mechatronic brake booster for electric vehicles: Design, control, and experiment. IEEE Transactions on Vehicular Technology, 2020, 69(7): 7040-7053.*

*[11] Shirvani H K, Zeng J Q C, Bevers P.Linear Time-Invariant Model Identification Algorithm for Mechatronic Systems Based on MIMO Frequency Response Data. IEEE/ASME Transactions on Mechatronics, 2022, 28(2): 703-714.*

*[12] Nuritdinovich N K, Rustamovich M N, Rakhimov T O. algorithm for calculating the parameters of a multi-position electromagnetic linear mechatronic module. Chemical Technology, Control and Management, 2021, 2021(6): 42-48.*

*[13] Wang X, Wu M, Wang J. On-line monitoring of steel ball stamping by mechatronics cold heading equipment based*

*on PVDF polymer sensing material. Nonlinear Engineering, 2022, 11(1): 168-174.*
*[14] Steinbuch M, Oomen T, Vermeulen H. Motion control, mechatronics design, and Moore's law. IEEJ Journal of Industry Applications, 2022, 11(2): 245-255.*
*[15] Rogers C, Piggott A Y, Thomson D J. A universal 3D imaging sensor on a silicon photonics platform. Nature, 2021, 590(7845): 256-261.*
*[16] El-Sheimy N, Youssef A. Inertial sensors technologies for navigation applications: State of the art and future trends. Satellite Navigation, 2020, 1(1): 1-21.*
*[17] Tyagi D, Wang H, Huang W.Recent advances in two-dimensional-material-based sensing technology toward health and environmental monitoring applications. Nanoscale, 2020, 12(6): 3535-3559.*
*[18] Gu X, Cao Z, Jolfaei A. EEG-based brain-computer interfaces (BCIs): A survey of recent studies on signal sensing technologies and computational intelligence approaches and their applications. IEEE/ACM transactions on computational biology and bioinformatics, 2021, 18(5): 1645-1666.*
*[19] Meng H, Wang S, Gao C. Research on recognition method of railway perimeter intrusions based on Φ-OTDR optical fiber sensing technology. IEEE Sensors Journal, 2020, 21(8): 9852-9859.*
*[20] Li X, Liu B, Zheng G. Deep-learning-based information mining from ocean remote-sensing imagery. National Science Review, 2020, 7(10): 1584-1605.*