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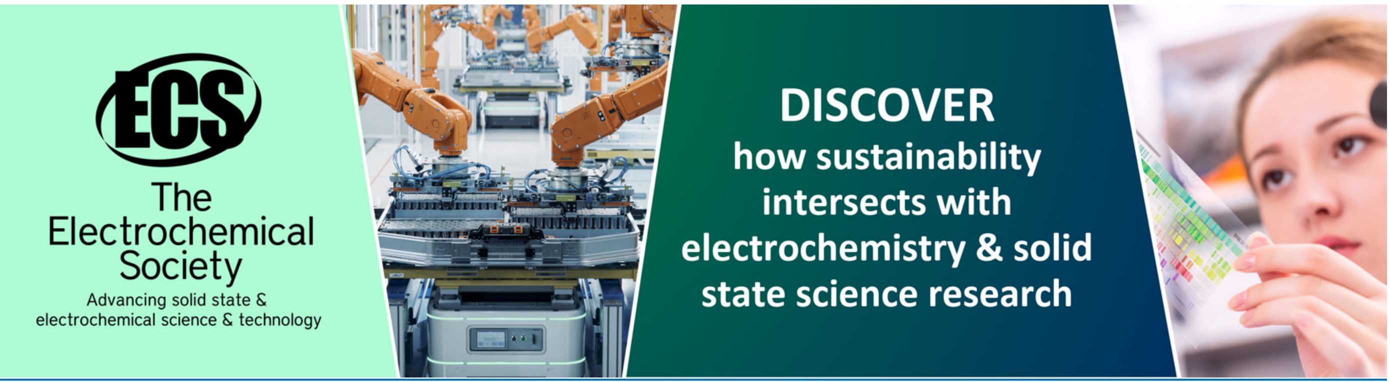

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Design and Implementation of Intelligent Robot Walking Control System Based on DSP

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Abstract: In recent years, the aging of the population and the acceleration of urbanization have led to a decrease in labor force, an increase in production costs and a decrease in labor productivity. In order to solve these problems, the degree of mechanical automation is bound to increase. This paper has completed the design and development of the automatic walking robot control system, mainly to realize the functions of visual navigation and walking control of the control system. The experiments prove that the vision navigation system of the automatic walking robot can provide the walking control system with direction identification and identification information of the ridge and furrow extension paths between fields. The designed walking control system can call the motor driver to realize the forward, backward, left forward, right forward, left backward and right backward rotation of the control object according to the path information. After experimental debugging, the automatic walking robot can move according to the direction of the identification image, which greatly improves the real-time and intelligent level of the automatic walking robot.

1. Introduction

Robot technology is a comprehensive result of the development of science and technology, which has had a significant impact on social and economic development, and its development is attributed to the strengthening of economic investment and economic development in various countries during the Second World War. On the one hand, it is the inevitable result of the development of productive forces and the development of human beings themselves [1]. In the process of transforming and understanding nature, a kind of slave capable of liberating people is needed. This slave can replace people to engage in complicated and heavy manual labor and realize people's understanding and transformation of the unreachable world. This is also an objective need of people in the process of scientific and technological development. On the other hand, the development of electronic technology, computer technology, manufacturing technology and other related technologies also provide a strong technical guarantee [2]. Robots are machines that have some human-like functions, which has two characteristics: one is some human-like functions, such as homework function, perception function, walking function, etc. Another feature is that it can work automatically according to the computer's programming. Through programming, its work, actions, working objects and some working requirements can be changed [3]. At present, there is no uniform definition of robot. Generally speaking, we think that robot is a computer-controlled programmable automated machine capable of completing certain work or moving.

The research on robot technology in our country began in the late 1970s when a Japanese industrial automation products fair was held in Beijing. Two products were displayed at the meeting: one was a numerical control machine tool, and the other was an industrial robot. So many scholars in our country saw such a direction and began to carry out research on robots. However, the research at this time is basically limited to the theoretical discussion stage [4]. In 1986, when research was developing at its fastest pace, our country set up the 863 High-tech Development Plan. Robot technology was listed as one of the important development themes. The country invested several hundred million dollars to support robot research, which made our country develop rapidly in the field of robots.

Research on mobile robots began in the late 1960s. Nilssen and Rosen of Stanford Research Institute created an autonomous mobile robot named Shakey from 1966 to 1972, of which purpose is to study the autonomous reasoning, control and planning of robot systems applying artificial intelligence technology in complex environments [5]. At the same time, the earliest operational walking robot has also been successfully developed. Recently, the robot walking mechanism has been studied to solve the problem of robot movement in uneven areas, and a multi-legged walking robot has been developed and designed. In the late 1970s, with the application of computers and the development of sensing technology, the research on mobile robots reached a new climax. Especially in the mid-1980s, the wave of designing and manufacturing robots swept across the world, and many world-famous companies began to develop mobile robot platforms. These mobile robots are mainly used as mobile robot experimental platforms for university laboratories and research institutions, thus promoting the emergence of various research directions in mobile robotics. Since the 1990s, with the development of high-level environmental information sensors, adaptive mobile robot control technology information processing technology and planning technology in real environment as the signs, higher-level research on mobile robots has been carried out.

With the development of control technology, sensing technology, machining and new material technology, especially the rapid development of computer, network and image processing technology, the research on intelligent navigation of mobile robots has made breakthrough progress [6]. At present, the application field of mobile robots is continuously expanding, the complexity of mobile robots' indoor and outdoor activities environment is also increasing day by day, and the requirements for mobile robots are also increasing. The robot is not only required to have the characteristics of small volume, strong load capacity, light self-weight, etc., but also required to be able to complete some complex tasks, and to cooperate with other robots to complete tasks or to improve its work efficiency through division of labor with other robots. At the same time, the requirements for robot navigation accuracy are also increasing.

On the basis of comprehensive analysis and comparison of various current robot control technology and methods, this study combines image processing with embedded system, analyzes the characteristics and principles of image sensors, and designs and develops an automatic walking robot platform based on embedded system by using embedded system.

2. Method for Realizing Double-Shaft Synchronous Control

During the operation of the servo system, the controlled object characteristics of the servo system are changed due to the influence of factors such as the change of moment of inertia and disturbance of external load torque, so that the setting parameter obtained before the system operation cannot match the system characteristics, causing the control performance of the servo system to decline and fluctuate [7]. In order to keep the servo system with good control performance all the time, the controlled object characteristics of the servo system must be identified on line, and the control parameters must be corrected on line according to the identification results.

AC servo system has been widely used in many high-tech fields, such as laser processing, robots, numerical control machine tools, large-scale integrated circuit manufacturing, office automation equipment, radar and various military weapon servo systems, and flexible manufacturing systems.

At present, there are usually two methods to realize dual-axis synchronous control at home and abroad: one is the traditional mechanical method, the other is the more popular electric control method [8]. The mechanical double-shaft synchronous control is consistent with the shaft control of common numerical control machine tools in the control mode, has no special requirements, and has simpler control. However, its mechanical transmission structure is complex, which further limits its application in space-constrained situations. However, the double-shaft synchronous control with electric control mode is not limited by structure and is more flexible to use. Compared with the mechanical type, it has a more compact transmission chain and greatly reduces the influence of errors caused by gaps. The electric control mode has become the preferred control mode for synchronous drive. The electrical synchronization methods mainly include master-slave reference synchronization control, master-slave synchronization control and cross-coupling synchronization control.

2.1 Master Order Reference Synchronization Control

The master command reference synchronous control [9] is the simplest double-shaft synchronous control method, i.e. the two identical drive shafts are used to run in parallel, and the structure diagram is shown in Fig. 1. In the master command reference synchronous control system, the input signal of the system acts directly on each shaft, so each unit obtains a consistent input signal. Since the shafts are controlled independently and have no interaction, when a certain shaft is disturbed in the operation process, the inter-shaft synchronization error cannot be eliminated. Especially when one of the shafts has poor dynamic characteristics, the running speed of the whole system will be greatly limited. The synchronization position deviation under the control mode is sensitive to the change of inter-axle characteristics and has poor synchronization performance, which is difficult to meet the requirements of dual-axle synchronization control in high-precision systems.

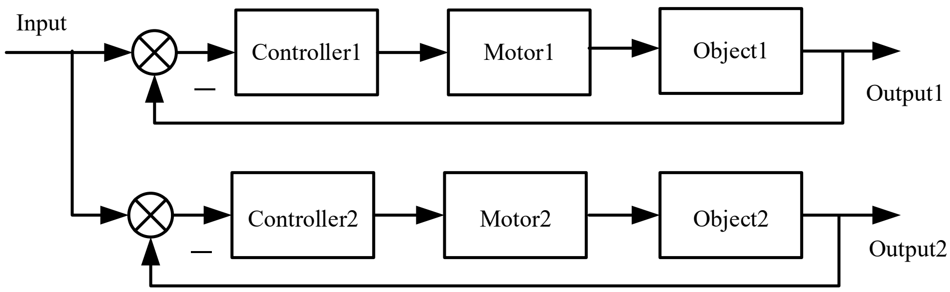

Fig.1 Master Command Reference Synchronization Control Structure Diagram

2.2 Master-Slave Synchronous Control

Master-slave synchronous control mode [10] is a synchronous control mode in which the output of the main shaft is taken as the input of the slave shaft, and the structural block diagram is shown in Figure 2. In this control mode, the changes caused by any disturbance on the driving shaft will be tracked and reflected by the driven shaft, while the disturbance on the driven shaft cannot be fed back to the driving shaft, thus the inter-shaft synchronous position deviation caused by the disturbance on the driven shaft cannot be eliminated. At the same time, due to the electrical and mechanical delay between the main and driven shaft control systems, especially for large inertia controlled objects, the mechanical delay time will be several times that of the electrical delay time, so that the motion of the driven shaft always lags behind the motion of the driving shaft, resulting in large synchronous position deviation, and the higher the running speed, the larger the synchronous deviation caused by the delay. This synchronous control method is mainly applied to systems with low requirement for position synchronization accuracy at low speed.

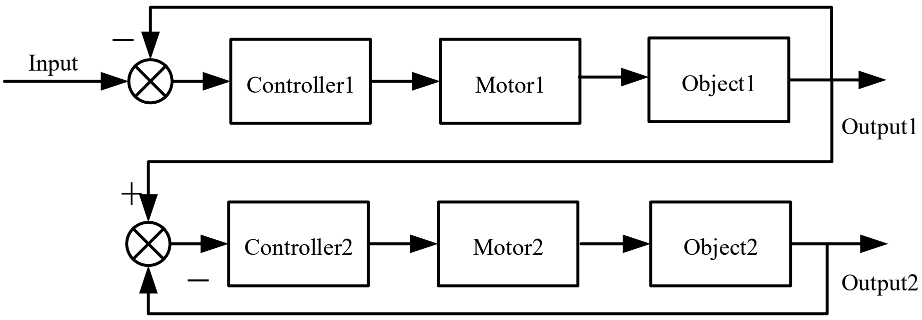

Fig.2 Master-Slave Synchronous Control Structure Diagram

2.3 Cross-Coupled Synchronous Control

The cross-coupling synchronous control structure diagram is shown in Figure 3, of which basic idea is that for a multi-axis system, the axes are in parallel relationship. When controlling the movement of a certain axis, the influence of other axes is introduced into the control of the axis, and then the axes are coordinated with each other to achieve the effect of synchronization, which makes each axis of the system independent. When each axis is disturbed, each axis can be controlled to achieve synchronization through mutual signal feedback. Under this control mode, the synchronization performance depends on the compensation strategy. Different algorithms will result in different synchronization performance between axes. At present, the research focus at home and abroad is also concentrated on this control method.

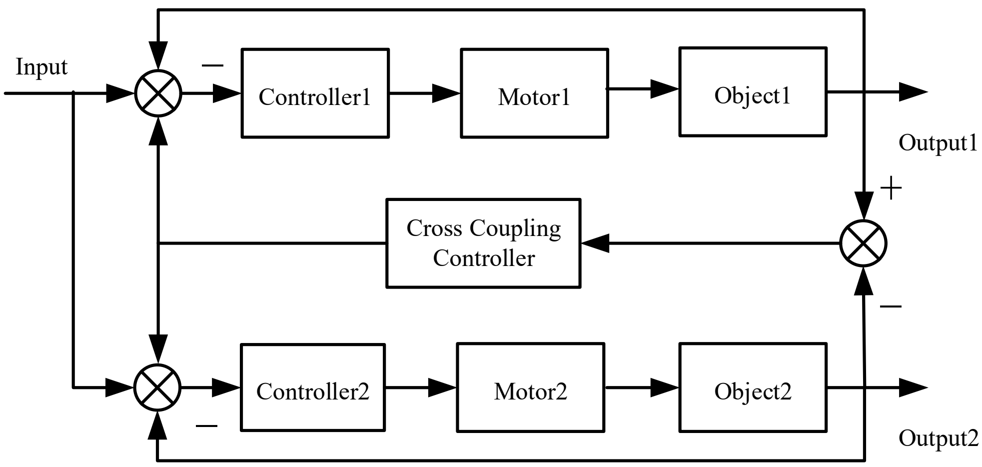

Fig.3 Cross-Coupling Synchronous Control Structure Diagram

3. Design of Control System for Motion Simulator

The core of the motion simulator control system is the DSP controller unit, which receives instructions from the upper computer and outputs control signals to the AKD servo driver after internal processing. The AKD servo driver generates current to drive the linear servo motor, and the linear servo motor generates thrust to push the load to move. Incremental linear grating ruler records displacement signal and feeds it back to DSP controller, thus forming feedback control loop. The DSP controller feeds back the displacement signal to the upper computer. The electrical system diagram is shown in Figure 4.

In the system design, the upper computer communicates with DSP controller through SCI serial port, and the communication speed is 19200bps.The DSP controller 50ms feeds back information to the upper computer once, including information such as displacement and operation status. The communication between the two X-axes is once every 2ms, which is difficult to meet the requirements by common serial communication. The system finally adopts CAN bus communication, and its communication rate is 500Kbps.

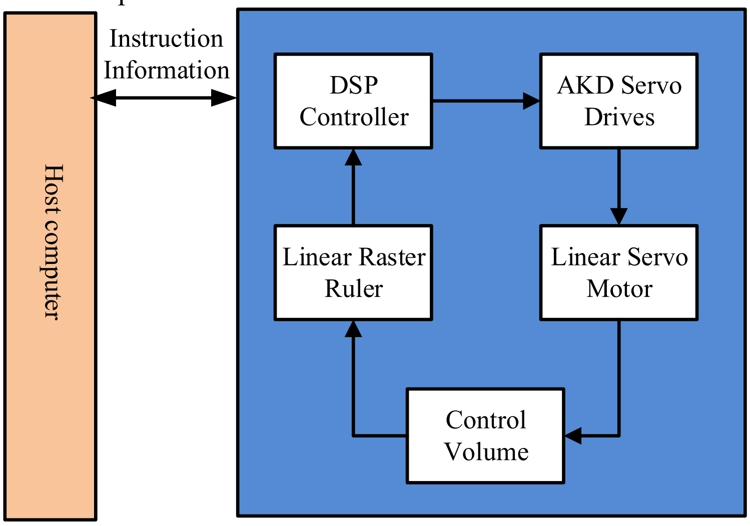

Fig.4 Electrical System of Motion Simulator

4. Design of Synchronization Control Algorithm

The servo system includes three layers of control links, namely current loop, speed loop and position loop. In the three-layer control link, the current loop is the inner control loop, the current loop uses the control algorithm of AKD servo driver, the speed loop is the middle control loop, and the position loop is the outer control loop, and the control structure is shown in Figure 5.

In the three-ring structure, the function of the current ring is to improve the rapidity of the system and restrain the interference inside the current ring in time. The function of the speed loop is to enhance the ability of the system to resist load disturbance and restrain speed fluctuation. The function of the position loop is to ensure the static accuracy and dynamic tracking performance of the system, so that the entire servo system can run stably and with high accuracy. The three-loop control structure can make the servo system obtain better dynamic following performance and anti-interference performance.

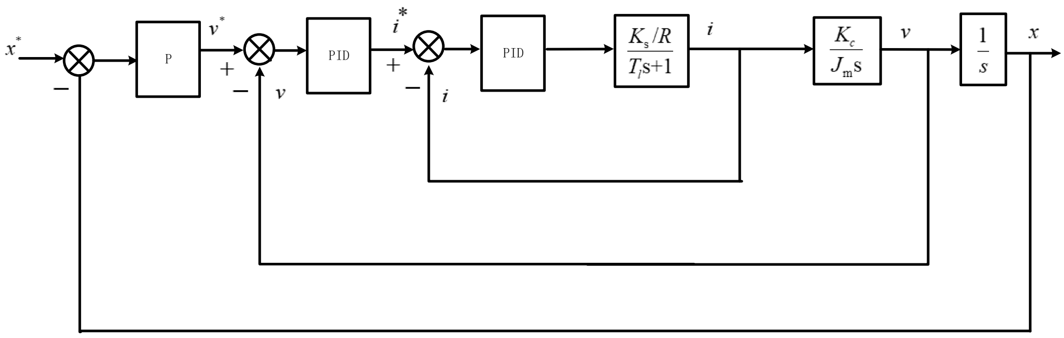

Fig.5 Structure Diagram of Servo Control System

For the double X-axis system, we use master-slave control method to carry out experiments first. The position error of X1 main shaft is used as the input signal of X2 slave shaft, and the master-slave control structure diagram is shown in Fig. 6. The position loop adopts proportional control and the speed loop adopts proportional-integral-differential control.

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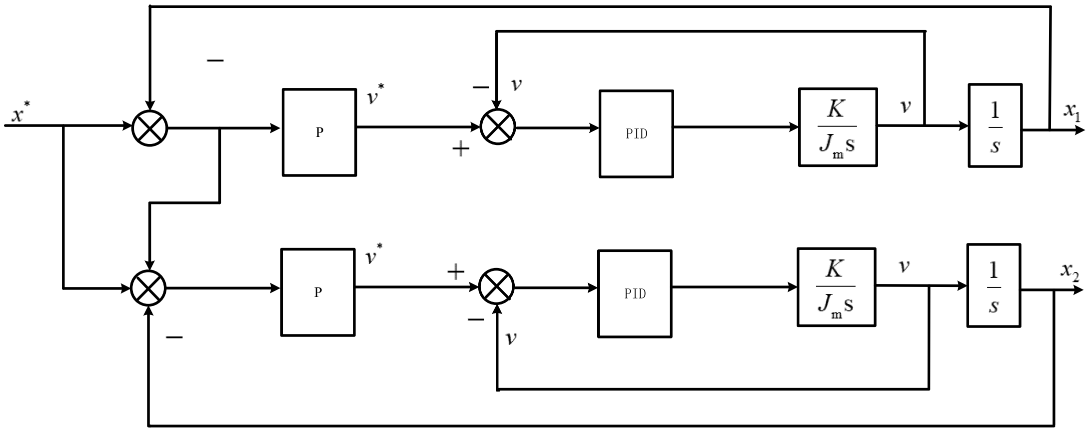

Fig.6 Master-Slave Control Structure Diagram

5. Design of Synchronization Controller Based on DSP

The design of synchronous controller is mainly divided into hardware part and software part. The hardware part mainly includes power supply module, measurement module, communication module, etc.

5.1 Power Module

Power supply is a prerequisite for any system to work. In the motion simulator control system, the controller needs to provide 5V, 12 V, 3.3V and 1.8V power supply forms according to the needs of F2812 and related external expansion chips.

The voltages of 3.3V and 1.8V are the working voltages of the F2812 core and internal integrated peripheral units. According to the requirements, TPS767D318 chip produced by TI Company is selected. The chip has the characteristics of long continuous stable working time, stable level conversion, small volume, etc. The chip can realize level conversion from 5V to 3.3V and 1.8V The power module diagram is shown in Figure 7

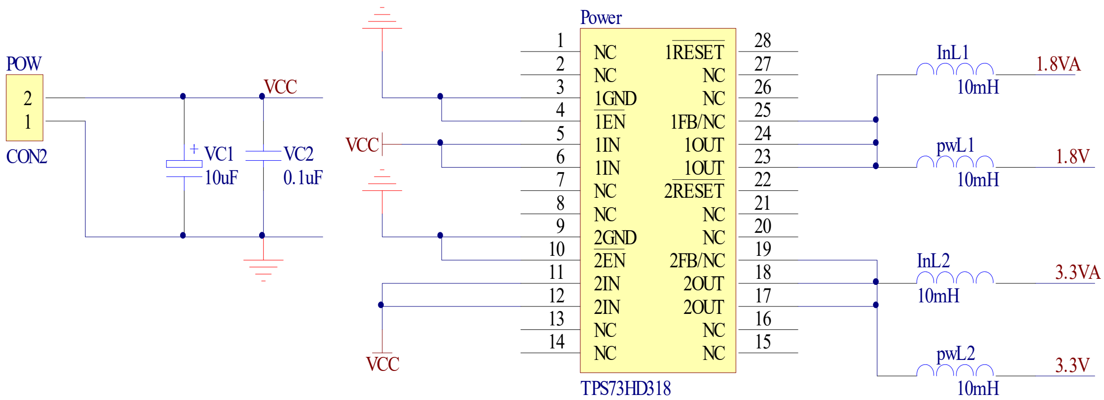

Fig.7 Schematic Diagram of Power Supply Module

5.2 Communication Module

The data communication module is a hardware circuit that realizes the communication of data, instructions and fault signals between the motion simulator data management platform and the digital controllers in all directions. In order to meet the real-time requirement of motion simulator communication, the data communication module must have real-time response capability.

Motion simulator has many subsystems, small data volume and long communication distance. Considering comprehensively, serial communication is selected. In order to solve the problem of long-distance transmission, RS232 and RS422 converters provided by MOXA are used to convert RS422

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signals to complete long-distance transmission.MAX232 is an RS232 standard serial port level conversion chip, which converts the RS232 standard serial port level to a level recognized by DSP. The conversion circuit is shown in Figure 8.

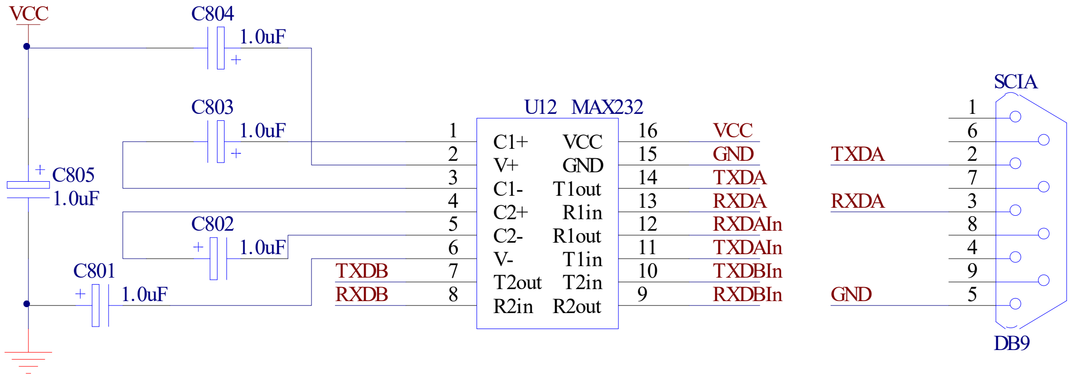

Fig.8 Schematic Diagram of Communication Module

6. Debugging Results of Master-Slave Tracking Synchronization Control

After the control system is built, the master-slave tracking mode is adopted to observe the synchronization error in the X direction when the Y direction is stationary and the Y direction participates in the motion respectively. When the Y direction is stationary, the synchronization result in the X direction is shown in Figure 4-5.When Y direction participates in sports, the synchronization result of X direction is shown in Figure 9.

As can be seen from the Figure 9, in the master-slave tracking synchronization control mode, the X-axis synchronization error is between 0.04~0.08mm and 0.08 mm when the Y direction is stationary. However, the synchronization error increases to -2~6mm when the Y-direction is involved in the movement, and increases as the Y-direction mover is closer to the X-axis.

According to the analysis of the experimental results, the classical PID algorithm has certain robustness, and the synchronization can be realized by two shafts when the Y direction is stationary, and the synchronization error is small .However, when the Y-direction participates in the motion, the disturbance of the system is large and the synchronization error is too large. Therefore, it is necessary to improve the performance of the system by improving the robustness of the single axis and adopting the cross-coupling method.

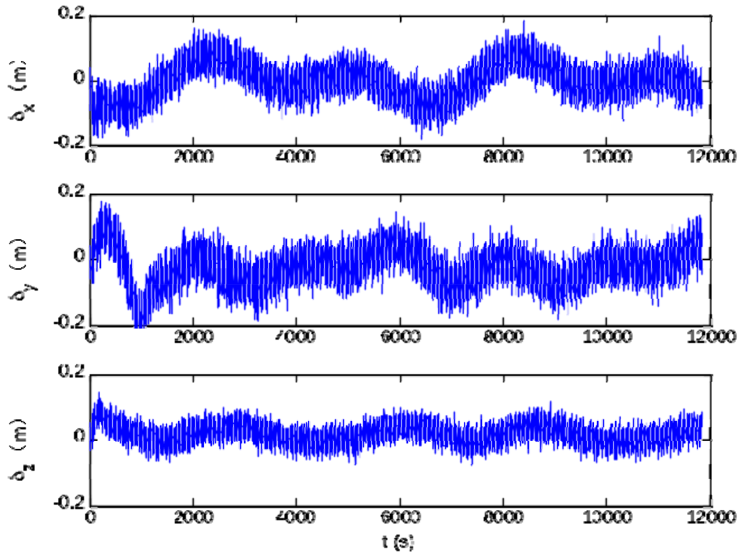

Fig.9 Position Error of Adaptive Continuous Control Method

The simulation results show that the adaptive continuous control method can still effectively track the nominal configuration under the influence of navigation errors. The thrust acceleration is shown in Figure 10.

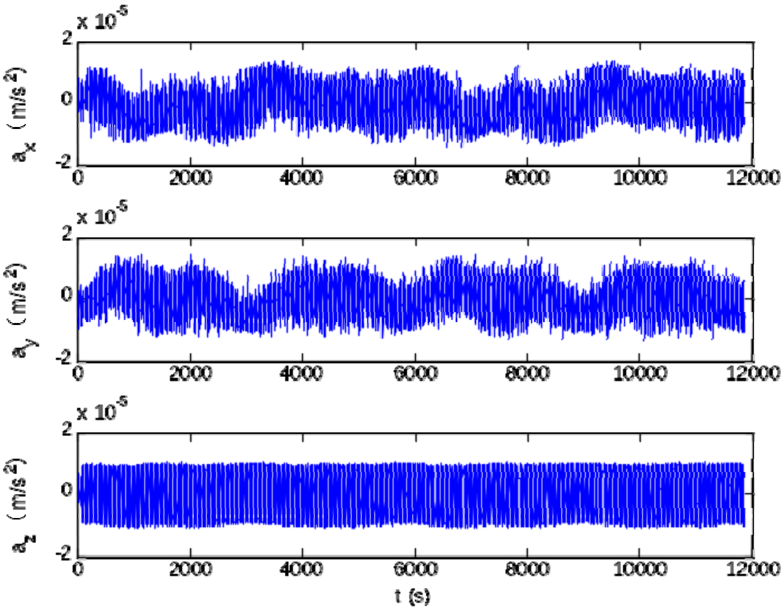

Fig.10 Thrust Acceleration of Adaptive Continuous Control Method

The semi-physical simulation results can verify that under the requirements of effectively completing the relative navigation and continuous maintenance control tasks, the control acceleration of the actuator is less than, and the speed increment required for one-year maintenance control is about 200 m/s, which meet the requirements of the task.

7. Conclusion

In recent years, with the development of computer vision technology, digital image processing technology has been widely used in the field of artificial intelligence. The identification of identification images by digital image processing technology is the premise to realize robot motion according to visual navigation results. This paper has completed the design and development of the automatic walking robot control system, mainly realizing the functions of visual navigation and walking control of the control system. Experiments prove that the vision navigation system of the automatic walking robot can provide the walking control system with direction identification and identification information of the ridge and furrow extension paths between fields; the walking control system can call the motor driver to realize the forward, backward, left forward, right forward, left backward and right backward rotation of the control object according to the path information. The overall debugging of the experiment verified the feasibility of the whole system and laid a certain foundation for the following research work.

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